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Dear Readers,

As last year 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 review the reached achievements in the previous year and bring you some personal insight into the reasons why MJSSM is such a great journal and you should cooperate with us.

We have to strengthen 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 second year (CiteScore 2018: 3.30, SJR 2018: 0.233; SNIP 2018: 0.459), while the ongoing tracker is promising not great as last year but recognizable CiteScore calculation in 2019 (CiteScoreTracker 2018: 1.08; updated on 08 January, 2020) which is scheduled for Spring 2020. 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. So, we want to thank all the participants in the rapid development of our journal again, 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 decreased for two per cents from last section. Currently, it is on 9% for original research submitted in period 2018-2019 and expected to keep on the same level for the upcoming period. On the other hand, the time from submission to first decision is a little bit increased (44 days), as well as the time from submission to publication (59 days).

From year to year, volume to volume and issue to issue, 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

# Does it Promote Physical Activity? College Students' Perceptions of Pokémon Go

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ABSTRACT The present study examined whether physical activity participation between Pokémon GO users was different from that of non-users. Participants' perceptions of the game in terms of promoting physical activity were also evaluated. A total of 393 college students (Female=175, age M=19.03, SD=2.04) took an online survey that measured user activity, perceptions on the game, and recalled physical activity participation. The participants were classified as non-users (n=227, 79.1%), non-active users (i.e., playing less than 30 min a day, n=24, 8.4%), and active-users (i.e., playing more than 30 min a day, n=36, 12.5%). Most users agreed that playing the game had a positive impact on their physical activity level. However, the non-active users and the active-users walked significantly less than the non-users did, and the non-users also had higher overall physical activity participation levels. Most Pokémon GO players perceived that the app made them more physically active, although they still walked less than non-players did. There may be pre-existing differences in the physical activity patterns between the users and the non-users. Health promotion professionals may encourage sedentary individuals to use this game to promote physical activity.

KEY WORDS college student, exergaming, physical activity, Pokémon GO

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## Introduction

Physical inactivity has been identified as a leading factor causing chronic diseases, including heart disease, diabetes, and some forms of cancer (Dietz, Douglas, & Brownson, 2016). Nevertheless, almost half of American adults do not meet physical activity recommendations (Center for Diseases Control and Prevention, 2015). As one of the leading reason for being physically inactive is a lack of enjoyment and fun (Lewis et al., 2016; Yan, Berger, Tobar, & Cardinal, 2014), the video game industry provides an alternative approach to this problem. Exergames, namely active video games, have gained popularity as a leisure pastime as well as a creative physical activity tool.

Exergames (e.g., Wii, Xbox Kinect) require whole-body movements, and thereby generate moderate levels of energy expenditure and elevated heart rate, which could potentially contribute to weight loss and cardiovascular health benefits (Staiano & Calvert, 2011). In a systematic review study, Sween and colleagues reported that, based on results from 27 studies, a strong correlation exists between exergaming and increased energy expenditure (Sween et al., 2014).

One of the latest advancements in the exergames industry is the location-based, augmented reality mobile games. Different from other exergames, the location-based augmented reality games utilize Global Positioning System (GPS) and camera-compatible devices to create a fantasy setting in which the games take place. The users need to physically walk in the real world to participate in the game. Pokémon GO, developed by Niantic Inc. for iOS and Android devices (Anderson et al., 2017), is one of the most popular location-based augmented reality games. When playing Pokémon GO, users need to download the app on their smartphones, and then walk in the real world to "catch" and collect the virtual creatures called "Pokémon" using their phones. Besides walking to catch Pokémon, the game also highlights other features to encourage users to walk (e.g., walking or jogging to hatch "eggs" or collect "candies", etc.). Since Pokémon GO was launched in the U.S. in July 2016, there have been 500 million downloads (Wong et al., 2017). It has achieved popular appeal in more than 100 countries.

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Conflict of interest: None declared.

Pokémon GO is also marketed as a game that encourages outdoor physical activity and, therefore, can improve players' health. According to Wong et al. (2017), Pokémon Go promotes physical activity by encouraging goal setting for exercise (e.g., hatch "egg" feature), mobilization to different locations, and encouraging evening and after-hours activities. A recent study has shown that Pokémon Go users increased their physical activity by 1437 steps/day on average, representing a 25% increase compared with prior activity (Althoff, White, & Horvitz, 2016). It was also estimated that a total of 144 billion steps could be gained in the US alone if the game was played by the whole population (Althoff et al., 2016).

Since the location-based augmented reality game is relatively new, there is limited research on it, especially on how it changes users' physical activity participation levels. There is also a limited understanding of the users' perceptions of how the game changes their physical activity patterns, particularly walking and jogging behaviours. Hence, the primary goal of this study was to assess the walking and overall physical activity behaviours among the Pokémon GO users and compare them to the non-users. The secondary goal of the study was to determine the users' perceptions of how the game impacted their physical activity participation, enjoyment, and confidence. To our knowledge, this is the first study that compares active and non-active Pokémon GO users to non-users' physical activity levels and perceptions of the game. We hypothesized that the Pokémon GO players would walk more than the non-players would and the active users would have a more positive perception of the game on physical activity compared to the non-active users.

## Methods

### *Participants*

The study was approved by the Institutional Review Board at the college where the study was conducted (Protocol Number 2016-0906). Three hundred and ninety-three college students from a medium-sized college in the north-eastern United States participated in the study through an online survey. They were recruited via campus flyers, class visits, and word of mouth. Based on the responses, 105 athletes were excluded from the study as they accumulated a significant amount of physical activity time daily, which would influence the study results. The remaining participants (n=288) included eighty-eight males (33.5%), average age M=19.03, SD=2.04. See Table 1 for details of the participant characteristics.

### *Measures*

An online survey was developed by the research team to measure participants' Pokémon Go related behaviour and perceptions, as well as their physical activity level. Specifically, eight questions measured whether they had ever played, how much time they spent on playing it in the previous seven days, and where they usually played. Fourteen questions were developed to measure participants' perceptions on how playing Pokémon Go influenced their physical activity participation, motivation, enjoyment, and confidence on a Liker scale between 1 (strongly disagree) to 5 (strongly agree). An exemplar question was "Since I start to play Pokémon Go, I get outdoors more often than before". The analysis showed good reliability of this perception scale, with Cronbach alpha value=.95.

Finally, seven questions asked participants to recall how much time they spent on different types of physical activities in the previous seven days, including walking, jogging, weightlifting, dancing, yoga, team sports, and other types of exercise. The purpose of those questions was to compare walking, jogging, as well as the overall physical activity participation level between users and non-users. An example question was "During last week, how much total time did you spend on walking." If they checked "other type", they were asked to specify what type of physical activity it was and how many minutes they spent performing it. The total time of physical activity was calculated by adding up time spent on each physical activity that the participants indicated.

### *Statistical analysis*

All data were entered into and analysed using SPSS 21.0. One-way ANOVA and post hoc analyses were performed to examine differences in physical activity behaviour among active users, non-active users, and non-users. A T-test was also implemented to compare the differences in perception of Pokémon Go between active users and non-active users.

## Results

Based on the responses, an active-user was defined as one who had played in the previous days and on average spent more than 30 mins/day on playing; A non-active user was defined as one who had played in the previous seven days but for less than 30 mins/day; Non-users were defined as those who have not played Pokémon Go in the previous seven days. Based on the responses, there were 227 non-users (79.1%), 24 non-active users (8.4%), and 36 active-users (12.5%).

The average time (minutes) spent on walking, jogging, and total physical activity were M (walking)=384 min, SD=280 min, M (jogging)=179 min, (SD=199), M (total)=921 min, SD=673 min, respectively. Females walked and jogged significantly more than males did: male (walking) M=285 min, SD=243 min, female (walking) M=430 min, SD=184min, t (240)=-4.86, p<.001; Male (jogging)=138 min, SD=112 min, female (jogging)=198 min, SD=223 min, t(250)=-2.81, p<.01. There were no gender differences in total physical activity participation time: male (total)=836 min, SD=653 min, female (total)=960 min, SD=680 min.


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TABLE 1. Basic characteristics of the study participants

| Users, n, (%) | Active Users (n=36) | Non-Active Users (n=24) | Non-Users (n=227) |
|---|---|---|---|
| Age, y, mean (SD) | 20.3(2.1) | 18.5(1.2) | 18.9(2.0) |
| Male, n, (%) | 19(57.6) | 12(60.0) | 57(27.1) |
| Year in college, n (%) | | | |
| Freshmen | 9(27.3) | 17(85.0) | 132(62.9) |
| Sophomore | 6(18.2) | 0(0) | 28(13.3) |
| Junior | 4(12.1) | 2(10) | 33(15.7) |
| Senior | 12(36.4) | 1(5) | 11(5.2) |
| Graduate Students | 2(6.1) | 0(0) | 6(2.9) |
| Last 7d walking Time, hr, mean(SD) | 4.7(3.8) | 4.7(3.6) | 7.0(4.7)*** |
| Last 7d jogging Time, hr, mean(SD) | 1.2(1.4) | 1.4(1.2) | 2.5(2.5) |
| Last 7d total physical activity Time, hr, mean(SD) | 9.1(6.7) | 9.3(4.9) | 13.1(9.9)* |

Note.* indicates significant level at .05; *** indicates significant level at .001.

Different from the hypothesis, ANOVA and Post hoc analyses showed that non-active users and active-users walked significantly less than non-users did: M=4.7hr/w SD=3.6, M=4.7hr/w SD=3.8, and M=7.0hr/w SD=4.7, respectively, F (2,247) =4.78, p=.001. In terms of total jogging time in the previous seven days, M=1.4 SD=1.2, M=1.2 SD=1.4, and M=2.5 SD=2.5, for non-active users, active users, and non-users, respectively. No group differences were observed (Ps>.05).

In terms of the total physical activity time in the previous seven days, the average of the non-active users was

TABLE 2. Perception of Pokémon Go's Influence on leisure activities

| Since I start to play Pokémon GO: | % Strongly Agree or Agree | |
|---|---|---|
| | Active Users | Non-Active Users |
| I walk more | 75.8** | 28.6 |
| I bike more | 11.2 | 14.3 |
| I jog more | 30.3 | 19.1 |
| I get outdoors more often than before | 69.7*** | 33.3 |
| I park my car further to walk more | 36.4** | 9.5 |
| I take the stairs instead of the elevator | 30.3 | 28.6 |
| I walk to a destination to play | 60.6** | 33.4 |
| I drive to a destination to play | 63.6** | 23.8 |
| I am more likely to walk instead of drive to the nearby locations | 45.5 | 28.6 |
| I walk/bike with my friends more than before | 57.6** | 19.1 |
| I walk/bike with my family more than before | 27.3** | 4.8 |
| I enjoy walking/biking more than before | 57.6* | 28.6 |
| I am more confident to walk/bike long distance than before | 39.4** | 14.3 |
| I want to continue using this APP to increase my physical activity level | 45.5** | 9.5 |

Note.* indicates significant level at .05; ** indicates significant level at .01; *** indicates significant level at .001.

M=9.3hr/w, SD=4.9hr/w, active users M=9.1hr/w, SD=6.7hr/w, non-users M=13.1hr/w, SD=9.9hr/w. One-way ANOVA analysis showed there were significant differences between the groups, F (2,250)=3.39, P=.04. The post hoc test showed that the non-users had significantly higher physical activity participation than the active users did (P=.02), but not the non-active users (P=.15).

We also examined how playing Pokémon Go influenced participants' physical activity participation, motivation, enjoyment, and confidence. Table 2 showed the percentages of the users who responded "strongly agree" or "agree" to the statements. According to the data, playing Pokémon Go had a positive influence on physical activity behaviour, for both active-users and non-active users. Specifically, more than half of the active Pokémon GO users agreed that playing the game had increased their walking behaviour (75.8%), motivated them to go outdoors more often (69.7%), motivated them walk to a destination to play (60.6%), walked/biked more with friends and family members (57.6%), and made them enjoy walking/biking more (57.6%). When comparing the active-users and non-active users, the positive responses among active users were higher than non-active users on all statements. Table 2 showed the results of the group differences examined by the independent T-tests.

## Discussion

The purpose of the present study was to compare the walking, jogging, and overall physical activity participation between Pokémon GO active, non-active users, and non-users. In addition, it assessed the users' perception of how playing the game changed their physical activity participation and perceptions. The results showed that the Pokémon GO active-users had less walking behaviour, as well as overall physical activity participation level, compared to the non-users.

Interestingly, the perception questions showed that the active Pokémon GO users agreed that, in general, playing the game had increased their walking behaviour, motivated them to walk more, and also made them enjoy walking more. The results of the perception questions were consistent with the recent research that also reported positive impacts of Pokémon GO on physical activity (Liu & Ligmann-Zielinska, 2017; Serino et al., 2016; Xian et al., 2017). Specifically, Xian and colleagues reported that playing Pokémon GO was associated with an average increase in 2000 steps per day (Xian et al., 2017). Liu and colleagues reported that playing the game was associated with 3 additional hours and 5.6 extra miles of physical activity in total per week. Consistent with our hypothesis, the active-users also reported more positive changes in physical activity than the non-active users, which indicated that the more users play, the more positive influences the game had on their physical activity participation and perceptions.

Although the users perceived that playing Pokémon GO increased their walking behaviour, they still walked less than the non-users. One possible explanation is that the individuals who are playing Pokémon GO and other video games are in general more sedentary than the non-user population, which is supported by the current results that the players had lower overall physical activity levels compared to the non-players. In addition, numerous studies report positive relationships between screen-time, including playing video games, and physical inactivity, indicating that video game players are more sedentary than non-players in general (Bickham, et al., 2013; Lepp et al., 2013). Finally, given the fact that the non-players in this study were so active (i.e., average 13 hours of physical activity time per week), it is not surprising that the Pokémon players accumulated less total physical activity participation time compared to them.

Another significant finding of this study was that the Pokémon Go users had a positive perception of the game on promoting their walking behaviour, motivating them to walk more, and making walking more enjoyable. Not surprisingly, the active-users had a significantly more positive evaluation of the game on their physical activity than the non-active users did. However, it is not clear whether it is because the active users play more, and hence obtain more physical activity-related benefits; Or, because they benefit more, and therefore they tend to play more. This question could be answered by studies in the future.

We determined that the active-users were significantly more likely to drive and play than non-active users. When people are highly motivated to play, they tend to use all possible means, including unsafe ways such as driving and playing, to advance themselves in the game. While the game developing company should work on detecting and prohibiting those unsafe playing behaviours, health educators at schools and communities should also reach out and provide safety education to the players.

Although recent studies have shown the positive impact of Pokémon Go on the users' physical activity levels, it is unclear how sustainable those changes are. Sustained behavioural change has proven challenging as consumers discontinue use and/or lapse back into previous behaviours (Foster et al., 2013). Recent data showed that the daily users of Pokémon Go dropped from 28.5 million in June 2016 to 5 million at the end of 2016 (Comscore, Inc.). This warns us to avoid being overly optimistic about using this type of video game as a long-term tool to promote physical activity. It also indicates that there should be more longitudinal studies, as well as qualitative studies, to understand the sustainability of this type of video game on physical activity promotion.

There are several limitations to this study. First, the cross-sectional study design does not provide direct evidence of the changes in physical activity levels before and after users playing Pokémon Go. In addition, the


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measure of physical activity was not objective, which resulted in more measurement error (e.g., recall bias). Third, participants may over-report their physical activity participation level as being more socially acceptable, causing a response bias. Finally, although the overall sample size was satisfactory, the number of active users and non-active users were significantly lower than the non-users, which lowered the overall power of the study to detect potential differences. Given those limitations, future studies could use a randomized experimental study design to examine the actual impact of Pokémon Go on players compared to the non-players. In addition, qualitative studies should be implemented to explore how the game impacts individual behaviours and psychological characteristics.

Although the current study only focused on the college population, the results may offer implications on physical activity promotion strategies to a larger population as well. Specifically, health practitioners may use this game to promote youth and young adults walking and/or jogging behaviours, with setting specific goals (e.g., walking/jogging a certain distance a day to hatch eggs). Schools and community organizations may use this game to design physical activity promotion programmes through individual participation, peer interaction (Yan & Cardinal, 2013), or group competition (e.g., competitions on the number of Pokémon collected, distances walked/jogged). In addition, organizations and worksites should also provide walking/jogging maps to participants, along with safety tips (e.g., do not play along late at night, drive and play, or bypass private areas while playing).

In conclusion, this study supported the positive impact of Pokémon Go on promoting physical activity, motivating participants to be more physically active, and making physical activity more enjoyable. Although this game has the same struggles of user sustainability as other video games, we believe it is a useful strategy for individuals who do not enjoy conventional exercise. More innovative exergames should be created to encourage the public to engage in physical activity while having fun during a game.

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# Evaluation of Risks and Benefits of Physical Activity of Hypertensives and Normotensives: Fighting a Societal Burden

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ABSTRACT Physical Activity (PA) is considered a coadjutant factor in the control of hypertension, helping to control this societal burden. This study investigates the factors that may influence the adoption of PA recommendations by hypertensive individuals by comparing physical activity patterns among hypertensives and normotensives and the importance placed on PA by both groups. Data from 966 Portuguese participants aged between 18 to 90 years old, representing hypertensives (n=144) and normotensives (n=822) were collected using a face-to-face questionnaire. The results show significant differences between the two groups in terms of causes of non-participation and dropping out, preferred PA activities, perceived knowledge, and information-seeking behaviour. The main barriers to exercise reported by hypertensives were the perception that PA is not adequate or even dangerous to their health. Doctors must be considered a key factor in promoting exercise. When compared to normotensives, hypertensives feel that PA information available is not appropriate (p=.0006). Hypertensives consider that existing programmes will not meet their needs and do not like traditional fitness classes, such as those in gyms. The fear of risks associated with exercise seems to be a significant barrier that impairs PA participation.

KEY WORDS hypertension, exercise, health benefits, behavioural change, barriers, risks

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PERCEPTION OF RISKS AND BENEFITS OF PA AMONG HYPERTENSIVES
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## Introduction

Hypertension affects 30 to 45% of adults worldwide and is responsible for approximately 13% of all deaths (Gerage et al., 2015). It is considered a significant risk factor for severe cardiovascular disease such as myocardial infarction or stroke (Eckel et al., 2014; James et al., 2014).

Hypertension has a strong relationship to a sedentary lifestyle, high sodium and high caloric intake, high alcohol consumption, and the ageing process (Cavalcante et al., 2015; Chobanian et al., 2003). Besides medical treatment with drug prescriptions, embracing a more active lifestyle is seen as a crucial factor for managing high blood pressure in adults (Wienert, Kuhlmann, Fink, Hambrecht, & Lippke, 2017). In fact, physical activity (PA) is present in most recommendations and treatment guidelines for hypertensive patients (James et al., 2014; Romero Blanco et al., 2015). Epidemiological studies indicate that higher PA levels are associated with lower blood pressure, and reviews of randomized controlled trials have shown that aerobic endurance training is able to control hypertension (Bakker, Sui, Brellenthin, & Lee, 2018; Cornelissen & Fagard, 2005). A primary physiological response to PA is post-exercise hypotension that promotes chronic adaptations and

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acute responses within the cardiovascular system. These changes have relevant clinical implications for hypertensive participants, as post-exercise hypotension can act as a nonpharmacological agent for hypertensives (Cavalcante et al., 2015). Besides post-exercise hypotension, PA has been shown to increase the capillary to fibre ratio in humans (Gliemann et al., 2015) and improve vascular function by improving the balance between vasodilator and vasoconstrictor systems (Nyberg, Gliemann, & Hellsten, 2015).

PA promotion for hypertensive individuals, among other healthy habits (such as diet) must be a key objective of primary care for this population. To substantiate this promotion, both the American Heart Association and American College of Cardiology (Eckel et al., 2014) and the Sixth Joint Task Force of the European Society of Cardiology (Piepoli et al., 2016) developed sets of guidelines for lifestyle management to provide an evidence-based overview for lifestyle changes, namely in PA patterns, in persons diagnosed with hypertension.

Operationalizing these guidelines requires collective action by government, nongovernment, for-profit, and non-profit entities working together at several levels (Kraus et al., 2015). A systematic review on interventions for lifestyle modification based on PA and diet by Patnode, Evans, Senger, Redmond, and Lin (2017) found that interventions varied considerably across studies. Differences were identified in the behavioural focus, delivery mode, and intensity. They conclude that PA behavioural interventions were associated with modest reductions in blood pressure measures at approximately 6 to 12 months of follow-up, compared with control conditions. Another systematic review by Widmer et al. (2015) focusing on digital health interventions for the prevention of cardiovascular diseases, including hypertension, showed that no significant changes in blood pressure were found after digital interventions. Combined, the two reviews suggest that there is insufficient evidence on the effects of interventions on sedentary behaviours.

Concerning these results, the American College of Cardiology/American Heart Association Task Force (Eckel et al., 2014) considers as future research needs: to determine strategies for effectively implementing PA recommendations and increasing the understanding of factors that influence the adoption of PA recommendations. Establishing effective strategies to promote the adoption of an active lifestyle should be based on in-depth knowledge about the target population in order to customize both the promotional information and the PA implementation.

Consequently, it is essential to evaluate if there are differences between hypertensive and normotensives individuals regarding the way they seek PA information, how they perceive the PA information they already have, as well as the barriers and the objectives/expectations towards exercise. The differences should be considered in the way PA is promoted among hypertensive individuals and how the interventions must be implemented. Therefore, the specific objectives of this study are: (1) to compare physical activity patterns among hypertensives and normotensives; (2) to determine differences among PA-related information sources, and (3) to determine differences in the evidenced perception that the target groups display regarding the need and importance of PA.

## Methods

This investigation is a cross-sectional population-based study in Portugal. 966 participants aged 18 to 90 years old (mean=41.9; SD=19.5) were included in this study. Individuals were asked to answer several questions. Participants were recruited in public places in different areas in Portugal, in large, medium, and small cities and in rural villages. Participants were completely free to participate in the study.

The hypertension status was assessed by asking the participants if they had ever been informed by any health professional that they had high systolic or diastolic pressure (Churilla & Ford, 2010). The participants' answers choices were (1) "yes"; (2) "yes, but only during pregnancy"; (3) "no"; and (4) "told borderline high or prehypertensive". In addition, participants were also asked if they were currently receiving any pharmacological intervention to treat hypertension. Those who answered "yes" to the hypertension question or were currently taking drugs for the high blood pressure were classified as being hypertensive (self-reported) (n=144). The other participants constitute the normotensive group (n=822). PA was assessed using the short form of the International Physical Activity Questionnaire (IPAQ) (Hagströmer, Oja, & Sjöström, 2006). The IPAQ is validated in Portugal (Craig et al., 2003).

The barriers were adapted from Thomas, Alder, and Leese (2004). Preferred physical activities were chosen from Booth, Bauman, Owen, and Gore (2006). Goals/expectations to into account the list from the American College of Sports Medicine (2018). Perceived knowledge about PA and PA information sources were based on the study from Pinheiro, Esteves, and Brás (2012).

To ensure content and face validity, all items were reviewed by an expert panel of professors and researchers not involved in the study. The board consisted of two sports scientists, one expert researcher on market studies and survey development and one expert researcher on knowledge management. Fieldwork supervisors applied the questionnaire to 25 individuals to ensure the comprehensibility of the wording and completion time. After attending ten hours of training on the application and coding of questionnaires, nine post-graduate students collected the data.

Independent t-tests were used to examine the differences between the group means, and Levene's test to check the homoscedasticity of the groups' variances. A Chi-squared test was used to compare hypertensives with normotensives for non-metric variables.


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## Results

### *Physical Activity Patterns among Hypertensives and Normotensives*

Regarding the PA level, hypertensives showed a higher prevalence of lower and higher PA levels, but no statistically significant differences were found between hypertensives and normotensives. These results suggest the existence of two behaviours among hypertensive Portuguese adults: a more active one, already engaged in PA routines and a more sedentary one (32%) that do not meet PA recommendations.

Considering the barriers to exercise (Figure 1), hypertensives are significantly different from normotensives in five impediments. A lack of interesting activities (53%), do not feel empathic with other participants (42%), not adequate to the health (37%) and potentially dangerous to the health (31%) are more significant barriers for the hypertensive group. The normotensives indicate a lack of time (69%). However, lack of time, schedule and laziness are also pointed out by more than 45% of the hypertensive group, which should be considered on the promotion of PA.

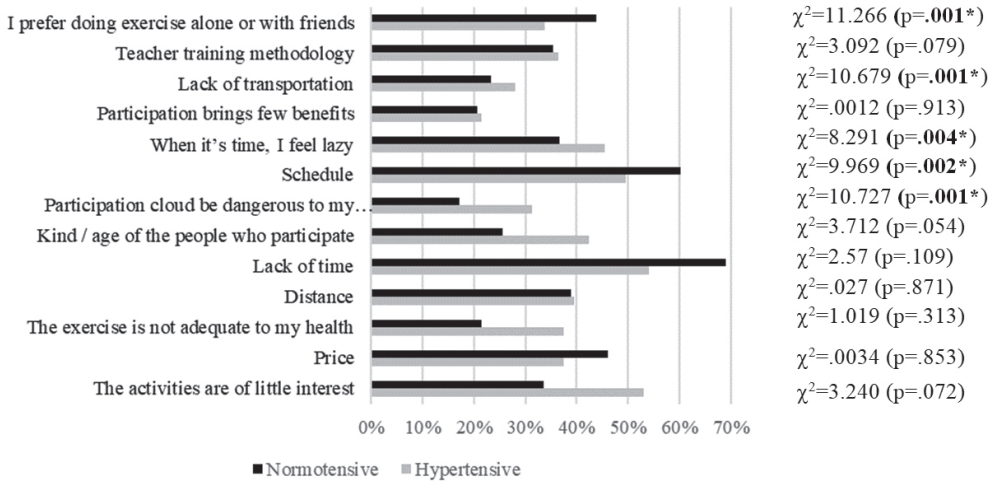


Figure 1. Causes of non-participation physical activities programmes

The results of the evaluation of goals/expectations are presented in Table 1. The main goals valued by the hypertensives are learning healthy living habits (90%), disease recovery (87%), to become strong and more agile (79%), prevention of diseases (76%), and decrease stress level (75%). The results in Table 1 showed significant differences between groups (p<.05) in almost all goals/expectations evaluated, but the hypertensives showed in general lower expectations about the results of participating in PA, with the exception of disease recovery (87%) and feeling more confident (43%) (p<.005).

Concerning the preferred physical activities (Table 2), the hypertensive group answers indicated a strong preference for the meditation/mobilization classes (92%) and walking activity (76%). In general, this group showed a lower propensity for participation in fitness classes and using gym exercise machines, as well as

TABLE 1. Evaluation of the goals/expectations of participation in physical activities

| | Hypertensive | | Normotensive | | Chi-square | p |
|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | | |
| Weight loss | 83 (72.8%) | 31 (27.2%) | 424 (67.7%) | 202 (32.3%) | 1.152 | 0.283 |
| Prevention of diseases | 109 (75.7%) | 35 (24.3%) | 613 (74.6%) | 209 (25.4%) | 0.081 | 0.775 |
| Staying stronger and more agile | 80 (79.2%) | 21 (20.8%) | 573 (87.9%) | 79 (12.1%) | 5.715 | 0.017* |
| Being with friends | 75 (71.4%) | 30 (28.6%) | 489 (82.0%) | 107 (18.0%) | 6.401 | 0.011* |
| Learning healthy living habits | 94 (89.5%) | 11 (10.5%) | 621 (92.5%) | 50 (7.5%) | 1.147 | 0.284 |
| Disease recovery | 88 (87.1%) | 13 (12.9%) | 428 (68.9%) | 193 (31.1%) | 14.123 | 0.000* |
| Recreation | 64 (69.6%) | 28 (30.4%) | 545 (86.4%) | 86 (13.6%) | 17.074 | 0.000* |
| More defined muscles | 40 (34.5%) | 76 (65.5%) | 363 (56.5%) | 280 (43.5%) | 19.049 | 0.000* |
| Eliminate Cellulite | 38 (33.3%) | 76 (66.7%) | 312 (47.2%) | 349 (52.8%) | 7.550 | 0.006* |
| Feeling more self-confident | 43 (43.4%) | 56 (56.6%) | 123 (20.1%) | 489 (79.9%) | 25.931 | 0.000* |
| Have a nicer body | 51 (45.9%) | 60 (54.1%) | 483 (75.7%) | 155 (24.3%) | 40.916 | 0.000* |
| Have a younger body | 60 (56.1%) | 47 (43.9%) | 452 (75.3%) | 148 (24.7%) | 16.862 | 0.000* |
| Decrease stress level | 84 (75.0%) | 28 (25.0%) | 584 (86.5%) | 91 (13.5%) | 9.930 | 0.002* |

Note. *p<95%.

combat and extreme sports. Overall, there are significant differences between groups (p<.005), with higher interest and preference of the normotensive group.

TABLE 2. Preferred physical activities

| | Hypertensive | | Normotensive | | Chi-square | p |
|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | | |
| Walking | 84 (76.4%) | 26 (23.6%) | 423 (67.9%) | 200 (32.1%) | 3.142 | .076 |
| Gym classes machines (alone) | 18 (12.5%) | 126 (87.5%) | 200 (24.3%) | 622 (75.7%) | 9.815 | .002* |
| Aerobics classes (in group, with music) | 33 (27.7%) | 86 (72.3%) | 260 (38.6%) | 414 (61.4%) | 5.106 | .024* |
| Structured classes (fitness) (with guidance) | 19 (15.8%) | 101 (84.2%) | 253 (38.0%) | 413 (62.0%) | 22.053 | .000* |
| Free classes in the gym (alone) | 22 (17.5%) | 104 (82.5%) | 204 (31.3%) | 447 (68.7%) | 9.855 | .002* |
| Outdoor classes (outdoor activities) | 47 (42.3%) | 64 (57.7%) | 392 (63.7%) | 223 (36.3%) | 18.010 | .000* |
| Amateur sports with friends | 31 (27.0%) | 84 (73.0%) | 385 (55.7%) | 306 (44.3%) | 32.653 | .000* |
| Structured amateur sports (with coach) | 15 (13.5%) | 96 (86.5%) | 218 (36.6%) | 378 (63.4%) | 22.527 | .000* |
| Classes of combat modalities | 11 (8.3%) | 121 (91.7%) | 107 (15.5%) | 583 (84.5%) | 4.638 | .031* |
| Classes of mobilization / meditation | 115 (92.0%) | 10 (8.0%) | 568 (83.8%) | 110 (16.2%) | 5.616 | .018* |
| Dance classes | 31 (24.8%) | 94 (75.2%) | 244 (34.3%) | 468 (65.7%) | 4.322 | .038* |
| Extreme sports in nature | 14 (11.1%) | 112 (88.9%) | 290 (43.2%) | 382 (56.8%) | 46.198 | .000* |
| Urban extreme sports | 21 (17.4%) | 100 (82.6%) | 223 (34.4%) | 426 (65.6%) | 13.624 | .000* |
| Traditional Games | 57 (50.9%) | 55 (49.1%) | 224 (38.4%) | 360 (61.6%) | 6.136 | .013* |

Note. *p<95%.

### *Differences in PA-related information sources*

Since information about PA benefits, risks and recommendations is a critical factor for hypertensives to embrace an active lifestyle, PA information-seeking behaviour was analysed. Table 3 shows that only 44% of the hypertensive individuals seek information about the type of physical activity that is appropriate for them, against 61% of normotensive participants ($x^2$=10,575, p=.0001). Doctors are the preferred source of information for hypertensives who rely less on Internet sites and on sports professionals. Online social media is not extensively used as a PA information source by both groups, suggesting that online PA promotion campaigns may not be adequate to reach hypertensives.

