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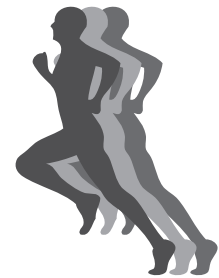


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Dear Readers,



It is end of the August and right time to introduce the second issue of this year's volume of Montenegrin Journal of Sports Science and Medicine (MJSSM). It is not easy to be systematic and objective about your own product or services, so we would appreciate if you don't regret us if we bring a little more personal insight into this introductory speech, mostly due to the reason our journal continues facing the great success. Namely, the current statistics from two strongest index databases (Web of Science and Scopus) conformed this fact. 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). 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 Expanded) and SSCI (Social Science Citation Index) databases and the current statistics, as we also mentioned earlier, promise that 2020 might be the year of our highest reach (total number of citation: 109; h-factor: 6; average citations per item: 1.47). So, we would like to thank the management of the journal, our editors, reviewers and authors, as well as readers, for their considerable efforts to achieve this success, and to invite all the others who have not cooperated with us so far to join in the efforts to achieve the greatest success that the journal has set out to achieve in 2020.

As we always emphasize in an introductory speech, we are sure 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 this issue authors, who have chosen precisely our Journal to publish their manuscripts, and we would like to invite you 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





# Examination of Exercise-Induced Skeletal and Cardiac Muscle Damage in Terms of Smoking

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**ABSTRACT** This study aimed to investigate the effect of acute endurance exercise on cardiac and skeletal muscles in smokers and non-smokers. Eight daily smokers ( $28.44 \pm 3.94$  years) and nine non-smokers ( $29.62 \pm 3.46$  years) were included. The subjects were not trained and performed continuous endurance exercise on a treadmill for 40 minutes at 70% of maximal heart rate. Venous blood samples were collected at baseline [pre-exercise (PRE)], at immediately after the exercise [post-exercise (POST)], at 2 hours after the exercise (2h), at 24 hours after the exercise (24h) to measure lactate dehydrogenase (LDH), creatine kinase (CK), creatine kinase-myocardial band (CK-MB), cardiac troponin T (TN-T), and myoglobin levels. A progressive increase was observed in all exercise-induced muscle damage parameters of the smoker and non-smoker from PRE to 2h. CK, myoglobin and T-NT levels of smokers were significantly higher than non-smokers at 24h ( $p=0.039$ ,  $p=0.018$ ,  $p=0.008$ , respectively). No significant difference was found between the smoking and non-smoking groups at all time points regarding CK-MB and LDH levels ( $p>0.05$ ). Acute endurance exercise leads to more skeletal and myocardial damage in smokers compared to non-smokers. Smoking may increase the risk of cardiovascular events during both exercise and daily physical activity.

**KEY WORDS** smoke, cardiac damage, muscle damage, aerobic exercise



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SKELETAL AND CARDIAC MUSCLE DAMAGE IN TERMS OF SMOKING

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## Introduction

The long-term adverse effects of cigarette smoking on human health have been proven by experts. It is known that smokers have a higher risk of death, heart diseases, and cancer (Srivastava et al., 2000). In the year 2000, an estimated 1.62 million cardiovascular deaths occurred due to smoking in the world; and this figure constitutes 11% of the total global cardiovascular deaths (Ezzati et al., 2005). Increasing physical activity is a potential strategy that can reduce the harmful effects of chronic smoking. However, it is unknown whether regular exercise alleviates the adverse effects of smoking on large artery distensibility (Tanaka & Safar, 2005; Park et al., 2014). Skeletal muscle performance may be affected negatively in smokers since oxygen extraction is limited in smokers than non-smokers (King et al., 1987). Although muscular damage is closely related to the intensity of the exercise, those who are unaccustomed to exercise can frequently cause muscular damage (Borg, 1982; Brown & Hill, 1991; Bryne & Eston, 2002; Colakoglu et al., 2014).

The affinity of haemoglobin for CO is 200 to 250 times greater than its affinity for oxygen. This results in competitive inhibition of oxygen release due to a shift in the oxygen-haemoglobin dissociation curve, reduced oxygen delivery, and subsequent tissue hypoxia (Ernst & Zibak, 1998; Fox et al., 1993). Smoking by causing catecholamine stimulation may lead to decreased maximal oxygen utilization, deterioration of the respiratory system and long-term cardiac damage (Green et al., 1986; Powders et al., 1989; Laustiola et al., 1988). Since the decrease in oxygen utilization capacity will also affect the amount of oxygen delivered to the tissues, the damage and recovery in muscle tissues will be expected to occur subsequently.

An increase in creatine kinase (CK) and lactate dehydrogenase (LDH), as indices of cellular necrosis and tissue damage in skeletal muscles, is widely used in the diagnosis of skeletal muscle diseases (Brancaccio et al., 2006).

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Conflict of interest: None declared.

The diagnosis of myocardial injury is aided by a number of biomarker assays including CK isoenzyme MB mass (CK-MB), cardiac troponin T (cTnT) and myoglobin (MYB) (Hachey et al., 2016; Nie et al., 2011).

Although results from previous studies are somewhat conflicting, it is usually agreed that cigarette smoking will reduce the capacity of an individual to perform aerobic exercise (Morton & Holmik, 1985). An expanded body of literature mentions that aerobic exercise has positive effects on physical functioning, psychological states, and mental processes (Martinsen & Stephens, 1994). Moreover, many of the variables influenced by regular exercise are the same ones that are negatively affected by smoking withdrawal (Prapavessis et al., 2007).

Although the adverse effects of smoking have been studied, the extent to which smoking damages the heart and skeletal muscle in relation to exercise types is an issue of concern. For this reason, this study aimed to examine the changes in cardiac and skeletal muscle injury levels in acute endurance exercise between the smoking and non-smoking individuals.

## Methods

### Participants

The study was carried out on eight male smokers ( $28.44 \pm 3.94$  years), who smoked at least 15 cigarettes per day for five years, and on nine male non-smokers ( $29.62 \pm 3.46$  years) (Table 1). All subjects were untrained. Subjects with any diseases (hypertension, thyroid, diabetes, cardiac, etc.) were not included in this study. We informed the participants in detail about the objectives of the study according to the Helsinki Declaration and obtained informed consent. This study was approved by the Ethics Committee of the University (decision number 40990478-05.99).

TABLE 1 The physical properties of smoking and non-smoking groups.

|                          | Smoker<br>(n=9)   | Non-smoker<br>(n=8) |
|--------------------------|-------------------|---------------------|
| Age (years)              | $28.44 \pm 3.94$  | $29.62 \pm 3.46$    |
| Body Height (cm)         | $175.45 \pm 4.70$ | $173.87 \pm 3.96$   |
| Body Weight (kg)         | $73.11 \pm 6.95$  | $71.12 \pm 5.61$    |
| BMI (kg/m <sup>2</sup> ) | $23.17 \pm 1.96$  | $22.72 \pm 2.72$    |

Note. Mean  $\pm$  SD \*Significant difference between groups ( $p < 0.05$ ).

### Exercise protocol

Subjects performed continuous endurance exercise on a treadmill (Dunlop EL900) for 40 minutes at 70% of maximal heart rate (HR). The target HR range was calculated as  $0.7 \times (\text{peak HR} - \text{resting HR}) + (\text{resting HR})$ , in accordance with the method of Karvonen. To verify and record the duration and intensity of exercise, participants wore a heart rate monitor (Polar RS400, Polar, Kempele, Finland).

### Measurements

A total of 15 cc venous blood samples were extracted from the forearm pre-exercise (PRE), post-exercise (POST), post-exercise 2 hours (2h), post-exercise 24 hours (24h) to measure levels of TN-T, MYB, CK, CK-MB, and LDH. The blood samples were first centrifuged at a rate of 5000 revolution/minute, and the upper phases were transferred to Eppendorf tubes and kept at  $-80^\circ\text{C}$  until the use. The concentrations were studied with the Beckman Coulter method using a Beckman Coulter AU2700 Plus biochemical auto-analyser with Beckman Coulter kits (Colakoglu et al., 2016).

### Statistics analysis

The data were analysed with the SPSS version 22 software package, and the distribution of the analysed variables was assessed using a Shapiro-Wilk test. The results showed that the distributions deviated from the normal distribution. The biochemical data were non-parametrically distributed and were expressed as the median (interquartile range) (IQR). The Mann-Whitney U test was used to compare the PRE, POST, 2h, and 24h values between the two groups. A Friedman rank test was undertaken to evaluate the statistical differences in time for each parameter. When a significant F-value in Friedmans' analysis was found, a post-hoc test was used to determine the between-means differences. The level of significance was set to be  $p < 0.05$ .

## Results

According to the results, the TN-T levels of the non-smokers showed no significant changes at all time points ( $p > 0.05$ ) except for 24h ( $p = 0.008$ ) when compared with pre-exercise. The 24h TN-T level was significantly lower than PRE in non-smokers ( $p = 0.007$ ). Compared with pre-exercise, the TN-T activity of the smoking group was significantly elevated at post-exercise ( $p = 0.040$ ). Furthermore, there were no significant differences among the 2h and 24h TN-T levels of the smoking group ( $p = 0.641$ ) (Table 2).