TABLE 3. Information seeking about physical activity

| | Levene's F | Levene's p-value | Mean Hypertensive | Mean Normotensive | t | df | t-test's p-value |
|---|---|---|---|---|---|---|---|
| By my doctor | 1.446 | .229 | 3.23 | 2.60 | 4.617 | 962 | 0.000* |
| By friends/family | 4.540 | .033 | 2.71 | 3.06 | -3.125 | 960 | 0.001* |
| By the Internet sites | 33.906 | .000 | 1.86 | 2.57 | -6.689 | 956 | 0.000* |
| By the Internet social media | 15.136 | .000 | 1.71 | 2.22 | -4.950 | 957 | 0.000* |
| By a sports professional | .884 | .347 | 2.50 | 3.21 | -5.742 | 959 | 0.000* |
| By newspaper/magazines | .696 | .404 | 2.33 | 2.46 | -1.174 | 959 | 0.242 |

Note.*p<95%.


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***Differences in the perception of the need and importance of PA.***

The perception of PA knowledge was also evaluated (Table 4). Hypertensives seem to be less secure with what they know about the benefits of PA (p=.0002) but highly interested to know more about what kind of PA is right for them (84%). The results in Table 4 also show that hypertensives (27%) have a stronger feeling that PA information is not appropriate for their condition than normotensives do (16%) (p=.0006). Both groups found that the information they receive is not clear.

TABLE 4. Perceived knowledge about physical activity

| | Hypertensive | | Normotensive | | Chi-square | p |
|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | | |
| Know the benefits that PA brings to my life. | 82 (83.7%) | 16 (16.9%) | 615 (93.0%) | 46 (7.0%) | 9.983 | 0.002* |
| Would like to know more about the benefits that PA brings to my life. | 81 (56.3%) | 63 (43.8%) | 525 (64.0%) | 295 (36.0%) | 3.171 | 0.075 |
| Would like to know more about what kind of PA is right for me. | 90 (84.1%) | 17 (15.9%) | 566 (89.8%) | 64 (10.2%) | 3.069 | 0.080 |
| Believe the information on PA I receive is correct and I trust them | 59 (72.0%) | 23 (28.0%) | 421 (81.0%) | 99 (19.0%) | 3.559 | 0.059 |
| Find that the information on PA I receive is not clear, and often do not understand it | 18 (20.5%) | 70 (79.5%) | 111 (18.3%) | 495 (81.7%) | 0.232 | 0.630 |
| Find that the information on PA I receive is not appropriate for my age/condition, so it's not useful | 27 (26.7%) | 74 (73.3%) | 100 (15.7%) | 537 (84.3%) | 7.450 | 0.006* |

Note.df=1.

## Discussion

Regular PA is considered a cornerstone in the prevention and management of hypertension due to its cardiovascular system benefits (Eckel et al., 2014; James et al., 2014; Piepoli et al., 2016). Although the PA recommendations for hypertension are well established, previous studies seem to indicate that there is no significant change in hypertensives' PA behaviours (Churilla & Ford, 2010; Patnode et al., 2017). The strategies for PA promotion and the interventions need in-depth knowledge about the hypertensive population to increase acceptance and adherence to PA programmes (Gallegos-Carrillo et al., 2014). Therefore, understanding what hypertensives think and knowing what the specific barriers preventing them from searching for information and engaging in PA are vital.

Self-reported data suggest that about one-third of adults globally are not meeting the necessary PA recommendations to be healthily active (Hallal et al., 2012). In this study, no differences were observed between groups regarding the PA level; consequently, it challenges previous studies suggesting that a sedentary lifestyle is associated with hypertension incidence (Jakes et al., 2003; Twinamasiko et al., 2018). The interaction with other significant hypertension factors, such as age, tobacco use, stress, dietary sodium, alcohol consumption, dyslipidaemia, or overweight and obesity that have been shown to be independent risk factors for the hypertension development should be explored (Hu et al., 2004).

The current results, although not significant, showed that the hypertensives are more sedentary (low-level PA) (31%) than the normotensives are (20%), but these results must be correlated with other risk factors. Nevertheless, the current study outcomes evidence that the Portuguese hypertensive population needs an effective PA strategy intervention since the protective effects of PA in hypertension prevention and management have been well demonstrated (Piepoli et al., 2016). Additionally, it is important to note that 40% of hypertensives self-reported high levels of PA, which could mean that there is a sub-group of hypertensive Portuguese adults that is physically active. These results are lower than the ones obtained by Churilla and Ford (2010), showing that 60% of self-reported American hypertensives accomplish the international physical activity recommendations (American College of Sports Medicine, 2018). The same proportion was observed by Romero Blanco et al. (2015) on a sample of Spanish hypertensives. The IPAQ survey used to assess PA level considers not only the amount of PA time (min/week) but also the frequency of PA to estimate the Metabolic Equivalent (METs). Therefore, an individual who reports 150 min of running 1 day per week would meet the international PA recommendations, but the calculated score IPAQ will correspond only to a moderate level because of the 1-day volume.

Regular exercise is recognized as a significant modifiable cause of hypertension (Pescatello, MacDonald, Lamberti, & Johnson, 2015). Understanding the influence of specific barriers to engage in exercise programmes is decisive in designing PA promotion strategies. The causes of non-participation or drop out presented in Figure 1 indicate that the hypertensives believe that physical activities (53%) and the profile of programmes (42%) are not very interesting (p<.005), suggesting that hypertensives do not have a positive perception about PA programmes. Moreover, compared to normotensives, hypertensives also report lower expectations towards exercise benefits. This issue will require better information about PA programmes, the adaptation of physical exercise to individual preferences, and inviting hypertensives to experiment with different types of exercises. Furthermore, since many of the hypertensives do not have a favourable social and family support to

engage or maintain on PA programmes (Gong et al., 2018) it is vital that PA programmes should be designed to nurture social integration.

Health-related barriers were also quoted as a significant obstacle for the hypertensives when compared to the normotensives. Despite the hypertension benefits of PA, particularly aerobic exercise, have been well established (Bakker et al., 2018), 37% of the self-reported hypertensive participants considered that exercise is not adequate for their health and 31% believed that exercise could even be dangerous for their health (31%) ($p<.005$). However, 87% indicated "Disease recovery" as the main PA participation goal ($p=.000$), which means that the hypertensives do not fully trust the health benefits of exercise. These results reinforce the need for better education and more information about the specifics benefits of PA on hypertension treatment.

The preferred physical activities by hypertensives were meditation/mobilization classes, walking or traditional games ($p<.005$), activities that demand a low or moderate level of effort. The less preferred ones were gym classes, machines, and fitness classes, as well as combat and extreme sports. Based on this evidence, a PA promotional strategy should incorporate activities that are energy less demanding and not require high skills. Only after the individual feels more self-confident and secure about the benefits of the PA is it possible to promote more demanding physical exercises and proceed with promoting additional healthy living habits. Appearance-related issues seem to be less important, so they should not be a priority for the communication strategy but must not be totally ignored.

Regarding PA information seeking, hypertensives search for less information than normotensives do, and they prefer doctors as the primary and almost sole information source. Health professionals working in primary health care have an essential role in promoting PA and healthy lifestyle due to their intimacy with hypertensive individuals (Gallegos-Carrillo et al., 2014; Plotnikoff, Johnson, Karunamuni, & Boule, 2010). However, a systematic review conducted by Hébert, Caughy, and Shuval (2012) shows that these professionals do not feel confident or properly trained to provide more than general advice about PA. Therefore, a PA promotion campaign targeting hypertensives must involve primary care staff who must be prepared to demystify the barriers that prevent the adoption of PA by hypertensives.

The findings suggest that online campaigns seem to be very little used by both groups despite the fact that websites, online tutorials, or social networking sites are the platforms most used to increase PA (Burke et al., 2015). A recent pilot study about the efficacy of a mobile application platform showed short-term potential to reduce the risk of hypertension (Toro-Ramos et al., 2017); the success of this digital programme was based a structured educational content and a live interaction with trained coaches and group motivation with peers, in order to realize the necessary lifestyle changes.

Hypertensives do not usually seek for PA information, but they want to know more about what kind of PA is adequate for them (84%). Moreover, compared to the normotensives, the hypertensive group acknowledge having low knowledge about PA benefits ($p=.0002$). The results suggest that hypertensives require more information, and probably provide stronger evidence of the gains associated with the increase of PA. Based on this, it is recommended that the PA promotion strategies should highlight information on the benefits to help hypertensives to adopt more active behaviour.

## Conclusions

This research aimed to increase knowledge about the factors that determine PA adoption by hypertensives. Based on the results, it is concluded that the fear of risks associated with exercise seems to be a significant barrier that impairs PA participation. In fact, hypertensives tend to prefer activities like walking, outdoor activities, classes of mobilization/meditation, and traditional games, displaying a lower propensity for participation in fitness classes. Since hypertensives do not like traditional fitness classes, gym owners should develop programmes that meet both the preferences, fears and expectations of this target. They should also adequately promote these programmes, emphasizing their safety and benefits to blood pressure (BP) management. The perception of potential risks may be considerably minimized by stressing the benefits of specifically designed, personalized, and supervised PA.

The main barriers to exercise reported by hypertensives were the perception that physical activities are not adequate or even potentially dangerous to their health; therefore, doctors must be considered a critical factor in promoting exercise. However, it is not enough to recommend exercise; guidelines should also be provided regarding the participation in specific PA programmes.

The main expectations that this population has on exercise is learning healthy habits, disease recovery and prevention, and mobility improvement. However, hypertensives think that existing programmes do not fulfil these. To assess their knowledge of the existing options the sources of information on PA were assessed, and the conclusion is that hypertensive individuals seek less information about physical activity than normotensives do and that physicians are the preferred sounds information for the promotion of an active lifestyle. Despite understanding the importance of BP control for their health, they seem to display some negligent behaviour regarding the knowledge of which BP is appropriate to their specific condition and the gains they could achieve. Governmental health organizations should consider implementing specific physical activity programmes for hypertensive individuals and communicate them with the endorsement of physicians using


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the available online and offline channels.

Finally, the behaviour of hypertensive patients was compared to normotensives to evaluate if there are differences that justify a specific strategy for hypertension. The conclusion is that there are differences significant enough to justify the development of specific exercise programmes for a hypertense population, but it is necessary that they are communicated in an appropriate way to be effective.

To summarize, the literature clearly indicates that the society in general and hypertensives' health condition would benefit from an active lifestyle and that PA is an essential factor for managing high blood pressure. However, the knowledge of physical activity patterns by hypertensives and on their perception of barriers and perceived knowledge on the benefits is scarce. This study closes the gap on the knowledge regarding how hypertensives evaluate physical activity programmes by showing that hypertensive individuals think that exercise is not safe for their health condition and present lower expectation towards exercise. However, they show signs of wanting to know more about what kind of PA is right for their condition by obtaining trustworthy and understandable information. Therefore, this study is significant as it establishes the basis for the development of more effective and tailored communication strategies to promote PA among hypertensive individuals by revealing the fears to address, barriers to overcome, and the best channels and more reliable information sources to use.

This study has a set of potential limitations that could be addressed in future research. First, causal inference is limited since it is a cross-sectional study design, and confirming these findings in future interventional studies will be required. Second, the final survey results from the adaptation of several questionnaires not extensively used, which limits the comparison with previous studies. Third, the age range sample is very large, which may be associated with different profiles of the hypertensive individuals interviewed, and this may constitute a limitation on the findings.

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ORIGINAL SCIENTIFIC PAPER

# The Association between Relative Age Effect, Goals Scored, Shooting Effectiveness and the Player's Position, and her Team's Final Classification in International Level Women's Youth Handball

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ABSTRACT The objectives of this study were (i) to determine whether there is a relationship between the relative age effect (RAE) and the final classification of the teams, player's positions, number of goals scored, and shooting effectiveness, and (ii) to determine whether there are differences in the number of goals scored and shooting effectiveness depending on the final classification and player's positions. The study subjects were 380 players who took part in the 2018 Women's Youth World Handball Championship. The independent variables were the relative age effect and the number of goals and shooting effectiveness of each type of shot. The dependent variables were the player's position and the team's final classification. To investigate the relationship between the RAE and the team's final classification, player's position, goals scored, and shooting effectiveness, contingency tables were drawn up and subjected to a chi-squared test. The dependence of the differences in goals and shooting effectiveness on the team's final classification and the player's position was studied by means of an ANOVA with a Tukey post hoc test. For the sample overall, there was no RAE, only an association between the classification and the year of birth, with more players born in the senior year in the teams ranked from 1st to 8th place than in those classified from 9th to 24th place. The teams classified from 1st to 4th had more significant numbers of several variables. There were differences in goals and shooting effectiveness, depending on the player's position.

KEY WORDS performance, game-related statistics, throwing, back, wing, pivot

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## Introduction

Team-handball (handball) emerged in the early 19th century in Scandinavia. It became an Olympic sport for men in 1972 and for women in 1976. A handball game lasts for two periods of 30 minutes. It is played on an indoor court of 40 × 20 m. Each team plays with seven players (six in the field plus the goalkeeper), the objective being to score more goals than the opponent to win the match. Players are organized defensively around the D-zone, which is marked six metres from the goalposts. Only the goalkeeper can be in contact with the ground within this zone during play. Handball, like other team sports, has well-defined field positions with differentiated roles: goalkeeper, back (centre, right, left), wing (right, left), and pivot.

Handball can be considered an intermittent contact sport that intercalates actions of high intensity (sprints, jumps, shots, and blocks) with those of medium/low intensity (walking or jogging movements, passes). Hand-

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ball performance is influenced by various factor: individual (coordination, strength, endurance, constitution-disposition, nutrition), collective (social, tactics, cognition), and environmental (ambient conditions, material) (Wagner, Finkenzeller, Wurth, & von Duvillard, 2014). While players are in their developmental ages, individual factors, to a large extent, depend on maturation and growth, and these do not have any linear relationship with chronological age (Balyi & Way, 2009). Since the rhythms of maturation and growth differ from individual to individual, young people with the same chronological age may have relevant differences. To avoid these differences, some federations organize their competitions according to the year of birth (in swimming, for example, the minimum mark required to take part in certain championships depends on the year of birth), while other federations organize their competitions by "pooling together" in the same age category players born in two different years. This is the case of the International Handball Federation, which, in international competitions, groups together players born in two different years, with the even year always being the senior year. Thus the categories in men are Junior (Under-21) and Youth (Under-19), and in women are Junior (Under-20) and Youth (Under-18). This organization, therefore, has players competing together who are up to 24 months apart in their chronological age.

The age difference between subjects of a given group relative to a cut-off point is known as the Relative Age, and the potential advantage that this difference may produce is known as the Relative Age Effect (RAE) (Andronikos, Elumaro, Westbury, & Martindale, 2016). The first studies on RAE were done in the field of education. They showed that schoolchildren who were older at the beginning of the school year had better academic performances (Davis, Trimble, & Vincent, 1980). In the field of sports, there have been RAE studies in basketball (Delorme & Raspaud, 2009), football (Yague, de la Rubia, Sánchez-Molina, Maroto-Izquierdo, & Molinero, 2018), ice hockey (Weir, Smith, Paterson, & Horton, 2010), volleyball (Campos, Stanganelli, Rabelo, Campos, & Pellegrinotti, 2016), and swimming (Cobley et al., 2019). In most cases, the RAE was analysed according to the trimester of birth (Q1, January-March; Q2, April-June; Q3, July-September; Q4, October-December). It was found that sportspersons born in the first or second trimesters of the year have a more significant presence in teams than those born in the third or fourth trimesters (Schorer, Baker, Busch, Wilhelm, & Pabst, 2009), with differences depending on the player's position (Yague et al., 2018) and even on their geographical location (Leite et al., 2018). The RAE decreases with increasing age of the sportsperson (Bjørndal, Luteberget, Till, & Holm, 2018). There have been few studies of RAE in handball. One study of German players (men and women) found that, for both sexes, as the players became older, the percentage of players born in the first trimester decreased (Schorer et al., 2009). Similarly, a study of Spanish international (male) players found that, in the junior (under-20) and cadet (under-16) categories, the players were born mostly in the first trimesters of the year, although there were no such differences in the senior teams (Sánchez-Rodríguez, Grande, Sampedro, & Rivilla, 2013). Similar results were found in a sample of Danish men at the international level (Wrang et al., 2018) and in Spanish players at the regional level (Gómez-López, Angosto, Granero-Gallegos, & Chirosa, 2017).

The handball action par excellence is the shot since its ultimate objective is to score a goal. This action differs according to the player's position. Thus, 75% of the shots in a match are made after a jump, an action that usually corresponds to the back and wing players, while the slowest shots are those of the pivot (Wagner et al., 2014). In recent years, there have been studies of the RAE in handball and its relationship with other variables (not only with the selection of players for a national team or club). One (Fonseca, Figueiredo, Gantois, de Lima-Junior, & Fortes, 2019) found that the RAE also influences the player's position (men) (U19), with more back and wing players having been born in the first and second trimesters, and similar data had been reported in a study of senior players (men) at international level (Karcher, Ahmaidi, & Buchheit, 2014). Another study analysed the relationship between the number of games played and the trimester of birth in an international sample of Norwegian players, finding that players born in Q1 (January-March of the senior year) played more games than those born in Q8 (October-December of the junior year) in the women's youth category (Bjørndal et al., 2018). Likewise, a study of Brazilian U13 male players found that those born in Q1 (January-March) played longer than those born in Q4 (October-December) (Leonardo, Lizana, Krahenbuhl, & Scaglia, 2018).

Although in recent years the number of studies being published has been increasing, we found none analysing the relationship between the RAE and the team's final classification, player's position, number of goals, or shooting effectiveness. Thus, the objectives of the present study were (i) to determine whether there is a relationship between the relative age effect and the team's final classification, player's position, number of goals scored, and shooting effectiveness, and (ii) to determine whether there are differences in the number of goals scored and shooting effectiveness depending on the final classification and player's position.

## Methods

### *Participants*

The sample comprised all the players (n=380) of the 24 national teams that participated in the 7th Women's Youth World Handball The teams participating in this championship were Angola, Argentina, Austria, Chile, Croatia, Denmark, Egypt, France, Germany, Japan, Kazakhstan, Korea, Montenegro, Netherlands, Norway, People's Republic of China, Poland, Romania, Russia, Slovakia, Spain, Sweden, and Tunisia.

### *Procedures*

The data were obtained from the official website of the International Handball Federation (IHF, 2018). They


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were entered into Excel by one of the authors (YS), then another of the authors (JMS) randomly reviewed them to detect potential errors. No informed consent or approval from the Ethics Committee was required as this was public domain data accessible on the Web. On this website, there is no prohibition, either explicit or implicit, to use these data for scientific purposes. In any case, the data were treated conjointly, without reference to each player's name. The analysis of public data taken from websites is habitual in the field of handball (Ferrari, Sarmento, & Vaz, 2019; Fonseca et al., 2019; Gómez-López et al., 2017; Sánchez-Rodríguez et al., 2013).

The independent variables of this study were the players' year, semester, and trimester of birth (RAE), and the number of goals and shooting effectiveness of each type of shot (game-related statistics). The RAE was categorized into different groups depending on the year of birth (2000, 2001 or 2002), the semester of birth (S1, January-June; S2, July-December), and the trimester of birth (Q1, January-March; Q2, April-June; Q3, July-September; Q4, October-December). These game-related statistics (Table 1) were already of general use among women's handball coaches and technicians and had been used in earlier studies (Melekatos, Vagenas, & Bayios, 2011). The dependent variables of the study were the team's final classification (1st to 4th place, 5th to 8th place, 9th to 16th place, 17th to 24th place) and the player's position (goalkeeper, centre back, left and right backs, left and right wings, pivot). The goalkeeper position was not taken into account for the analyses of goals and effectiveness.

### *Statistical analysis*

Contingency tables were constructed, and the chi-squared ($\chi^2$) values were calculated to determine the relationship between the RAE (players' birth year, semester, and trimester) and the team's final classification, the player's position, goals scored, and shooting effectiveness. The basic statistical descriptors (mean and standard deviation) were calculated for the goals and shooting effectiveness variables. Finally, to determine the differences in goals and shooting effectiveness based on the team's final classification and player's position, the data were subjected to an ANOVA with a Tukey post hoc test. The eta-squared ($\eta^2$) statistic, which describes the proportion of the variance attributable to a given factor, was also calculated. A p-value <0.05 was considered to be statistically significant. The statistical analysis was performed with the SPSS software package, version 15.0 (SPSS Inc., Chicago, IL, USA).

TABLE 1. Definitions of the shots' variables

| Variable | Definition |
|---|---|
| Total goals | Number of goals scored. |
| Total shots | Percentage of converted shots relative to the number of shots made. |
| 6-m goals | Number of goals scored at 6 m. The shot was made at an angle greater than 45° from the left or the right. |
| 6-m shots | Percentage of converted shots at 6-m relative to the number of such shots made. |
| 7-m goals | Number of goals scored from the penalty line (7 m). |
| 7-m shots | Percentage of penalties converted relative to the number of penalties taken. |
| 9-m goal | Number of goals scored at 9 m. The shot was made by a backcourt player either (a) over or through the defence, or (b) after a breakthrough but with another defending player in front. |
| 9-m shots | Number of goals scored at 9 m. Percentage of converted shots at 9 m relative to the number of such shots made. |
| Wing goals | Number of goals scored from the wing area, the zones within an angle of 45° from the left and right without a defending player in front. |
| Wing shots | Percentage of converted shots from the wing area relative to the number of such shots made. |
| Fast-break goals | Number of goals scored in a fast-break situation – rapid switch from defence to attack with the defence still disorganized. |
| Fast-break shots | Percentage of converted fast-break shots relative to the number of such shots made. |
| Breakthrough goals | Number of goals scored in a breakthrough situation – (a) by the backcourt players after a breakthrough in the 9-m zone without a defending player in front, (b) by the pivot after a 1:1 situation, (c) by the left or right back after breaking through 1:1 situations. |
| Breakthrough shots | Percentage of shots converted in a breakthrough situation relative to the number of such shots made. |

## Results

Table 2 presents the distribution of the overall sample by year, semester, and trimester of birth. The greatest percentages of players correspond to the senior year (60.53%) ($\chi^2$=172.49; p<0.001), the first semester (61.58%) ($\chi^2$=20.38; p<0.001). and the first trimester (37.11%) ($\chi^2$=34.61; p<0.001).

Table 3 presents the distribution of the players by birth year, semester, and trimester, and the team's final clas-

sification. There was an association between birth year and the team's final classification ($\chi^2$=13 703, p=0.045), with the percentage of players born in the senior year being higher among the teams classified in the 1st to 4th and 9th to 16th place. There was no association between the birth semester or trimester and the team's final classification. Neither were there any associations between the birth year, semester, or trimester and the player's position ($5552<\chi^2<14\ 227$; $0.076<p<0.564$), goals scored ($1496<\chi^2<8229$; $0.222<p<0.956$), or shooting effectiveness ($1280<\chi^2<5208$; $0.648<p<0.816$).

TABLE 2. Number and percentage distribution by birth year, semester, and trimester for the full sample

| Year | n | % | $\chi^2$ | p | Semester | n | % | $\chi^2$ | p | Trimester | n | % | $\chi^2$ | p |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 230 | 60.53 | | | S1 (January-June) | 234 | 61.58 | | | Q1 (January-March) | 141 | 37.11 | | |
| 2001 | 129 | 33.95 | 172.49 | <0.001 | S2 (July-December) | 146 | 38.52 | 20.38 | <0.001 | Q2 (April-June) | 93 | 24.47 | 34.61 | <0.001 |
| 2002 | 21 | 5.52 | | | | | | | | Q3 (July-September) | 83 | 21.84 | | |
| | | | | | | | | | | Q4 (October-December) | 63 | 16.58 | | |
| Total | 380 | 100.00 | | | | 380 | 100.00 | | | | 380 | 100.00 | | |

Table 4 presents the mean and SD of each variable (goals and shooting effectiveness) and the results of the one-way ANOVA depending on the team's final classification. There were differences between the teams classified from 1st to 4th and those classified from 9th to 24th place in the variables total goals, total shots, 9-m shots, fast-break goals, and fast-break shots. There were no differences in any variable between the teams classified from 1st to 4th and 5th to 8th.

TABLE 3. Number, percentage distribution, and association ($\chi^2$) between birth year, semester, and trimester and the team's final classification

| | 1st to 4th place | | 5th to 8th place | | 9th to 16th place | | 17th to 24th place | | $\chi^2$ | p |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | | |
| **Year** | | | | | | | | | | |
| 2000 | 43 | 67.19 | 44 | 68.75 | 74 | 58.27 | 70 | 56.00 | | |
| 2001 | 20 | 31.25 | 20 | 31.25 | 47 | 37.01 | 42 | 33.60 | 13.703 | 0.045 |
| 2002 | 1 | 1.56 | | | 6 | 4.72 | 13 | 10.40 | | |
| **Semester** | | | | | | | | | | |
| S1 (January-June) | 43 | 67.19 | 39 | 60.94 | 86 | 67.72 | 66 | 52.80 | 6.956 | 0.073 |
| S2 (July-December) | 21 | 32.01 | 25 | 39.06 | 41 | 32.28 | 59 | 47.20 | | |
| **Trimester** | | | | | | | | | | |
| Q1 (January-March) | 24 | 37.50 | 24 | 37.50 | 55 | 43.31 | 38 | 30.40 | | |
| Q2 (April-June) | 19 | 29.69 | 15 | 23.44 | 31 | 24.41 | 28 | 22.40 | 6.214 | 0.750 |
| Q3 (July-September) | 12 | 18.75 | 16 | 25.00 | 21 | 16.54 | 34 | 27.20 | | |
| Q4 (October-December) | 9 | 14.06 | 9 | 14.06 | 20 | 15.75 | 25 | 20.00 | | |

Table 5 presents the mean and SD of each variable (goals and shooting effectiveness) and the results of the one-way ANOVA depending on the player's position (excluding the goalkeepers). There were differences in all the variables except total goals.

## Discussion

This work has analysed the relationship between the RAE (year, semester, and trimester) and the team's final classification, player's position, number of goals scored, and shooting effectiveness. There was a greater representation of players born in the senior year, the first semester, and the first trimester among the subjects in the Women's Youth World Handball Championship. However, only the birth year had any association with the best-ranked teams, with the older players having greater representation in the teams ranked from 1st to 8th place. Both the goals scored and shooting effectiveness showed differences in terms of both the team's final classification and the player's position. To the best of our knowledge, this has been the first study of international youth handball players that has analysed the RAE, the team's final classification, player's position, number of goals scored, and shooting effectiveness.

For the total sample, the RAE was found to be present whether the data were considered by year, semester, or trimester, with the players born in the senior year, in S1, and in Q1 being more frequently represented (Table 2). This finding coincides with those of studies conducted on both women (Gómez-López et al., 2017; Schorer et al., 2009) and men (Fonseca et al., 2019; Gómez-López et al., 2017; Karcher et al., 2014; Sánchez-Rodríguez et al., 2013; Schorer et al., 2009; Wrang et al., 2018) at international (Fonseca et al., 2019; Karcher et al., 2014), national (Sánchez-Rodríguez et al., 2013; Schorer et al., 2009; Wrang et al., 2018), and regional (Gómez-López et al., 2017) levels. The association between the RAE and the team's final classification was found to depend


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TABLE 4. Mean and standard deviation of each variable. A one-way analysis of variance (ANOVA) with Tukey posthoc test was used to compare means between team classifications (Eta squared is also given)

| | 1st to 4th place (a) M ± SD | 5th to 8th place (b) M ± SD | 9th to 16th place (c) M ± SD | 17th to 24th place (d) M ± SD | F | p | $\eta^2$ | Differences |
|---|---|---|---|---|---|---|---|---|
| Total goals (n) | 17.63 ± 15.89 | 14.97 ± 13.53 | 9.78 ± 11.55 | 9.78 ± 11.55 | 6.880 | <0.001 | 0.052 | a>c,d; b>d |
| Total shots (%) | 63.32 ± 20.08 | 56.89 ± 16.66 | 51.17 ± 21.89 | 48.12 ± 24.64 | 7.005 | <0.001 | 0.060 | a>c,d |
| 6-m goals (n) | 2.30 ± 3.70 | 2.75 ± 4.91 | 1.65 ± 3.30 | 1.45 ± 2.72 | 2.400 | 0.068 | 0.019 | n.s. |
| 6-m shots (%) | 47.72 ± 42.64 | 55.34 ± 39.79 | 37.04 ± 41.30 | 32.90 ± 40.75 | 5.167 | 0.002 | 0.040 | b>c,d |
| 7-m goals (n) | 1.88 ± 5.23 | 1.84 ± 4.43 | 1.52 ± 3.71 | 1.26 ± 3.11 | 0.481 | 0.695 | 0.004 | n.s. |
| 7-m shots (%) | 19.72 ± 34.68 | 28.45 ± 41.09 | 21.52 ± 36.87 | 22.38 ± 37.44 | 0.684 | 0.562 | 0.005 | n.s. |
| 9-m goals (n) | 4.91 ± 7.28 | 3.70 ± 5.65 | 3.25 ± 5.24 | 3.08 ± 5.72 | 1.540 | 0.240 | 0.012 | n.s. |
| 9-m shots (%) | 36.45 ± 35.54 | 29.94 ± 31.37 | 21.02 ± 24.33 | 18.62 ± 25.84 | 7.083 | <0.001 | 0.053 | a>c,d; b>d |
| Wing goals (n) | 3.03 ± 6.84 | 2.19 ± 4.31 | 1.72 ± 3.66 | 1.54 ± 2.85 | 1.929 | 0.123 | 0.015 | n.s. |
| Wing shots (%) | 30.25 ± 39.93 | 17.17 ± 28.67 | 20.38 ± 32.14 | 19.94 ± 30.91 | 2.050 | 0.106 | 0.016 | n.s. |
| Fast break goals (n) | 3.19 ± 4.11 | 2.42 ± 2.92 | 1.65 ± 2.81 | 1.15 ± 1.94 | 8.214 | <0.001 | 0.062 | a>c,d; b>d |
| Fast break shots (%) | 57.28 ± 43.52 | 49.38 ± 40.24 | 38.83 ± 42.44 | 36.28 ± 42.46 | 4.380 | 0.005 | 0.034 | a>c,d |
| Breakthrough goals (n) | 2.02 ± 3.51 | 1.86 ± 2.98 | 1.33 ± 2.58 | 1.19 ± 2.41 | 1.763 | 0.154 | 0.014 | n.s. |
| Breakthrough shots (%) | 30.61 ± 37.37 | 30.84 ± 39.19 | 32.39 ± 42.81 | 29.63 ± 40.47 | 0.099 | 0.961 | 0.001 | n.s. |

Note. n.s., not significant.

only on the year of birth, with the teams classified from 1st to 8th place having older players than the teams classified from 9th to 24th (Table 3). This seems to highlight the relevance of the players' experience for the team's final classification (González, 2004). Some studies, however, have indicated that both men and women players from Q1 (born in January-March) tend to play more games (Bjørndal et al., 2018) and more time per game (Leonardo et al., 2018) than those born in the subsequent trimesters. No relationship was found between RAE and the player's position or goals scored. This does not agree with previous studies which have found differences in men (U19) at the international level, with there being greater representation of backs and wings born in the first and second trimesters (Fonseca et al., 2019) or in the first semester (Karcher et al., 2014). Another recent study (Alsharji, 2019) suggests that this RAE is also present in goalkeepers and centre back players.

Regarding the differences in the goals scored and shooting effectiveness depending on the classification, there were no such differences between the teams classified from 1st to 4th place and those classified from 5th to

TABLE 5. Mean and standard deviation of each variable. A one-way analysis of variance (ANOVA) with Tukey posthoc test was used to compare means between player positions. Eta squared is also given

| | Centre back (c) M ± SD | Back (b) M ± SD | Wing (w) M ± SD | Pivot (p) M ± SD | F | p | $\eta^2$ | Differences |
|---|---|---|---|---|---|---|---|---|
| Total goals (n) | 16.64 ± 14.49 | 15.59 ± 13.60 | 14.15 ± 11.51 | 10.85 ± 10.01 | 2.579 | 0.054 | 0.024 | n.s. |
| Total shots (%) | 50.64 ± 17.17 | 47.83 ± 20.58 | 54.44 ± 21.30 | 65.51 ± 18.96 | 11.521 | <0.001 | 0.099 | c,b,w<p |
| 6-m goals (n) | 1.30 ± 1.52 | 1.19 ± 1.64 | 0.96 ± 1.21 | 6.90 ± 6.29 | 58.842 | <0.001 | 0.355 | c,b,w<p |
| 6-m shots (%) | 50.72 ± 41.10 | 40.91 ± 43.41 | 41.73 ± 42.71 | 64.46 ± 30.19 | 25.006 | <0.001 | 0.189 | b,w<p |
| 7-m goals (n) | 2.78 ± 4.63 | 2.62 ± 5.28 | 1.07 ± 3.16 | 0.50 ± 1.99 | 5.547 | 0.001 | 0.049 | c,b>p; b>w |
| 7-m shots (%) | 34.84 ± 40.15 | 34.67 ± 41.44 | 15.60 ± 35.27 | 16.98 ± 35.24 | 5.544 | 0.001 | 0.049 | c,b>w,p |
| 9-m goals (n) | 6.94 ±7.17 | 6.87 ± 6.67 | 1.19 ± 3.62 | 0.97 ± 2.32 | 30.632 | <0.001 | 0.223 | c,b>w,p |
| 9-m shots (%) | 35.39 ± 21.49 | 32.64 ± 20.95 | 19.64 ± 32.89 | 27.38 ± 38.90 | 4.968 | 0.002 | 0.044 | c,b>p |
| Wing goals (n) | 0.55 ± 1.48 | 0.73 ± 2.43 | 6.52 ± 6.19 | 0.33 ± 1.10 | 60.259 | <0.001 | 0.360 | c,b,p<w |
| Wing shots (%) | 18.02 ± 33.65 | 16.00 ± 32.25 | 48 ±27.33 | 12.18 ± 30.66 | 5.198 | 0.002 | 0.046 | c,p<w |
| Fast break goals (n) | 1.42 ± 1.83 | 1.65 ± 2.21 | 3.86 ± 4.20 | 1.37 ± 2.12 | 19.819 | <0.001 | 0.156 | c,b,p<w |
| Fast break shots (%) | 44.45 ± 44.64 | 49.78 ± 42.76 | 60.49 ± 36.80 | 40.62 ± 44.00 | 20.159 | <0.001 | 0.159 | w>p |
| Breakthrough goals (n) | 3.47 ± 3.47 | 2.36 ± 3.20 | 0.55 ± 1.45 | 0.65 ± 2.33 | 14.907 | <0.001 | 0.122 | c,b>w,p |
| Breakthrough shots (%) | 60.11 ± 34.74 | 45.48 ± 40.20 | 21.55 ± 39.29 | 16.85 ± 36.46 | 3.364 | 0.109 | 0.030 | c,b>w,p |

Note. n.s., not significant.

8th place. However, there were differences between the teams classified from 1st to 4th and those classified from 9th to 24th in total goals, total shots, 9-m shots, fast-break goals, and fast-break shots. While differences in total goals and total shots were to be expected since these variables constitute the ultimate expression of a team's performance, the other three variables reveal important information. The effectiveness from 9 m (9-m shot) highlighted the importance of throws from this position, especially taking into account that, for all four groups of team classification, this position was that from which most goals were scored (Table 4). The differences in fast-break goals and fast-break shots showed the importance of rapid transitions that generate situations of superiority since these facilitate the scoring of goals (Calin, 2010). For the variables goals scored and shooting effectiveness depending on the player's position (Table 5), there were differences that reflected the specialization of the different positions (Cardinale, Whiteley, Hosny, & Popovic, 2017). Thus, the pivots had more goals and greater effectiveness from 6 m, reflecting the specific function of their position (Santos et al., 2009). They also had the greatest total shot effectiveness, possibly because when they throw they do so after gaining an advantage over their marker, as well as usually doing so from the central area (Zapardiel Cortés, Vila, Abraldes, Manchado, & Ferragut, 2017). The centre back and left and right backs had more goals and greater effectiveness from 9 m than the other positions did. It should be noted that these players are characterized by faster throwing speeds (Shalfawi, Seiler, Tønnessen, & Haugen, 2014). Finally, the wing players scored more goals and had greater effectiveness from the wing position than the rest of the positions did, as well as more fast-break goals, which was also found in previous studies (Michalsik, Aagaard, & Madsen, 2015). This is because wing players spend more time during the game in sprint situations (Michalsik, Madsen, & Aagaard, 2014) which allows them to successfully finalize fast-break situations.

The present work has a series of limitations. The first is that, although the data analysed come from the 2018 World Championship, the results might be different if the study were of another world championships or a different level championship (European Championship, Spanish Championship, etc.). The second is that the individual performance criteria (number of goals and effectiveness) bias the measured relevance of the goalkeeper since this player scores very few goals, and these data were not analysed in the study. The goalkeeper position is, however, especially important in today's handball performance (Calin, 2010).

In conclusion, it was found that, in the overall sample of players participating in the Women's Youth World Handball Championship (U18), there was an over-representation (relative age effect) of the senior year, the first semester, and the first trimester. Nevertheless, we only found an association with the classification for the year of birth, with there being more players born in the senior year (2000) in the teams classified from 1st to 8th place than in those classified from 9th to 24th. The teams classified from 1st to 4th place had more total goals, total shots, 9-m shots, and fast-break goals and shots, indicative of the relevance of these variables for performance. All the positions (centre back, backs, wings, and pivot) had a greater number of goals and effectiveness from their specific positions. Also, we found the wings to have a greater number of goals and effectiveness in fast-break situations. Coaches might consider taking these results into account when assessing the composition of their national teams, especially thinking of the evolution of the younger players.

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ORIGINAL SCIENTIFIC PAPER

# The Effects of A 6-Week Plyometric Training Programme on Sand Versus Wooden Parquet Surfaces on the Physical Performance Parameters of Well-Trained Young Basketball Players

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ABSTRACT The purpose of this study was to investigate the effect of plyometric training on sand and wooden parquet training surfaces on the physical performance parameters of young male basketball players. Twelve well-trained young male basketball players with age 17.58±0.5 years, body mass 87.73±9.82 kg, and height 193.75±7.02 cm were voluntarily involved in the study. All participants were grouped randomly as sand and wooden training groups. A six-week plyometric training programme was performed on the sand and wooden parquet surfaces. Anthropometric measurements and physical performance tests; vertical and standing long jump, box agility, and 30m sprint tests were performed. Data were collected before and after six weeks of plyometric training and were analysed using ANCOVA. The results indicated that the plyometric training programme significantly improved jumping, agility and 30m sprint performance for both groups. Significant differences were found between the post-test mean values of two groups in the box-drill agility and 30m sprint test scores ($p < .05$). The results of this study suggest that while the plyometric training performed on a wooden or sand surface does not cause a different effect on the improvement of jumping performance, plyometric training on the sand surface may be a more effective training surface to improve the agility and sprint performance of young players.

KEY WORDS athletic performance, basketball, plyometric training, sand, surface

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## Introduction

Basketball, which was invented in the USA at the end of the 19th century, is a team sport. The numbers of basketball players, coaches, and spectators have increased significantly since the 20th century (Nuñez & Lyras, 2018). Today, basketball is a worldwide sport that is played by millions of people of all ages in many countries. It is one of the most popular sports branches in the USA, as well as European and Asian countries. Many leagues and tournaments, including the NBA and Euroleague, are organized every year (Paulauskas, Masiulis, Vaquera, Figueira, & Sampaio, 2018).

Basketball is a dynamic team sport played at high speed and that incorporates physical, mental, technical, and tactical elements. Basketball players need to possess high-levels of motor abilities and athletic performance to be successful in matches and tournaments. (Ostojic, Mazic, & Dikic, 2006). During a match, players demonstrate a variety of physical performance characteristics for specific movement patterns (dribbling, shooting, passing, throwing, rebounding blocking) and basic movement patterns (running, jumping, change of direction). The performance of basketball players is influenced by many factors, such as strength, speed, agility, endurance, and mobility. Therefore,

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different training models should be applied to players to develop their motor skills from an early age (Wissel, 2011).

Basketball requires a wide variety of physical fitness qualities. In particular, the leg strength and jumping ability of players play an essential role in basketball matches (Alemdaroğlu, 2012). Plyometric training (PT) was developed by Verkoshanski as a training method to improve explosive leg strength in sports. Also called "jump training" or "shock exercises", PT is a widely used training method to significantly improve jumping performance. PT is a unit of resistance training that increases the jumping capacity of athletes. Plyometric exercises (plyometrics), such as jumping, bounding, clapping push-up, and jump squats are used to increase the capacity of the muscle fibres to produce more tension and resultant force generation (Davies, Riemann, & Manske, 2015; Verkoshanski, 1967). Prior studies have reported that PT has been demonstrated to be an effective training method for the improvement of leg strength, explosiveness, and power (Amrinder, Sakshi, & Singh, 2014; Ramlan, Pitil, & Wahed, 2018).

In the majority of sports, PT can cause improvement in athletic performance parameters, such as speed, agility, and power. However, many individual and environmental factors affect the performance of athletes in plyometric training (Davies et al., 2015). Many researchers have indicated that the level of effect on athletic performance in PT is influenced by the amount of energy returned to the athlete from the training surfaces, depending on the stiffness of the surface (Arazi & Asadi, 2011; Impellizzeri et al., 2008). The recoil energy of the training surface together with the stretch-reflex cycle in PT affects the training efficiency. Therefore, the type of training surface plays an essential role in the effect of PT through the stretch-reflex mechanism (Ramlan et al., 2018).

Basketball games are usually played on wooden parquet or tartan surfaces. Thus, the players and coaches usually have a preference to train on these firm surfaces, but not preference different surfaces such as grass, sand or soil (Ozen, Koc, & Aksoy, 2017). Scientific studies have indicated that training or playing on different surfaces affected basic physical skills such as running, jumping and hopping. Additionally, they have reported that the long-term sports training on different surfaces caused different metabolic adaptations in athletes (Gortsila, et al., 2013; Hardin, Van Den Bogert, & Hamill, 2004; Martin et al., 2011, Ozen, Koc, & Aksoy, 2017). Therefore, different training surfaces for PT may cause the different level improvement of physical performance parameters in basketball players. In this context, the effect of the training surface in PT on athletic performance is an issue to be investigated. To this end, we investigated the effect of PT on the sand and wooden parquet training surfaces on the physical performance parameters of young male basketball players.

## Methods

### *Participants*

Twelve highly trained young male basketball players with age 17.58±0.5 years, body mass 87.73±9.82 kg, and height 193.75±7.02 cm were voluntarily involved in the study. They were both healthy and regularly trained at least five years, three times a week for about 3-5 hours in every training session. Also, all of the participants belonged to the same competitive basketball team. The demographic characteristics of the participants are described in Table 1.

TABLE 1. Demographic Characteristics of Participants

| Variables | Min | Max | M±SD |
|---|---|---|---|
| Age (year) | 17 | 18 | 17.58±0.504 |
| Body Mass (kg) | 182 | 204 | 193.75±7.02 |
| Height (cm) | 69.4 | 98.8 | 87.73±9.82 |
| Body Fat (%) | 8.3 | 17.4 | 12.22±2.93 |
| Years of basketball experience | 4.0 | 9.0 | 6.4±2.63 |

### *Study Procedure*

This study was carried out during the off-season period of the training year in Turkey. A single-blind randomized controlled trial design was used to determine the effect of a six-week PT on a dry sand surface and a wooden parquet surface. All participants were grouped randomly as PT sand (PTS) and PT wooden (PTW) groups. The six-week training programme was performed on a 20-cm-deep sand surface for PTS and a 10-cm-thick wooden parquet surface for PTW. Before the study commenced, the objectives, tests procedures and training programme of this study were explained to all participants and their parents. Signed informed consent was obtained from all participants as well as their parents. All subjects had experience of physical performance tests and PT. This study was conducted according to the criteria set by the Declaration of Helsinki and ethical standards in sport and exercise science research (Harriss & Atkinson, 2011).

### *Data Collection*

Anthropometric measurements; body mass, height and body fat (%), and physical performance tests; vertical (VJ) and standing long jump (SLJ), box agility and 30m sprint tests were performed to determine the effect of six-week PT on the physical performance of participants. Pre- and post-tests were carried out in an indoor sports hall with wooden parquet surface. First, baseline measurements and tests of participants were performed. Following baseline measurements, their post-intervention measurements and tests were performed after the end of the six-week plyometric training period.


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***Anthropometric measurements***

The body mass and standing heights of participants were measured using standardized techniques and calibrated equipment. These measurements were measured with participants in minimal clothing. Body mass (in kg) was measured using a TANITA scale accurate to within 0.1 kg. Height (in cm) was measured using a stadiometer (Seca, Germany) accurate to within 0.1 cm. Body fat (%) was estimated with a bioelectrical impedance analysis (Tanita, Japan) after body height and chronological age were entered, and body mass was measured.

***Standing long jump (SLJ)***

The SLJ test was used to assess the long jump performance of participants. They were allowed a five-minute warm-up before the standing long jump test. They were requested to stand behind the starting line marked, with feet together, and pushed off vigorously and jumped forward as far as they could. They were allowed to swing their arms during the test. The participant had to land with the feet together and to stay upright. The distance is measured from the take-off line to the point where the back of the heel nearest to the take-off line lands on the mat. The length of the jump was measured using a tape measure. This test was repeated two times with a one-minute rest between trials, and the better of the two trials was recorded.

***Vertical jump (VJ)***

The countermovement jump technique was used to assess the VJ performance of participants. After a 5-10 min warm-up that included submaximal running and jumping exercises, participants performed two trials of VJ test. The VJ test was measured by using a Takei digital jump meter device (Takei, Japan). The belt of digital jump meter, which connected to the elastic mat by a cord, was fitted to the participants. VJ tests were performed after each player was requested to jump as high as possible. Each test was performed two times with a one-minute rest between the trials. The best VJ performance of participants was recorded.

***Agility test***

The Box agility test was used to evaluate the ability to turn in different directions and body control. This test included four different movement stiles: running forward, shuffle, backpedal, turn, and sprint. A stopwatch, measuring tape, and four marker cones were used as test equipment. This test was made on a non-split floor. Four marker cones were placed 9.14 m apart in a square configuration. Before the start of the test, researchers gave verbal instructions explaining the test procedures. A participant started by getting down in a three-point stance next to the 1st cone. Upon the command "go", the timer would begin, and the participant started from the first cone sprinting to the 2nd cone, between 2nd cone and the 3rd he shuffled, between the 3rd cone and the 4th cone, he backpedalled, and after passing the fourth cone turned and sprinted to the 1st cone. Measurements were recorded to the second.

***30 m Sprint tests***

The participants performed two maximum 30 m sprints on the wooden parquet court. Participants performed the 30 m sprint test after a 10-minute warm-up that included submaximal running. Sprint times were measured using an electronic timing system. Each sprint test was repeated two times, separated by three minutes of passive recovery, and the best sprint performance was recorded.

***Training Protocol***

Following the literature (Miller, Herniman, Ricard, Cheatham, & Michael, 2006; Ramirez-Campillo et al., 2019) a six-week PT programme was developed to determine the effect of PT on the sand surface on physical parameters of basketball players. During the study period, the participants were not participating in any competitive sport or similar exerted effort. All participants were asked not to change the current training programme or increase the training volume during the period of the study. Plyometric training sessions were performed: three training sessions per week with a two-day break to allow for adequate recovery between training in accordance with the suggestion of researchers. In the training sessions, 40 cm plyo-

TABLE 2. The 6-Week Plyometric Training Program.

| Plyometrics | Weeks 1-2 (repetitions x sets) | Weeks 3-4 (repetitions x sets) | Weeks 5-6 (repetitions x sets) |
|---|---|---|---|
| VJ | 8x3 | 10x3 | 12x3 |
| SLJ | 8x3 | 10x3 | 12x3 |
| UCJ | 8x3 | 10x3 | 12x3 |
| $180^0$ jumps | 8x3 | 10x3 | 12x3 |
| RCJ | 8x3 | 10x3 | 12x3 |
| BJ | 8x3 | 10x3 | 12x3 |
| DJ | 8x3 | 10x3 | 12x3 |
| Total number of contact (volume) | 168 | 210 | 252 |

Note. VJ–vertical jump, SLJ - standing long jump, UCJ - unilateral countermovement jumping, RCJ - repeated countermovement jumping, BJ - board jumping, DJ - drop jumps.

metric boxes and hurdles were used as the PT equipment. Plyometric exercises were performed on wooden parquet surface for the PTW group and on a 0.2 m deep dry sand surface for the PTS group. Each PT session included the VJ, SLJ, unilateral countermovement jumping (UCJ), 180° jumping, repeated countermovement jumping (RCJ), board jumping (BJ), and drop jumps (DJ) exercises. The six-week PT training programme is presented in Table 2.

### *Statistical Analysis*

Statistical analyses were carried out using SPSS statistic software package (version 15.0, SPSS Inc., Chicago, IL, USA). Data are presented as means with a standard deviation (M ± SD). The Shapiro-Wilk W test was used to determine that data was acceptable with regard to homogeneity. As variances showed a normal distribution, a Paired t-tests were used for within-group comparisons. An analysis of covariance (ANCOVA) with the pretest value as the covariate was performed to compare the effects of sand and wooden parquet surfaces of plyometric training between PTS and PTW groups for posttest values. For all analyses, the level of statistical significance was set at 0.05.

## Results

The pretest and posttest mean values of the PTS and PTW groups were presented in Table 3. The results of the present study indicated that a six-week PT programme significantly improved VJ, SLJ, agility, and 30m sprint performance for both PT groups ($p < .05$). However, there was no significant difference in body mass and body fat mass percentage following the six-week PT programme ($p > .05$).

TABLE 3. Effect of 6-Week Plyometric Training on Physical Performance Parameters of PTS and PTW

| Variables | Group | Pre-test M±SD | Post-test M±SD | Pre-post Mean Difference |
|---|---|---|---|---|
| Body Mass (kg) | PTS | 87.73±9.82 | 86.54±9.78 | -1.17 |
| | PTW | 86.94±8.32 | 86.17±8.66 | -0.77 |
| Body Fat (%) | PTS | 12.22±2.93 | 11.54±2.91 | -0.68 |
| | PTW | 11.87±2.51 | 11.14±2.36 | -0.73 |
| VJ (cm) | PTS | 54.92±6.61 | 63.34±6.03* | 8.58 |
| | PTW | 55.73±6.82 | 65.42±6.21* | 9.69 |
| SLJ (cm) | PTS | 171.75±9.50 | 184.83±9.08* | 13.08 |
| | PTW | 173.87±9.41 | 185.52±8.19* | 11.65 |
| Box Drill Agility (sec) | PTS | 15.61±1.42 | 14.12±1.36* ǂ | -1.49 |
| | PTW | 15.92±1.87 | 14.82±1.56* | -1.10 |
| 30m Sprint (sec) | PTS | 4.03±0.24 | 3.70±0.25* ǂ | -0.33 |
| | PTW | 4.11±0.36 | 3.98±0.27* | -0,13 |

Note: * - $p < .05$ (Significantly different within group, between pretest ant posttest); ǂ - $p > .05$ (Significantly different than posttest between two groups).

When comparing pretest data (baseline values) in between PT groups, there were no statistically significant differences in the baseline mean values of PTS and PTW ($p > .05$). When the pretest scores of PTS and PTW groups were controlled as covariates, significant differences were found between the post-test mean values of two groups in the box-drill agility ($F(2,10) = 3.67$, $p = 0.027$) and 30m sprint test scores ($F(2,10) = 5.69$, $p = 0.014$). After six weeks of training, agility, and 30m sprint ability of PTS was significantly more improved as compared with that of the PTW group.

## Discussion

PT is a training method commonly used for improving agility, sprint, and jumping performances in young and adult basketball players (Khlifa et al., 2010; Palma-Muñoz et al., 2018). However, some researchers have determined that the effectiveness of plyometrics on these performance parameters may vary with the training conditions (Impellizzeri et al., 2008; Ramirez-Campillo et al., 2019). Training surfaces are one of the most important environmental variables for PT (Arazi, Eston, Asadi, Roozbeh, & Saati Zarei, 2016). It is essential to examine the effect of different training surfaces in basketball considering that basketball training sessions are frequently performed on tartan or wooden parquet surface. Thus, we sought to determine the influence of PT performed on wooden parquet and sand surface on agility, sprint, and jumping performance of young basketball players.

Based on the results of the present study, significant enhancements were found in the post-tests of agility, 30m sprint, VC and SLJ performance in both groups. These findings revealed that the PT was effective in developing these performance parameters of the young basketball players irrespective of the training surfaces. This is in good agreement with the results of the previous studies for the PT (Bavli, 2012; Nikolic, 2018). This finding has been confirmed in many previous studies examining the effect of PT on athletic performance on


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different training surfaces, such as grass, concrete, sand, and tartan. In this context, the improvement of physical performance after the six-week PT programme in this study may be ascribed to the increasing muscular strength and capacity of positive energy production due to utilizing the recoil of elastic energy stored (Amrinder, Sakshi, & Singh, 2014; Impellizzeri et al., 2008; Ramlan et al., 2018). In contrast, in comparing their body weight and fat percentage, there were no significant differences between pre and post-test values. In agreement with our findings, some researchers also have reported that there were no changes in the body fat percentage, body mass, and body composition after PT programs (Campo et al., 2009; Luebbers et al., 2003) equalized for training volume, followed by a 4-week recovery period of no plyometric training on anaerobic power and vertical jump performance. Physically active, college-aged men were randomly assigned to either a 4-week (n = 19, weight = 73.4 +/- 7.5 kg. It may be said that PT does not significantly distinguish young basketball players' body weights and fat ratios in spite of the fact that PT has positive effects on their agility, sprint and jumping performance.

When comparing the differences between the posttest values of PTS and PTW groups, our analysis demonstrated that there were no significant differences in the jumping performance. Even though VJ and SLC performance of both groups after six-weeks of PT intervention was significantly higher than their baseline values, the different training surface did not cause a difference in the jumping performance development of athletes. Similarly, several studies reported that meaningful differences were found in the between pre and post-test scores of VJ and SLJ performance after PT performed on different training surfaces but no difference in between posttest scores of these groups (Arazi, Mohammadi, & Asadi, 2014; Bavli, 2012). Taken together, these results indicated that the different training surfaces for plyometrics did not cause a considerable difference to improve the jumping performance that required explosive power.

In contrast, it was found that the box agility and 30 m sprint performances of PTS group were significantly more improved than the PTW group. A possible explanation for these effects of plyometric exercises on the soft surfaces is it requires a stronger concentric push-off phase, which was caused by a reduction of the potential elastic energy and the difficulty of the ankle to push along the vertical axis due to sand absorption (Ramlan et al., 2018). Moreover, doing exercise on sand cause a higher level of physiological strain experienced than on firmer surfaces, such as tartan, concrete, wood (Binnie, Dawson, Pinnington, Landers, & Peeling, 2014). Scientific evidence demonstrates that when athletes are exposed to high levels of physiological strain, they might gain more muscular strength and endurance. Therefore, the sports training on the sand surface has the potential for more improvement in the muscular strength and endurance compared to training on firmer surfaces. In this connection, having the higher box agility and 30 m sprint performances of PTS group may be explained by the fact that they gain higher level muscular strength and endurance than the PTW group during the training programme. In addition, these differences between athletes may be a result of this, and the box agility and sprint tests require more muscular endurance capacity than the jump tests which required explosive power.

## Conclusions

The results from this study confirmed the well-known benefits of PT in agility, jumping and sprint performance of young basketball players. These results show that enhances in agility, jumping, and sprint performance can occur in as little as six weeks of PT, performed on both sand and a wooden training surface. Our key finding is the box agility and 30 m sprint performances of PTS group were significantly more improved than those of the PTW group. Overall, the results of this study suggest that while PT performed on a wooden or sand surface does not cause a different effect on the improvement of jumping performance, PT on the sand surface may be a more effective training surface to improve agility and sprint performance of young players. Accordingly, plyometric training on sand can be considered an effective option within the yearly training plan for coaches to enhance sprint and agility performance in young basketball players. Future studies have to examine the underlying physiological dimensions of PTs performed on different surfaces.

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ORIGINAL SCIENTIFIC PAPER

# The Effect of an In-Season 8-Week Plyometric Training Programme Followed By a Detraining Period on Explosive Skills in Competitive Junior Soccer Players

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ABSTRACT The aim of this study was to examine the effect of an eight-week plyometric training and resistance programme, on different motor abilities, kicking speeds, and individual techniques in competitive junior soccer players. A training programme was applied for eight weeks and was composed of countermovement jump, countermovement onto a box, sprints, and sprints with change of direction. The players were evaluated in three moments: before the start of the training programme, after the application of the training programme, and after four weeks of detraining. The applied tests were: countermovement jump, speed dribbling, 30-meter sprint, kicking speed, and a Yo-Yo recovery intermittent recovery test Level 2 (Yo-Yo IE2). The results showed statistically significant differences ($p<0.05$) in sprint performance, countermovement jump, Yo-yo IE 2, and speed dribbling. The maximum velocity of the ball did not present statistically significant differences ($p > 0.05$). In addition, these results indicate that general performance may not be sensitive to four weeks of detraining in the trained soccer players. These results demonstrate that the combination of soccer drills and specific power training with no additional training time in-season optimizes some general and soccer-specific performance.

KEY WORDS explosive actions, soccer, young soccer players

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## Introduction

During a soccer game, players perform a series of critical actions such as sprinting, changes of direction, jumps, ball recoveries, kicks and other actions which make a specific appeal to the ability to produce force quickly because such high levels of strength in the lower limbs are essential (Ramirez-Campillo et al., 2014). Based on the consensual importance of the explosive efforts in the outcome of a soccer game, strength training is crucial in order to make them physically prepared for competition (Rodriguez-Rosell et al., 2016). In this sense, explosive high-velocity training has demonstrated greater improvements in the rate of force development and explosive actions in comparison with traditional weight training methods for maximal strength (Wilson, Newton, Murphy, & Humphries, 1993). This divergence could be explained by the absence of various crucial stimuli during strength training, in particular: segmental coordination, in regard to power transport by biarticular muscles, and neural control mechanisms for optimal movement patterns (Komi, 2008); specificity, according to joint angle and angular velocities (Komi, 2008); and eccentric overloading (de Hoyo et al., 2015).

Regarding this, plyometric training (PT) provides such training load stimuli and has been shown to improve

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significantly explosive actions in soccer players (Ramirez-Campillo et al., 2014). Additionally, PT is commonly used because, in addition to its easy application during training (space, time and equipment), it is also representative of neuromuscular demands found in soccer during explosive actions (i.e., sprinting and jumping) (Ferraz, van den Tillar, Pereira, & Marques, 2016). Regarding this, a previous study demonstrated that high-intensity plyometric exercises could be used safely and effectively in soccer players to improve those abilities (Sáez de Villarreal, Requena, & Cronin, 2012). Several other studies showed the benefits of a PT programme, specifically in young competitive soccer players (de Hoyo et al., 2015; Ramirez-Campillo et al., 2014). Moreover, significant relationships have been observed between lower limb strength and sprint time, vertical jumps, and changes of direction. A recent study by Chtara et al. (2017) presents PT as the most effective training programme to improve power performance among young soccer players. Nevertheless, Thomas, French, and Hayes (2009) observed, through the application of a six-week training programme, which included both squat (SJ) and countermovement jumps (CMJ), improvements in vertical jump heights ($p < 0.05$) in youth football players, although the performance remained the same in sprints ($p < 0.05$). Another study experimented with PT for ten weeks, leading to distinctive results (Markovic, Jukic, Milanovic, & Metikos, 2007), this study claimed improvements in SJs, height and power of the CMJs but no changes in sprint times.

Regarding the influence of PT in improving kicking velocity, some studies have shown that there is a positive impact on this ability (Wong, Chamari, & Wisløff, 2010). However, the optimum training design for improving high-intensity actions is still not well established and needs to be found (Ramirez-Campillo et al., 2014). Some studies were unable to find any sign of improvements in this regard (Kraemer et al., 2002; Wong, Chamari, & Wisløff, 2010), while others found some benefits after the application of PT (Marques & González-Badillo, 2006).

Another topic that continues to require further clarification is related to the discontinuation of training sessions, an issue which may be due to various factors such as illnesses, injuries, vacations, post-season breaks or other normal factors in any type of sport, thus resulting in a reduction or cessation of their normal physical activity level (Kraemer et al., 2002; Marques & González-Badillo, 2006). This phase of reduction or complete training cessation has been defined as "detraining" (Mujika & Padilla, 2000). Several studies have reported that the magnitude of this reduction may depend upon the length of the detraining period (Kraemer et al., 2002), in addition to training levels attained by the subject (Izquierdo et al., 2007). Data from various athletic populations indicate that three to six weeks of detraining negatively affects aerobic capacity, strength (Izquierdo et al., 2007), neuromuscular performance (Izquierdo et al., 2007), and body composition. In contrast, according to Diallo, Dore, Duche, and Van Praagh (2001), a detraining period of eight weeks after the implementation of PT did not cause a decrease in the performance in prepubertal soccer players, suggesting that PT is beneficial for the youth soccer population. However, the detraining period and its consequences have not been completely clarified in the literature, particularly with respect to young soccer players. To the best of our knowledge, modifications in jumping, sprinting, kicking performance, aerobic performance, technical ability and impact on detraining as a result of a simple strength training programme with low volume, in addition to normal soccer training, have not been investigated as part of a study involving competitive junior soccer players.

Therefore, the objective of this study was to examine the effect of an eight-week strength training programme, consisting of explosive strength exercises for the lower extremities (e.g., sprints and jumps), on different motor abilities, kicking speed and individual technique in competitive junior soccer players. It also aimed to verify whether there was a positive impact on the reduction of loss of physical capacity after a period of detraining, with respect to gains previously achieved. It was hypothesized that the training group would enhance their jumping, sprinting, and aerobic performance. Enhancement of technical ability and kicking performance were also hypothesized, due to an expected increase in explosive strength established by the PT programme.

Furthermore, it is expected that there will be a positive impact on the effects of detraining. Because of ethical considerations, it was not possible to include a control group, so all athletes completed the same in-season resistance-training programme. Experimental studies in competitive athletes, especially in team sports, are very difficult to put into practice (Marques & González-Badillo, 2006; Marques, van den Tillaar, Vescovi, & González-Badillo, 2008). These difficulties are compounded by a problem discussed by Marques et al. (2008). In practical terms, to locate a specific control group (i.e., another elite team volleyball sample with the same training and at the same performance level as the experimental team) and to access testing conditions is not an easy task for coaches or researchers. However, such considerations ought not to detract from the necessity and importance of this type of investigation or of the present case report, especially in volleyball.

## Methods

### *Subjects*

A group of 15 young male soccer players belonging to a Portuguese team playing at the national level in their age category under 18 years (Mean±SD age: 17.27±0.458 years) participated in the study, with none of the participants having regular habits of strength training. With respect to the characteristic anthropometrics, the group presents the following data: weight (68.8±9.77 kg) height (1.76±0.07 m). Before the study started, players had a physical examination by the team physician, and each was cleared of any medical disorders that may have limited full participation in the investigation. All participants and the coach were fully informed verbally and in writing regarding the nature and demands of the study, as well as the known health risks. They completed a health history questionnaire and were informed that they could withdraw from the study at any time, even after giving their


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written consent. All parents provided their informed consent attesting the voluntary participation of their children in the study, which had the approval of the Academy's Ethical Advisory Commission, and was conducted in accordance with the Declaration of Helsinki.