TABLE 2 Changes in the serum troponin (pg/ml), myoglobin (ng/ml), CK (u/l), CK-MB (u/l) and LDH (u/l) concentrations at different time points

| Variables         | Groups     | Pre               | Post                 | 2 hr                 | 24 hr               |
|-------------------|------------|-------------------|----------------------|----------------------|---------------------|
| Troponin (pg/ml)  | Smoker     | 5.17 (4.32-6.84)  | 5.44 (3.00-8.87)*    | 5.79 (3.00-18.37)    | 4.82 (3.00-6.10)    |
|                   | Non-smoker | 5.75 (4.78-6.99)  | 5.84 (4.00-7.52)     | 8.86 (3.00-22.26)    | 3.00 (3.00-5.60)*   |
| Myoglobin (ng/ml) | Smoker     | 40.07 (23.01-226) | 54.52 (23.58-234)    | 88.40 (47.95-291.3)  | 49.76 (28.94-159.1) |
|                   | Non-smoker | 29.85 (21-70.20)  | 50.51 (33.31-110.4)* | 58.28 (39.75-188.20) | 35.06 (26.47-219.1) |
| CK (u/l)          | Smoker     | 116.00 (47-996)   | 150.50 (55-1056)*    | 149.50 (72-1073)*    | 275.50 (103-938)*   |
|                   | Non-smoker | 132.00 (90-316)   | 157.00 (107-383)*    | 181.00 (128-361)*    | 235.00 (133-802)*   |
| CK-MB (u/l)       | Smoker     | 15.50 (11-26)     | 17.50 (12-30)*       | 16.00 (11-26)        | 16.00 (11-24)       |
|                   | Non-smoker | 15.00 (13-19)     | 18.00 (17-23)*       | 16.00 (14-23)*       | 17.00 (13-44)       |
| LDH (u/l)         | Smoker     | 136.50 (116-228)  | 179.00 (144-242)*    | 166.00 (135-262)*    | 168.50 (108-251)    |
|                   | Non-smoker | 161.00 (92-195)   | 177.00 (144-228)*    | 196.00 (120-228)*    | 188.11 (110-357)    |

Note. Median (Interquartile Range); \*Significant difference compared with Pre ( $p < 0.05$ ).

The TN-T levels were significantly different between the smoking and non-smoking groups at PRE ( $p = 0.039$ ) and 24h ( $p = 0.008$ ) (Figure 1).

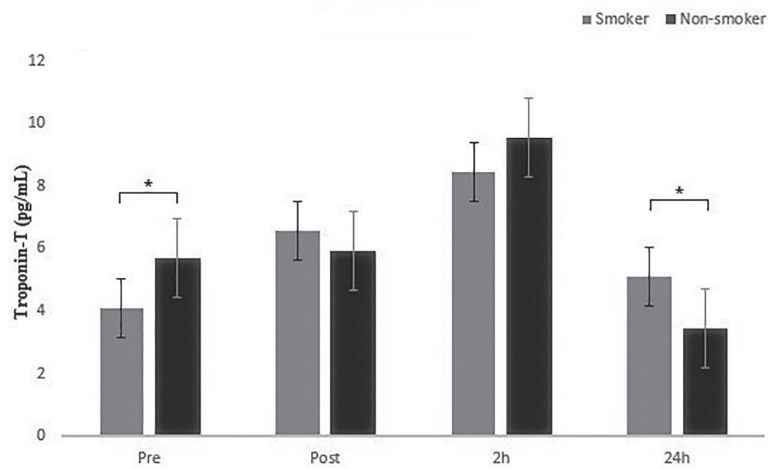


FIGURE 1 Changes in the serum cardiac troponin-T (pg/mL). \* $p < 0.05$  indicates significant difference smoker vs. non-smoker.

The MYB levels of the non-smokers showed no significant changes at all time points ( $p > 0.05$ ), except for POST ( $p = 0.015$ ), when compared with pre-exercise. The MYB activity of the smoking group significantly increased only at 2h ( $p = 0.045$ ). Although the PRE MYB levels were similar between the groups ( $p = 0.137$ ), the POST ( $p = 0.027$ ), 2h ( $p = 0.043$ ), and 24h ( $p = 0.039$ ) MYB levels were significantly higher in the smoking group compared to non-smoking group (Figure 2).

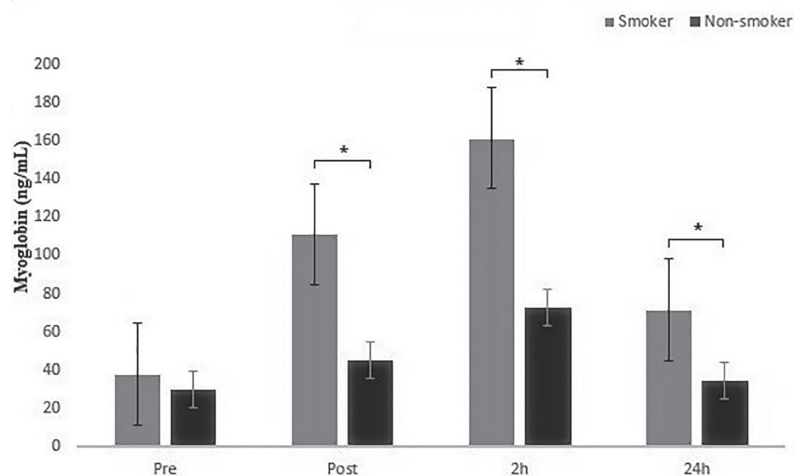


FIGURE 2 Changes in the serum cardiac troponin-T (pg/mL). \* $p < 0.05$  indicates significant difference smoker vs. non-smoker.

The results indicated significant difference between CK activities of the smoking group. It increased significantly at post-exercise ( $p=0.008$ ), 2h ( $p=0.031$ ) and 24h ( $p=0.040$ ). Furthermore, the CK activities of the non-smoking group were elevated at post-exercise ( $p=0.000$ ), 2h ( $p=0.011$ ), and 24h ( $p=0.008$ ) (Table 2). The CK level was significantly higher in the smoking group than the non-smoking group at 24h ( $p=0.018$ ). There was no significant difference between the groups at other time points ( $p>0.05$ ) (Figure 3).

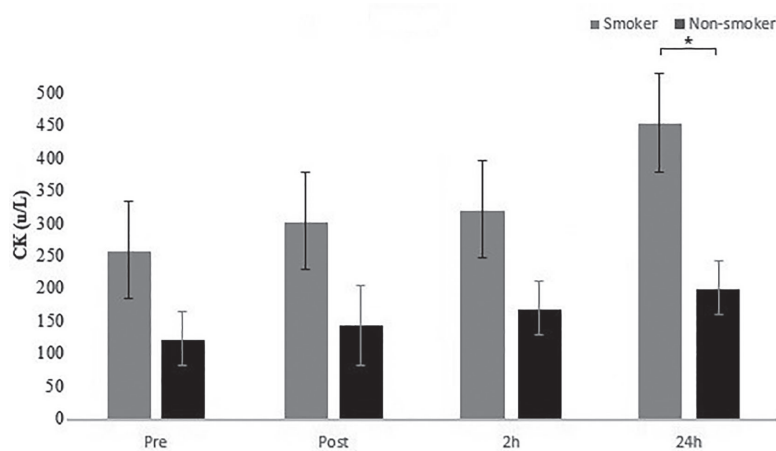


FIGURE 3 Changes in the serum creatine kinase(u/L). \* $p < 0.05$  indicates significant difference smoker vs. non-smoker.

Post hoc analysis revealed that the 2h CK-MB level for the non-smoking group was higher than both PRE and POST ( $p=0.000$ ,  $p=0.007$ , respectively). Furthermore, the CK-MB activity of the smoking group significantly increased only at POST ( $p=0.045$ ). No significant difference was found between the smoking and non-smoking groups at all time points regarding CK-MB levels ( $p>0.05$ ) (Figure 4).

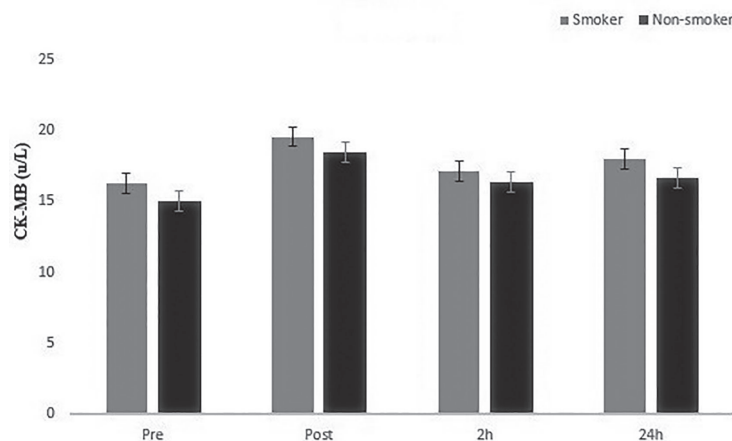


FIGURE 4 Changes in the serum creatine kinase-Myocardial Band (u/L)

In both groups, both post-exercise LDH levels (n-smoker  $p=0.001$ , smoker  $p=0.012$ ) and LDH levels 2 hours after exercise (n-smoker  $p=0.000$ , smoker  $p=0.042$ ) showed a significant increase compared to the pre-exercise LDH levels. No significant difference was found between the smoking and non-smoking groups at all time points regarding LDH levels ( $p>0.05$ ) (Figure 5).