### *Experimental design*

The objective of this study was to examine the effect of an eight-week PT programme, consisting of explosive strength exercises for the lower extremities, on different motor abilities, kicking speed and individual technique in competitive junior soccer players. The training programme took place during a period of eight weeks followed by four weeks of detraining. In addition, to allow us to realize the effects of PT as a complement to specific technical and tactical training, the detraining period enabled us to better understand the impact of this complementary training. All players competed in one match per week combined with four soccer practice sessions. Players had completed a pre-season testing and training programme prior to the initiation of this in-season study. The players were in good physical condition and were adequately familiarized with all procedures prior to commencing the study. Apart from standard technical and tactical practice sessions (two hours per day) and regular competitions, the subjects completed a physical training regimen that included lower-body exercises targeting strength and power. All experimental procedures were carried out in coordination with the technical team and so did not cause any change in the routine of the players. All testing was carried out during one week at the completion of the second half of the in-season, which took place between January and April. Before the pre-test stage, the participants were familiarized with the different tests during a practice session in order to minimize learning effects. Pre- and post-tests were performed with maximal intensity. All tests were conducted in an indoor facility in order to eliminate the effect of weather conditions on results. The players were evaluated at three different times: before the start of the training programme (Pre-training test) (T1), after the application of the training programme (Post-training test) (T2) and after four weeks of detraining (Post - detraining test) (T3).The tests conducted during the current study were: countermovement jump, speed dribbling, 30-metre sprint, kicking speed and a Yo-Yo recovery intermittent recovery test Level 2 (Yo-Yo IE2). Tests were performed over a 3-day period: Say 1: anthropometric measures, countermovement jump, speed dribbling; Day 2: 30-metre sprint and Speed Shooting; Day 3: (Yo-Yo IE2). These were tests that could be rapidly administered and were highly specific to soccer.

### *Procedures*

The soccer history of each player and their game positions were determined using a questionnaire. The anthropometric variables of height and body mass were measured for each subject, on a levelled platform scale (Año Sayol, Barcelona, Spain) with an accuracy of 0.001 m and 0.01 kg, respectively.

### *Warm up*

Before each of the exercises, a warm-up was performed based on the protocol described by van den Tillaar, Lerberg, and von Heimburg (in press). The short specific warm-up consisted of 8 × 60 m runs with 60 s rest in between (10 min in total). The first 60 m was performed at a self-estimated intensity of around 60% of estimated maximal sprinting velocity. Every next 60 m was increased by around 5% until it reached 95% of maximal self-estimated intensity. In each rest period, one of the same seven dynamic exercises as in the other two warm-up protocols was used.

### *CMJ*

CMJ height was measured using a trigonometric carpet (Ergo jump Digitimer 1000, Digest Finland) using previously described methods (Marques, van den Tillaar, Vescovi, & González-Badillo, 2008). Subjects began from a standing position, performed a crouching action followed immediately by a jump for maximal height. The hands were on the hips during the entire jump. Each participant performed three jumps, and the highest jump was recorded. Between each repetition, there was a two-minute rest period.

### *Sprint*

The 30-m sprint was performed in an indoor school physical education facility with a Copolymer Polypropylene floor, with subjects wearing indoor shoes. The time required to run 30 m was obtained using photocells (Brower Timing System, Fairlee, Vermont, USA). Times at 10, 20 and 30 m were also recorded. Prior to each sprint, each subject trod the cell pad using the right hand, with the time being recorded from when the subject intercepted the photocell beam. All subjects were encouraged to run as fast as possible and to decelerate only after listening to the beep emitted by the last pair of photocells. Each player repeated the same procedure for three attempts, with only the best time taken to cover the 30-m distance in the sprint test being used in data analysis. A rest period of 10 min was provided between attempts.

### *Kicking Speed*

For the kicking speed and accuracy test, a standard soccer ball (mass approximately 430 g, circumference 70 cm) was used. After a general warm-up of 15 min, which included jogging and kicking drills, kicking performance was tested. The instruction was to kick a regular ball with maximum force and attempt to hit a target from an 11-m distance, aiming at a 1 m by 1 m circled target at 2 m height located in the middle of a goal (3 × 2 m). The kicking velocity of the ball was determined using a Doppler radar gun (Sports Radar 3300, Sports

Electronics Inc.), with±0.028 m·s-1 accuracy within a field of ten degrees from the gun. The radar gun was located 1 m behind the goal at ball height. Three trials were conducted, and the highest ball kicking velocity was used for further analysis.

### *Dribbling Speed*

Dribbling with the ball is a skill required by all players but is particularly effective for those attacking players looking to break open a defence by running at opponents through tight spaces. This drill tests a player's ability to dribble the ball rapidly through a marked circuit, where good performance relies on close ball control and the ability to maintain control during rapid changes of direction. Dribbling speed was quantified by recording the total time taken for an individual to dribble (i.e., kick) the soccer ball through a 61.2-m agility course. Each individual was given three attempts at the task, with a 2.5-min rest between each and the quickest being taken as their peak performance (for all skill tests, an individual's peak performance was their single best performance in that task). Each player started with the ball behind the first cone and proceeded through the circuit as fast as possible. Time was stopped when both the player and ball crossed the finish line. The time taken to complete the circuit was recorded with a stopwatch and then converted to an average speed over the 61.2 m. Time penalties were allotted to a player's total time to account for errors using the following system: (i) +1 s for each missed cone, (ii) +2 s if two cones in succession were missed (note: although this penalty was applied, it was never part of an individual's quickest time, which was taken as their peak performance), and (iii) +0.5 s for each cone knocked over. Repeatability was calculated by comparing a player's first and second tests of dribbling speed.

### *The Yo-yo recovery intermittent test lv 2*

All players (n = 15) completed the Yo-Yo IE2 test at the beginning and at the end of the training programme. The test lasts 5–25 min and consists of repeated 20-m shuttle runs at progressively increasing speeds dictated by an audio beep emitted from a CD player. Between each shuttle, the players had a 10-s period of jogging around a marker placed 5 m behind the finishing line. Failure to achieve the shuttle run in time on two occasions resulted in termination of the test and the distance covered in the last complete successful shuttle was recorded as the test result. All testing sessions were performed indoors. Before the test, all players carried out a warm-up period consisting of the first three running bouts of the Yo-Yo IE2 test followed by a period of lower-extremity stretching. All players had previously been familiarized with the Yo-Yo IE2 test and experimental procedures.

### *Training Programme*

Briefly, the programme was performed twice per week, with each session lasting approximately 20 minutes and performed just after the warm-up to ensure that the players were in a rested state and gained optimal

TABLE 1. Strength training programme

| | | CMJ | CMJ OB | Sprint | SCOD |
|---|---|---|---|---|---|
| **Week 1** | **Session 1** | 2 × 4 | 2 × 4 | 2 × 20m | 2 × 10s |
| | **Session 2** | 2 × 4 | 2 × 4 | 3 × 20m | 2 × 10s |
| **Week 2** | **Session 3** | 2 × 4 | 3 × 4 | 2 × 20m | 3 × 10s |
| | **Session 4** | 3 × 4 | 2 × 4 | 3 × 20m | 2 × 10s |
| **Week 3** | **Session 5** | 3 × 4 | 3 × 4 | 3 × 20m | 3 × 10s |
| | **Session 6** | 3 × 4 | 2 × 4 | 3 × 20m | 3 × 10s |
| **Week 4** | **Session 7** | 3 × 4 | 3 × 4 | 3 × 20m | 4 × 10s |
| | **Session 8** | 3 × 5 | 2 × 4 | 4 × 20m | 3 × 10s |
| **Week 5** | **Session 9** | 3 × 4 | 3 × 5 | 3 × 20m | 4 × 10s |
| | **Session 10** | 3 × 5 | 2 × 5 | 4 × 20m | 3 × 10s |
| **Week 6** | **Session 11** | 3 × 4 | 3 × 5 | 2 × 30m | 4 × 10s |
| | **Session 12** | 4 × 4 | 3 × 5 | 3 × 20m | 3 × 10s |
| **Week 7** | **Session 13** | 4 × 4 | 3 × 5 | 3X 30m | 4 × 10s |
| | **Session 14** | 4 × 5 | 3 × 4 | 3 × 20m | 3 × 10s |
| **Week 8** | **Session 15** | 3 × 5 | 3 × 4 | 2 × 20m | 3 × 10s |
| | **Session 16** | 3 × 4 | 2 × 4 | 2 × 20m | 1X 10s |

Note. CMJ – counter-movement jump, CMJ OB– counter-movement jump onto a box, SPRINT – 20-metres sprint, SCOD – Sprint with change of direction.


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benefits from the specific programme, according to the training principle of priority. The training programme was applied for eight weeks and was composed of countermovement jump (CMJ), countermovement onto a box, sprints and sprints with change of direction as shown in Table 1.

### *Statistical analysis*

The normality of all distributions was verified by the Shapiro–Wilk test, and the t-test analysis was used to compare means from the sets of data. Standard statistical procedures were selected for the calculation of means, standard deviations and 95% confidence intervals. The level of significance was set at $p < 0.05$. The statistical analysis was performed with SPSS version 22.0 (SPSS, Inc., Chicago, IL, USA). The effect size was evaluated with d (Cohen's d), where $0.20 < d < 0.30$ constitutes a small effect, $0.40 < d < 0.70$ constitutes a medium effect, and $d \geq 0.80$ indicates a large effect.

## Results

The three moments of evaluation were paired, as shown below for analysis: T1 / T2; T2 / T3; T1 / T3. In sprint performance, statistically significant differences ($p<0.05$) were found between T1 / T2; T2 / T3; T1 / T3, with an effect size (d = 0.51); (D = 0.41); (D = 0.04). The CMJ performance changed significantly during the training application, T1 / T2 ($p<0.05$; d = 0.51). However, the maximum velocity of the ball did not present statistically significant differences between the three moments analysed ($p>0.05$, d = 0.44, d = 0.10, d = 0.35). The variables analysed in the Yo-yo IE 2 obtained different results. For stage distance, statistically significant differences were found between T1 / T2 ($p<0.05$). For the distance travelled, statistically significant differences in T1 / T2 ($p>0.05$) were not observed; however, the T2 / T3; T1 / T3 showed statistically significant differences, despite there only being a small effect size (d = 0.02; d = 0.17). The initial lactate concentration did not change significantly before starting the Yo-Yo IE2 ($p>0.05$), contrary to what happened with the final concentration of lactate, with which there were statistically significant differences ($p<0.05$) with a high effect size (d = 0.71; d = 0.55; d = 1.21), respectively. For speed dribbling, the best time achieved at each of the evaluated moments was analysed. In the analysis of the T1 / T2, no differences were found ($p>0.05$), but the same did not occur for T2 / T3; T1 / T3 where there were statistically significant differences ($p<0.05$; d = 0.30; d = 0.35) as shown in Tables 2.

TABLE 2. Comparison between the three moments analysed

| | | Pre-training | Post-training | detraining | T1 vs. T2 | | | T2 vs. T3 | | | T1 vs. T3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (T1) | (T2) | (T3) | p | Δ (%) | d | p | Δ (%) | D | p | Δ (%) | d |
| **CMJ** | | 32.33±5.25 | 35.06±5.39 | 34.16±5.16 | 0.001*** | 8.44 | 0.51 | 0.001*** | -2.57 | 0.17 | 0.005** | 5.66 | 0.35 |
| **Sprint 30m** | | 4.54±0.015 | 4.46±0.14 | 4.55±0.19 | 0.015* | -1.76 | 0.51 | 0.015 | 2.02 | 0.49 | 0.834 | 0.22 | 0.04 |
| **Kicking speed** | | 90.66±3.58 | 92.11±2.89 | 91.82±2.80 | 0.067 | 1..60 | 0.44 | 0.489* | -0.31 | 0.10 | 0.069 | 1.28 | 0.35 |
| **Dribbling speed** | | 25.04±1.79 | 24.93±1.64 | 24.45±1.48 | 0.730 | -0.44 | 0.06 | 0.013* | -1.93 | 0.30 | 0.023* | -2.36 | 0.35 |
| **Yo-Yo IE** | **Stage** | 11.60±3.26 | 12.20±3.05 | 12.13±2.47 | 0.007** | 5.17 | 0.18 | 0.751 | -0.57 | 0.02 | 0.088 | 4.57 | 0.17 |
| | **Distance** | 464±130.7 | 488±128.4 | 488±101.6 | 0.014* | 5.17 | 0.18 | 1.000 | 0 | 0 | 0.057 | 5.17 | 0.20 |
| | **Blood lactate BT** | 1.51±0.28 | 1.60±0.28 | 1.66±0.21 | 0.657 | -5.96 | 0.32 | 0.454 | 3.75 | 0.23 | 0.163 | 9.93 | 0.59 |
| | **Blood lactate AT** | 10.10 ± 1.42 | 9.16 ± 1.17 | 8.52 ± 1.13 | 0.008** | -9.31 | 0.71 | 0.001*** | -6.99 | 0.55 | 0.001*** | 15.64 | 1.21 |

Note. p – p-value, Δ (%) – Pre – post change, d – Cohens d. * indicates P<0.05, ** indicates P<0.01 and *** indicates P<0.001.

## Discussion

The main aim of this study was to examine the effect of an eight-week PT training programme on different motor abilities and also on VO2 max in competitive junior soccer players. In addition, it was intended to verify the influence of four weeks of detraining on the minimization of losses in relation to the previously achieved gains. It was found that the training programme significantly improved sprint ability and CMJ. However, kicking speed, speed dribbling and Yo-yo IE 2 did not show significant improvements in the T2 period. Therefore, these results demonstrate that the combination of soccer drills and specific explosive training with no additional training time in-season optimize some general and soccer-specific explosiveness and endurance performance in junior soccer payers. In addition, the results of this investigation indicate that short-term PT

using moderate training frequency and low volume produces similar enhancements in sprint time and CMJ compared with high training and volume, which is in accordance with what was previously been reported (de Villarreal, Requena and Cronin, 2012).

As a result of the application of a PT programme of low volume and high intensity, there was a decrease in the time of the 30-m sprint. These results are contrary to other studies showing no improvements in sprint time after a plyometric programme (Fry et al., 1991; Wilson, Newton, Murphy and Humphries, 1993). However, recent investigations including a meta-analysis (Sáez de Villarreal et al., 2012) have also found a decrease in sprint times with PT (Sáez de Villarreal et al., 2012). Earlier studies have reported no significant increases in sprint acceleration or velocity after training programmes involving essentially vertical plyometric exercises and weight training in trained subjects (Fry et al., 1991; Wilson et al., 1993). As the training stimulus applied during the study was vertical and horizontal in nature, this set-up could have increased the chances of soccer players becoming adapted, considering the importance of horizontal force production and the application in running performance (Morin et al., 2012) and the principle of specificity of training (Sáez de Villarreal et al., 2012). Gains of sprint performance reflect neural adaptations such as an increased nerve conduction velocity, maximizing of the electromyogram, improved intermuscular coordination, an enhanced motor unit recruitment strategy, and an increased excitability of the Hoffman reflex (H-reflex) (Markovic & Mikulic, 2010) as well as changes in muscle size and architecture, in the mechanical characteristics of the muscle-tendon complex and changes in single-fibre mechanics (Markovic & Mikulic, 2010). Thus, it is apparent that the PT performed during the regular soccer practices in the current study may be important for sprint adaptations. To the best of our knowledge, this is one of the few studies to investigate the effect of a PT with low volume and high intensity on the sprint performance of junior soccer players.

The plyometric programme was also effective in significantly increasing jump height of CMJ. The improvement in CMJ height indicates that adaptations relating to increases in leg power occurred. Improvements of muscle power and vertical jump height with PT have been described previously (Markovic & Mikulic, 2010), and our results are consistent with these findings. The adaptation occurred in response to the type of training that was applied is probably neural because it predominates in the initial stages of strength and power training, and has been shown to be the main adaptation to plyometric exercise. In addition, this phenomenon may be because the CMJ involves a stretch-shortening cycle and is thus very similar to the one plyometric exercise used in our study. Moreover, PT is likely to improve coordination and thus induces a neuromuscular adaptation that augments power production (Sáez de Villarreal et al., 2012). The properly developed ability to jump can be a determining factor in the success during a game, given its importance in the dispute of the ball in offensive and defensive actions during a game.

Kicking performance did not change significantly after PT application. Although several studies have reported improvements in kicking ball velocity performance as a result of specific strength training (Ferraz et al., 2016; Wong et al., 2010), this improvement was not observed in our study. However, the data found are in agreement with that described in an earlier study, in which the data revealed that although six weeks of PT was sufficient to produce significant improvements in explosive strength, players required 12 weeks to produce significant increases in kicking speed. The improvements in kicking speed after PT could be attributed to a change in some kinematic variables, such as linear velocity of the distal segments and the position of the body throughout the shot. Possibly, these changes promote an adaptation in the kicking movement after gains in strength and may be the result of an altered SCC of musculature involved (Ferraz, van den Tillar, & Marques, 2017; Wong et al., 2010). This could be the reason for the lack of significant improvements in kicking speed after eight weeks of PT.

The results showed that the time of dribbling speed did not improve significantly after PT application. Speed dribbling mainly requires agility in its execution, a factor that is defined as the ability to change the direction of the body abruptly; thus, there seems to be a positive relationship between agility and dribbling performance, with an earlier study speculating that improvements in agility were a result of enhanced motor unit recruitment patters (Potteiger et al., 1999). Neural adaptations occur mainly when athletes respond or react as a result of improved coordination between the central nervous system signal and proprioceptive feedback. These adaptations occurred via synchronous firing of the motor neurons or better facilitation of neural impulses to the spinal cord, further supporting the suggestions of a previous study (Potteiger et al., 1999). However, we cannot determine the reason for the lack of improvements. In addition, the ability to sprint is another of the skills required to complete the circuit quickly. Although sprint capacity has been optimized (30 metres) with PT application, the total distance of the circuit is higher, which may help to justify the lack of significant improvements. Furthermore, it has been reported that strength training does not always improve 20–100 m sprint times (Kotzamanidis, Chatzopoulos, Michailidis, Papaiakovou, & Patikas, 2005).

To the best of our knowledge, this is the first study to demonstrate the effects of a low volume PT in the Yo-Yo IR2 performance in a group of young competitive soccer players. Our results demonstrated that the stage variable improved significantly after PT application. These results are in line with those described in previous studies (Barnes & Kilding, 2015). One of the possible explanations may be related to a better running economy, which in turn might be explained by decreased ground contact times increasing musculotendinous stiffness, elastic energy returns neuromuscular activity or enhanced running mechanics. The final blood lactate values change significantly during the three analysed moments. The increment of blood lactate tolerance at submaximal intensity seems to be a key factor in avoiding diminished performance on repeated high-intensity


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exercise, such as the Yo-Yo IR2 (Nakamura, Suzuki, Yasumatsu, & Akimoto, 2012). These data can help to justify the maintenance of the values of some variables (stage, distance) during the four weeks of detraining. In addition, a weak but significant relation between Yo-Yo IR2 performance and VO2 max has been shown in samples consisting of both professional and amateur players (Rampinini et al., 2010), which is in agreement with our findings, where it is described that for the VO2 max, there were few significant alterations after PT application. Soccer players may suffer interruptions in the training process and competitive calendars, which may result in a reduction of the normal parameters of physical capacity (Kraemer et al., 2002). With regard to the four-week DT, our findings revealed that the detraining period failed to bring out significant differences from amongst all the parameters, with the exception of sprint performance. These results are similar to others previously reported (Nakamura et al., 2012), indicating that short duration and high-intensity exercise performances did not change after short-term training cessation (<4 weeks). Previous studies have also reported that the detraining period in which the regular training of a specific sport is maintained allows an athlete to maintain the gains achieved (Marques & González-Badillo, 2006). However, these results are different from others reported previously (Hakkinen, Alen, & Komi, 1985), where significant reductions were specifically observed in the CMJ after 12 weeks of DT; these identified differences may be due to a longer detraining period (Marques & González-Badillo, 2006) The inability to stimulate motor units or fast contraction fibres required for explosive abilities raises the hypothesis that the absence of training stimulus causes significant neural losses to the muscles. However, with a shorter detraining period between 2-7 weeks the jump performance seems could be maintained (Kraemer et al., 2002). In our study, the reduced impact of detraining period can be a good indicator of the positive impact resulting from the PT used to increase the performance of junior soccer players

In addition, these results indicate that anaerobic exercise performance may not be sensitive to short-term detraining in the trained soccer players. Several possibilities may explain these findings in the trained athletes. It may be that the reason for decreased sprint performance is related to accumulated fatigue through the course of the soccer season. Another possible mechanism for increased sprint performance after detraining is likely to be related to the adaptation in anaerobic enzyme activities in human skeletal muscle (Joo, 2016). Furthermore, insufficient training stimulus or training cessation are commonly associated with reductions in blood volume, stroke volume, cardiac output, ventilator functions and cardiac dimension, all of which may have been associated with the differences found (Mujika & Padilla, 2000). Future studies are, therefore, required. In summary, the data from the present study support the assumption that a PT programme with low volume and high intensity may be a suitable training method for obtaining strength improvements.

In conclusion, the current study demonstrates that the combination of soccer drills and specific power training with no additional training time in-season optimize some aspects of general and soccer-specific explosiveness and endurance performance in junior soccer payers. Also showed that four weeks of detraining period are not sufficient to cause significant losses in the explosive variables required to soccer players. The data support the application of PT programmes during the season. This type of programme is easy to apply and occupied a short time in the training unit. In addition, also has the added advantage that it can be applied without the need for large investments by the clubs, which makes it applicable to all clubs in the world.

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ORIGINAL SCIENTIFIC PAPER

# Normative Profile of the Efficacy and Way of Execution for the Block in Women's Volleyball from Under-14 to Elite Levels

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ABSTRACT This study aimed to establish reference values for technical performance profile of the block regarding execution and efficacy according to the category of competition in female volleyball. The sample of the study was composed of a total of 9,024 blocks from 187 sets of 48 matches played by the top eight teams of under-14, under-16, under-18, 2nd national senior division, 1st national senior division, and international senior division. The design of the study was observational. The study's variables were the category of competition, game phase, block performance, block zone, number of player blocking, block intervention, and attack tempo. A descriptive and inferential analysis of official matches in all the levels of competition was carried out. The results show that at higher levels of competition, there was an increase in the number of errors, the number of direct points, and the number of contacts that limit the counterattack of the opponent. At higher levels, there is also higher participation of players in the block, mainly against 3rd tempo attacks. These values can help to monitor the evolution of female volleyball players and to establish training and competition goals.

KEY WORDS sport performance, team sport, match analysis, developmental stage

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## Introduction

In volleyball, the block is the first defensive action of a team to neutralize the opponent's attack (Selinger & Ackermann-Blount, 1985). In high levels of competition, the block is the second action in importance related to success in a match (Castro, Souza, & Mesquita, 2011; Eom & Schutz, 1992; Marcelino & Mesquita, 2006; Palao, Santos, & Ureña, 2004a; Peña, Rodríguez-Guerra, Buscá, & Serra, 2013; Rodriguez-Ruiz et al., 2011). When players do a block, they have a disadvantage compared to spikers, due to biomechanical and tactical aspects (Afonso & Mesquita, 2011; Vint, 1998). For that reason, block efficacy is also measured in the restrictions that it imposed to the opposite team in the type and direction of hitting (Palao et al., 2004b; Selinger & Ackermann-Blount, 1985). An effective block depends on the anthropometrics of players, their physical condition, blocking technique, strategy, experience, and decision making (Amasay, 2008; Araujo, Afonso, & Mesquita, 2011; Malá, Malý, Záhalka, & Bunc, 2010). These aspects may be improved through the different stages of development of players due to maturation, training, and experience. Therefore, it is possible that block efficacy and way of execution change through these stages. The absence of this information could affect the way of the development of the block action by players in different age groups and levels of competition.

The block is one of the most difficult skills to master (García-Alcaraz, Ortega, & Palao, 2016; Palao et al., 2004b). Specifically, the variables that affect the success in the block are (Silva, Lacerda, & João, 2014): a) timing with a defensive line; b) speed in passing of opposite setter; c) variety of attacking options in the opposite team; and d) direction of the ball's trajectory. The higher the level of competition, the quicker and more unpredictable the opposite's attack becomes (Katsikadelli, 1995; Marcelino, Afonso, Moraes, & Mesquita, 2014; Palao et al., 2005). This gives the attack an advantage over the block (Inkinen, Häyrinen, & Linnamo, 2013).

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Despite the imbalance between attack and block, the block is still a critical element in a game. For instance, in male volleyball, the block is a skill that differentiates teams of similar level in senior high competition (Kapidzic, Ahmic, & Selimovic, 2013; Palao et al., 2004a; Rodriguez-Ruiz et al., 2010). In female volleyball, the block is not as relevant as it is in male volleyball, due to the players' lower jump heights and movement capacities (Bergeles, Barzouka, & Nikolaidou, 2009), but some differences arise in the way of playing. These differences make a slightly higher occurrence of collective block in female volleyball than in male volleyball (Palao et al., 2004a).

The information found about the block action is related to higher levels of competition, not to formative groups. The information available does not provide objective reference values to evaluate players' progression through their athletic development. This information could enhance the knowledge of how the training process takes effect and provides guidelines of training to coaches. Also, this data can provide specific technical-tactical reference values to evaluate the block actions in different age groups and levels of competition. The study aimed to establish reference values for the technical performance profile of the block regarding execution and efficacy according to the category of competition in female volleyball.

TABLE 1. Distribution of the sample for the different age groups and levels of competition (women's volleyball)

| Sample | Levels | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | U-14 | U-16 | U-18 | 2nd national | 1st national | International | |
| Matches | 8 | 8 | 8 | 8 | 8 | 8 | 48 |
| Sets | 29 | 35 | 32 | 27 | 31 | 33 | 187 |
| Sequences | 1,216 | 1,402 | 1,406 | 1,798 | 1,753 | 1,449 | 9,024 |

## Methods

The sample was 9,024 sequences from 187 sets of 48 volleyball matches (eight matches of each category of competition studied: Spanish national U-14 championship, Spanish national U-16 championship, Spanish national U-18 championship, Spanish senior 2nd national division, Spanish senior 1st national division, and senior international level). The sample was intentional and included matches between the top eight teams in the 2006 Spanish National Championship and the 2006 World Championship, respectively. The matches selected were the quarterfinals, semifinals, and finals. Table 1 shows the distribution of the sample by categories. The ethics commission of the principal researcher pre-approved the study project, in compliance with the principles of the Helsinki Declaration.

TABLE 2. Performance of the block according to game phase and levels of competition (women's volleyball)

| Performance | U-14 | | U-16 | | U-18 | | 2nd national | | 1st national | | International | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % | n | % |
| Serve and side-out defense | | | | | | | | | | | | |
| Error | 30⁻ | 5.8 | 43⁻ | 6.8 | 61⁻ | 9.3 | 107 | 11.8 | 149⁺ | 15.5 | 143⁺ | 16.9 |
| Allow all attacks | 426⁺ | 83.0 | 464⁺ | 73.3 | 446 | 67.7 | 558 | 61.5 | 555⁻ | 57.8 | 499⁻ | 58.8 |
| Limited attacks | 19⁻ | 3.7 | 69 | 10.9 | 88 | 13.4 | 153⁺ | 16.9 | 146 | 15.2 | 123 | 14.5 |
| No attack | 12 | 2.3 | 15 | 2.4 | 25 | 3.8 | 28 | 3.1 | 31 | 3.2 | 24 | 2.8 |
| Point | 26 | 5.1 | 42 | 6.6 | 39 | 5.9 | 61 | 6.7 | 80 | 8.3 | 59 | 7.0 |
| Coefficient | 1.18 | | 1.29 | | 1.29 | | 1.31 | | 1.31 | | 1.24 | |
| Counter-attack defense | | | | | | | | | | | | |
| Error | 39⁻ | 5.5 | 49⁻ | 6.4 | 68 | 9.1 | 101 | 11.3 | 77 | 9.7 | 94⁺ | 15.6 |
| Allow all attacks | 577⁺ | 82.1 | 597⁺ | 77.6 | 517 | 69.2 | 580 | 65.1 | 524 | 66.2 | 333⁻ | 55.4 |
| Limited attacks | 45⁻ | 6.4 | 76⁻ | 9.9 | 101 | 13.5 | 135 | 15.2 | 117 | 14.8 | 110⁺ | 18.3 |
| No attack | 13 | 1.8 | 18 | 2.3 | 21 | 2.8 | 23 | 2.6 | 26 | 3.3 | 16 | 2.7 |
| Point | 29 | 4.1 | 29⁻ | 3.8 | 40 | 5.4 | 52 | 5.8 | 48 | 6.1 | 48⁺ | 8.0 |
| Coefficient | 1.17 | | 1.20 | | 1.26 | | 1.26 | | 1.30 | | 1.32 | |
| Total | | | | | | | | | | | | |
| Error | 69⁻ | 5.7 | 92⁻ | 6.6 | 129 | 9.2 | 208 | 11.6 | 226⁺ | 12.9 | 237⁺ | 16.4 |
| Allow all attacks | 1003⁺ | 82.5 | 1061⁺ | 75.7 | 963 | 68.5 | 1138⁻ | 63.3 | 1079⁻ | 61.6 | 832⁻ | 57.4 |
| Limited attacks | 64⁻ | 5.3 | 145⁻ | 10.3 | 189 | 13.4 | 288⁺ | 16.0 | 263⁺ | 15.0 | 233⁺ | 16.1 |
| No attack | 25 | 2.1 | 33 | 2.4 | 46 | 3.3 | 51 | 2.8 | 57 | 3.3 | 40 | 2.8 |
| Point | 55⁻ | 4.5 | 71 | 5.1 | 79 | 5.6 | 113 | 6.3 | 128⁺ | 7.3 | 107⁺ | 7.4 |
| Coefficient | 1.00 | | 1.23 | | 1.19 | | 1.22 | | 1.23 | | 1.19 | |

Note: ⁻ o ⁺ statistical signification of p< 0.05 (chi square test). ⁺ o ⁻ relationship found (positive or negative).


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TABLE 3. Efficiency of blocking according to game phase, timing of the attack and levels of competition (women's volleyball)

| Timing attack | U-14 | | U-16 | | U-18 | | 2nd national | | 1st national | | International | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | Coef | N | Coef | n | Coef | n | Coef | n | Coef | n | Coef |
| Serve and side-out defense | | | | | | | | | | | | |
| 1º Tempo | - | - | - | - | 19 | 1.12 | 84 | 1.32 | 133 | 1.23 | 126 | 1.31 |
| 2º Tempo | - | - | 3 | 1 | 48 | 1.23 | 122 | 1.37 | 107 | 1.30 | 146 | 1.15 |
| 3º Tempo | 492 | 1.14[cde] | 611 | 1.27 | 584 | 1.37[a] | 685 | 1.30[a] | 701 | 1.34[a] | 565 | 1.19 |
| At 2nd touch | 29 | 1.74 | 18 | 1.68 | 9 | 1.56 | 16 | 0.83 | 25 | 1.55 | 15 | 1.42 |
| At 1st touch | - | - | 1 | 0 | - | - | 1 | 1 | 1 | 2 | 2 | 1 |
| Counter-attack defense | | | | | | | | | | | | |
| 1º Tempo | - | - | 1 | 1 | 16 | 1.07 | 42 | 1.22 | 45 | 1.14 | 37 | 1.18 |
| 2º Tempo | 10 | 1.15 | 21 | 1.39 | 46 | 1.34 | 45 | 1.42 | 46 | 1.43 | 22 | 1.08 |
| 3º Tempo | 578 | 1.09[def] | 653 | 1.16[e] | 612 | 1.18 | 694 | 1.29[a] | 559 | 1.28[ab] | 456 | 1.38[a] |
| At 2nd touch | 47 | 1.62 | 42 | 1.39 | 21 | 1.75 | 33 | 1.36 | 40 | 1.70 | 21 | 1.43 |
| At 1st touch | 29 | 1.12 | 28 | 1.25[c] | 22 | 0.64[bef] | 52 | 1.26 | 57 | 1.21[c] | 34 | 0.95[c] |
| Total | | | | | | | | | | | | |
| 1º Tempo | - | - | 1 | 1 | 35 | 1.09 | 126 | 1.25 | 178 | 1.17 | 163 | 1.23 |
| 2º Tempo | 10 | 1.15 | 24 | 1.34 | 94 | 1.31 | 167 | 1.40 | 153 | 1.38 | 168 | 1.11 |
| 3º Tempo | 1070 | 1.11[bcdef] | 1264 | 1.20[ae] | 1196 | 1.25[a] | 1379 | 1.29[a] | 1260 | 1.30[ab] | 1021 | 1.31[a] |
| At 2nd touch | 76 | 1.66 | 60 | 1.48 | 30 | 1.68 | 49 | 1.72 | 65 | 1.65 | 36 | 1.43 |
| At 1st touch | 29 | 1.12 | 29 | 1.11 | 22 | 0.64[de] | 53 | 1.24[c] | 58 | 1.28[c] | 36 | 0.96 |

Note: [a]p<0.05 in U-14. [b]p<0.05 in U-16. [c]p<0.05 in U-18. [d]p<0.05 in 2nd national division. [e]p<0.05 in 1st national division. [f]p<0.05 in international. $^{-}$ o $^{+}$ statistical signification of p<0.05 (chi square test). $^{+}$ o $^{-}$ relationship found (positive or negative).

The design of the study was descriptive punctual, nomothetic, multidimensional, inter-, and intra-group correlational (Anguera, Blanco, & Losada, 2001). The variables of the study were: "age group and level of competition" (national U-14, national U-16, national U-18, 2nd national senior division, 1st national senior division, and international senior level), game phase (side-out defence, and counter-attack defence), block performance (on a scale from 0 to 4), block zone (net was divided into three equal zones), number of players blocking (one, two or three), block intervention (no touch, block-out, ball returned to the attacker court, and ball contact and not returned), and attack tempo (first-tempo, second-tempo, third-tempo, second contact attack, and attacks at the first contact of the sequence of the game). For the categories of block performance, an efficacy coefficient (sum of attempts per category multiplied by the value of the level and divided by total attempts (0-4)), a point-to-error ratio, and an efficiency value (points or perfect actions minus errors) were calculated.

All recordings were made at public sport events without any influence in the game. All of them were official matches, and they were recorded with a video camera in live performance. The variables registered are part of the observation instrument (Observation Instrument of Techniques and Efficacy in Volleyball) that was designed and validated by Palao and Manzanares (2009) and Palao, Manzanares, and Ortega (2015). The observation was done by a single observer, who held a sports science degree, had the highest coaching certification in Spain, and had more than five years of experience as a coach and volleyball analyst. The observer was trained with the observation instrument before beginning the study (Palao & Manzanares, 2009). After the training period, inter- and intra-observer reliability were calculated (Cronbach's Alpha). To calculate the inter-observer reliability, another researcher was used as a reference. This researcher also held a sports science degree, had the highest coaching certification in Spain, and had more than ten years of experience. A lowest inter-observer reliability of 0.82 and a lowest intra-observer reliability of 0.96 (Kappa-Cohen test) were calculated.

A descriptive analysis (occurrence, occurrence percentage, means, standard deviation, and coefficient of performance values) and an inferential analysis were made. The Kolmogorov-Smirnov test was used to analyse the normality of the sample. Due to the normal distribution of all variables, the Chi-square test was used to study the differences in each category, and the Mann-Whitney U was used to analyse the differences between categories. The analyses were done with SPSS 21 software. The level of significance was established at p<.05.

## Results

In general, the errors, direct points, and blocks that limited the opposite's counterattack were significantly lower in early stages and significantly higher in the 1st national senior division and senior international levels. The blocks that allowed all counterattack options to the opponent team had a significantly higher occurrence in under-14 and under-16 and significantly lower occurrence in all senior categories. Regarding the game phase (Table 2), in the serve-defence phase, the errors had significantly lower occurrence in the early stages of training than in senior categories. The blocks that limit the opponent counterattack had a significantly higher occurrence in under-14 and under-16 and significantly lower in the 1st national senior

division and senior international levels. In the counter-attack defence phase, the errors and the blocks that limited the opponents' counter-attack options had a lower occurrence in under-14 and under-16 and significantly higher occurrence at the international level. The blocks that limited the opponent's counterattack had a significantly higher occurrence in under-14 and under-16 and significantly lower occurrence in the senior international level.

TABLE 4. Destination of the block according to game phase, timing of the attack and levels of competition (women's volleyball)

| Participation | U-14 | | U-16 | | U-18 | | 2nd national | | 1st national | | International | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | n | % | n | % | n | % | n | % | n | % |
| Serve and side-out defense | | | | | | | | | | | | |
| No touch | 429+ | 82.5 | 427+ | 67.5 | 400 | 60.7 | 516 | 56.8 | 536- | 55.4 | 477- | 55.9 |
| Block-out | 6- | 1.2 | 20- | 3.2 | 40 | 6.1 | 54 | 5.9 | 82+ | 8.5 | 81+ | 9.5 |
| Ball returned | 41- | 7.9 | 114 | 18.0 | 129 | 19.6 | 170 | 18.7 | 185 | 19.1 | 175 | 20.5 |
| Ball not returned | 44- | 8.5 | 72- | 11.4 | 90 | 13.7 | 168+ | 18.5 | 164+ | 17.0 | 121 | 14.2 |
| Counter-attack defense | | | | | | | | | | | | |
| No touch | 538+ | 75.9 | 565+ | 72.3 | 478 | 63.3 | 532- | 58.3 | 489 | 59.9 | 326- | 52.6 |
| Block-out | 14- | 2.0 | 29- | 3.7 | 38 | 5.0 | 67 | 7.3 | 64 | 7.8 | 73+ | 11.8 |
| Ball returned | 97- | 13.7 | 118 | 15.1 | 143 | 18.9 | 173 | 19.0 | 137 | 16.8 | 118 | 19.0 |
| Ball not returned | 59- | 8.3 | 69- | 8.8 | 95 | 12.6 | 140+ | 15.4 | 127+ | 15.5 | 103+ | 16.6 |
| Total | | | | | | | | | | | | |
| No touch | 967+ | 78.7 | 992+ | 70.2 | 878 | 62.1 | 1048- | 57.6 | 1025- | 57.5 | 803- | 54.5 |
| Block-out | 20- | 1.6 | 49- | 3.5 | 78 | 5.5 | 121 | 6.6 | 146+ | 8.2 | 154+ | 10.4 |
| Ball returned | 138- | 11.2 | 232 | 16.4 | 272 | 19.2 | 343 | 18.8 | 322 | 18.0 | 293+ | 19.9 |
| Ball not returned | 103- | 8.4 | 141- | 10.0 | 185 | 13.1 | 308+ | 16.9 | 291+ | 16.3 | 224 | 15.2 |

Note: - o + statistical signification of p<0.05 (chi square test). + o − relationship found (positive or negative).

According to the attack tempo (Table 3), the efficacy of blocks against the 3rd tempo attack had significantly lower occurrence in under-14 and significantly higher occurrence in all senior categories in the side-out defence and counter-attack defence phases.

Regarding the participation of the block (Table 4), the blocks that did not contact the ball in the serve-defence phase and counter-attack defence phase were significantly higher in under-14 and under-16, and significantly lower in the 2nd and the 1st national senior divisions and senior international levels. The occurrence of block-out had a significantly higher occurrence in the 1st national division and international level and lower in under-14 and under-16. The occurrences of the blocks that touched the ball and the ball that passed behind the block were significantly lower in under-14 and significantly higher in the senior international level. The occurrence of the blocks that touched the ball and returned to the opposite field had a significantly lower occurrence in under-14 and under-16 and significantly higher in the 2nd and 1st national senior divisions.

TABLE 5. Efficiency of the block according to game phase, zone and levels of competition (women's volleyball)

| Zone of blocking | U-14 | | U-16 | | U-18 | | 2nd national | | 1st national | | International | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | Coef | n | Coef | n | Coef | n | Coef | n | Coef | n | Coef |
| Serve and side-out defense | | | | | | | | | | | | |
| Zone 4 | 163+ | 1.18 | 158 | 1.20 | 168 | 1.41 | 281 | 1.28 | 322 | 1.31 | 310 | 1.24 |
| Zone 3 | 134- | 1.22 | 179- | 1.23 | 141 | 1.29 | 218+ | 1.37 | 203+ | 1.23 | 182+ | 1.20 |
| Zone 2 | 221 | 1.13[bcde] | 292 | 1.33[a] | 349 | 1.35[a] | 407 | 1.28[a] | 424 | 1.42[a] | 355 | 1.21 |
| Counter-attack defense | | | | | | | | | | | | |
| Zone 4 | 75- | 1.12[e] | 111 | 1.11[de] | 162 | 1.13 | 265 | 1.24[b] | 237 | 1.48[ab] | 187 | 1.24 |
| Zone 3 | 368+ | 1.13[e] | 313+ | 1.22 | 170 | 1.08 | 200- | 1.19 | 143- | 1.32[a] | 100- | 1.04 |
| Zone 2 | 266 | 1.24 | 358 | 1.2[c] | 425 | 1.62[b] | 435 | 1.33 | 405 | 1.35 | 323 | 1.50 |
| Total | | | | | | | | | | | | |
| Zone 4 | 238- | 1.15[e] | 269- | 1.15[e] | 330- | 1.27 | 546+ | 1.26 | 559+ | 1.39[ab] | 497+ | 1.24 |
| Zone 3 | 502+ | 1.18 | 492+ | 1.23 | 311- | 1.74 | 418- | 1.28 | 346- | 1.27 | 282- | 1.12 |
| Zone 2 | 487- | 1.19 | 650- | 1.26 | 774- | 1.49 | 842+ | 1.30 | 829+ | 1.39 | 678+ | 1.35 |

Note: [a]p<0.05 in U-14. [b]p<0.05 in U-16. [c]p<0.05 in U-18. [d]p<0.05 in 2nd national division. [e]p<0.05 in 1st national division. [f]p<0.05 in international. - o + statistical signification of p<0.05 (chi square test). + o − relationship found (positive or negative).


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TABLE 6. Efficiency of the block according to the number of hands blocking and levels of competition (women's volleyball)

| Action | U-14 | | U-16 | | U-18 | | 2nd national | | 1st national | | International | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % | n | % |
| One blocker | | | | | | | | | | | | |
| No touch | 620+ | 29.5 | 407 | 19.4 | 282 | 13.4 | 314 | 15.0 | 283 | 13.5 | 194- | 9.2 |
| BlockOut | 7- | 8.9 | 6- | 7.6 | 10 | 12.7 | 14 | 17.7 | 18 | 22.8 | 24+ | 30.4 |
| Ball returned | 77- | 21.2 | 62 | 17.1 | 45 | 12.4 | 61 | 16.8 | 66 | 18.2 | 52+ | 14.3 |
| Ball not returned | 64 | 21.2[def] | 32- | 10.6 | 38 | 12.6 | 72+ | 23.8[a] | 55 | 18.2[a] | 41 | 13.6[a] |
| Two blockers | | | | | | | | | | | | |
| No touch | 302+ | 9.1 | 547+ | 16.5 | 559 | 16.8 | 689 | 20.7 | 678 | 20.4 | 548- | 16.5 |
| BlockOut | 9- | 2.2 | 32- | 7.8 | 60 | 14.6 | 91 | 22.1 | 101 | 24.5 | 119+ | 28.9 |
| Ball returned | 60- | 5.1[bcdef] | 166 | 14.1[a] | 215 | 18.3[a] | 273 | 23.2 [a] | 240 | 20.4 [a] | 221 | 18.8 [a] |
| Ball not returned | 29- | 3.3 | 105- | 11.9[cde] | 138 | 15.7[b] | 225+ | 25.6[bef] | 217+ | 24.7 [bd] | 166 | 18.9 [d] |
| Three blockers | | | | | | | | | | | | |
| No touch | 3 | 4.5 | 11 | 16.4 | 7 | 10.4 | 7 | 10.4 | 21 | 31.3 | 18 | 26.9 |
| BlockOut | - | - | - | - | 1 | 16.7 | - | - | 3 | 50.0 | 2 | 33.3 |
| Ball returned | - | - | 4 | 8.9 | 11 | 24.4 | 9 | 20.0 | 9 | 20.0 | 12 | 26.7 |
| Ball not returned | 1 | 4.8 | - | - | 2 | 9.5 | 4 | 19.0 | 7 | 33.3 | 7 | 33.3 |

Note: [a]p<0.05 in U-14. [b]p<0.05 in U-16. [c]p<0.05 in U-18. [d]p<0.05 in 2nd national division. [e]p<0.05 in 1st national division. [f]p<0.05 in international. - o + statistical signification of p<0.05 (chi square test). + o - relationship found (positive or negative).

According to the zone of execution (Table 5), in the side-out defence, the occurrence of blocks in zone 3 was significantly higher in the senior levels and significantly lower in under-14 and under-16. In the counter-attack defence phase, the occurrence of blocks in zone 3 was significantly higher in under-14 and under-16 and significantly lower in senior categories. In zone 3, there was a significantly higher number of blocks in under-14 and under-16 than in senior categories. In zone 4, the occurrence of blocks was significantly lower in under-14, under 16 and under-18 than in the 2nd and 1st national senior divisions and the senior international level. The efficacy of the block in zone 2 was significantly lower in under-14 in the side out defence phase than in the rest of the categories studied.

Regarding the number of blockers (Table 6), the occurrence of the block by one player and two players without touching the ball was significantly higher in under-14 and significantly lower in the senior international level. The occurrence of block-out by one player and two players was significantly lower in under-14 and under-16 and significantly higher in the senior international level. The occurrence of block by one player that returned the ball to the opponent court was significantly lower in under-14 and significantly higher in the senior international level. The occurrence of blocks by two players and the ball passing behind the block was significantly lower in under-14 and under-16 and significantly higher in 2nd and 1st national senior divisions. Senior levels had an efficacy significantly lower in the one-player-block that touched the ball and passed behind the block. The efficacy of two players-block that touched the ball and returned to the opponent court was significantly lower in under-14 than the rest of categories studied.

## Discussion

This study provides reference values of the performance and a way of execution of the block in female volleyball players from under-14 to senior international categories. The results showed that the higher the category of competition, the higher the involvement of the block in the game. However, the higher participation does not involve a higher efficiency, due to the increase of the block errors and the block that limits the attack options. The block is the most difficult technical action to make (McGown, Fronske, & Moser, 2001; Palao et al., 2004b; Selinger & Ackermann-Blount, 1985). Its difficulty comes from the imbalance with the attack (Afonso & Mesquita, 2011; Marcelino et al., 2014; Silva et al., 2014), due to the types of opposite's setting, attack's tactics, ball's trajectory. All of these put the blockers at a disadvantage compared to the opposite's spikers (Inkinen et al., 2013; Marcelino & Mesquita, 2006; Palao et al., 2004b). As the level becomes higher, it becomes more difficult to block quicker and unpredictable opposite attacks (Katsikadelli, 1995; Marcelino et al., 2014; Palao et al., 2005). The highest demands in competition necessitate specific training and an appropriate physical condition (Malá et al., 2010; McGown et al., 2001). These improvements could increase the participation in the game (e.g., block that contacts the ball) with similar levels of block performance (Eom & Schutz, 1992a; Palao et al., 2004a; Peña et al., 2013; Rodríguez-Ruiz et al., 2011).

The efficiency of the block shows differences according to the game phase. In the side-out defence phase, there were no differences between the categories of competition. In the counterattack defence phase, the highest level of competition achieves a larger number of points that the lower level of competition (4% to 8%). The trend could be due to the higher occurrence of "out of system" attacks. In these situations, the blockers may balance their options against the spikers (Palao et al., 2004b) with a higher occurrence of slower passes (Castro et al., 2011; Silva et al., 2014). In the side-out phase, spikers have better conditions to finish the rally

(Bergeles & Nikolaidou, 2011; Inkinen et al., 2013; Palao et al., 2005). The counter-attack impacts the construction of the offence more often than the serve does; therefore, in this phase, the spike and the block have a greater balance (Bergeles et al., 2009; Kapidzic et al., 2013).

Related to the block intervention, in early stages, there are fewer contacts with the ball in blocking than at higher levels. In these categories, although the net height is lower, the players' jump capacity, technical skill, experience and decision making about the ball's trajectory are also lower (Amasay, 2008; Araujo et al., 2011; Inkinen et al., 2013; Malá et al., 2010). In a higher level of competition, there is a similar use of the block of two players and an increase in the errors and block that limits the opponent attacks (Marcelino & Mequita, 2006). The disadvantage of the blockers compared to the opposite's spikers could cause these tendencies. There is a deficit in time from having to "read" the setter's movements in their passes, to watch the movements of the quicker attacks, and the conjunction with the partners in a collective block (Afonso & Mesquita, 2011; Marcelino et al., 2014; Palao et al., 2005; Selinger & Ackermann-Blount, 1985).

Regarding the blocking zone, a higher number of blocking actions in the lower categories were found in zone 3 in the counterattack phase. This could be due to teams attacking, in early stages, in the middle of the net using a second tempo attack. This type can be executed in all game conditions. At senior levels, the type of offence done in the middle of the net change, due to the improvement of the ball control, the realization of quick attacks by the middle hitters, and the usage of attacks from zone six (Palao & Echeverría, 2008; Palao et al., 2005). At senior categories, the use of zone 3 is lower, although there are better conditions to build the offence (Costa, Afonso, Barbosa, Coutinho, & Mesquita, 2014; Inkinen et al., 2013; João, Carvalho, Sattler & Mota, 2007; João, Mesquita & Sampaio, 2010). At senior categories, the zones most commonly used were the side of the net. The difficulty if making a good floor-defense against the higher level's spikers (Palao et al., 2005) may lead to playing the attacks at the wings side of the net with slower tempos (Costa et al., 2014; Palao et al., 2009), and thus makes a higher number of blocks in those zones.

Regarding the number of blockers, the under-18 and senior categories presented similar proportions: seven out of 10 blocks were done by two players, and two out of 10 blocks were done by one player. The blocks done by three players presented a low occurrence (1-3%). These findings show that teams do not use a common strategy to neutralize the opponents' attack. At early stages, there was a higher occurrence of the blocks done by one player, and there were fewer blocks that touched the ball. At these categories, the development of abilities such as decision-making, anticipation or physical capacities are not completely developed (Afonso & Mesquita, 2011; Amasay, 2008; Malá et al., 2010; Marcelino et al. 2014). Analysing this variable, it should take into account that the target of the block is not only to stop the attack but also to serve as a reference position to organize the second-line defence (Selinger & Ackermann-Blount, 1985). At higher competition levels, there is a reduction of the time from the reception to the set and from the set to the attack (Inkinen et al., 2013; Katsikadelli, 1995). For that reason, although the physical capacity, training, and experience of the blockers increase, these improvements do not improve the block performance.

## Conclusions

The data of this study provide reference values of the evolution of the occurrence, frequency of use, way of execution, and block efficacy from under-14 to elite female volleyball players. At higher categories, the participation of the block in the game increases. The efficacy of the block is similar in the different categories, due to the increase of the number of errors and the blocks that limits the opponent attack. The blockers participate more in the game when the attack is done in slower and less stable conditions (counter-attack). These data could help coaches to analyse and evaluate the block in their players and to develop training plans adapted to their requirements. An example of a practical application of the results of these studies could be the criteria of how many attack blocks should touch and get points for each age group and level of competition. For example, at the international level, the goal should be that the block contacts the ball with at least five out of 10 attacks, without allowing more than one block-out of 10 attacks. To properly apply the results, it should be taken into account that the data come from teams at a specific moment of their development and top-teams of each competition. Future longitudinal studies with large samples are necessary in order to confirm these results.

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ORIGINAL SCIENTIFIC PAPER

# Doping Knowledge and Attitudes of Turkish Athletes: A Cross-Sectional Study

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ABSTRACT The use of prohibited substances in the world of sport, in and out of competition, is a major global problem. A number of similar studies have been conducted in other parts of the world that investigate the knowledge, attitudes, and practices of athletes about doping. The results of those studies cannot entirely be extrapolated to elite Turkish athletes. Therefore, this study aimed to investigate elite athletes' current knowledge of appropriate drug use, doping and use of supplements, and to explore the need for further education on these topics. A total of 202 Turkish athletes participated in this descriptive cross-sectional study. The data were collected through a questionnaire. A five-point Likert scale was used for questions. The most commonly used over-the-counter medications by athletes were painkillers (78.2%). A remarkable proportion of athletes considered painkillers (41.1%), protein powder (43.1%), and caffeine (41.1%) to be prohibited drugs. According to the athletes, physicians (84.6%) and coaches (78.6%) were the two most frequently used sources of information, and 87.6% of the athletes found the physician to be the most reliable source of information. Elite athletes have poor knowledge about doping in Turkey. There is an urgent need for educational anti-doping programmes to address the knowledge gaps observed amongst athletes in this study.

KEY WORDS Turkish athletes, doping in sports, surveys and questionnaires

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## Introduction

Doping is defined as the use of drugs or other substances to enhance performance, and it has become an important issue in recent years (Bloodworth & McNamee, 2010). Drug abuse in athletes may involve gaining an advantage in competition, coping with several stressors such as performance anxiety, physical pain, and mental illnesses (Reardon & Creado, 2014). The use of prohibited substances in athletes in- and out-of-competition is a global problem, causing not only gaining an illicitly competitive advantage in sports, but also severe and harmful health threats, including a wide variety of cardiovascular, psychiatric, metabolic, endocrine, neurologic, infectious, hepatic, renal, and musculoskeletal disorders, and an increased risk of death (Pope et al., 2014).

Since 2004, the World Anti-Doping Agency (WADA) has annually published its "List of Prohibited Substances and Methods", which defines the substances and methods that are prohibited both in- and out-of-competition, and in particular sports ("The Prohibited List | World Anti-Doping Agency," n.d.). Under WADA's Anti-Doping Code, athletes are ultimately responsible for any substance found in their body, regardless of how it got there. The presence of a prohibited substance may result in an anti-doping rule violation, whether its use was intentional or unintentional.

In a review, in which Morente-Sánchez et al. aimed to gather and critically analyse the most recent publications describing elite athletes' attitudes, beliefs, and knowledge of doping in sport, it was found that the athletes mostly receive information about prohibited substances from their coaches, and physicians do not play an essential informative role in this regard (Morente-Sánchez & Zabala, 2013). According to this study, athletes thought that doping was unethical, harmful and risky for health; however, it would bring them success (Morente-Sán-

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chez & Zabala, 2013). Although there are studies about the knowledge and attitudes of athletes in the world, to our knowledge, there is only one study from Turkey. Ozdemir et al. determined the rate of doping and performance-enhancing drug use in 883 subjects and analysed the main reasons for it (Ozdemir et al., 2005). They reported that doping and performance-enhancing drug use was 8%, it was significantly higher (14.5%) in the athletes, and 52.4% of doping and performance-enhancing drug users accepted that they were unaware of the drugs full and/or potential side effects (Ozdemir et al., 2005).

There is limited data in the literature on how elite Turkish athletes perceive doping and performance-enhancing drugs. The issue of doping is complex and is presumably predicted by a variety of situational and personal factors, and the results from other countries' studies cannot entirely be extrapolated to elite Turkish athletes. Therefore, this study aimed to evaluate the doping knowledge, attitudes, and behaviour of elite Turkish athletes.

## Methods

### *Questionnaire*

To investigate the doping knowledge, attitudes and behaviour, data were collected via questionnaire adopted from the study of Malek et al. (2014). The questionnaire was also reviewed and approved by the authors, who are also members of the Turkish Anti-Doping Commission (TADC). The final version of the questionnaire has a total of 10 items and was written in Turkish. A five-point Likert scale was used for questions, in which participants were instructed to respond if they strongly agreed, agreed, disagreed, strongly disagreed or had neutral feelings to the question. Participants were asked questions about which substances they used, whether these substances were banned, their attitudes and awareness about the prohibited substance, whether and from whom they received information about doping and their confidence in these sources of information. The questionnaire was administered from 1 September 2017 to 1 September 2018. The questionnaire was validated using face and content validity methods. The reliability of the questionnaire was calculated using Cronbach's alpha coefficient ($\alpha = 0.88$).

### *Participants*

A total of 202 elite Turkish athletes, over 18 years of age, from 11 sports including ice hockey, soccer, swimming, diving, basketball, Muay Thai, weightlifting, volleyball, cycling, track and field, and taekwondo enrolled for this study. Participants who had retired from a sport or those who had not participated in a competitive game or competition in the past year were excluded. Verbal information about the aims and objectives of the study was given to athletes before their participation. After this information, written and oral consents were received from all athletes who agreed to participate in this study. The questionnaires were anonymous, and the data were kept confidential to protect the privacy of the participants. This study was approved by the local ethics committee of the Hacettepe University Human Ethics Committee (Decision number: GO 17/680-17).

### *Statistics*

Statistical analyses were performed using the SPSS software version 21 (SPSS, Chicago, IL, United States). All data were expressed as mean and standard deviation or frequencies and percentages, depending on the characteristics of the variables.

## Results

### *Demographic Characteristics*

The mean age of the athletes was 20.8 ± 3.61 years, and the majority of the interviewed athletes were male (n = 139, 68.8%). The distribution of athletes by type of sports was; 39 in ice hockey (19.3%), 33 in soccer

TABLE 1. Distribution of the athletes according to sport type and doping training status

| | | n | % |
|---|---|---|---|
| Sports type (N=202) | Ice hockey | 39 | 19.3 |
| | Soccer | 33 | 16.3 |
| | Swimming | 29 | 14.4 |
| | Diving | 25 | 12.4 |
| | Basketball | 21 | 10.4 |
| | Muay Thai | 17 | 8.4 |
| | Weightlifting | 16 | 7.9 |
| | Volleyball | 13 | 6.4 |
| | Cycling | 6 | 3.0 |
| | Track and field | 2 | 1.0 |
| | Taekwondo | 1 | 0.5 |
| Education (N=202) | Have you ever had education about doping? | | |
| | Yes | 43 | 21.3 |
| | No | 159 | 78.7 |


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(16.3%), 29 in swimming (14.4%), 25 in diving (12.4%), 21 in basketball (10.4%), 17 in Muay Thai (8,4%), 16 in weightlifting (7,9%), 13 in volleyball (6.4%), 6 in cycling (3.0%), 2 in track and field (1.0%) and 1 in taekwondo (0,5%) (Table 1).

TABLE 2. Medications or supplements used by the athletes in the previous 12 months

| Drugs | I used last year | | I did not use last year | | I don't remember | |
|---|---|---|---|---|---|---|
| N=202 | n | % | n | % | n | % |
| Pain killers | 158 | 78.2 | 35 | 17.3 | 9 | 4.5 |
| Cough and cold medications | 131 | 64.9 | 58 | 28.7 | 13 | 6.4 |
| Antibiotics | 112 | 55.4 | 72 | 35.6 | 18 | 8.9 |
| Multivitamin | 104 | 51.5 | 84 | 41.6 | 14 | 6.9 |
| Caffeine | 78 | 38.6 | 103 | 51.0 | 21 | 10.4 |
| Protein powder | 62 | 30.7 | 126 | 62.4 | 14 | 6.9 |
| Creatinine | 38 | 18.8 | 122 | 60.4 | 42 | 20.8 |
| Allergy medications | 36 | 17.8 | 145 | 71.8 | 21 | 10.4 |
| L-carnitine | 30 | 14.9 | 130 | 64.4 | 42 | 20.8 |
| Diuretics | 8 | 4.0 | 167 | 82.7 | 27 | 13.4 |
| Asthmatic medications | 5 | 2.5 | 177 | 87.6 | 20 | 9.9 |
| Insulin | 5 | 2.5 | 172 | 85.1 | 25 | 12.4 |
| Antidepressants | 4 | 2.0 | 171 | 84.7 | 27 | 13.4 |
| Contraceptive pills | 3 | 1.5 | 178 | 88.1 | 21 | 10.4 |
| Thyroid medications | 1 | 0.5 | 169 | 83.7 | 32 | 15.8 |

### *Medication Usage*

Participants were asked to choose which medications or supplements (from a provided list) they had used in the previous 12 months (Table 2). The most commonly used over-the-counter medications were for pain (78.2%), cough and cold (64.9%), while the percentage of antibiotic usage was 55.4%.

### *Medication Awareness for Doping Violation*

Three-quarters of respondents (159, 78.7%) declared that they did not obtain any education regarding doping (Table 1). Participants were asked whether these medications or supplements were prohibited by WADA for causing a doping violation (Table 3). The most common substance considered to be prohibited was protein-powders (43.1%), followed by caffeine (41.1%), painkillers (41.1%), and antidepressants (39.6%). Participants mostly had no knowledge about diuretics (51.5%), thyroid medications (49.0%), creatinine (48.5%), L-carnitine (47.5 %) and contraceptive pills (46.5%).

TABLE 3. Athletes' awareness of medications or supplements prohibited by WADA for causing a doping violation

| N=202 | Includes doping | | Not include doping | | I don't know | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| Protein-powders | 87 | 43.1 | 70 | 34.7 | 45 | 22.3 |
| Caffeine | 83 | 41.1 | 60 | 29.7 | 59 | 29.2 |
| Pain killers | 83 | 41.1 | 69 | 34.2 | 50 | 24.8 |
| Antidepressants | 80 | 39.6 | 39 | 19.3 | 83 | 41.1 |
| Antibiotics | 73 | 36.1 | 68 | 33.7 | 61 | 30.2 |
| Cough and cold medications | 67 | 33.2 | 76 | 37.6 | 59 | 29.2 |
| Insulin | 58 | 28.7 | 54 | 26.7 | 90 | 44.6 |
| Thyroid medications | 57 | 28.2 | 46 | 22.8 | 99 | 49.0 |
| Multivitamin | 53 | 26.2 | 96 | 47.5 | 53 | 26.2 |
| Creatinine | 51 | 25.2 | 53 | 26.2 | 98 | 48.5 |
| Diuretics | 51 | 25.2 | 47 | 23.3 | 104 | 51.5 |
| Allergy medications | 51 | 25.2 | 75 | 37.1 | 76 | 37.6 |
| Contraceptive pills | 47 | 23.3 | 61 | 30.2 | 94 | 46.5 |
| Asthmatic medications | 46 | 22.8 | 73 | 36.1 | 83 | 41.1 |
| L-carnitine | 44 | 21.8 | 62 | 30.7 | 96 | 47.5 |

TABLE 4. Athletes' attitudes and awareness of prohibited substances

| N=202 | Strongly agree | | Agree | | Disagree | | Strongly disagree | | Unsure | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % |
| Doping is not worth the risk. | 119 | 58.9 | 44 | 21.8 | 5 | 2.5 | 22 | 10.9 | 12 | 5.9 |
| I am aware of the substances I cannot use in competition. | 113 | 55.9 | 66 | 32.7 | 7 | 3.5 | 2 | 1.0 | 14 | 6.9 |
| When the medication is prescribed by the doctor for another condition, I declare that I am an athlete. | 109 | 54.0 | 65 | 32.2 | 10 | 5.0 | 7 | 3.5 | 11 | 5.4 |
| I am aware of the substances I cannot use out of competition. | 100 | 49.5 | 65 | 32.2 | 7 | 3.5 | 4 | 2.0 | 26 | 12.9 |
| When getting a prescription medication, I often seek information from the pharmacist. | 83 | 41.1 | 76 | 37.6 | 13 | 6.4 | 9 | 4.5 | 21 | 10.4 |
| When getting a nonprescription medication or supplement, I consult a pharmacist each time. | 81 | 40.1 | 65 | 32.2 | 18 | 8.9 | 16 | 7.9 | 22 | 10.9 |
| A physician would be a useful source of information about banned substances. | 80 | 39.6 | 74 | 36.6 | 21 | 10.4 | 13 | 6.4 | 14 | 6.9 |
| When using a medication or supplement, I am concerned about the possibility of a doping violation. | 63 | 31.3 | 58 | 28.9 | 32 | 15.9 | 19 | 9.5 | 29 | 14.4 |
| Most athletes competing are not using banned substances. | 47 | 23.3 | 55 | 27.2 | 54 | 26.7 | 12 | 5.9 | 34 | 16.8 |
| My performance would be improved by banned substances. | 19 | 9.4 | 31 | 15.3 | 61 | 30.2 | 69 | 34.2 | 22 | 10.9 |
| Doping is necessary to achieve the best results. | 14 | 6.9 | 13 | 6.4 | 45 | 22.3 | 113 | 55.9 | 17 | 8.4 |
| I feel pressure to use banned substances. | 10 | 5.0 | 9 | 4.5 | 58 | 28.7 | 108 | 53.5 | 17 | 8.4 |

### *Attitudes and Awareness about Prohibited Substances*

Table 4 summarizes the athletes' responses to their attitudes and awareness about prohibited substances. A majority of the athletes thought that they had an awareness of the substances that should not be used during both in (88.6%) and out (81.7%) of competition. Most of the participants (67.3%) don't believe that most of their colleagues and competitors use prohibited substances (except disagree and strongly disagree in Table 4). Participants generally thought that doping is not necessary to achieve the best results (86.6%), and they mostly did not feel pressure to use prohibited substances (90.6%). A significant number of participants were not certain about what they are or are not allowed to take regarding medication or supplements (39.6%).