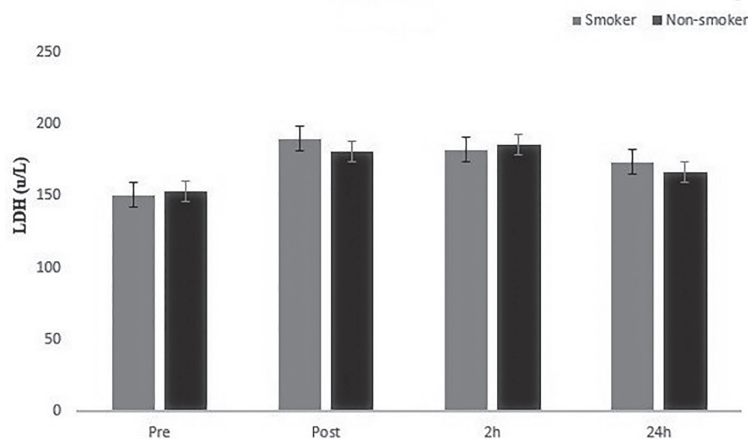


FIGURE 5 Changes in the serum lactate dehydrogenase (u/L)

## Discussion

The levels of muscle damage parameters measured in the study show that smoking constitutes a strong risk factor for both cardiac and skeletal damage. In addition to cigarette use, there is a physiologically significant increase in the exercise-induced muscle damage parameters. The results of the study are in agreement with the literature (Maughan et al., 1989; Clarkson et al., 2006; Greer et al., 2007; Lewicki et al., 1987; Coombes et al., 2000; Schumann et al., 2003) and it was noted that the LDH levels measured 2 hours after exercise peaked in both groups. Statistical comparison of the LDH levels between the smoking and non-smoking groups indicated that there was no statistically significant difference between the groups at any time point.

According to our study, in both the smoking and non-smoking groups, there was a significant increase in CK levels immediately after exercise, 2 hours after exercise and 24 hours after exercise compared to the pre-exercise levels. These increases are considered to be due to exercise. The CK level gradually increased in both groups and reached the maximal level 24 hours after exercise. No significant difference was detected in terms of CK levels between the smoker and non-smoker subjects in any of the other periods except 24 hours after exercise. The serum CK level reference interval in a healthy person should be between 45-171 U/L (Schumann et al., 2003) but the CK level of the smoking group was above the normal level even before the exercise. This result showed that the CK levels of the smoking group were higher than the level that a healthy person should have. Another point to note is that the 24-hour CK level of the non-smoking group was lower than the pre-exercise CK value of the smoking group.

Exercise causes excessive disruption of skeletal muscle structure. As a result, CK is released from the cells (Suzuki et al., 2000). In sedentary individuals, both low and high severity endurance exercises lead to a significant increase in plasma CK levels starting within 6 hours after exercise (Guzel et al., 2007). CK level peaks 6 hours after low-intensity exercise, but it peaks after 24 hours following high-intensity exercise. In another study on untrained individuals, it was observed that with the endurance exercise at the intensity of 70% of VO<sub>2</sub>max, the CK level reached peak levels before, after, and even 48 hours after exercise (Coombes & McNaughton, 2000). In a study examining the effect of smoking on CK isoenzymes, rats were exposed to cigarette smoke for 12 weeks. The serum CK levels of the rats who were exposed to cigarette smoke increased significantly compared to the previous period (Anbarasi et al., 2005). No similar study has been conducted on humans.

Myoglobin is a protein structure found only in the muscles. As a result of muscle or tissue injury, it may get into the blood. Although it is one of the markers of both skeletal and cardiac muscle injury, myoglobin is a parameter that is examined more frequently in the diagnosis of heart attack (Chiu et al., 1999). In a study in which aerobic endurance exercise was performed, myoglobin level during exercise did not show significant increase before exercise, it peaked 1 hour after exercise and returned to normal level 12 hours after exercise (Suzuki et al., 1999).

In a study examining the level of myoglobin according to the condition of the subjects, the subjects were given a gradually increased training for 24 days. According to the obtained data, the myoglobin levels between the first training and the last training decreased significantly (Ross et al., 1983). This situation indicated that the increase in the condition of the subjects was inversely proportional to the level of myoglobin in the blood. Sewright et al. (2008) investigated the effect of gender on eccentric exercise. At the end of the study, no difference was found in serum myoglobin levels between male and female athletes (Sewright et al., 2008). In general, with many types of exercise, myoglobin can be said to peak at about 2 hours following exercise (Chiu et al., 1999; Suzuki et al., 1999; Sewright et al., 2008; Volek et al., 2002).

When the effect of endurance exercise on the myoglobin level in the smokers and non-smokers was examined; there was no statistically significant difference between the pre-exercise and post-exercise myoglobin levels in the non-smoker subjects. In the time parameters other than this, no statistically significant difference was detected. In contrast, a comparison of post-exercise and 2 hours after exercise myoglobin levels of untrained smokers showed that the serum myoglobin level 2 hours after exercise was higher. No significant difference other than this was found. The myoglobin levels in both groups peaked 2 hours after exercise. In the comparisons of subjects among smoking and non-smoking groups, there were statistical significances in all periods other than the pre-exercise period. While pre-exercise serum myoglobin levels did not differ, the levels of myoglobin in the blood samples taken immediately after the exercise were observed to be significantly higher in the smoking group. The serum myoglobin levels of the smokers 2 hours after exercise were found to be significantly higher than those of the non-smokers. Also 24 hours after exercise, the myoglobin level in smokers was higher than those of the non-smokers. When the myoglobin levels 24 hours after exercise were examined, it was found that the levels of myoglobin of the non-smokers after 24 hours reduced almost to the baseline level, while it remains at high levels in the smokers. This finding suggested that skeletal muscle and cardiac injury were more prominent in the smokers than non-smokers; furthermore, the recovery time after exercise with the smokers lasted longer than the non-smokers.

The highest reference myoglobin level in a healthy person is known as 90 ng/ml (De Winter et al., 1995). In the non-smokers, the serum myoglobin level did not exceed the critical value even 2 hours after exercise, while the myoglobin level of the smokers reached 111.14 ng/mL immediately after exercise. The maximum serum myoglobin level of the smokers reached nearly double the amount of the critical value of 161.28 ng/ml (Figure 2). The adverse effect of smoking on recovery time and myoglobin level after exercise were observed in this study.

One of the other determinants of cardiac injury used in this study was troponin-T (De Winter et al., 1995; Lippi et al., 2008; Newby & Ohman, 2000). Serum troponin level is the most commonly used parameter in case of cardiac damage. There are many studies investigating the increase in serum troponin-T in relation to various factors. In one study, it was reported that exercise-dependent troponin-T release in adolescent long-distance athletes showed a more significant increase compared to that of adult colleagues (Nie et al., 2011). This may be partially due to the undeveloped antioxidant defence system in the hearts of adolescent athletes (Fu et al., 2009). In another study, remarkable results were detected in the blood samples taken during a marathon. While the troponin-T levels of the athletes gradually increased during the race, they returned to baseline level after exercise. However, they were observed to rise again 4-6 hours after exercise (Middleton et al., 2008). In the literature, no studies investigating the effect of smoking on cardiac troponin level were found.

We determined that troponin-T levels measured after exercise and 2 hours after exercise were not different from baseline levels in the non-smoking group. However, it was noticeable that the troponin-T level 24 hours after exercise was significantly higher than the pre-exercise troponin-T level. In the case of smokers, however, there was a significant difference only between the pre-exercise levels and the levels immediately after exercise. The fact that the pre-exercise basal level did not show a significant increase after exercise indicated that the increase of exercise-dependent cardiac troponin-T level in the smokers was higher than that of the non-smokers. There was a significant difference concerning troponin-T levels between the groups (Figure 1) with regards to pre-exercise and post-exercise measurements. Although the basal levels of troponin-T in non-smokers were higher than those of the smokers, their response to exercise was less pronounced. It was observed that the values of the smoking group did not fall to the basal level 24 hours after exercise while that of the non-smoking group were far below the basal level. When examined broadly, the recovery levels of the non-smokers were more rapid than the smokers.

In the study, the last parameter examined for cardiac injury was CK-MB. It is known that CK-MB increases in the case of cardiac diseases and long-lasting exhausting endurance exercises (Middleton et al., 2008; Newby et al., 2000; Sanchis Gomar et al., 2015; Smith et al., 2004). CK-MB levels may increase and may even rise to 26-fold of its basal levels in exercises that force the metabolism to work extremely hard, such as ultra-marathon (Smith et al., 2004; Siegel et al., 1983). CK-MB levels were found to be higher in rats exposed to cigarette smoke for 12 weeks than those not exposed (Sewrigh et al., 2008). In our study, the pre-exercise levels of both the smoking and non-smoking groups showed a significant increase after exercise (Figure 4). There was no statistically significant difference at all time points between the groups regarding CK-MB levels. The CK-MB levels began to return to the basal level 2 hours after exercise. In this respect, we can say that the CK-MB levels showed almost similar results in both smokers and non-smokers. However, longer exercise may lead to different results.

Since this study was conducted with limited resources, it did not reveal whether there were any changes in the CK and LDH levels 48 hours after the subjects exercising. Another limitation of the study is that the number of subjects was 17. Different exercise programs that will be performed to the smokers on a higher number of subjects may provide more general and clear results for researchers.