### *Sources of Doping Information and Reliability of Sources*

A list of sources of information was provided to participants for rating the frequency of the source of information (Table 5). The most common source of information about doping was physicians (84.6%), followed by coaches (78.6%), pharmacists (70.1 %), and team-mates (67.0%). In contrast, WADA (57.3%) and TADC (55.0%) were some of the least sources used for information. According to the participants, the physician was declared to be the most reliable source of information about prohibited substances and doping (96.5%, neutral and more) (Table 6). The web pages other than WADA, TADC and sports federations were the least reliable source of information (57.5%, neutral and more), followed by their teammates (71.7%, neutral and more).

## Discussion

Various sports have captured the attention of spectators. With growing interest, the financial value of the global sports market has significantly increased and is estimated to be worth around $600-700 billion per year (Au,

TABLE 5. Sources of information used by athletes about doping

| N=202 | Always | | Often | | Sometimes | | Rarely | | Never | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % |
| Physician | 63 | 31.3 | 48 | 23.9 | 45 | 22.4 | 14 | 7.0 | 31 | 15.4 |
| Coach | 49 | 24.4 | 34 | 16.9 | 53 | 26.4 | 22 | 10.9 | 43 | 21.4 |
| WADA | 34 | 17.1 | 25 | 12.6 | 35 | 17.6 | 20 | 10.1 | 85 | 42.7 |
| TADC | 34 | 17.0 | 16 | 8.0 | 39 | 19.5 | 21 | 10.5 | 90 | 45.0 |
| Pharmacist | 28 | 13.9 | 31 | 15.4 | 40 | 19.9 | 42 | 20.9 | 60 | 29.9 |
| Federation | 28 | 13.9 | 23 | 11.4 | 34 | 16.9 | 31 | 15.4 | 85 | 42.3 |
| Physiotherapist | 25 | 12.5 | 27 | 13.5 | 32 | 16.0 | 26 | 13.0 | 90 | 45.0 |
| Other | 19 | 9.5 | 23 | 11.6 | 39 | 19.6 | 43 | 21.6 | 75 | 37.7 |
| Webpages | 16 | 8.0 | 15 | 7.5 | 40 | 20.0 | 25 | 12.5 | 104 | 52.0 |
| Teammate | 15 | 7.5 | 34 | 17.0 | 50 | 25.0 | 35 | 17.5 | 66 | 33.0 |

Note: WADA=World Anti-Doping Agency, TADC=Turkish Anti-Doping Commission.


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TABLE 6. Reliability of sources used by athletes about doping

| N=202 | Strongly trustful | | Trustful | | Neutral | | Untrustful | | Strongly untrustful | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % |
| Physician | 122 | 60.7 | 54 | 26.9 | 18 | 9.0 | 4 | 2.0 | 3 | 1.5 |
| WADA | 101 | 50.5 | 39 | 19.5 | 37 | 18.5 | 10 | 5.0 | 13 | 6.5 |
| TADC | 98 | 49.0 | 55 | 27.5 | 30 | 15.0 | 4 | 2.0 | 13 | 6.5 |
| Coach | 87 | 43.7 | 54 | 27.1 | 42 | 21.1 | 4 | 2.0 | 12 | 6.0 |
| Federation | 63 | 31.7 | 50 | 25.1 | 50 | 25.1 | 17 | 8.5 | 19 | 9.5 |
| Pharmacist | 62 | 30.8 | 66 | 32.8 | 47 | 23.4 | 13 | 6.5 | 13 | 6.5 |
| Physiotherapist | 61 | 30.5 | 64 | 32.0 | 32 | 16.0 | 22 | 11.0 | 21 | 10.5 |
| Teammate | 35 | 17.7 | 25 | 12.6 | 82 | 41.4 | 21 | 10.6 | 35 | 17.7 |
| Other | 32 | 16.1 | 55 | 27.6 | 66 | 33.2 | 22 | 11.1 | 24 | 12.1 |
| Web pages | 23 | 11.5 | 39 | 19.5 | 53 | 26.5 | 29 | 14.5 | 56 | 28.0 |

Note: WADA=World Anti-Doping Agency, TADC=Turkish Anti-Doping Commission.

2017). Therefore, athletes face the thorny situation in which it is desired that they be "better, stronger, and faster". However, in the interest of the athletes' health, it is obligatory to control and limit medication or supplements by which sports performance can be improved and which are prohibited by WADA (Petróczi & Strauss, 2015). Therefore, because prohibited substances are entered onto the existing list annually, it is necessary to determine whether athletes are aware of doping and their perception regarding it. With that in mind, this study was aimed to investigate the perceptions and awareness of athletes on the use of prohibited substances, whether they received any information about doping, from which source they received the information and the reliability of these sources.

The most striking result to emerge from our study's data was that 78.7% of the athletes did not obtain any education regarding doping. Although our results differed considerably from those of Moran et al. (2008), in which athletes from 16 different countries stated that 62.6% of them received information regarding prohibited substances in their sports, these values correlate favourably with the study of Muwonge et al. (2015), who found that 60% of Ugandan professional athletes participating in different types of sports were familiar with information on doping, but 80% of them could not give a definition of doping. In a more recent study by Murofushi et al. (2018), results showed that 30.1% of Japanese university athletes had received an anti-doping education at least once, and 20.8% more than once. Perhaps the results of the present paper differ from the results of previous studies because WADA accredited the laboratory in our country later in comparison with the other countries. Therefore, doping education among the athletes started later on. In 2018, to promote education about Health and Anti-Doping among athletes, coaches, and others, WADA launched a new learning platform the Anti-Doping e-Learning platform (ADeL) ("WADA launches new anti-doping eLearning platform (ADeL) | World Anti-Doping Agency," 2018). This anti-doping programme may increase the awareness of athletes about banned substances in the long term.

Most elite athletes, especially during competitions, use some medications and supplements to improve their performance (Burke, 2017) or to influence musculotendinous healing during recovery (Tack, Shorthouse, & Kass, 2018). During the 2016 Rio Olympic Games, Soligard et al. recorded the injury and illness rate of athletes and found 9.8 injuries and 5.4 illnesses per 100 athletes over the 17-day period [16]. In our study, when athletes were asked about which medication they use, 78.2% reported that they used over-the-counter painkillers, followed by a cough and cold drugs (64.9%) and antibiotics (55.4%).

The results of the present paper are similar to those of Tscholl et al., (2010) who reported that NSAIDs, respiratory drugs, and analgesics were more frequently used. A further epidemiology study carried out by Tscholl et al. (2015) concurred with the findings of the present paper, reporting that the mean medication intake of male football players was 0.77 substances per player and per match.

Regarding the supplements used by athletes, in the present study, 30.7% of the participants reported consuming protein-powder, while more than half of the participants (51.5%) reported using multivitamins. In 2000, during the doping control at the Sydney Olympics, athletes stated the use of 26 separate supplements in a single day (Corrigan & Kazlauskas, 2003). The athletes thought that they were aware of substances that were allowed to be used within and outside the competition, despite their high drug use. (88.6% and 81.7%, respectively) (Corrigan & Kazlauskas, 2003). In the present study, almost half (43.1%) of the participants considered protein powder and 41.1% caffeine to be prohibited substances by WADA for causing a doping violation. The same lack of awareness regarding doping among high-level football players has also been supported by Ama et al. (2003).

Since the 1990s, creatinine has become one of the most popular supplement to improve athletic performance (Hall & Trojian, 2013). However, in our study, only 26.2% of the athletes did not consider creatinine to be a prohibited substance, while 48.5% of the athletes did not know about this. Taking into consideration the abovementioned, education or obtaining information from reliable sources are very important for the athlete's

career. The results of our study show that the physician was seen as the most frequently consulted (%84.6) and reliable (96.5%, neutral and more) source of doping knowledge by the athletes. Our findings are in contradiction with previous studies on French high school athletes and Iranian athletes, who declared their peers and coaches to be the primary sources about doping (Seif Barghi, Halabchi, Dvorak, & Hosseinnejad, 2015; Backhouse, Kenna, Robinson, & Atkin, 2007). It is important to note that physicians have the potential to influence athletes with regards to doping information. Thus, to ensure that athletes receive accurate information about doping, they must update their knowledge of prohibited substances and develop trustworthy relationships with the athletes.

Another reassuring finding of our study was that athletes have negative perceptions toward using prohibited substances to achieve better results and that 82.2% of them feel no pressure to use any doping substance. Furthermore, 80.7% of the participants stated that doping was not worth the risk. This confirms the previous finding in the literature (Malek et al., 2014).

In conclusion, the present study provides information about the doping knowledge and attitudes of Turkish athletes. According to the results, more than two thirds of these athletes did not receive doping training during their career. There is an urgent need to increase the awareness and the knowledge of athletes in the prevention of the usage of prohibited substances. Furthermore, it is necessary to provide educational programmes not only for the athletes but also to the physicians, coaches and other personnel in the athlete's team, and a professional development plan should be implemented to ensure that the information remains accurate and up-to-date.

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ORIGINAL SCIENTIFIC PAPER

# The Effect of 16-Minute Thermal Stress and 2-Minute Cold Water Immersion on the Physiological Parameters of Young Sedentary Men

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ABSTRACT This study aimed to determine the effect of 16 minutes of thermal stress followed by 2 minutes of cold water immersion on the physiological parameters of fifty-five sedentary men (mean age 20.15±1.30 years), who were exposed to 16 minutes of sauna (temperature: 90-91°C; relative humidity: 14-16%) followed by 2 minutes of cold water immersion (12°C). The participants' somatic characteristics were determined before entering the sauna, and their body mass and blood pressure were measured before and after sauna treatment. Physiological parameters were monitored during the 16-minute sauna session and the 2-minute cold water immersion (CRIO) or shower. The subjects perspired 0.21-0.27 litres during the 18-minute session. Heart rate values did not differ significantly between groups during the 16-minute sauna session, but significantly ($p<0.001$) lower HR values were noted in the CRIO group than in the control group (68.6:105.7 and 57.5:90.7 bpm). The values of SBP and DBP did not differ significantly between groups before the sauna but were significantly ($p<0.001$) lower in the CRIO group after sauna (SBP – 122.0:127.3 mmHg, DBP – 89.9:76.3 mmHg). In both groups, the participants remained within the easy effort range during most of the 18-minute session (650.9 and 492.6 s). A 16-minute sauna session followed by 2 minutes of cold water immersion induces a significantly greater decrease in HR and BP (SBP and DBP) than a 16-minute sauna session followed by 30 seconds in the shower and a 90 s resting period. During cold water immersion, HR values often decrease to the bradycardia range. Heart rate increased steadily in both groups.

KEY WORDS Finnish sauna, cryotherapy, sedentary men, physiological parameters, somatic features, body composition

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## Introduction

The sauna is a type of physical activity (PA) that is highly popular in Scandinavia in all age groups (Hussain & Cohen, 2018). This form of passive heat therapy is widely used for relaxation and pleasure (Laukkanen et al., 2018). Sauna bathing is renowned for its health benefits, and many users, in particular in the Scandinavian countries, visit a sauna at least once a week to improve their health (Kukkonen-Harjula & Kauppinen, 2006). For this reason, the majority of studies investigating the benefits of and contraindications to sauna bathing have been conducted in Finland since the late 1970s (Eisalo & Luurila, 1988; Hannuksela & Ellahham, 2001; Kauppinen, 1989 a, b, c; Kauppinen & Voori, 1986; Koljonen, 2009; Kosunen, Pakarinen, Kouppasalmi, & Adlercreutz, 1976; Kukkonen-Harjula & Kauppinen, 2006; Leppäluoto, Tuominen, Väänänen, Karpakka, & Vouri, 1986; Luurila, 1980; Vuori, 1987). Over the years, the influence of sauna bathing on physiological parameters has attracted the interest of researchers from other countries.

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Conflict of interest: None declared.

A single sauna session induces changes in the cardiovascular system, including vasodilation, redistribution of blood flow, and increase in sweating as the body attempts to maintain homeostasis under exposure to heat. The high temperature during sauna bathing induces acute physiological responses, fluid loss, and an increase in heart rate (Boraczyński, Boraczyński, Podstawski, Borysławski, & Jankowski, 2018; Hannuksela & Ellahham, 2001; Kukkonen-Harjula & Kauppinen, 2006). Sauna bathing activates various bodily systems, including the endocrine system, which promotes adrenalin secretion (Jezová, Kvestnanský, & Vigaš, 1994; Kukkonen-Harjula & Kauppinen, 2006; Leppäluoto et al., 1986; Pilch, Szyguła, Tori, & Hackney, 2008; Pilch et al., 2010).

Regular sauna use improves adaptability to various environmental conditions, increases physical effort (Blum & Blum, 2007) and contributes to emotional wellbeing (Podstawski, Choszcz, Honkanen, Tuohino, & Kolankowska, 2016). Repeated sauna therapy has been shown to increase left ventricular ejection fraction, reduce the levels of plasma norepinephrine and brain natriuretic peptides, and improve performance in a 6-min walk test (Ohori et al., 2012). Diastolic blood pressure (DBP) decreased substantially after one week of repeated sauna use (twice a day) (Leppäluoto et al., 1986). Sauna exposure increases core temperature and induces similar changes in cardiovascular hemodynamics, cardiac output and vascular shear stress as exercise; therefore; it could be regarded as an alternative method of improving health (Brunt, Howard, Francisco, Ely, & Minson, 2016). Flow-mediated endothelium-dependent dilation improved significantly in patients with cardiovascular risk factors who participated in a two-week trial involving single daily exposure to an infrared sauna (Imamura et al., 2001). A long-term general population-based prospective study revealed that frequent bathing in a Finnish sauna delivered numerous health benefits by lowering the risk of hypertension, dementia, fatal cardiovascular outcomes and all-cause mortality (Laukkanen, Kunutsor, Kauhanen, & Laukkanen., 2016; Zaccardi et al., 2017).

Cold-water immersion (CWI) is thought to influence the body by stimulating cold- and baroreceptors and by activating the sympathetic nervous system and endocrine function. In turn, these responses may influence water balance and cardiovascular control functions (Epstein, 1992). The hypothesis that cold-induced responses are mainly caused by increased activity of the sympathetic nervous system, whereas water-immersion induced responses are mediated by humoral control mechanisms has been supported by findings by Šrámek, Šimečková, Janskỳ, Savliková, and Vybiral (2000), who found that one-hour head-out immersions in 32°C, 20°C, and 14°C water did not increase blood concentrations of cortisol and that changes in rectal temperature did not correlate with changes in hormone production. However, CWI was effective for maintaining repeat cycling performance in the heat, and this improvement in performance was associated with changes in core temperature and limb blood flow (Vaile et al. 2009). In another study with cyclists, five-minute periods of CWI significantly lowered rectal temperature and maintained endurance performance during subsequent high-intensity exercise (Abbiss, Watson, Nosaka, & Laursen, 2008). Taken together, these studies indicate that repeat exercise performance in heat may be improved when short periods of cold-water immersion are applied during recovery periods (Peiffer, Abbiss, Watson, Nosaka, & Laursen, 2008). A similar conclusion was reached by Gill, Beaven, and Cook (2006), who found that the use of cold and hot water immersion improved post-match recovery in elite rugby players.

The physiological effect of thermal stress followed by cold water immersion has never been explored in sedentary individuals who are sporadic sauna users. There is a general lack of evidence to demonstrate the positive effects of such treatment on cardiovascular function and the potential reduction of the risk of cardiovascular disease (CVD) (Laukkanen et al., 2018). Therefore, the aim of this study was to evaluate the effect of thermal stress and cold water immersion on physiological parameters in men with low habitual levels of physical activity who use the sauna sporadically.

## Methods

### *Participants*

A total of 55 male university students aged 18-23 years (mean=20.15, SD=1.30) volunteered for the study. The participants were divided into two groups: the CRIO group of 30 subjects (who remained immersed in cold water to neck level for 2 minutes immediately after sauna) and the SHOWER group of 25 subjects (who took a cold shower for 30 seconds immediately after sauna and then rested in a sitting position for 90 seconds). The participants were informed about the purpose of the study during obligatory physical education (PE) classes at the University of Warmia and Mazury in Olsztyn. The subjects attended only mandatory PE classes (90 min per week); they did not participate in any extra-curricular PA programmes and had visited the sauna only sporadically before the study. The students did not take any medication or nutritional supplements, were in good health, and had no history of disease affecting biochemical and biomechanical factors. None of the evaluated participants had respiratory or circulatory ailments. Their PA levels were evaluated using the standardized and validated International Physical Activity Questionnaire (IPAQ) (Lee, Macfarlane, Lam, & Stewart, 2011). The IPAQ was used only to select a homogenous sample of male students, and the results were presented only in terms of Metabolic Equivalent of Task (MET) units indicative of the participants' PA levels. The students declared the number of minutes dedicated to PA (minimum 10 minutes) during an average week preceding the study. The energy expenditure associated with weekly PA levels was expressed in terms of MET units, where the MET is the ratio of the work metabolic rate to the resting metabolic rate, and 1 MET denotes the amount of oxygen consumed in 1 minute at rest, which is estimated at 3.5 mL/kg/min. Based on the frequency, intensity and duration of the PA levels declared by the surveyed students, the respondents were classified into groups characterized by low (L < 600 METs-min/week), moderate (M < 1,500 METs-min/week) and high (H ≥ 1,500 METs-min/week) levels of activity. Only male students with low levels of PA (energy expenditure of up to 600 METs per week) and a sedentary lifestyle were chosen for the study. All participants gave their written informed consent to participate in the study. The study was conducted in line with the guidelines of


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the University of Warmia and Mazury in Olsztyn (UWM), Poland, the ethics committee, and the provisions of the Declaration of Helsinki.

### *Instruments and procedures*

The participants received comprehensive information about sauna rules before the study. They were instructed to drink at least one litre (L) of water on the day before the test and 0.5 L of water 2 hours before the test. During the study, every participant remained in a dry sauna (temperature: 90-92oC; relative humidity: 14-16%) in a seated position for 16 minutes. The students assigned to the CRIO group cooled down in a paddling pool (pool width: 100 cm; pool depth: 130 cm; water temperature: +10-11oC) for two minutes immediately after the 16-minute sauna session. The students assigned to the SHOWER group took a cold shower (10-11°C) lasting around 30 seconds directly after sauna and then rested in a sitting position for 90 seconds in a neutral compartment (i.e., a room with a temperature of 20–22°C and relative air humidity of approximately 50%).

Body height was measured to the nearest 0.1 mm with a stadiometer, and nude body mass was measured to the nearest 0.1 kg with a calibrated WB-150 medical scale (ZPU Tryb Wag, Poland) prior to the first sauna session. The measured values were used to calculate the participants' BMI. Blood pressure (BP) was determined with an automatic digital blood pressure monitor (Omron M6 Comfort, Japan) immediately before sauna and during cooldown at room temperature. Somatic features, including body mass, body mass index (BMI), body surface area (BSA) and the waist-hip ratio (WHR), as well as body composition parameters, including body mass, total body water (TBW), protein and mineral content, body fat mass (BFM), fat-free mass (FFM), skeletal muscle mass (SMM), percentage body fat (PBF), InBody score, target weight, visceral fat level (VFL), basal metabolic rate (BMR) and degree of obesity, were determined via bioelectrical impedance (Gibson, Holmes, Desautels, Edmonds, & Nuudi, 2008) with the InBody 720 body composition analyser. Due to high temperature in the sauna, physiological parameters, including heart rate (HR min, avg, max), recovery time, peak training effect (PTE), energy expenditure, oxygen uptake (VO2 avg, max), excess post-exercise oxygen consumption (EPOC avg, peak), respiratory rate (avg, max) and physical effort (easy, moderate, difficult, very difficult, maximal), were measured indirectly with Suunto Ambit3 Peak heart rate monitors which are widely used in studies of the type (Scoon, Hopkins, Mayhew, & Cotter, 2007). Every pulsometer was calibrated to the male sex, year of birth, body mass and PA level before sauna exposure.

### *Statistical analysis*

Measurement results were processed statistically in the Statistica PL v. 13.5 application with the use of descriptive statistics. The analysed parameters were tested for normal distribution. Arithmetic means were compared by the Student's t-test at a significance level of $p \leq 0.05$.

TABLE 1. Descriptive statistics of the studied anthropometric and body composition parameters in (CRIO) and (SHOWER) groups

| Parameters | 1. CRIO (n=30) | | | | 2. SHOWER (n=25) | | | | Difference (1-2) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | min-max | As | Mean | SD | min-max | As | *t* | *p* |
| Age [years] | 20.07 | 1.34 | 18-23 | 0.24 | 20.24 | 1.27 | 18-22 | 0.04 | -0.49 | ns |
| Body height [cm] | 179.64 | 7.13 | 166.0-196.2 | 0.12 | 180.02 | 6.10 | 166.0-192.3 | -0.27 | -0.21 | ns |
| Body mass before sauna [kg] | 85.03 | 12.94 | 55.9-109.9 | -0.07 | 83.84 | 10.31 | 58.0-99.7 | -0.88 | 0.37 | ns |
| Body mass after sauna [kg] | 84.82 | 12.91 | 55.7-109.7 | -0.07 | 83.57 | 10.22 | 57.9-99.4 | -0.89 | 0.39 | ns |
| BML (Body Mass Loss) [kg] | 0.21 | 0.08 | 0.1-0.4 | 0.34 | 0.27 | 0.22 | 0.1-1.2 | 3.59 | -1.35 | ns |
| Weight Control [kg] | -4.98 | 6.54 | -16.8-7.9 | 0.17 | -4.760 | 7.53 | -16.2-19.2 | 1.48 | -0.12 | ns |
| BMI (Body Mass Index) [kg/m$^2$] | 26.31 | 3.41 | 19.34-33.07 | -0.28 | 25.93 | 3.40 | 16.79-31.32 | -1.07 | 0.41 | ns |
| BSA (Body Surface Area) [m$^2$] | 2.06 | 0.18 | 1.63-2.37 | -0.22 | 2.05 | 0.14 | 1.69-2.31 | -0.67 | 0.26 | ns |
| WHR (Waist-Hip Ratio) | 0.89 | 0.07 | 0.77-1.03 | 0.11 | 0.89 | 0.08 | 0.72-1.01 | -0.68 | 0.10 | ns |
| TBW (Total Body Water) [L] | 49.57 | 6.56 | 32.9-60.5 | -0.52 | 49.57 | 5.03 | 41.9-61.7 | 0.69 | 0.00 | ns |
| Proteins [kg] | 13.46 | 1.81 | 8.9-16.4 | -0.53 | 13.34 | 1.46 | 10.7-16.8 | 0.58 | 0.28 | ns |
| Minerals [kg] | 4.62 | 0.68 | 3.24-5.59 | -0.35 | 4.61 | 0.53 | 3.55-5.71 | -0.40 | 0.07 | ns |
| SMM (Skeletal Muscle Mass) [kg] | 38.64 | 5.49 | 24.7-47.6 | -0.53 | 38.22 | 4.38 | 30.4-48.5 | 0.56 | 0.31 | ns |
| PBF (Percent Body Fat) [%] | 20.00 | 5.4930 | 11.3-30.3 | 0.12 | 19.70 | 6.37 | 6.7-29.9 | -0.59 | 0.19 | ns |
| BFM (Body Fat Mass) [kg] | 17.33 | 6.34 | 7.9-30.8 | 0.24 | 16.87 | 6.32 | 3.9-27.8 | -0.48 | 0.27 | ns |
| BF-LBM Control [kg] | -5.57 | 5.65 | -16.8-3.3 | -0.30 | -5.42 | 5.81 | -16.2-6.9 | 0.32 | -0.09 | ns |
| FFM (Fat Free Mass) [kg] | 67.71 | 9.06 | 45.0-82.5 | -0.50 | 67.01 | 7.17 | 54.1-84.2 | 0.56 | 0.31 | ns |
| FFM Control [kg] | 0.57 | 1.91 | 0.0-9.1 | 3.73 | 0.66 | 2.55 | 0.0-12.3 | 4.40 | -0.14 | ns |
| Target weight | 80.07 | 9.59 | 63.0-97.0 | -0.18 | 79.08 | 7.34 | 68.2-99.0 | 0.75 | 0.41 | ns |
| MET | 478.6 | 68.0 | 397-599 | 0.38 | 470.1 | 66.4 | 387-590 | 0.55 | 0.47 | ns |

## Results

No significant differences in age, somatic or anthropometric parameters were observed between the CRIO

group and the SHOWER group, which suggests that the analysed groups were homogeneous and could be compared. In both groups, the participants' BMI values approximated the overweight threshold (26.3 and 25.93 kg/m2, respectively). Only 27.3% of the studied subjects had a BMI below 25. The waist-to-hip ratio was identical in both groups (0.89), and it was not indicative of obesity. The students perspired 0.21-0.27 litres during the 18-minute treatment (16 minutes of sauna, followed by 2 minutes of cooldown). The values of Body Fat-Lean Body Mass Control indicate that the participants should lose 5.42-5.57 kg of body fat mass and gain 0.57-0.66 kg of fat-free mass. Both groups were characterized by low and statistically similar PA levels.

TABLE 2. Descriptive statistics of HR values in (CRIO) and (SHOWER) groups

| HR [bpm] | 1. CRIO (n=30) | | | | 2. SHOWER (n=25) | | | | Difference (1-2) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | min-max | As | Mean | SD | min-max | As | *t* | *p* |
| $HR_{BS}$ | 82.1 | 10.7 | 68-119 | 1.49 | 80.2 | 8.1 | 61-98 | -0.06 | 0.76 | ns |
| $HR_{AS+cryo\ or\ S+shower}$ | 66.2 | 6.0 | 52-77 | -0.26 | 85.2 | 7.5 | 72-99 | -0.11 | -10.41 | <0.001 |
| $HR_{min}$ | 57.4 | 6.9 | 46-70 | 0.20 | 80.1 | 9.6 | 61-102 | 0.29 | -10.14 | <0.001 |
| $HR_{avg}$ | 104.1 | 8.5 | 89-122 | 0.12 | 109.5 | 8.3 | 91-122 | -0.19 | -2.34 | 0.023 |
| $HR_{max}$ | 128.1 | 7.5 | 114-141 | 0.18 | 129.5 | 6.7 | 112-141 | -0.89 | -0.75 | ns |
| $HR_{1min}$ | 84.9 | 7.4 | 72-98 | 0.06 | 83.2 | 9.4 | 63-101 | 0.05 | 0.73 | ns |
| $HR_{2min}$ | 89.6 | 7.7 | 81-112 | 1.41 | 89.9 | 8.1 | 79-106 | 0.43 | -0.17 | ns |
| $HR_{4min}$ | 94.3 | 7.3 | 83-113 | 1.16 | 96.1 | 7.6 | 82-111 | 0.19 | -0.91 | ns |
| $HR_{6min}$ | 99.1 | 8.3 | 88-120 | 0.89 | 102.5 | 8.6 | 85-117 | -0.31 | -1.47 | ns |
| $HR_{8min}$ | 105.9 | 7.7 | 91-126 | 0.72 | 106.0 | 8.7 | 87-124 | -0.25 | -0.05 | ns |
| $HR_{10min}$ | 108.8 | 8.5 | 89-127 | -0.01 | 111.1 | 8.8 | 91-125 | -0.53 | -0.98 | ns |
| $HR_{12min}$ | 114.0 | 8.6 | 92-130 | -0.54 | 114.9 | 8.5 | 96-133 | -0.03 | -0.41 | ns |
| $HR_{14min}$ | 120.1 | 6.7 | 106-132 | -0.21 | 119.6 | 7.9 | 103-133 | -0.41 | 0.24 | ns |
| $HR_{16min}$ | 126.3 | 8.5 | 111-141 | 0.09 | 128.5 | 6.6 | 112-137 | -0.78 | -1.08 | ns |
| $HR_{17min}$ | 68.6 | 6.2 | 57-91 | 1.31 | 105.7 | 14.6 | 65-126 | -1.37 | -12.62 | <0.001 |
| $HR_{18min}$ | 57.5 | 6.8 | 46-70 | 0.15 | 90.7 | 12.7 | 61-113 | -0.48 | -12.40 | <0.001 |

Notes: HRBS – heart rate before sauna, HRAS+crio or S+shower – heart rate after sauna + cryotherapy or sauna + shower.

Before the sauna, HR values did not differ significantly between groups (82.1 and 80.2 bpm, respectively), but HR values determined directly after the 18-minute session were significantly ($p<0.001$) lower in the CRIO group than in the SHOWER group (66.2±6.0 and 85.2±7.5 bpm, respectively). The measurements conducted during the 16-minute sauna session did not reveal significant differences in HR between

TABLE 3. Descriptive statistics of the studied physiological parameters in (CRIO) and (SHOWER) groups

| Traits | | 1. CRIO (n=30) | | | | 2. SHOWER (n=25) | | | | Difference (1-2) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | min-max | As | Mean | SD | min-max | As | *t* | *p* |
| Energy expenditure [kcal] | | 143.80 | 17.31 | 103-183 | -0.31 | 145.68 | 20.85 | 102-184 | -0.09 | -0.37 | ns |
| $VO_2$ [mL/kg/min] | avg | 15.27 | 2.59 | 11-22 | 0.80 | 16.96 | 3.18 | 12-23 | 0.39 | -2.18 | 0.034 |
| | max | 22.50 | 3.01 | 17-28 | 0.29 | 24.60 | 3.56 | 19-33 | 0.47 | -2.37 | 0.021 |
| EPOC [mL/kg] | avg | 4.37 | 2.40 | 2-10 | 0.93 | 5.68 | 3.06 | 2-12 | 0.61 | -1.78 | ns |
| | max | 9.33 | 5.60 | 4-23 | 1.01 | 12.80 | 6.28 | 4-28 | 0.71 | -2.16 | 0.036 |
| Systolic blood pressure-SBP [mmHg] | before sauna | 130.5 | 9.2 | 107-147 | 0.29 | 131.0 | 9.6 | 117-153 | 0.37 | -0.20 | ns |
| | after sauna | 122.0 | 7.3 | 105-136 | -0.33 | 127.3 | 7.8 | 114-146 | 0.14 | -2.57 | 0.012 |
| Diastolic blood pressure-DBP [mmHg] | before sauna | 77.8 | 11.4 | 53-113 | 0.58 | 78.6 | 8.0 | 66-97 | 0.34 | -0.31 | ns |
| | after sauna | 69.9 | 8.7 | 50-83 | -0.40 | 76.3 | 8.4 | 65-99 | 0.83 | -2.76 | 0.008 |
| **Physical effort range [s]** | | | | | | | | | | | |
| Easy <107 [bpm] | | 650.9 | 264.7 | 189-1080 | -0.17 | 492.6 | 267.3 | 57-1004 | 0.16 | 2.19 | 0.032 |
| Moderate 107-124 [bpm] | | 346.5 | 190.8 | 0-725 | -0.02 | 415.2 | 208.6 | 76-1023 | 1.18 | -1.26 | ns |
| Difficult 125-141 [bpm] | | 82.6 | 121.3 | 0-444 | 1.68 | 164.4 | 183.7 | 0-626 | 1.19 | -1.97 | ns |
| Very difficult 142-159 [bpm] | | 0.1 | 0.4 | 0-2 | 5.48 | 8.0 | 36.4 | 0-182 | 4.93 | -1.19 | ns |
| Maximal ≥ 160 [bpm] | | All values are zero | | | | | | | | | |


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groups. However, HR values determined in the 17th and 18th minute were significantly ($p<0.001$) lower in the CRIO group (for 37.1 and 33.2 bpm, respectively) than in the SHOWER group (17th minute – 68.6:105.7 bpm, 18th minute – 57.5:90.7 bpm). As a result, the average HR was also significantly ($p=0.023$) lower (by 5.4 bpm) in the CRIO group than in the SHOWER group (HRavg - 104.1:109.5 bpm).

The average estimated values of VO2avg (15.27 mL/kg/min), VO2max (22.5 mL/kg/min), EPOCavg (4.37 mL/kg) and EPOCmax (9.33 mL/kg) were significantly higher in the SHOWER group than in the CRIO group (for: 1.7 and 2.1 mL/kg/min, as well as 1.3 and 4.4 mL/kg, respectively). The differences in BP values were similar to those noted in HR values. The values of SBP and DBP did not differ significantly between groups before the sauna but were significantly lower in the CRIO group after it (SBP – 122.0:127.3 mmHg, DPB – 89.9:76.3 mmHg). The participants from the CRIO group remained within the easy effort range significantly ($p=0.032$) longer than the males from the SHOWER group (650.9: 492.6 s). The students from the SHOWER group remained within the moderate (415.2: 346.5 s), difficult and very difficult effort rate longer than the participants from the CRIO group, but the noted differences were not significant ($p>0.05$).

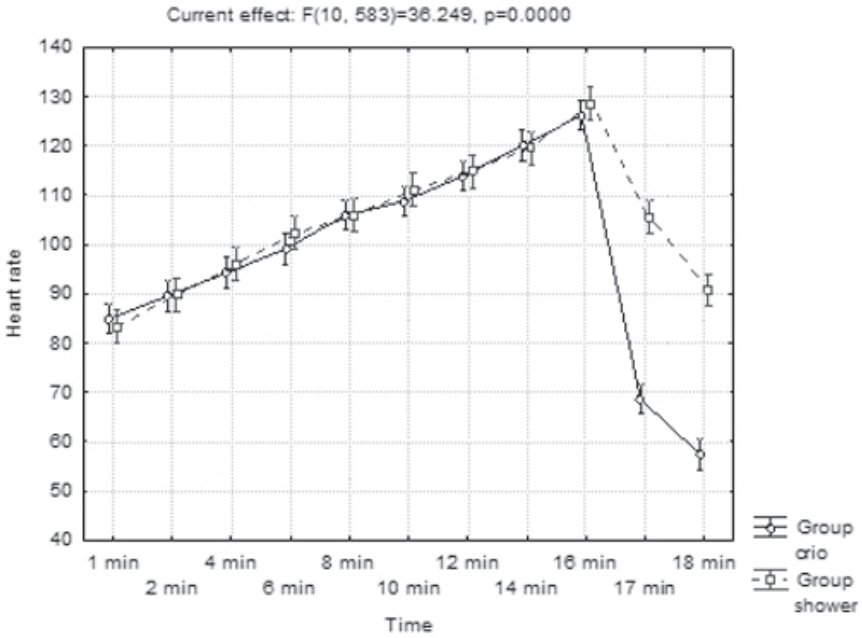


FIGURE 1. Changes in HR values at 1-minute and 2-minute intervals in CRIO and SHOWER groups

The average HR values increased at a similar rate during sauna in both groups, but HR measured in the 17th and 18th minutes decreased at a significantly higher rate in the CRIO group (immersion in cool water with a temperature of 11-12°C).

In both groups, HR increased at a relatively steady rate of 2.70 bpm. Lower values were noted only between the 8th and 10th minute (1.9 bpm), and higher values were observed between the 14th and 16th minutes (3.7 bpm).

Clear differences in recovery HR were found between the analysed groups. The greatest decrease in HR

TABLE 4. Changes in heart rate during sauna at one-minute intervals (up to the 16th minute)

| Time [min] | CRIO + SHOWER (n=55) [bpm] | | |
|---|---|---|---|
| | Mean | SD | min÷max |
| 1* - 2 | 2.8 | 2.7 | -4÷ 13 |
| 2 – 4 | 2.7 | 2.2 | -3 ÷ 8 |
| 4 – 6 | 2.8 | 2.1 | -2 ÷ 10 |
| 6 – 8 | 2.7 | 2.2 | -4 ÷ 9 |
| 8 – 10 | 1.9 | 2.4 | -6 ÷12 |
| 10 – 12 | 2.3 | 2.0 | -7 ÷ 6 |
| 12 – 14 | 2.7 | 2.2 | -2 ÷ 10 |
| 14 – 16 | 3.7 | 2.7 | -3 ÷ 10 |

Note: * starting from the first second of sauna use.

was observed between the 16th and 17th minutes (one minute after sauna) in both groups (-57.6 and -22.8 bpm, respectively). One minute after the sauna, the decrease in HR was significantly ($p<0.001$) higher in the CRIO group than in the SHOWER group. In the second minute after the sauna, the decrease in HR was significantly ($p = 0.049$) higher in the SHOWER group (-15 bpm).

TABLE 5. Changes in resting heart rate at one-minute intervals (in the 17th and 18th minute)

| Time [min] | 1. CRIO (n=30) [bpm] | | | 2. SHOWER (n=25) bpm] | | | Difference(1-2) | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | min÷max | Mean | SD | min÷max | *t* | *p* |
| 16 - 17 | -57.6 | 8.8 | -73 ÷ -36 | -22.8 | 11.5 | -54 ÷ -7 | 12.70 | <0.001 |
| 17 - 18 | -11.2 | 6.4 | -35 ÷ -2 | -15.0 | 7.6 | -35 ÷ -1 | 2.01 | 0.049 |

## Discussion

The results of this study provide novel and valuable insights into the physiological responses of young sedentary men to sauna treatment. One sauna session lasting 16 minutes, followed by 2 minutes of immersion in cold water (11-12°C) induced significant differences in the tested subjects' physiological parameters. The values measured after sauna in the CRIO group differed significantly from those noted in men who took a cold shower for 30 seconds and then rested for 90 minutes in a temperature-neutral room. The post-sauna decrease in HR and BP was significantly more rapid in the CRIO group than in the SHOWER group. The participants' HR values were significantly ($p<0.001$) lower (HRASC = 66.2 bpm) after cold water immersion (CWI) than immediately before the 16-minute sauna session (HRBSC = 82.1 bpm). In the SHOWER group, HR values after sauna, shower and relaxation were significantly ($p=0.028$) higher (HRASPR = 85.2 bpm) than before sauna (HRBSPR = 80.2 bpm). The above findings could have practical implications for persons who attend multiple rounds of sauna with breaks in between. A study of university students who attended four sauna sessions with 5-minute breaks between sessions under nearly identical conditions to those described in the present study (temperature: 90°C; relative humidity: 14-16%) revealed a steady increase in HRavg during successive sauna sessions, from 98 bpm during the first session to more than 133 bpm during the fourth session (Podstawski et al., 2019). The recovery HR during every successive break also increased and exceeded baseline values, which could indicate that 5-minute breaks after 10-minute sauna sessions are insufficient for full physiological recovery. In young people who regularly use the sauna, HR increases to approximately 100-110 bpm and may exceed 140-150 bpm with a rise in ambient temperature (Hasan, Karvonen, & Pirronen, 1967; Leppäluoto et al., 1986; Luuira, 1980; Tei et al., 1995). The increase in HR can be even higher in participants who do not use the sauna regularly, which can be attributed to the lack of physiological adaptation to high temperature (Leppäluoto et al., 1986). The rise in HR is also influenced by other factors, such as the length of stay in the sauna, age, sex and physical endurance (Sawicka & Brzostek, 2007). In terms of health outcomes, the increase in HR to around 120 bpm is regarded as a beneficial adaptive response, whereas an increase in excess of 140 bpm can have adverse consequences because it is associated with higher cardiac effort and diastole shortening (Sawicka & Brzostek, 2007). In some participants from the SHOWER group, HR reached 141 bpm immediately after 16 minutes of sauna and 113 bpm after the 2-minute break. In these subjects, HR is likely to exceed normal values after successive sauna sessions. Coldwater immersion between sauna sessions appears to be more effective in cooling the body and speeding up recovery, and it can be recommended for persons who rarely use the sauna. Similar conclusions were formulated by Hasan et al. (1967) who observed that HR decreased slowly during prolonged and gradual body cooling, such as a cold shower. Baseline HR is restored approximately 1-4 hours after sauna if the body is cooled at room temperature.

In the CRIO group, the decrease in HR after CWI was accompanied by a clear drop in BP (SBP and DBP). In the CRIO group, SBP decreased significantly ($p<0.001$) by 8.5 mmHg, whereas the corresponding decrease in the SHOWER group reached only 3.7 mmHg and was not significant ($p=0.143$). In the CRIO group, DBP decreased significantly ($p=0.004$) by 7.9 mmHg, whereas in the SHOWER group, this corresponding decrease (by 2 mmHg) was not significant ($p=0.327$). The above findings indicate that CWI in between sauna sessions leads to a greater decrease in BP than a cold shower followed by a resting period. In the literature, the effects of sauna bathing on BP vary considerably, depending on the applied method of measurement, type of sauna, duration of exposure which elicits the evaporation effect, and user adaptation to high temperature. Considerable variations were reported in studies in which BP was measured with a sphygmomanometer, ranging from a minor increase (Eisalo & Luurila, 1988; Kukkonen-Harjula & Kauppinen, 2006) or the absence of any changes (Luuira, 1980, Miyamoto et al., 2005, Rismann, al-Karawi, & Jorch, 2002), to a decrease in SBP (Gianetti et al., 1999; Kihara et al., 2002, Kiss, Popp, Wagner, Zwick, & Sertl, 1994; Miyamoto et al., 2005) and DBP values (Hasan & Karvonen, 1967; Imamura et al., 2001; Kauppinen & Vuori, 1986; Kihara et al., 2002; Leppäluoto et al., 1986; Luuira, 1980; Kauppinen, 1989; Tei et al., 1995; Tei & Tanaka, 1996). In the cited studies, BP was measured immediately after sauna, whereas in the current study, the relevant measurements were performed around 30 seconds after the entire session to determine the health benefits of the sauna (several hours after the treatment) rather than the direct effects of thermal stress. In subjects with a higher risk of cardiovascular disease, sauna exposure may improve vascular compliance, which indicates that heat therapy prevents arterial stiffening (Imamura et al., 2001). Sauna bathing is generally well tolerated, but according to some authors, it could increase the risk of myocardial ischemia in patients with coronary artery disease (Giannetti et al., 1999).


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An increase in ambient temperature can decrease blood pressure, which further confirms that passive heat therapy delivers health benefits (Gayda et al., 2012; Kunutsor & Powles, 2010).

Sauna bathing can also contribute to a decrease in body mass. Sweat volume during sauna bathing is estimated at 0.6 to 1.0 kg/h, and sweating generally intensifies with a rise in temperature and humidity, although individual responses may vary (Luuira, 1980, Podstawski et al., 2019). In the present study, average perspiration was considerably lower, ranging from 0.21 kg in the CRIO group to 0.27 kg in the SHOWER group. Low BML values can be attributed to the relatively short duration of sauna treatment (16 minutes). According to Kauppinen (1989a), peak sweating and significant physiological changes can be observed after at least 15 minutes of sauna use. For this reason, in most published research, the effects of thermal stress on the human body are investigated during longer sauna sessions. The values of BML are significantly correlated not only with anthropometric indicators (in particular body mass, BMI, BSA and WHR) but also with body composition parameters, in particular, those indicative of body fat content (BFM, PBF and VFM) and degree of obesity (Podstawski et al., 2014; Podstawski et al., 2019). In our previous study (Podstawski et al., 2016), BML values measured after sauna bathing were significantly higher in female and male subjects with higher body mass, but they tended to be lower in taller participants (less so in men). With every kilogram increase in body mass, the corresponding BML values increased by 0.0144 kg in women and 0.0146 kg in men on average. Kauppinen (1989a) determined the average total sweat secretion during sauna at 0.5 kg. Core body temperature increases by 0.1 to 0.25°C per every percentage point of BML (Montain & Coyle, 1992; Sawka, Young, Francesconi, Muza, & Pandolf, 1985). One of the first studies into the effect of sweating on the fluid balance was conducted by Kozłowski and Saltin (1964), who analysed sweating-induced dehydration in six healthy males exposed to a temperature of 80°C in a sauna for 2.5 hours, which is nearly four times longer than in our study. In the cited study, the average BML during the 2.5-hour sauna session was determined at 3.1 kg (4.1%). In other studies, the average sauna-induced BML was estimated at 400–600 g (Kauppinen & Vuori, 1986; Hawkins, 1987).

## Limitations

The use of HR monitors for measuring the participants' physiological parameters was a potential limitation of this study. However, the evaluated males were exposed to extreme temperature (from 11 to 90°C), and different measuring equipment could not have been used as effectively in a study conducted on a large and homogenous sample (55 males) with similar environmental conditions (day, hour, duration, temperature and humidity). Future studies may, therefore, wish to examine the reliability and validity of various HR monitors in extreme conditions.

## Conclusion

A 16-minute stay in the sauna followed by 2 minutes of cold water immersion induces a greater decrease in HR and BP (SBP and DBP) than 16 minutes of the sauna by 30 seconds in the shower and a 90 s resting period. During cryotherapy, HR values often decrease to the bradycardia range (below 60 bpm). In both groups, HR increases steadily at 2.70 bpm on average.

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ORIGINAL SCIENTIFIC PAPER

# Investigation of Pool Workouts on Weight, Body Composition, Resting Energy Expenditure, and Quality of Life among Sedentary Obese Older Women

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ABSTRACT The effects of water-based exercises on body composition continue to be controversial. The present study was proposed to assess the impact of pool workouts on weight, body composition, resting energy expenditure (REE), and the quality of life of sedentary obese older women without dietary intervention. Fifty-five sedentary obese women (mean age 69.5 ± 4.3 years) were selected in this prospective experimental study (2018). Participants were divided randomly into two groups: moderate-intensity continuous training (MICT) and high-intensity intermittent training (HIIT). Both pool workouts models included a similar energy expenditure (1500 kcal/week), which were performed three times a week for 60 minutes each time and lasted for three months. The following measurements were carried out pre- and post-study: anthropometry, body composition, REE, and quality of life. The Wilcoxon nonparametric test was applied to compare between groups and times (pre- and post-study). The comparison of pre- and post-study showed significant decreases of body weight (-0.7 kg), BMI (-0.5 kg/m$^2$), fat mass (FM, -0.7 kg), and REE (-81 kcal/day) for the MICT ($p < 0.05$), and a significant decrease of the only FM (-0.7 kg) for the HIIT ($p < 0.05$). Regarding the quality of life, decreased pain, social and vitality improvements were significant in the MICT group, but improved vitality and health status in the group of HIIT were significant. Pool workouts without the dietary control revealed a modest influence on the body composition of sedentary obese older women, with better results for MICT. However, the improvement in the quality of life cannot be ignored.

KEY WORDS aged, body composition, exercise, obesity, weight reduction programs, women

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## Introduction

Several studies (Guillory et al., 2017; Rezaeipour & Apanasenko, 2018) suggest that ageing is associated with obesity. There are many reasons for this, such as sarcopenia (Fielding, Vellas, Evans, Bhasin, Morley, et al., 2011). Poehlman et al. (2002) stated that physical exercise hinders the loss of fat-free tissue that usually occurs in certain situations of weight reduction and also can increase energy expenditure and cause weight loss. Pool workouts are a form of physical exercises that is widely recommended for various benefits for the health of those who practice them (Alves, Mota, Costa, & Alves, 2004; Pöyhönen, Sipilä, Keskinen, Hautala, Savolainen, et al., 2002; Takeshima, Rogers, Watanabe, Brechue, Okada et al., 2002), and also because bodyweight is not a limiting factor to their practice, which lead to increased adherence to sports programmes (Pinto, Dias, Salvador, Figueira Júnior, & Lima, 2008). The body loses about 90% of its weight when immersed to the shoulder in water (Kruel et al., 2005; Sova, 1998). In 1988, Sova suggested that pool workouts are particularly beneficial for persons with obesity who are at increased risk for the development of orthopaedic injury secondary to physical exercise; an exercise intensity kept at a lower level than recommended for the achievement of the improved cardiorespiratory resistance can be necessary.

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Aerobic exercise programs are known to contribute to weight loss and body fat without significant changes in muscle mass, while anaerobic exercises decrease fat mass and increase muscle mass, but have no significant impact on overall weight loss (Medicine, 2009). Therefore, characteristics of the prescribed exercises are essential as they apparently have a direct impact on the body composition of practitioners. Intermittent exercise, for example, seems to contribute to a loss of fat in comparison to continuous exercise, and this seems to be related to the increase in oxygen consumption after exercise (EPOC) and the oxidation of lipids, as a result of high-intensity exercise (Shiraev & Barclay, 2012; Wallman, Plant, Rakimov, & Maiorana, 2009). However, the aerobic and anaerobic effects of exercises on the body fat and muscle of the body continue to be controversial (Viana, Dantas, & Perez, 2007).

There are few studies about the impacts of pool workouts on body composition and the health of obese older women. In addition, the existing studies vary greatly in terms of participants' time, age, goals, and model of exercises used, which makes it difficult to compare results. Therefore, the purpose of the study was to compare the effects of exercise-time-related models during pool workouts (traditional moderate-intensity continuous training (MICT) vs high-intensity intermittent training (HIIT)) on body composition, resting energy expenditure (REE), and quality of life among sedentary obese older women without dietary intervention.

## Methods

### *Participants*

The research complies with all relevant national statutes, institutional policies, and principles of the Helsinki Declaration. The Institutional Research Ethics Committee has approved informed consent forms and study protocol. All participants were informed about the study and, after obtaining a medical certificate that stated this study was not contraindicated, voluntarily provided written informed consent prior to enrollment. Fifty-five study participants were selected based on the following equation for 0.05 (error of 5%), from sedentary obese older women between 65 to 75 years old (mean age 69.5 ± 4.3 years) who had taken part in the weight loss counselling program.

$$n = \frac{z^2 Np(1-p)}{(d^2 N) + (z^2 p[1-p])} = \frac{1.96^2 \times 64 \times 0.5 \times (1-0.5)}{(0.05^2 \times 64) + (1.96^2 \times 0.5 \times [1-0.5])} = 54.86$$

This prospective experimental study was conducted at the Helal Sports Complex (Ferdos, 2018). The participants were randomly divided into two groups, including the high-intensity intermittent training program as a HIIT group, and the moderate-intensity continuous training program as a MICT group. Both programs lasted three months and consisted of three weekly sessions of 60 minutes each. The participants were evaluated at pre- and post-study. All activities were carried out in an indoor pool. Other criteria for inclusion were based on the following: weight stability over three-month (± 2 kg), blood pressures less than 140/85 mm Hg, body mass index (BMI) of more than 30 kg/m2 and age over 65 years (Rezaeipour, 2014; Rezaeipour, 2018; Rezaeipour & Apanasenko, 2018; Viana et al., 2007). Participants with diabetes mellitus, cardiovascular disease, smokers, infectious-contagious diseases, orthopaedic limitations, any medical contraindication to the water exercise, and who missed three consecutive sessions or more than one-third of the total sessions, were excluded (Rezaeipour, 2014; MR Rezaeipour, 2018; Rezaeipour & Apanasenko, 2018; Viana et al., 2007).

### *Pool workouts models*

The pool workout model for the HIT group was performed with intermittent movements of the upper (UL) and lower (LL) limbs. The exercise sessions for HIIT consisted of three phases: ten initial minutes of warming up using stretching movements, 40 minutes of a circuit program consisting of five standardized exercises in series (lasting two-minute each one with intermittent of two-minute between them and repeated three times) at 90-95% of maximum heart rate (HRmax), characterizing a vigorous-intensity according ACSM (Medicine, 2007), and ten final minutes of relaxation (cool-down). For the rest of the intervals, they had a light walk to the next station (to continue the exercise), and while waiting, they walked inside the pool (back and forth) to use active recovery. HR monitoring was measured by the formula of maximum heart rate (HRmax) = 220 – age (years). Heart rate (HR) in the HIIT group was measured immediately after each exercise session. The pool workout program for the MICT group was performed without a break and with continuous movements of UL and LL. The sessions also included three phases: ten initial minutes of warming up by stretching exercises, 40 minutes of pool workouts involving the large muscle groups of UL and LL, and ten final minutes of relaxation (cooldown). The exercises were performed at 70-85% HRmax, characterizing moderate to vigorous-intensity according to ACSM (Medicine, 2007). HR was monitored in the MICT group by being measured three times during and after the session.

Activities used during pool training are shown in Table 1. Plastic dumbbells and foam “noodles” were sports tools for both pool workouts models. Energy expenditure in both groups was the same (1500 kcal


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TABLE 1. Exercise Activities Used During the Pool Training

| Stages | Exercise type |
|---|---|
| Warming up | Walk - 10 laps in the swimming pool |
| Aquatic exercises | 1- Endurance activities(dancing and walking or both combined);<br>2- Resistance activities (upper limbs: biceps curl, chest press, and lumbar rotation; lower limbs: leg abduction and adduction, knee flexion and extension, leg curl and leg press, and press of the calf) |
| Cool down / Relaxation | Stretching arms and legs and slow walking |

per week), which has been converted into minutes per week, and the duration of the weekly exercises was adjusted accordingly.

### *Measurements*

BMI was computed by dividing weight (kg) by height (m) squared, and the participants were classified according to the cut-off points recommended by the World Health Organization (WHO, 2000). Body weight was measured with light clothing and no shoes using a Scale-Tronix model 5002 (Wheaton, IL, USA) with a precision of 0.1 kg. Height was computed with a stadiometer with 0.5 cm graduations and a maximum capacity of 2.0 m (Rezaeipour, 2014; Rezaeipour, Apanasenko, & Nychyporuk, 2014). Both measures were implemented in duplicate and averaged.

Body composition analysis was evaluated using a tetrapolar bioelectrical impedance analyser (BIA 310A, Biodynamics, USA) according to a standardized manner. Fat-free mass (FFM) was estimated utilizing the tetrapolar resistance and reactance. Participants of the study were obese women; therefore, the following equation was utilized to calculate FFM and fat mass (FM) for obese women (Segal, Van Loan, Fitzgerald, Hodgdon, & Van Itallie, 1988):

FFM (woman) = 0.00091186 (height)2 – 0.01466 × (resistance at 50 Hz) + 0.29990 (bodyweight) – 0.07012 (Wagenmakers, Coakley, & EDWARDS) + 9.37938; FM(kg) = W – FFM.

(FFM mass in kg; height in cm; resistance in ohms; body weight in Kg; age in full years)

Measurements of carbon dioxide production (VCO2) and oxygen consumption (VO2) were determined by indirect calorimetry (IC) via a Sensor Medics Calorimeter Vmax 29® instrument (Sensor Medics Corporation, Yorba Linda – CA, USA). These gases were then included in Weir's formula (Weir, 1949) for the calculation of REE. Quality of life was evaluated through the SF-36 Quality of Life questionnaire that evaluates physical aspects, functional capacity, pain, mental health, emotional aspects, social aspects, vitality, and general health status (Campolina & Ciconelli, 2008; Lima, Barros, César, Goldbaum, Carandina, et al., 2009).

### *Method management*

Both groups were trained (three sessions) to adapt to water before the study. Alterations in leisure-time physical activity or energy consumption are associated with potentially conflicting research implications. Therefore, Participants were asked to complete diary records for four days (three weekdays and a weekend day) prior the starting the study and the same procedure was performed just after the intervention to report their leisure-time physical activity and nutrition habits throughout the study (Rezaeipour, 2014; Rezaeipour et al., 2014).

### *Statistical analysis*

Normality distribution of data was not confirmed using the test of Kolmogorov-Smirnov. The Wilcoxon test was used for group and time point (pre- and post) comparisons. Data are reported as means and standard deviations (± SD). The $p < 0.05$ was set as a significance level. All analyses were performed with the software of SPSS ver. 21.0 (for Windows).

## Results

Fifty-five participants were selected at the preliminary phase of the study, 28 in the MICT group and 27 in the HIIT group. Loss of motivation and dissatisfaction with randomization were reasons for the elimination of seven participants (4 in MICT and 3 in HIIT), with 48 individuals completing the study (MICT: 24 and HIIT: 24). The variables studied at baseline have no significant differences between groups, and the groups were similar in all quality aspects of life ($p > 0.05$).

As shown in Table 2, the assessment of the outcomes within each group regarding time points (pre- and post-study) revealed modest but significant reductions of weight, BMI, and FM for the MICT group ($p < 0.05$). Furthermore, REE decreased significantly in the MICT group ($p < 0.05$), while slightly increased in the HIIT group ($p > 0.05$). In the HIIT group, only a significant decrease was observed in FM ($p < 0.05$).

TABLE 2. Mean Comparison of Evaluated Parameters in Both Groups at Pre- and Post-study

| Variables | MICT group (n =24) | | Mean variation | HIIT group (n =24) | | Mean variation |
|---|---|---|---|---|---|---|
| | Before | After | | Before | After | |
| Weight, kg | 86.5 (15.6) | 85.8 (16.1) | - 0.7* | 85.6 (16.4) | 85.5(15.3) | - 0.1 |
| BMI, kg/m$^2$ | 35.1 (5.8) | 34.6 (6.1) | - 0.5* | 32.6 (5.6) | 32.5 (5.9) | - 0.1 |
| FM, kg | 40.3 (13.1) | 39.6 (12.1) | - 0.7* | 38.9 (25.4) | 38.2 (27.5) | - 0.7* |
| FFM, kg | 45.8 (8.1) | 45.7 (7.5) | - 0.1 | 46.4 (7.2) | 46.9 (7.3) | + 0.5 |
| REE, kcal/day | 1459.1 (176.2) | 1378.1 (158.3) | -81.0* | 1466.9 (229.7) | 1491.1 (151.5) | + 24.2 |

Note. Data are reported as mean (±SD), MICT: moderate-intensity continuous training, HIIT: high-intensity intermittent training, FM: fat mass, FFM: fat-free mass, REE: resting energy expenditure, *p < 0.05.

A comparison of pre and post-study results have identified the improvement of vitality and social aspects and worsening of pain in the MICT as well as improved vitality and health status in the group of HIIT (Table 3).

As reported in Table 2, no differences between the groups were found in any of the assessed items in the post-study phase (p > 0.05).

TABLE 3. Evolution of Quality of Life Variables in MICT and HIIT Groups During the Study

| SF-36 Variables | MICT group (n =24) | | Mean variation | HIIT group (n =24) | | Mean variation |
|---|---|---|---|---|---|---|
| | Before | After | | Before | After | |
| Physical aspect | 73.6 (35.9) | 86.6 (14.5) | +13.0 | 81.0 (21.1) | 82.6 (21.8) | +1.6 |
| Functional capacity | 64.8 (19.1) | 78.8 (15.6) | +14.0 | 66.0 (14.3) | 72.1 (24.7) | +6.1 |
| Pain | 54.0 (19.3) | 73.1 (15.0) | +19.1* | 70.2 (17.1) | 63.4 (27.8) | -6.8 |
| Mental health | 55.5 (18.9) | 66.8 (17.76) | +11.3 | 60.0 (17.1) | 66.5 (17.4) | +6.5 |
| Emotional aspects | 58.1 (28.9) | 58.9 (26.8) | +0.8 | 68.7 (14.3) | 55.6 (32.1) | -13.1 |
| Social aspects | 61.9 (29.5) | 79.4 (19.3) | +17.5* | 67.3 (27.1) | 67.4 (23.8) | +0.1 |
| Vitality | 46.1 (18.3) | 67.6 (13.5) | +21.5* | 50.3 (16.5) | 63.4 (17.3) | +13.1* |
| Health status | 68.0 (17.1) | 73.5 (16.5) | +5.5 | 63.4 (17.5) | 76.7 (16.9) | +13.3* |

Note. Data are reported as mean (±SD), MICT: moderate-intensity continuous training, HIIT: high-intensity intermittent training, *p < 0.05.

## Discussion

Current results showed that exercise-time-related models during pool workouts (intermittent vs continuous) are ineffective in terms of weight loss, changes in body composition, or changes in energy expenditure in sedentary obese older women. Pool workouts with continuous exercise have shown a slight advantage by providing some improvements in items related to the quality of life. Modest but significant weight loss, observed only in women of the MICT group, demonstrates that, in this case, a continuous pool workout had a more active role in weight loss than an intermittent pool workout. However, both groups reached a similar and significant loss of fat mass. Based on several studies (Rezaeipour, 2014; Rezaeipour et al., 2014), changes in body weight and composition in the state of exercise take at least three months, so the study was completed in three months.

In one previous study of ground-based exercise (Rezaeipour & Apanasenko, 2018), more positive results on weight and body composition were achieved in women throughout the 12-week study of continuous and intermittent exercise, although the study included the category of middle age and was linked to an energy-restricted diet. However, measuring body composition by Louzada (2007) in women with obesity after an exercise program longer than the current (four-month), which were included walks and weight training within 30 minutes twice a week, has also not revealed significant differences in weight.

Gubiani, Pires Neto, Petroski, and Lopes (2001) stated that even aqua aerobics programs with a duration of eight-month and moderate intensity of 75% of HRmax cause significant, although modest, loss of body weight and composition, especially considering the duration. A review and meta-analysis of research (Garrow & Summerbell, 1995; Wing, 1999) suggest similar outcomes: despite the benefits, the impact of exercise on body weight is modest, especially when exercise has nothing to do with an energy-restricted diet. In the study by Pöyhönen et al. (2002), the advantages of pool workouts are connected with the physical properties


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of water, with emphasis on resistance to advance, which is directly connected with the movement velocity. Therefore, it can be used as an alternative form of physical conditioning, taking benefits of the buoyancy of the water as an impact reducer (Kruel et al., 2005). It must also be noted that even when doing exercises in water, obese individuals have restrictions in mobility and difficulties in overcoming the resistance of water. Therefore, the intensity and activity velocity can be insufficient to generate greater influence on the studied variables, as both are directly connected with the exercise results. Another factor that may have contributed to the slight changes observed in the current study was the program duration and the isolated utilization of exercises for losing weight, not associated with food control. Both factors may have been limiting the effectiveness of pool workouts models. The lack of significant differences in three-month weight loss between the studied groups may be a reflection of the fact that water exercises do not have the effectiveness of the exercises on the ground or exercise with an energy restriction diet. Thus, the outcomes of this study are not consistent with the findings of Rezaeipour (2018) and Rezaeipour et al. (2018), who studied exercise-time-related models on the ground.

According to measured parameters of quality of life, a significant improvement of social and vitality aspects in MICT and vitality and health in HIIT was observed. Several studies (Anish, 2005; Wagenmakers et al., 1988) suggest that these improvements are related to increased synthesis of endorphins in the body of people who regularly exercise. Regular aerobic exercises have a positive impact on psychological and emotional disorders such as anxiety and depression, and also cognitive aspects (memory and learning), quality of life improvement and therefore are considered important therapeutic allies in treatment of these disorders (Anish, 2005; Antunes, Stella, Santos, Bueno, & Mello, 2005).

The selection of older women made it impossible to generalize the results of the study. Other legal restrictions, such as potential bias and multiple analyses, were not found, except for the lack of commitment of some individuals who excluded from the study. This study is also suggested for men.

In conclusion, the research outcomes show that pool workouts models without an energy restriction have the same effect on FM. At the same time, the best results in terms of body weight are obtained with a model with the MICT feature. The social and health improvements have observed in these two programmes highlights the significant benefits of pool workouts for quality of life. These findings can be used clinically.