The literature and the results of this study suggest that aerobic exercise causes injury in the skeletal and heart muscles. Except for LDH and CK-MB parameters, it can be stated that long-term use of cigarettes increases the damage caused by exercise in both skeletal and heart muscles and prolongs the recovery time of the smokers more than that of the non-smokers. These results may contribute to the ability of smoking athletes to work and make their recovery period in this direction. It is also believed that the occurrence of cardiac injury due to smoking increases the risk of cardiovascular disease both during exercise and daily life.

In conclusion, when athletes or sedentary people are exposed to cigarette smoke, it affects their performance adversely and increases their level of exhaustion. Thus, they are advised to keep themselves directly or indirectly away from cigarette smoke. In addition to aerobic exercise, high-intensity anaerobic studies in trained smokers and non-smokers should be investigated for future studies. Furthermore, the effects of cigarette smoke exposure while exercising can be examined.

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# Psychological State and Behavioural Profiles of Freshman Enrolled in College and University Instructional Physical Activity Programmes under Different Policy Conditions

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**ABSTRACT** Between late adolescence and early adulthood, people experience a precipitous decline in their participation in physical activity. Those attending college or university are often presented with opportunities to partake in physical activity, sometimes under compulsory conditions and sometimes under elective conditions. This study examined the psychological and behavioural characteristics of freshman students under these two separate conditions. The main finding was that students under the elective condition felt more competent and motivated compared to those in the compulsory condition. They were also more physically active. When offered as electives, tertiary level physical activity education courses may be limited in reach, primarily attracting those who would likely be physically active without any such coursework.

**KEY WORDS** competence, compulsory, elective, exercise, higher education, motivation, physical activity, requirement



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## Introduction

Regularly engaging in physical activity is an essential individual health behaviour and a significant public health priority (U.S. Department of Health and Human Services (USDHHS), 2008). However, during the transition from late adolescence to early adulthood, there is a precipitous decline in physical activity participation (Blackwell & Clarke, 2018; Center for Disease Control and Prevention (CDC), 2016; Li, Cardinal, & Settersten, 2009; Zick, Smith, Brown, Fan, & Kowaleski, 2007). This is apparent on college and university campuses, as only half of college/university students meet physical activity recommendations (i.e., >150 minutes of moderate or >75 minutes of vigorous intensity physical activity per week or the equivalent combination of the two) (American College Health Association (ACHA), 2018). As such, during the transitional period between secondary and tertiary education, colleges and universities have been encouraged to do more to support the physical activity behaviours of their students (Cardinal, 2017; Corbin & Cardinal, 2008; Curry, Jenkins, & Weatherford, 2015; Sparling, 2003).

Some colleges and universities seek to accomplish this by offering their students a range of physical activity education (PAE) courses in either an elective or a required (i.e., compulsory) format (Beaudoin, Parker, Tiemersma, & Lewis, 2018; Cardinal, Sorensen, & Cardinal, 2012; Hensley, 2000). Within academic units, these have been labelled, “College and University Instructional Physical Activity Programmes” (C/UIPAP; a.k.a. basic instruction programmes, physical activity classes, service programmes; Cardinal, 2017), though other organizational arrangements, names, and purposes have been proposed (You, Craig, & Oh, 2018). Such courses have been positively associated with college and university students’ physical activity attitudes, behaviours, knowledge, and skills during

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the college/university years and beyond (Adams & Brynteson, 1992; Brynteson & Adams, 1993; Casebolt, Chiang, Melton, & Russell, 2017; Pearman et al., 1997; Sparling & Snow, 2002; Williams, Greene, Fry, Neuberger, & Satinsky, 2018; Woelke, Ebbeck, Concepcion, Readdy, Li, Lee, & Cardinal, 2013).

Despite this, not all institutions support C/UIPAP. When they do, they are more likely to be supported as electives versus requirements in the curriculum (Cardinal et al., 2012; Hensley, 2000). For example, Cardinal et al. (2012) found that only 39.6% of higher institutions in the U.S. required their students to experience PAE as a core component of their baccalaureate degree education. In subsequent work, Cardinal (2017) reported that only an estimated 3.43% of college and university students in the United States participate in C/UIPAP. Given their potential value in promoting student health and wellbeing, widespread reach within the American higher education system, and contributions in helping achieve other institutional goals such as academic success (Casebolt et al., 2017), interdisciplinary studies (Cardinal, 2016), internationalization efforts (Yan & Cardinal, 2013), and student retention (Kim & Cardinal, 2016), understanding how different policy arrangements might affect students could help inform policy decisions and their ramifications. For example, Ansuini (2001) reported that within three years of dropping their requirement, one university observed negative trends in the exercise and nutritional behaviours of their students.

Whether the elective or required arrangement is in the best interest of students has been debated for at least a century (Mak & Cheung, 2018; Sargent, 1908). The timing of any such requirement has received research attention, too, with the recommendation that it might best serve the interests and needs of the students during their freshman year versus just prior to graduating (Sallis et al., 1999).

Of course, policy decisions alone are not panaceas or cures in solving the problems associated with physical inactivity (Sallis, 2018). On the basis of the social-ecological model (Stokols, 1992), an individual's behavioural choices are affected through the dynamic interplay between individual characteristics (e.g., self-efficacy, self-determined motivation, knowledge) and environmental features (e.g., campus fitness facilities, college and university PAE policy). This proposition is in agreement with other leading psychological theorists of the 20th century (Gill, 2009). For example, Lewin (1936) proposed that behaviour is a function of the person and her/his environment, expressed in a formula as  $B = f(P, E)$ . Bandura (1986) also recognized the reciprocal, triadic relationship among person, environment, and behaviour in his social learning/cognitive theory. In the context of tertiary PAE settings, an institution's PAE policy (e.g., elective versus required) would be hypothesized to influence college and university freshmen participation in C/UIPAP.

Individual characteristics (e.g., gender, self-efficacy, self-determination) also may differentially affect physical activity behaviour and participation in C/UIPAP. For example, Doerkesen, Umstattd, and McAuley (2009) found that self-efficacy and physical activity goals are factors predicting freshmen engagement in vigorous physical activity. Different types of motivation also appear to affect students' participation in C/UIPAP. While intrinsic motivation (e.g., enjoyment, fun) is associated with students' sport participation (e.g., basketball, soccer), extrinsic motivation (e.g., appearance, weight management) is associated with fitness-enhancing exercise classes (Kilpatrick, Herbert, & Bartholomew, 2005; Kim & Cardinal, 2016; Leenders, Sherman, & Ward, 2003). Furthermore, gender is another predictor that affects college and university students' participation in C/UIPAP (Kim & Cardinal, 2017). Specifically, females tend to enrol in fitness classes more so than do males (Lackman, Smith, & McNeill, 2015; Weinfeldt & Visek, 2009).

In an attempt to elucidate this situation, the aims of this study were to: (1) determine entering university freshman's physical activity motivation, competence, and physical activity levels at institutions that had different PAE policies (i.e., a required versus an elective PAE policy), and (2) to examine how individual characteristics (e.g., competence, gender, motivation) and institutional PAE policies were associated with freshman's enrolment in C/UIPAP. Entering freshmen allow for a unique glimpse into the potential effect of institutional policy, as the students have yet to be socialized into their new environment. That is, they very likely enrolled in their courses well before the term began; therefore, their behaviours, psychological dispositions, and course choices are indicative of their distinct interests under the two different policy arrangements (i.e., elective or required).

## Methods

### *Participants and Setting*

University students enrolled in PAE courses at two universities were recruited for this study. Both institutions were located in the Pacific Northwest region of the United States and are classified as "R1: Doctoral Universities – Highest research activity". Given their geographical proximity, they have nearly identical seasons, topography, and weather.

Identical recruitment strategies were employed at each university, which occurred during the first week of the students' first term of enrolment of their freshman year. For the recruitment, the directors of each university's C/UIPAP were contacted. The directors agreed to distribute an online Uniform Resource Locator (URL) that took potential study participants to a Qualtrics (Provo, UT, USA) survey that was created for the purposes of data collection.

All study participants ( $N = 226$ ) provided their informed consent in accordance with the authors' Institutional Review Board and agreed to participate in the study. The significant distinction between the two institutions was that at one of the universities the students were required to complete a PAE course in order to graduate, whereas at



the other they were not; in other words at the latter university, the students enrolled in PAE courses on an elective basis.

### Measures

Participants completed the online survey comprised of 32 items. The online survey had four sections: a) demographic variables, b) students' motivation toward physical activity, c) students' perceived competence toward physical activity, and d) a 1-week recall of their past week's physical activity behaviour. Participants were asked to provide information about their age, gender, height, weight, race, and type of C/UIPAP they were enrolled in (e.g., dance, fitness, lifetime sports, mind-body, outdoor sports, or team sports). The C/UIPAP courses were classified into these categories using the same classification scheme that has been used in previous research (Barney, Pleban, Wilkinson, & Prusak, 2015; Hensley, 2000).