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ORIGINAL SCIENTIFIC PAPER

# Warm-Up Striding Under Load Does Not Improve 5-Km Time Trial Performance in Collegiate Cross-Country Runners

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ABSTRACT Post-activation potentiation has proven to be an effective strategy to enhance performance for many tasks, but little research has been conducted specifically concerning endurance sport performance. This study examined whether 5-km run performance could be improved by completing pre-run strides while wearing a 6.8 kg weighted compression garment (LOAD). A counter-balanced crossover field study design was incorporated with NCAA Division I Cross Country runners (n = 10) during coach-led, official team pre-season "speed day" practices. On Monday of Week 1, testing participants completed a course preview run and strategy session with their coach as they would do in preparation for a meet. The following two Mondays, participants completed the 5-km run as quickly as possible while blinded to pace. The team's habitual warm-up routine was used, which included a 3.22-km run followed by a series of dynamic warm-up movements before four, 80-m strides were completed with LOAD or without load (CON). Average wet-bulb globe temperature for both sessions was 22.3 °C. CON did not differ ($p>0.05$) from LOAD in split times for kilometres 0.00-1.61 (339±13 vs 341±13 s), 1.61-3.22 (312±15 vs 312±16 s), 3.22-4.83 (339±21 vs 338±22 s), or the 0.17 km distance kick at the end of the run (71±16 vs 69±14 s). Overall time was also not improved for LOAD (1060±49 s) versus CON (1062±55 s). The ~10% body mass LOAD warm-up strategy failed to improve early, mid-, or finishing kick performance in a 5-km time-trial with well-trained runners.

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KEY WORDS post-activation potentiation, running economy, endurance athletes, leg stiffness

## Introduction

A thorough warm-up (WU) is common, provides a multitude of physiological advantages, and is widely supported for competitive athletes (Bishop, 2003a). However, the facets of optimizing WU for athletic performance are complex, possibly even more so for endurance athletes (Bishop, 2003b). Manipulating non-supramaximal WU activity variables does not appear to improve endurance performance across a variety of exercise modalities. Both the addition of 3 min of higher intensity cycling at the end of a 15-minute WU (Hajoglou et al., 2005) and 15-min steady-state WU running at an intensity of 80% versus 60 or 70% of VO2 max (Takizawa, Yamaguchi, & Shibata, 2018) failed to result in improved cycling or running performance, respectively. Furthermore, a 15 min steady state WU at 75% versus 55 or 65% of VO2 max resulted in impaired kayaking performance (Bishop, Bonetti, & Dawson, 2001). In contrast, shorter supra-maximal intensity WU interventions have produced more promising outcomes, possibly due to post-activation potentiation or improved movement economy. Chronic strength and plyometric style training can enhance distance running performance (Paavolainen, Hakkinen, Hamalainen, Nummela, & Rusko, 1999; Saunders et al., 2006; Spurrs, Murphy, & Watsford, 2003), but there are sparse data and a lack of understanding concerning the acute effects of the addition of a supramaximal intensity drill to WU to enhance endurance performance. The substitution of five 10-s sprint intervals during the last 5 min of WU improved kayak power versus a continuous lower

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intensity WU-only protocol (Bishop, Bonetti, & Spencer, 2003), and 4-km cycling performance was improved with the addition of three, 10-s sprints at 70% of peak power after 5 min of moderate-intensity cycling versus 6.5 minutes of moderate-intensity pedalling only (Chorley & Lamb, 2019). Conversely, too high of intensity or duration of priming may also be detrimental to performance. McIntyre and Kilding (2015) found 5 sets of 10-s sprints at maximal effort during a 15 min warm-up phase produced pre-exercise fatigue levels that impaired 3-km cycling time trial performance compared to lower relative intensity sprint priming bouts.

Two similar supramaximal intensity WU manipulation investigations have also been completed using running modalities. Following a typical WU with jogging and change-of-direction drills, Ingham, Fudge, Pringle, and Jones (2013) had elite runners complete 300 m of total striding at 800-m race pace. One WU protocol used six, 50-m strides and the other included two, 50-m and one, 200-m strides. In contrast to McIntyre and Kilding (2015), the more demanding protocol with the 200-m run at race pace resulted in improved 800-m run performance. The investigators hypothesized that the enhancement in performance was likely due to increased VO2 capacity during the run related to the doubling in lactate concentration prior to the time trial with the longer duration stride bout versus the shorter distance repeated strides. A limitation of the study of Ingham et al. (2013), was there was no low-intensity-only WU control group for comparison. However, a recent investigation by Gonzalez-Mohino et al. (2018) reported the two different high-intensity WU modalities improved a timed run to exhaustion by approximately 5 and 10% compared to a low intensity only WU, respectively supporting high intensity striding addition to WU protocols. Interestingly and in opposition to Ingham et al. (2013), the high-intensity WU method with the most improvement were the 6 short duration (6-s) uphill (5% grade) sprints versus nine, 20-s strides at the same speed but only a 1% grade (Gonzalez-Mohino et al., 2018).

Alternatively to altering stride duration or gradient, Barnes, Hopkins, McGuigan, and Kilding (2015) increased WU striding intensity by having runners wear weight vests with a load equivalent to 20% of body mass during six, 10-s strides. The external loading improved trained runners' time to fatigue on a treadmill protocol of increasing velocity and inclination versus the same WU protocol with unloaded sprints (Barnes et al., 2015). The investigators mechanistically attributed the majority of performance enhancement to increased leg stiffness. These findings suggest a WU alteration to intentionally increase leg stiffness via post-activation potentiation in addition to the traditional thermoregulatory or metabolic alterations typically attributed to WU benefits might be worthy of investigation. The effects of post-activation potentiation on endurance performance are not well documented, but Barnes et al. (2015) have demonstrated a potential benefit for runners by adding loaded strides to their WU regimens. However, we are unaware of any studies that have measured performance under conditions akin to actual racing. Therefore, the purpose of this field-based study was to examine if completing a WU protocol in which striding completed while wearing a weighted compression garment could improve 5-km time trial performance versus unloaded striding in collegiate cross country runners.

## Methods

### *Participants*

Male, NCAA Division I cross-country team runners (n = 10; 20.2 ± 2.8 years) completed all aspects of the current study. In an initial session, after study explanation and confirmed written consent, participants were screened for apparent health risk associated with physical activity (Canadian Society for Exercise Physiology, 1994) and completed a short training history questionnaire. Runners were then assessed for height (177±6 cm) and body mass (66.4±8.5 kg) using a standard stadiometer and digital scale (BWB-800AS, Tanita, Tokyo, Japan). Body fat percentage (7.7±2.1%) was estimated using a three-site skinfold test (Jackson & Pollock, 1985). Runners then completed a self-selected warm-up followed by a graded exercise treadmill test to determine VO2peak (61.2±3.3 ml/kg/min) in accordance with procedures by Heatherly et al. (2018). In brief, participants began running at a pace 4.02 km/h slower than their personal best 5-km pace. Treadmill speed increased by 0.8 km/h every 2 minutes until volitional fatigue with treadmill grade maintained at 1%. This study was approved by the University of North Alabama's Institutional Review Board. All participants gave written informed consent prior to data collection.

### *Experimental Sessions*

The runners reported to the laboratory for three additional sessions during pre-season training approximately one month before the season-opening meet. All sessions coincided with coach-led practices, and multiple facets of the protocol were designed with input from the coaching staff. The experimental performance tests were part of the athletes' "speed day" in the coach-designed, periodized training schedules. All runs took place early in the morning on the same day of the week during the month prior to the start of the collegiate cross-country regular season. Wet bulb globe temperature (Thermalert TH-8, physitemp Inc.) was assessed at the beginning and end of each time trial and, when averaged, was identical between trials at 22.3 °C. Similar "easy" runs were performed the day prior to each time trial. Runners were asked to eat a similar dinner the night before each time trial and were asked to consume a 500 ml bottle of water provided by the investigators before going to bed the night before testing and another 500 ml bottle of water upon waking. Breakfast preference was chosen by each individual runner, and meal choices were replicated if a pre-run meal was consumed. All other beverage intake was ad libitum. No alcohol or substantial caffeine consumption was permitted in


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the 24 h prior to testing. The first session was simply the teams' traditional WU routine led by coaches and athletes on a rubber turf field and asphalt track followed by a 10 min break to simulate the "holding" period typically included as part of distance running competitions before a familiarization run session on the 5-km road time trial course. The familiarization trial included the coaching staff running with the team and discussing race strategies for the course as would be completed as part of regular meet preparation. This run was not timed by the investigators. The remaining two trials occurred 7 and 14 days after the first session and were identical with the exception of the type of WU used (described below); the runners completed their second and third runs at maximal effort.

### *Time trial procedures and course*

The 5-km course selected has been repeatedly used in past investigations from our laboratory and was familiar to the university cross country runners. The first third of the course included two challenging climbs followed by a section of modest rolling hills. The middle third portion of the route was a continual slight descent, and the final third of the course was a continual slight ascent to the finish. The course received minimal vehicular traffic during early morning testing. Members of the investigative team were positioned throughout the course wearing bright clothing and signs to caution drivers that runners were on the road. A traditional cross-country start was used, with runners spaced out along both lanes of the road. After ~200 m, a right turn led to the first hill. Investigators were located at the 1.61-km (1-mile reference for the American runners), 3.22-km (2-mile), 4.83-km (3-mile), and 5-km marks collected splits and overall finishing time on digital stopwatches. All investigators on the course provided consistent verbal support to the runners. To encourage maximal effort and competition, trials were performed with coaches present. Runners were not allowed to wear watches and were not informed of their pace at any point during running. Runners were also not made aware of their finishing times or splits until all trials were completed.

### *Loading scheme and treatment warm-up protocols*

The experimental WU protocol design matched the habitual WU routine used by the cross-country team members. Runners completed a moderate intensity 3.22 km run before starting their dynamic movement phase of their WU. This phase included lunge variations, dynamic walking drills, skipping drills, arm swings, carioca, and A, B, and C skips. Immediately after the last skip drills, participants donned the weighted compression garments. Next participants completed four, 80 meter (1 turn) strides with an external load (LOAD) or without an external load (CON) in a counterbalanced crossover design. Loading was accomplished using a unique weighted compression garment (TITIN ForceTM Weighted Shirt System, Titin Tech, USA) (see Figure 1). The garment consisted of an outer short sleeve shirt (87% Sorbtek, 13% Lycra) and an inner short sleeve shirt (Pocket Suiri 52% A.M.Y. 48% Polyester). Together both shirts weighed ~0.5 kg. The inner shirt had pockets that were loaded with flat, dense gel inserts. The outer compression shirt was used to minimize weight shifting inserts and allow for unrestricted and comfortable movement while under load. There were two chest and upper back pockets, two abdomen and lower back pockets, pockets above each clavicle area, and pockets on the upper arm areas. The pockets held inserts that weighed ~0.2 or 0.3 kg. Two inserts were inserted into each pocket resulting in a load of approximately 6.8 kg (10.4±1.1% of body mass).

FIGURE 1. Visual representation of the weighted compression garment inner and outer shirts plus inserts. With all pockets loaded with two inserts, the final mass of the weighted compression garment was 6.8 kg.

After the strides, investigative team members helped participants remove the weighted compression garments before runners walked ~200 m and rested for 10 min before their time trials, similar to the protocol used

prior to collegiate cross country competitions. Immediately following the second/final time trial, participants were asked to respond to the following question, "Without knowing your time, how effective do you feel the warm-up with the weight vest was in preparation for running compared to the warm-up without the weight vest?" Runners made a vertical mark on a 100-mm horizontal line with anchors of "weight vest was much less effective" and "weight vest warm-up was much more effective".

### *Data analysis*

Paired samples t-tests were used to determine if there were differences between splits and cumulative time at distances of 1.61, 3.22, 4.83, and 5.00 km for CON and LOAD. Pearson's r was used to analyse the relationship between efficacy belief in the LOAD to improve performance and percentage change in overall 5-km performance. An alpha level of 0.05 was deemed to be significant a priori.

TABLE 1. Time trial performance data (n = 10; mean ± SD)

| **Cumulative running time (min)** | **1.61-km** | **3.22-km** | **4.83-km** | **5.00-km** |
|---|---|---|---|---|
| *CON* | 5.67±0.24 | 10.85±0.50 | 16.51±0.89 | 17.59±0.92 |
| *LOAD* | 5.66±0.18 | 11.19±0.75 | 16.54±0.69 | 17.78±0.81 |
| **Splits (s)** | **0-1.61 km** | **1.61-3.22 km** | **3.22-4.83 km** | **4.83-5.00 km** |
| *CON* | 339±13 | 312±15 | 339±21 | 71±16 |
| *LOAD* | 341±13 | 312±16 | 338±22 | 69±14 |

## Results

There were no differences for splits or cumulative time at any marker point (Table 1). Figure 2 displays data for finishing time change percentage and the WU efficacy questionnaire. Under LOAD, five participants improved by 1% or more; three exhibited less than a 1% change between treatments, and two runners were slower by more than 1% (Figure 2). Seven participants reported a modest favouring of LOAD warm-up routine to improve run performance, and the mean WU efficacy scaled displayed a trend of preference for LOAD (69±13 mm). However, there was no relationship between change in performance and WU efficacy questionnaire response (Figure 2). Four of the five participants that improved by greater than 1% under LOAD reported favouring LOAD, but both of the runners that ran greater than 1% slower under LOAD also reported a favouring of LOAD.

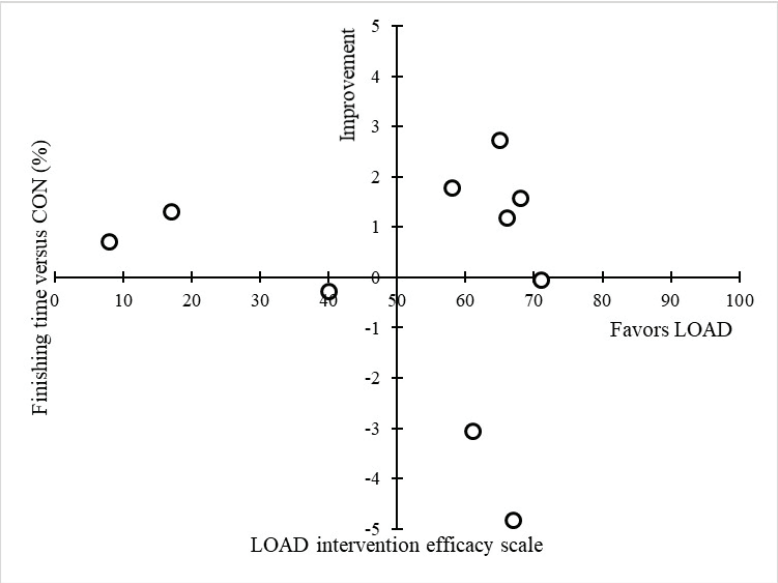


FIGURE 2. Relationship between percentage change in overall finishing time versus CON and response to, "Without knowing your time, how effective do you feel the warm-up with the weight vest was in preparation for running compared to the warm-up without the weight vest?". Runners made a vertical mark on a 100-mm horizontal line with anchors of "weight vest was much less effective" (0) and "weight vest warm-up was much more effective" (100). (r=-0.18; p=0.61).

## Discussion

Growing evidence supports the fact that short, supramaximal drills during WU routines may improve endurance running performance. A unique approach to manipulate WU supramaximal exercise drills was developed by Barnes et al. (2015). The investigators reported that completing strides while wearing a weighted vest led to longer time-to-fatigue capacity during a graded, incremental intensity treadmill task in trained runners. The inspiration for the current field study was to test this finding in a more ecologically valid per-


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formance task. Time trials to exhaustion lack the between-trial consistency of time trials of a set distance on a treadmill (Laursen, Francis, Abbiss, Newton, & Nosaka, 2007), and overground running on a familiar 5-km course in a competitive group environment has produced time trial replication coefficient-of-variation levels of < 1% (Hurst & Board, 2017). The main finding of the current study was that under ideal conditions and with participants closely matching the anthropometric and running capabilities, the performance advantages reported by Barnes et al. (2015) were not manifested (Table 1) in a competitive, road course 5-km time trial scenario despite mostly positive subjective beliefs (Figure 2) that LOAD intervention was efficacious.

Barnes et al. (2015) used a load equal to 20% versus ~10% of a participant's body mass. The most probable reason our findings differed was potentially due to the reduced load mass stimulus. The major limitation of this field study was no mechanistic outcomes that might affect performance were evaluated. It is plausible that the lesser load failed to promote increased leg stiffness levels conducive to improved running performance. The 6.8-kg load used reached the weighted compression garment's maximal capacity with all pockets filled with two inserts (Figure 1). After completing numerous investigations with both the weighted compression garment and traditional vests with lead weight loading, our experience has anecdotally supported the claim that the weighted compression garment is more accepted in terms of comfort, particularly during running tasks (Lowe et al., 2016; Scudamore et al., 2016). Supporting this conclusion, the weighted compression garment was generally viewed as favourable (Figure 2) compared to the negative race readiness perceptual effect reported by Barnes et al. (2005). Ergonomic fit and comfort could be critical in terms of promoting runners to adopt loaded striding in real-world practice. An additional practical consideration for the amount of load to be used is the transportation of the garment used to produce the load. Nearly all cross-country meets are held away from runners' home training facilities. With a typical high school or collegiate cross-country team made up of 10-20 runners for both sexes, the lighter and more compact weighted compression garments could be more easily transported and used during meets if the lighter weighted compression garments were used.

Addressing stimulus duration, Barnes et al. (2015) had participants perform six, 10-s strides at 1500 m pace. The distance and number of strides were designed based on the customary team WU protocol of our collegiate cross-country runner participants. While there was a difference in load mass, we do not feel loading exposure duration likely contributed to differences in performance findings. The stride time duration was not assessed in the current study, but the overall duration of Barnes et al. (2015) was likely similar to the current design using four, 80-m strides. Striding duration was similar or longer than the 300 m of total striding in (Ingham et al., 2013) or six sets of 6-s strides used by Gonzalez-Mohino et al. (2018).

An important takeaway from Barnes et al. (2015) was that almost all improvement in the run-to-exhaustion time was related to increases in leg stiffness, not running economy. We are unaware of any literature that establishes a minimum threshold for increasing leg stiffness in distance runners. Quantifying this threshold and possibly looking at other methods to increase leg stiffness will be key to further defining optimal supra-maximal WU interventions. Subjective assessments of WU efficacy (Figure 2) were not taken until the completion of the final run. Most runners provided favourable opinions for LOAD in contrast to Barnes et al. (2015) who reported runners felt less ready to race after heavier loaded strides. Runners were only asked to complete the 100-mm efficacy scale, but several runners without prompting from investigators commented anecdotally that they felt more "springy" or made similar comments concerning LOAD. With this consideration, increased leg stiffness plausibly could result in a stronger start, but there were no advantages at the 1.61-km mark during the time trials (Table 1). Due to the nature of the run to exhaustion, no early exercise performance advantages were assessable in Barnes et al. (2015) findings, but improvement in overall durations suggests a potential for late exercise performance enhancement following LOAD. However, this again was not the case in the current study with pace for 3.22-4.83 km or the final 0.17-km kick failing to exhibit an advantage for LOAD (Table 1).

In conclusion, the findings from the recent study by Barnes et al. (2015) reporting increased leg stiffness and improved running economy following striding under load leading to enhanced time to fatigue during a treadmill performance test was not replicated for collegiate cross-country runners during a road course 5-km time trial. Although mostly well-accepted by the runners, this field-based study found adding external loading to normal pre-race striding routine failed to manifest the performance improvements early, mid-race, or during the final kick phase of a competitive race like scenario. If weighted striding is undertaken during WU, a load greater than 10% body mass is likely needed to enhance running performance capacity.

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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


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## 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]

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*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 |

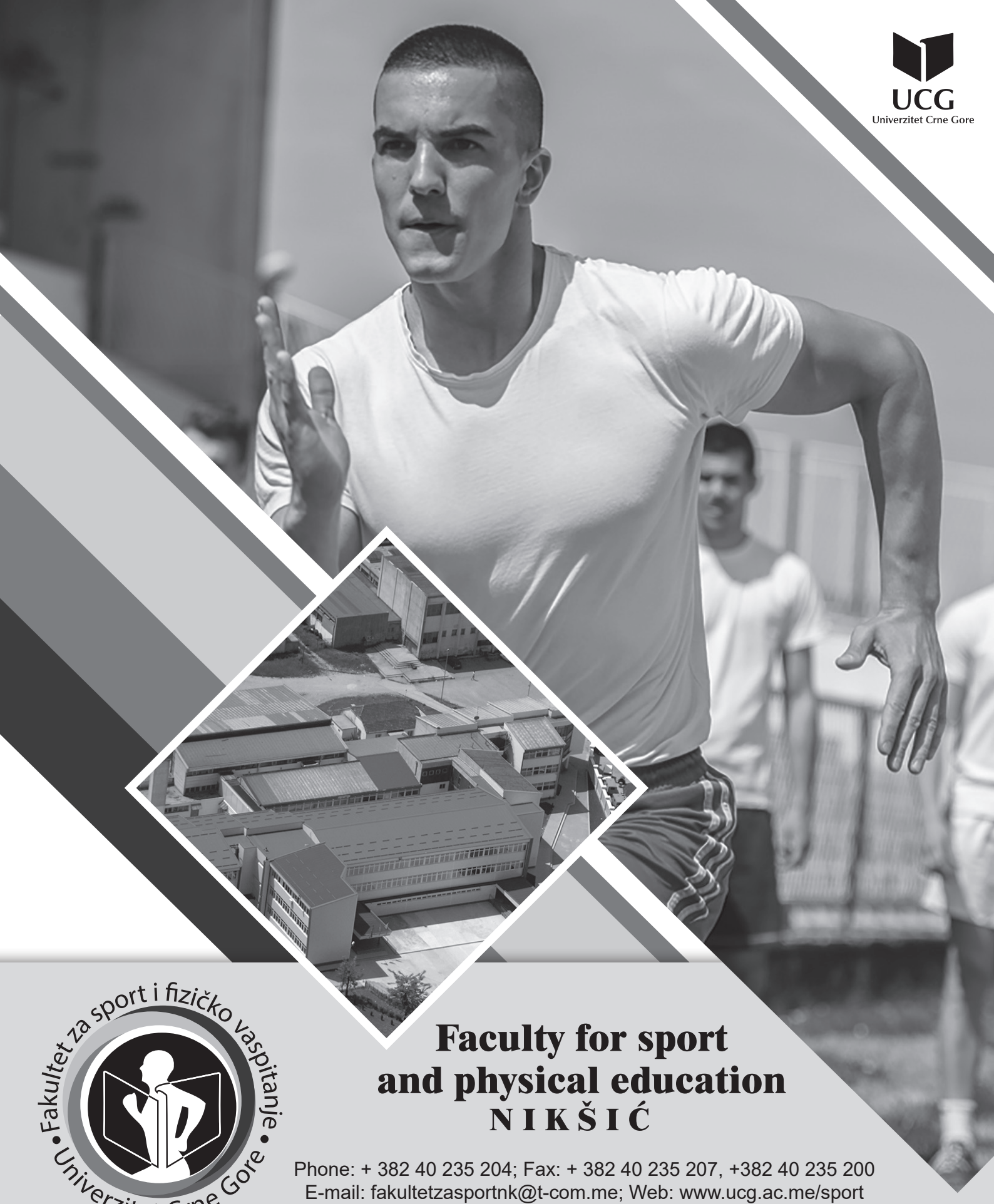
| Signs should be placed immediately preceding the relevant number. | | |
|---|---|---|
| ✓ 45±3.4 | ✓ p<0.01 | ✓ males >30 years of age |
| × 45 ± 3.4 | × p < 0.01 | × males > 30 years of age |

## 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*



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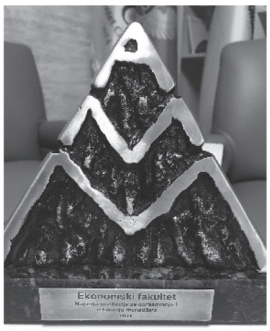
# Faculty of Economics
# University of Montenegro

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.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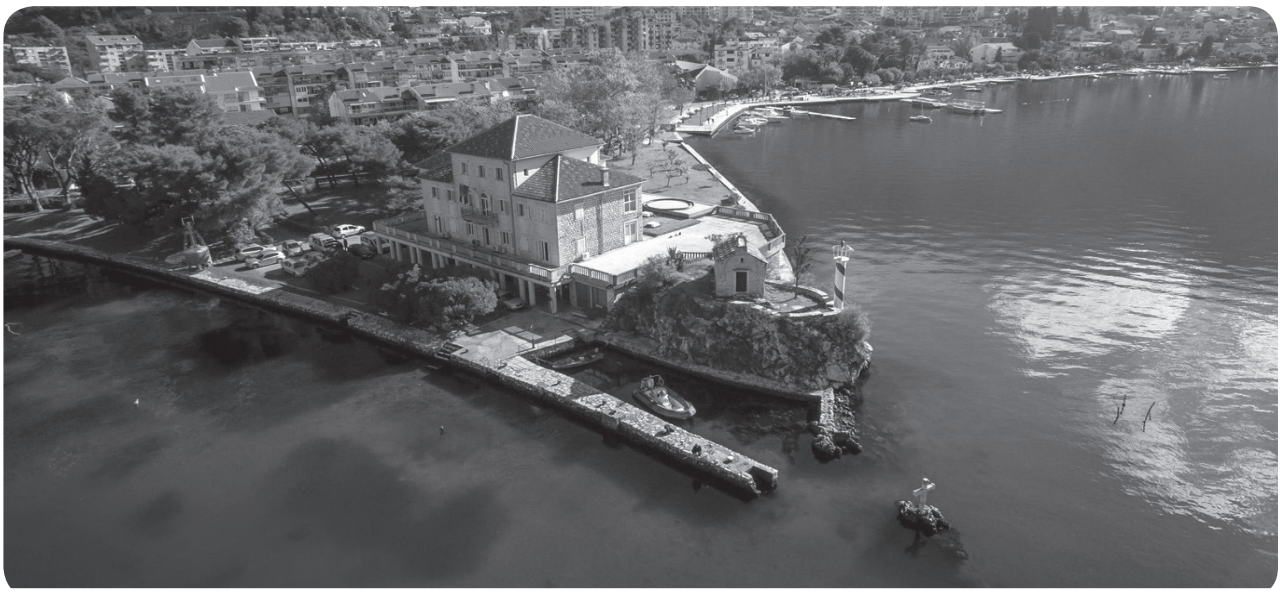
# UNIVERZITET CRNE GORE
# INSTITUT ZA BIOLOGIJU MORA



University of Montenegro – Institute for marine biology is located in Kotor, Montenegro. Since its establishment in 1961, the Institute performed comprehensive research of the marine and coastal area, which has its wide impact to the environmental protection, pollution-prevention and practical application. Core competencies of the Institute are focused on research in the fields of marine conservation, ichthyology and marine fisheries, marine chemistry, aquaculture, plankton research, neuro and eco-physiology. The main research area is investigating and protection of Adriatic sea with special interest of South Adriatic area. Institute for marine biology have a wide range of international cooperation with Marine research institutions and Universities all over Mediterranean area trough a numerous Eu funded scientific projects.

All over the year Institute is looking to hire a young students from the field of general biology, marine biology, marine chemistry, molecular biology or similar disciplines on voluntary basis to work with us. We need opportunity for international internship or MSc or PhD thesis that could be performed on Institute in our 5 different labs: Fisheries and ichthyology, Aquaculture, Marine chemistry, Plankton and sea water quality and Benthos and marine conservation.

Every year Institute organize several summer schools and workshop for interested students, MSc and PhD candidates. From 01-05 July 2019 we will organize Summer school "Blue Growth: emerging technologies, trends and opportunities" in frame of InnoBlueGrowth Project who is financed by Interreg Med programme. Through the specific theme courses, workshops and working labs offered – covering different areas of the blue economy – the Summer School aims at encouraging young people involvement in blue economy sectors by offering high-quality technical knowledge and fostering their entrepreneurial spirit. The Summer School will facilitate fruitful exchanges and a stronger understanding among a variety of actors coming from different Mediterranean countries with diverse profiles, including representatives from the academia, the public and private sectors, but also potential funders and investors. These activities will count on specific team building activities for participants as well to reinforce interpersonal skills and foster cohesion among blue academia and sectors.

If You are interested apply on the following link: https://www.ucg.ac.me/objava/blog/1221/objava/45392-ljetnja-skola-plavi-rast-nove-tehnologije-trendovi-i-mogucnosti

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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.

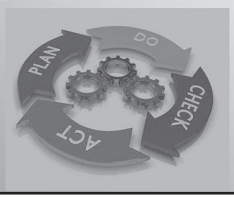
Two study programmes were accredited within the Faculty of Mechanical Engineering:

- 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.

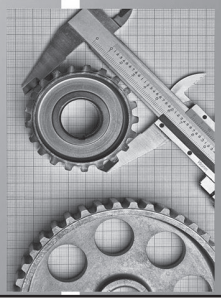
On the study program Mechanical Engineering it is possible to study next modules:

- 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



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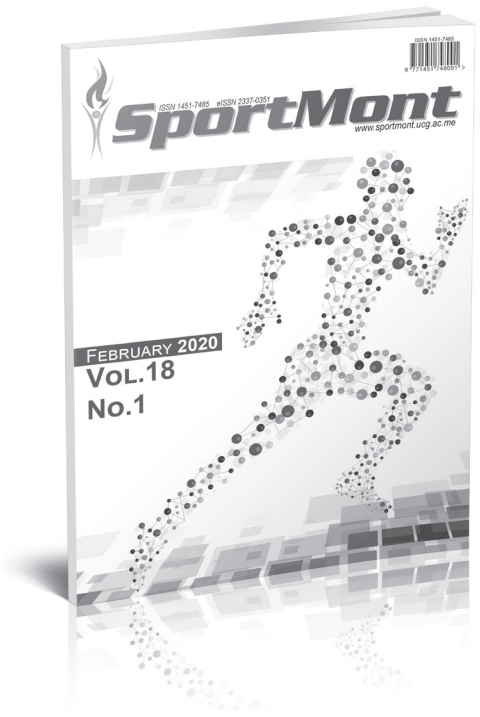


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- Open-access and freely accessible online;
- Fast publication time;
- Peer review by expert, practicing researchers;
- Post-publication tools to indicate quality and impact;
- Community-based dialogue on articles;
- Worldwide media coverage.

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:

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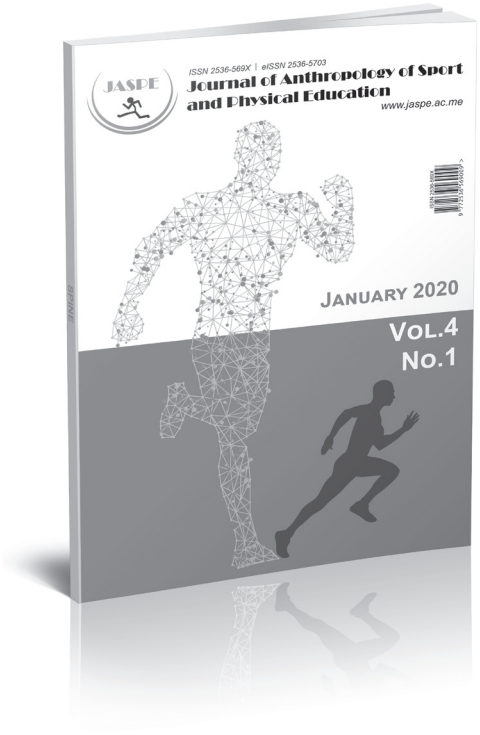
Autumn issue – October 2020
Winter issue – February 2021

# Journal of Anthropology of Sport and Physical Education




ISSN 2536-569X

Journal of Anthropology of Sport and Physical Education (JASPE) is a print (ISSN 2536-569X) and electronic scientific journal (eISSN 2536-5703) aims to present easy access to the scientific knowledge for sport-conscious individuals using contemporary methods. The purpose is to minimize the problems like the delays in publishing process of the articles or to acquire previous issues by drawing advantage from electronic medium. Hence, it provides:

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- 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*

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