The Behavioral Regulation in Exercise Questionnaire (BREQ-2; Markland & Tobin, 2004) was used to measure the participants' self-determined motivation. The BREQ-2 measures five different types of motivation (i.e., amotivation, external regulation, introjected regulation, identified regulation, and intrinsic motivation). An example intrinsic motivation item is, "I enjoy my physical activity". Response options were displayed using a Likert scale format ranging from 1 (i.e., "do not agree at all") to 7 (i.e., "very strongly agree"). The perceived competence subscale of the Intrinsic Motivation Inventory (McAuley, Duncan, & Tammen, 1989) was used to assess the participants' perceived competence. A sample item is, "I am pretty skilled at physical activity". Response options were displayed using a Likert scale format ranging from 1 (i.e., "do not agree at all") to 7 (i.e., "very strongly agree"). The Weekly Leisure Time Exercise Questionnaire (WLTEQ; Godin & Shephard, 1985) was used to measure the participants' recalled physical activity behaviour. The WLTEQ contains three questions assessing the frequency of 15 minutes or longer bouts of mild (e.g., easy walking), moderate (e.g., fast walking and easy cycling), or vigorous (e.g., swimming and running) physical activity during the previous seven days. Weekly exercise METs (i.e., metabolic equivalent units) were calculated by multiplying the frequencies given for mild, moderate, and vigorous by 3, 5, and 9, respectively, and then summing the results.

### Data Analysis

Descriptive statistics were used to summarize the participants' enrolment in the C/UIPAP course types. A one-way (required vs elective) MANOVA was used to examine whether those who were required to take PAE courses and those who elected to take PAE courses differed on motivation, competence, and/or physical activity behaviour. Furthermore, binary logistic regression was employed to determine whether individual characteristics (i.e., gender, self-determined motivation, competence, and weekly exercise METs) and PAE policies (i.e., a required vs an elective PAE policy) predicted freshman student's enrolments in C/UIPAP. Data were analysed using the IBM Statistical Package for the Social Sciences (SPSS) 22 (Armonk, NY, USA) software.

### Results

#### Internal consistency, descriptive statistics, and correlation matrix

Table 1 presents the internal consistency values for the psychological measures used in the present study, all of which were acceptable (i.e., Cronbach alpha values ranging from .76 to .91). The Cronbach alpha for the behavioural measure employed in this study (i.e., WLTEQ) was .69. Table 1 also provides descriptive statistics for each variable and a correlation matrix for the various measures used in the study.

TABLE 1 Descriptive statistics, correlations, and reliability among variables (N = 226)

| Variables | 1       | 2       | 3      | 4      | 5      | 6     | 7   | $\alpha$ | A required PAE                       |                  | An elective PAE                      |                  |
|-----------|---------|---------|--------|--------|--------|-------|-----|----------|--------------------------------------|------------------|--------------------------------------|------------------|
|           |         |         |        |        |        |       |     |          | Female<br>(N=88)                     | Male<br>(N=29)   | Female<br>(N=89)                     | Male<br>(N=20)   |
|           |         |         |        |        |        |       |     |          | M<br>(SD)                            | M<br>(SD)        | M<br>(SD)                            | M<br>(SD)        |
| AM        | 1.0     |         |        |        |        |       |     | .798     | 1.74<br>(.92)                        | 1.67<br>(.76)    | 1.47<br>(.68)                        | 1.46<br>(.68)    |
| ER        | .27 **  | 1.0     |        |        |        |       |     | .761     | 2.78<br>(1.42)                       | 2.63<br>(1.23)   | 2.61<br>(1.29)                       | 2.03<br>(.85)    |
| INR       | -.29 ** | .12     | 1.0    |        |        |       |     | .878     | 4.67<br>(1.58)                       | 3.99<br>(1.67)   | 5.06<br>(1.46)                       | 5.15<br>(1.51)   |
| IDR       | -.57 ** | -.26 ** | .39 ** | 1.0    |        |       |     | .756     | 5.76<br>(1.01)                       | 5.97<br>(.95)    | 6.06<br>(.73)                        | 6.14<br>(.66)    |
| IM        | -.52 ** | -.33 ** | .15 *  | .70 ** | 1.0    |       |     | .910     | 5.58<br>(1.16)                       | 6.06<br>(1.09)   | 5.83<br>(1.08)                       | 6.05<br>(0.73)   |
| COM       | -.49 ** | -.29 ** | .12    | .62 ** | .76 ** | 1.0   |     | .892     | 5.13<br>(1.25)                       | 5.47<br>(1.28)   | 5.43<br>(1.10)                       | 5.76<br>(0.79)   |
| PA        | -.12    | .06     | .06    | .23 ** | .22 ** | .15 * | 1.0 | .687     | 40.44<br>(35.39)                     | 48.64<br>(33.64) | 36.44<br>(26.23)                     | 36.53<br>(25.88) |
|           |         |         |        |        |        |       |     |          | M <sub>age</sub> = 18.19<br>SD = .65 |                  | M <sub>age</sub> = 18.10<br>SD = .79 |                  |

Note. \*\*  $p < .01$ ; \*  $p < .05$ ; AM = Amotivation; ER = Extrinsic Regulation; INR = Introject Regulation; IDR = Identified Regulation; IM = Intrinsic Motivation; Com = Competence; PA = Weekly exercise METs; M = Mean; SD = Standard Deviation;  $\alpha$  = Cronbach's alpha.

### Primary analysis

Prior to conducting the primary analysis, age and gender were checked against the multivariate constellation of dependent variables. In this analysis, neither age or gender was significantly associated with the multivariate constellation of dependent variables, Wilks' Lambda = .94,  $F(7, 189) = 1.82$ ,  $p = .084$ ,  $\eta^2 = .06$  for age, and Wilks' Lambda = .96,  $F(7, 189) = 1.24$ ,  $p = .285$ ,  $\eta^2 = .04$  for gender. As neither was significant, they were not controlled for in the main analysis.

The one-way (required vs. elective) MANOVA yielded a significant main effect for PAE policy, Wilks' Lambda = .90,  $F(7, 191) = 3.21$ ,  $p < .01$ ,  $\eta^2 = .11$ . The follow up ANOVAs for the PAE policy revealed differences in amotivation,  $F(1, 197) = 4.57$ ,  $p < .05$ ,  $\eta^2 = .02$ , introjected regulation,  $F(1, 197) = 10.24$ ,  $p < .01$ ,  $\eta^2 = .05$ , identified regulation,  $F(1, 197) = 6.77$ ,  $p < .05$ ,  $\eta^2 = .03$ , and competence,  $F(1, 197) = 4.83$ ,  $p < .05$ ,  $\eta^2 = .02$ . However, the following variables were unrelated to PAE policy, intrinsic motivation,  $F(1, 197) = 1.42$ ,  $p = .23$ ,  $\eta^2 = .007$ , extrinsic regulation,  $F(1, 197) = 1.49$ ,  $p = .22$ ,  $\eta^2 = .008$ , and physical activity levels,  $F(1, 197) = 3.10$ ,  $p = .08$ ,  $\eta^2 = .01$ .

With regard to the student's enrolment in C/UIPAP, under the required policy, the most commonly enrolled-in classes were team sports (27.8%) and mind-body (24.8%), whereas under the elective arrangement they were fitness (38.2%) and mind-body (28.9%). As summarized in Table 2, the predictors of students' enrolment in team sports (e.g., basketball, frisbee, soccer) classes included having a required PAE policy (OR = 5.42, 95% CI [2.24, 13.12]), identified regulation (OR = 0.35, 95% CI [0.16, 0.78]), and competence (OR = 2.27, 95% CI [1.15, 4.47]). The predictors of enrolment in mind-body (e.g., Pilates, yoga) classes included gender (OR = 6.50, 95% CI [2.01, 21.02]), amotivation (OR = 2.08, 95% CI [1.21, 3.56]), and competence (OR = 0.46, 95% CI [0.29, 0.74]). The predictors of enrolment in fitness classes (e.g., aerobics, conditioning, running) included having an elective PAE policy (OR=0.53 95% CI [0.28, 0.99]) and the participants' weekly MET scores (OR = 1.01, 95% CI [1.00, 1.02]).

TABLE 2 Results of logistic regression analysis for freshman's enrollment in C/UIPAP

| Variables                | Team sports                          |      |         | Mind body                            |      |         | Fitness                              |      |         |
|--------------------------|--------------------------------------|------|---------|--------------------------------------|------|---------|--------------------------------------|------|---------|
|                          | B (SE)                               | OR   | p value | B (SE)                               | OR   | p value | B (SE)                               | OR   | p value |
| AM                       | -.77<br>(.45)                        | 0.46 | .086    | .73<br>(.28)                         | 2.08 | 0.08    | -.44<br>(.28)                        | 0.65 | .123    |
| ER                       | .19<br>(.17)                         | 1.20 | .263    | -.03<br>(.14)                        | 0.97 | .808    | -.04<br>(.13)                        | 0.89 | .326    |
| INR                      | -.20<br>(.15)                        | 0.82 | .179    | .00<br>(.13)                         | 1.00 | .997    | .07<br>(.12)                         | 1.07 | .562    |
| IDR                      | -1.04<br>(.40)                       | 0.35 | .010    | .55<br>(.33)                         | 1.74 | .091    | .05<br>(.29)                         | 1.05 | .867    |
| IM                       | .67<br>(.42)                         | 1.95 | .109    | .46<br>(.26)                         | 1.58 | .085    | -.42<br>(.25)                        | 0.66 | .094    |
| Com                      | .82<br>(.35)                         | 2.27 | .018    | -.78<br>(.24)                        | 0.46 | .001    | .16<br>(.22)                         | 1.17 | .472    |
| PA                       | -.01<br>(.01)                        | 0.99 | .354    | .01<br>(.01)                         | 1.01 | .286    | .01<br>(.005)                        | 1.01 | .037    |
| PAE policy<br>(Required) | 1.69<br>(.45)                        | 5.42 | .000    | -.52<br>(.36)                        | 0.60 | .153    | -.64<br>(.33)                        | 0.53 | .048    |
| Gender<br>(Female)       | -.29<br>(.48)                        | 0.75 | .545    | 1.88<br>(.60)                        | 6.50 | 0.02    | -.20<br>(.38)                        | 0.82 | .592    |
| Model fit                | $\chi^2(9) = 46.976$ ,<br>$p < .001$ |      |         | $\chi^2(9) = 35.631$ ,<br>$p < .001$ |      |         | $\chi^2(9) = 15.662$ ,<br>$p = .074$ |      |         |

Note. AM = Amotivation; ER = Extrinsic Regulation; INR = Introject Regulation; IDR = Identified Regulation; IM = Intrinsic Motivation; Com = Competence; PA = Weekly exercise METs.

### Discussion

Participants enrolled at the university that required them to experience PAE in order to graduate exhibited lower levels of motivation in comparison to those enrolled at the university where PAE was an elective. Amotivation is characterized by a low state of perceived competence and/or not valuing an activity or its potential outcomes. While values and outcomes were not directly assessed in the present study, competence was. In this analysis, the direct bivariate relationship between amotivation and competence was inverse. Higher degrees of competence were also found to be associated with enrolment in team sport- and mind-body-type PAE courses (i.e., those with higher levels of skills tended to enrol).

Similarly, one possible indirect indicator of valuing an activity and/or its potential outcomes is to actually participate in the activity. In the present study, the direct bivariate relationship between amotivation and weekly physical activity participation was also inverse. The direction of this relationship is suggestive of an amotivated state. The study participants' who engaged in the most physical activity during the previous week were also most likely to be enrolled in a fitness-type PAE course.

Of course, amotivation, competence, and physical activity behaviours are all states. That is, unlike traits, which are relatively permanent and stable, states have the possibility of being changed. A quality PAE experience during the impressionable early adult years has the potential to establish long-term physical activity habits (Adams &

Brynteson, 1992; Brynteson & Adams, 1993; Casebolt et al., 2017; Pearman et al., 1997; Sparling & Snow, 2002). As service delivery programmes within academic units; however, C/UIPAP are often taught by novice teachers with very little guidance, preparation, or supervision (Cardinal, 2017; Russell, 2011). Those teaching C/UIPAP courses may also have various degrees of real or perceived role-conflict associated with their other assigned duties, obligations, and responsibilities (Beaudoin et al., 2018; Cardinal, 2017; Hensley, 2000). Obviously a situation in which students enter a course in an amotivated state and who encounter an instructor who may be less than fully committed or prepared is undesirable.

Similar to what has been observed to occur in K-12 settings (Cardinal, Yan, & Cardinal, 2013; Ladwig, Vazou, & Ekkekakis, 2018), a bad PAE experience as a college or university student is unlikely to foster a positive shift in the students' psychological state. As such, efforts aimed at avoiding the possible scenarios described above and improving instruction within C/UIPAP courses have occurred (Beaudoin et al., 2018; Brock, Russell, Cosgrove, & Richards, 2018; Kim, Cardinal, & Cardinal, 2015; Kim, Cardinal, & Yun, 2015; National Association for Sport and Physical Education, 2009; Russell, 2011; Russell, Wadsworth, Hastie, Rudisill, 2014; Stapleton, Taliaferro, & Bulger, 2017). More efforts like this are needed, particularly if students are being required to take PAE in order to earn a baccalaureate degree. Quality instructors are able to adapt and modify their teaching methodologies and approaches to best match the collective and individual interests, needs, and skill-levels of their students (Beaudoin et al., 2018). Moreover, C/UIPAP programme administrators and PAE course instructors must focus on eliminating negative experiences, fostering positive experiences, and minimizing embarrassment by promoting enjoyment and inclusion and creating an environment of optimal challenge and social support.

Under the required policy arrangement, PAE courses reach all students, including those who might not otherwise be motivated to participate in elective PAE courses (Kim & Cardinal, 2018). In contrast, elective PAE courses are the most respectful of students' educational autonomy (Hensley, 2000; Issues, 2009, 2018; Kim & Cardinal, 2016). Self-determination theory (Deci & Ryan, 2000) posits that an individuals' intrinsic motivation for being physical activity is at least partially related to their having a choice in the matter. Being required to take a course may be met with resistance (Corbin & Cardinal, 2008). As such, and to at least partially account for this, C/UIPAPs, even when required, can be structured in a way that allows for individual student choice, options, and variety (e.g., choice of class/classes, format of class/classes (i.e., activity-based, lecture/lab-based), grading structure (e.g., Pass/Fail versus letter grade), scheduling/timing).

In considering the findings of this study, several limitations should be kept in mind. First, as a cross-sectional study, causal inference is not implied and should not be assumed. Second, the participating universities were selected on the basis of their different PAE policies and their geographic proximity to one another. Third, the study participants self-selected into the study; as such, our sample was one of convenience. Lastly, the data were obtained by self-report; therefore, item interpretation, recall, and/or social desirability may have affected the participants' responses in an undermining manner.

With only half of college/university students engaging in physical activity on a regular basis (ACHA, 2018), there is an urgent need to address this problem. In the mid-19th century, a compulsory PAE programme debuted in higher education for the expressed need of addressing the generally poor state of health of students at Amherst College (Cardinal et al., 2012). Other institutions followed suit and began offering compulsory PAE programmes. However, required PAE courses have declined in the 21st century in comparison to the 20th century. In studies of college alumni, those who report having taken PAE courses while in college/university report higher levels of physical activity in adulthood in comparison to those who did not (Adams & Brynteson, 1992; Brynteson & Adams, 1993; Casebolt et al., 2017; Pearman et al., 1997; Sparling & Snow, 2002). It is not entirely clear, though, whether the alumni in those studies were required to take PAE or whether they elected to take PAE.

On the basis of the present study as well as one past study (Kim & Cardinal, 2018), when PAE courses are offered on an elective basis, the most competent, motivated, and physically active students tend to enrol. In other words, the programmes are most likely catering to an audience that would likely be physically active without any such coursework vis-à-vis campus or community-based physical activity and recreational opportunities; some of which may not be fully inclusive environments and/or structured in an educational manner (Cardinal & Spaziani, 2003; Hoang, Cardinal, Newhart, 2016). On the other hand, when quality PAE courses are required of students, all students can benefit. The information obtained in this study might contribute to better informed C/UIPAP advocacy and programming efforts.

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# Manner of Execution and Efficacy of Reception in Men's Beach Volleyball

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**ABSTRACT** The purpose of this study was to determine the effect of the way the reception was executed on the efficacy of the reception in men's beach volleyball. The sample of this study was composed of 5,161 receptions, corresponding to 84 matches (179 sets) of the Men's Beach Volleyball World Tour organized by the Fédération Internationale de Volleyball (FIVB). The sample included only confrontations between the first 30 teams of the World Tour (FIVB ranking). The variables studied were: a) manner of serve execution: standing, power jump serve, and floating jump serve; b) reception technique (bump, overhead, and other); c) zone of reception: the court was divided into 10 equal zones; d) reception efficacy; e) spike efficacy; and f) rally result: win, continuity, or loss. The bump reception involved the highest efficacy coefficient, the number of receptions that allowed all options, and it was the most used reception. The power jump serve was the type of serve that most limited the receivers. This limitation was found when the serve required the receivers to move. The same tendency was found in the reception of the floating jump serve and standing serve, although not in the interference zone. Reception efficacy has a direct relationship with spike efficacy and winning the rally. The reception is the foundation for building a team's attack. The data found in the present study can be used as a reference to guide match analysis and practices in men's performance-level beach volleyball.

**KEY WORDS** sport, match analysis, scouting, observation



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RECEPTION IN MEN'S BEACH VOLLEYBALL

<http://mjssm.me/?sekcija=article&artid=178>

## Introduction

Athletes, teams, and coaches work to improve performance in competition. However, not all aspects of the sport have the same importance. It is possible to find many studies in sport science about performance indicators of different sports. The technical-tactical performance indicators can be established in relation to the way that points are scored or in relation to how the score is achieved (Hughes & Barlett, 2002). In beach volleyball, the skills that are executed are discrete, but their executions in the game are repeated cyclically (neutralizing the opponent's actions, preparing the team's attack, and attacking). The skills related to the way a team is organized and attempts to score are called actions of continuity (reception, dig, and set), and the skills related to the possibility of scoring are called terminal actions (serve, attack, and block).

More studies and information are available in relation to terminal actions than to actions of continuity (Medeiros, Palao, Marcelino, & Mesquita, 2014; Mesquita, Palao, Marcelino, & Afonso, 2013). Additionally, beach volleyball is a relatively new sport. Its first World Championship was in 1987, and its first inclusion in the Olympic Games was in 1996. Therefore, the same volume of studies as in other sports does not exist. Most of the information about the reception and the dig can be deduced by studies about the serve and the attack (Buscà et al., 2012; Jimenez-Olmedo, Penichet-Tomas, Saiz-Colomina, Martínez-Carbonell, and Jove-Tossi, 2012; López-Martínez & Palao, 2009), respectively, because these actions are attempts to neutralize the serve and attack actions to organize the team's offence. The information about reception in indoor volleyball is not applicable to beach volleyball due to the differences between these sports (e.g., number of players, surface area to be covered by players, type of surface, specialization

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of the players, target zone, etc.). In beach volleyball, the efficacy of the reception is high. In nine out of ten receptions, the execution allows the team to build an attack (Lacerda & Mesquita, 2003; Lopez-Martinez & Palao, 2009). The serve only reduces the reception efficacy when the serve moves the receivers (Homberg & Papageorgiou, 1995). The deep right zone (Lacerda & Mesquita, 2003) and the zone between the receivers (Lacerda & Mesquita, 2003; Lopez-Martinez & Palao, 2009) are the zones where most of the errors are found. The reason for this is probably the difficulty of moving in the sand, in addition to communication problems in the zone between the receivers (Noël, Hüttermann, van der Kamp, & Memmert, 2016; Smith, 2006). Most of the information available about reception is obtained from serve studies.

The fact that there is little available information about the way the reception is executed may mean that coaches are using subjective data to guide and analyse their training and competition processes. Also, this deficit of information makes it difficult to know the effect of rule changes and the sport's evolution. Previous researchers have focused on the terminal actions; however, the analysis of these aspects alone does not give an accurate perspective of the game. The actions of continuity do not allow teams to get points, but they are the ones that allow the terminal actions to do it. The purpose of this study was to determine the effect of the way the reception was executed on the efficacy of the reception in men's beach volleyball.

## Methods

The sample of this study was composed of 5,161 receptions carried out by 91 players (from 23 countries, with an average height of  $1.93 \pm 0.06$  metres, an average weight of  $88.7 \pm 6.3$  kilograms, and an average age of  $30.3 \pm 5.3$  years), corresponding to 84 matches (179 sets) of the 2008 Men's Beach Volleyball World Tour organized by the Fédération Internationale de Volleyball (FIVB). The sample only included confrontations between the first 30 teams of the World Tour (FIVB ranking). Sample selection was made according to the following criteria: a) three levels of teams were established (those that were classified 1st-10th, 11th-20th, and 21st-30th). An equal number of matches of the six possible combinations of confrontations between these three levels was included, and b) a maximum of four matches or twelve sets per team was included in the sample. The video recordings of the matches were obtained from the researchers' records and from recordings by the Spanish National Coach.

The study's design was descriptive, correlational, and transversal. The observation instrument that was used was a category system (Anguera, 2003). The variables that were studied included: a) manner of serve execution: standing, power jump serve, and floating jump serve (Palao, Manzanares, & Ortega, 2015); b) reception technique (bump, overhead, and other); c) zone of reception (Figure 1): the court was divided into 10 zones; d) reception efficacy (Coleman, Neville, & Gordon, 1969); e) spike efficacy (Coleman et al., 1969); and f) rally result: win, continuity, or loss. The studied variables are part of the observational instrument developed and validated by Palao and Manzanares (2009), and Palao et al. (2015).

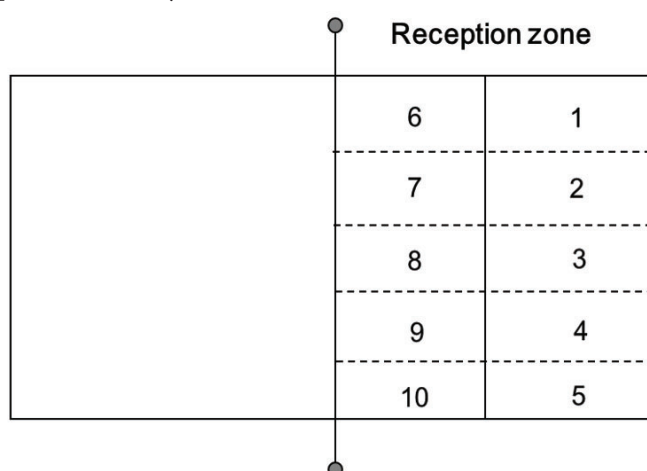


FIGURE 1 Reception zones

The zone of serve destination was determined by the player position in reception (zones 2 and 4), and the court zones were established in relation to player movement. It was considered a displacement of the players to another zone when the players' second foot lost contact with the sand when taking a step. Reception and spike efficacy performance were evaluated in relation to their success and the options they gave for the following actions (Coleman et al., 1969). The four levels to categorize reception performance were: a) Error: point for the opponent (0); b) no attack options (1); c) limited attack options (2); and d) maximum attack options (3). The five levels distinguished to categorize spike performance were: a) error/point for the opponent (0); b) maximum opponent attack options (1); c) limited attack options for the opponent (2); d) no opponent attack options (3); and e) point (4). With the categories of serve performance, an efficacy coefficient (sum of the attempts per category multiplied by the value of the category and divided by the total attempts (Coleman et al., 1969)) and the point-to-error ratio were calculated.

The matches were analysed through systematic observation by four experienced observers, who were trained using the methodology described by Anguera (2003). The matches were recorded from a posterior view by researchers or coaches. The recording included the entire volleyball court. The coding was done in a spreadsheet. The quality of the data registered by the observers was monitored through the elimination of incongruities, random review of the analysis, and spreadsheet cell blocking and/or protecting. Ten per cent of the sample was re-analysed to ensure the quality of the data. After training and during the analysis, the inter-observer and intra-observer reliability percentages of the studied variables were calculated between the observer and one of the researchers (Anguera, 2003). The inter- and intra-reliability of two separate observations was calculated to guarantee sufficient quality of the observation system. An inter-reliability index of 0.87 and intra-reliability index of 0.98 were found (intra-class correlation coefficient and Kappa index).

Actions in which the video recording did not allow all variables to be properly observed were considered lost values, and they were not taken into account in the data analysis. A descriptive analysis of the different variables was carried out. Contingency tables and non-parametric  $\chi^2$  (Chi-square) tests were used to establish the relationships between the nominal variables. The Student t-test for independent samples was used to assess differences between the manner of execution of the reception and reception efficacy and rally result. Statistical significance was set at 0.05.

## Results

Significant differences between technique and efficacy ( $p < .001$ ) were found (Table 1). The bump was the technique that was most used (94.7%). The use of the bump involved a significantly higher number of receptions that allowed the maximum options (56.7%). The overhead and other receptions involved a significantly higher number of errors (16.7% and 20.8%) and receptions that limited options (66.7% and 54.7%).

TABLE 1 Technique used in reception and efficacy in men's beach volleyball

|             | Bump     |      | Overhead |      | Other    |      | Total    |       |
|-------------|----------|------|----------|------|----------|------|----------|-------|
|             | n        | %    | n        | %    | n        | %    | n        | %     |
| Error       | 73       | 1.5  | 1*       | 16.7 | 55*      | 20.8 | 129      | 2.5   |
| No options  | 72       | 1.5  | 0        | 0.0  | 24       | 9.1  | 96       | 1.9   |
| Options     | 1934     | 40.3 | 4*       | 66.7 | 145*     | 54.7 | 2083     | 41.1  |
| Max options | 2719*    | 56.7 | 1        | 16.7 | 41       | 15.5 | 2761     | 54.5  |
| Occurrence  | 4798     | 94.7 | 6        | 0.1  | 265      | 5.2  | 5069     | 100.0 |
| Coefficient | 2.52     |      | 1.83     |      | 1.65     |      | 2.47     |       |
| Ratio       | 1 : 0.03 |      | 1 : 1.00 |      | 1 : 1.34 |      | 1 : 0.05 |       |

Note. \* $P < 0.001$ .

Significant differences between serve type and reception efficacy ( $p < .001$ ) were found (Table 2). Reception of the power jump serve (42.7%), and reception of the floating jump serve (37.7%) occurred the most often. The reception of the standing serve and the floating jump serve involved a significantly higher number of serves that allowed the maximum options (64.8% and 59.3%, respectively). The power jump serve involved a significantly higher number of reception errors (8.9%) and receptions that did not allow the team to attack (2.5%).

TABLE 2 Serve technique and reception efficacy in men's beach volleyball

|             | Standing serve |      | Power jump serve |      | Floating jump serve |      | Total    |       |
|-------------|----------------|------|------------------|------|---------------------|------|----------|-------|
|             | n              | %    | n                | %    | n                   | %    | n        | %     |
| Error       | 15             | 1.5  | 195 *            | 8.9  | 36                  | 1.9  | 246      | 4.8   |
| No options  | 10             | 1.0  | 56 *             | 2.5  | 28                  | 1.4  | 94       | 1.8   |
| Options     | 328            | 32.7 | 1013             | 46.4 | 721                 | 37.9 | 2062     | 40.3  |
| Max options | 650 *          | 64.8 | 920 *            | 42.1 | 1144                | 59.3 | 2714     | 53.0  |
| Occurrence  | 1003           | 19.6 | 2184             | 42.7 | 1929                | 37.7 | 5116     | 100.0 |
| Coefficient | 2.61           |      | 2.22             |      | 2.54                |      | 2.42     |       |
| Ratio       | 1 : 0.02       |      | 1 : 1.21         |      | 1 : 1.03            |      | 1 : 0.09 |       |

Note. \* $P < 0.001$ .

Significant differences were found in the reception of the standing serve in the different zones of reception ( $p < .001$ ) (Figure 2). The serves to zones 2 and 4 had a significantly higher number of receptions that allowed the opponent team all attack options. The deep and lateral receptions (zones 1 and 5) obtained significantly lower efficacies. Significant differences were found in the reception of the power jump serve in the different zones of reception ( $p < .001$ ). The serves directed to zones 2 and 4 had a significantly higher number of receptions that allowed the opponent team all attack options. The receptions carried out in zones 1, 3, 5, 6, 7, 8, 9, and 10 ob-



tained significantly lower efficacies than receptions carried out in zones 2 and 4. Significant differences were found in the reception of the floating jump serve in the different zones of reception ( $p < .001$ ). The receptions carried out in zones 2 and 4 had a significantly higher number of receptions that allowed the team all attack options. The deep and lateral receptions (zones 1 and 5) obtained significantly lower efficacies. Regardless of the type of serve, the reception done in the short zones (close to the net) occurred infrequently.

| Standing serve (n=1,004) |       |       |       |       | Power jump serve (n=2,200) |       |       |       |       | Floating jump serve (n=1,928) |       |       |       |       |
|--------------------------|-------|-------|-------|-------|----------------------------|-------|-------|-------|-------|-------------------------------|-------|-------|-------|-------|
| 5.5%                     | 34.2% | 15.5% | 24.5% | 4.9%  | 5.5%                       | 38.6% | 13.6% | 32.5% | 4.8%  | 6.7%                          | 30.7% | 16.1% | 27.7% | 6.5%  |
| 2.47                     | 2.70  | 2.55  | 2.67  | 2.42  | 1.92                       | 2.43  | 1.94  | 2.44  | 1.90  | 2.48                          | 2.59  | 2.41  | 2.69  | 2.43  |
| 54.5%                    | 71.4% | 62.7% | 69.4% | 45.1% | 29.8%                      | 51.2% | 27.5% | 51.8% | 28.2% | 52.1%                         | 62.8% | 50.4% | 70.1% | 51.0% |
| 1.2%                     | 3.8%  | 4.9%  | 2.9%  | 2.5%  | 0.5%                       | 0.9%  | 2.0%  | 1.0%  | 0.7%  | 1.8%                          | 3.2%  | 2.9%  | 2.2%  | 2.2%  |
| 2.50                     | 2.60  | 2.44  | 2.63  | 2.63  | 1.52                       | 2.08  | 2.05  | 1.80  | 1.62  | 2.36                          | 2.49  | 2.37  | 2.57  | 2.54  |
| 57.1%                    | 59.5% | 59.3% | 70.4% | 70.4% | 16.1%                      | 33.3% | 47.4% | 45.0% | 28.6% | 44.7%                         | 55.4% | 55.0% | 59.5% | 54.3% |

FIGURE 2 Occurrence (percentage), efficacy coefficient of the reception, and percentage of receptions that allowed maximum attack options in relation to different types of serve and the reception zone in men's beach volleyball

Significant differences were found between reception efficacy and spike ( $p < .001$ ) (Table 3). The reception that allowed the spiker all attack options had a significantly higher number of points and lower number of errors. The spike efficacy was higher when the reception allowed maximal attack options.

TABLE 3 Type of serve and rally result in men's beach volleyball

|                             | Reception efficacy     |      |                    |      |          |       |
|-----------------------------|------------------------|------|--------------------|------|----------|-------|
|                             | Limited attack options |      | Max attack options |      | Total    |       |
| Spike efficacy              | n                      | %    | n                  | %    | n        | %     |
| Error                       | 337                    | 16.6 | 350 *              | 12.8 | 687      | 14.4  |
| Max opp. options            | 70                     | 3.4  | 73                 | 2.7  | 143      | 3.0   |
| Limited opp. attack options | 458                    | 22.5 | 533                | 19.5 | 991      | 20.8  |
| No opponent attack          | 148                    | 7.3  | 167                | 6.1  | 315      | 6.6   |
| Point                       | 1023                   | 50.2 | 1610 *             | 58.9 | 2633     | 55.2  |
| Occurrence                  | 2036                   | 42.7 | 2733               | 57.3 | 4769     | 100.0 |
| Coefficient                 | 2.71                   |      | 2.96               |      | 2.85     |       |
| Ratio                       | 1 : 2.28               |      | 1 : 2.10           |      | 1 : 2.18 |       |
| Efficacy                    | 33.7 %                 |      | 46.1 %             |      | 40.8 %   |       |

Note. \* $P < 0.001$ .

Significant differences were found between reception efficacy and rally result ( $p < .001$ ) (Table 4). The reception that allowed maximal attack options had significantly higher possibilities of winning the rally. The reception that limited the attack options had significantly lower possibilities of winning the rally.

TABLE 4 Relationship between reception efficacy and side-out result in men's beach volleyball

|               | Loss |      | Continuity |      | Win    |      | Total |      |
|---------------|------|------|------------|------|--------|------|-------|------|
|               | n    | %    | n          | %    | n      | %    | n     | %    |
| Error         | 245  | 26.3 | 0          | 0.0  | 0      | 0.0  | 245   | 4.7  |
| No options    | 10   | 1.1  | 73         | 4.7  | 13     | 0.5  | 96    | 1.9  |
| Limit options | 334  | 35.8 | 699        | 45.3 | 1051 * | 38.8 | 2084  | 40.2 |
| Max options   | 343  | 36.8 | 772        | 50.0 | 1646 * | 60.7 | 2761  | 53.2 |
| Occurrence    | 932  | 18.0 | 1544       | 29.8 | 2710   | 52.3 | 5186  | 100  |

Note. \* $P < 0.001$ .

## Discussion

The purpose of this paper was to assess the effect of the manner of reception execution on the reception's efficacy in men's beach volleyball. The values found regarding efficacy demonstrate why the bump is the type of reception that is most used. In part, these results are logical given the goal of this technique and beach volleyball rules, which establish that ball contacts must be clean. The bump allows players to reduce

the speed of the ball, to intercept the ball at a higher range of angles, and to adapt the different trajectories. The occurrence found in the rest of the actions is very low (<5%), and those actions have low efficacy. These techniques are used as a resource when the receiver does not get his body behind the ball. The use of these techniques has decreased with the reduction in court size (8 × 8 m).

With regard to the type of serve, the reception of the power serve presented lower efficacy than the floating jump serve and the standing serve did. The reason for this result is probably because the speed of the ball does not allow the player to execute the reception properly. This aspect is confirmed with the information about the efficacy of the reception in the different zones. In the reception of the power jump serve, if the players have to move (laterally) or the ball goes to the interference zone between the players, the efficacy of the reception is significantly lower. The same tendency is observed in the rest of the serves although the reduction of the efficacy is also lower. The fact that there is less uncertainty with the floating and jump serves reduces the problems in reception in the interference zone between receivers (zone 3). The values found show that the analysis of the reception should take into consideration the type of serve. This aspect must be considered in match analysis and in practice. For example, although the general values are similar, the difference is the quality of the reception. The power jump serve only allows maximal attack options in 30% of receptions.

The relationship between reception efficacy, spike efficacy, and the possibility of winning the rally confirms the importance of the reception in the game. This relationship, called a “second order relationship” because it is the second-to-last action before the attack, has been confirmed in indoor volleyball (Eom & Schultz, 1992; Palao, Santos, / Ureña, 2006).

Data found can be used for planning and monitoring practice and competition for players of a similar level. The data can be considered as normative profiles for the peak performance level and can be used as a reference to be achieved by players in formation. The results show that reception analysis should take into consideration the type of serve and, if possible, the serve speed (Buscà, Moras, Peña, AND Rodríguez-Jiménez, 2012; Palao & Valades, 2014). The use of the observational methodology to collect the data increases the risk of error in the measurement of court zone usage (Koch et al., 2009; Mauthner, Koch, Tilp, & Bischof, 2007). However, the goals of the study were to give applicable and useful data to coaches and players. The authors believe that the criteria followed to determine the serve destination according to players' displacement allow coaches and players to easily interpret and use the data.

The bump reception involved a higher efficacy coefficient (i.e., a higher number of receptions that allowed all options), and it was the most used reception. The power jump serve was the type of serve that most limited the receptors. This limitation was found when the serve moved the receivers. The same tendency was found in the reception of the floating jump serve and standing serve, although not in the interference zone. Reception efficacy has a direct relationship with spike efficacy and winning the rally. The reception is the foundation for building the team's attack. The data found in the present study can be used as a reference to guide match analysis and practices in men's performance-level beach volleyball. Future studies should attempt to assess whether there is any relationship between the receiver's actions and their posterior actions (e.g., type of attack, number of receptions done, etc.).

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# Factors Affecting Critical Features of Fundamental Movement Skills in Young Children

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**ABSTRACT** Despite significant advances in the knowledge and understanding of associations between the phenomenon of excess body weight (hereafter “overweightness”) and fundamental movement skill (FMS) proficiency, the question of how overweightness affects critical features of movement remains unanswered. This study examined the differences in the proficiency of FMS between boys and girls with different weight status on the level of critical features. Three hundred and twenty-two boys and girls aged 5 to 10 years were assessed in eight FMS (run, vertical jump, long jump, ball catch, ball kick, ball pass, ball bounce, and forehand strike) and were assigned to non-overweight and overweight groups according to their waist-to-height ratio, with a cut-off point of 0.5. FMS score differences ( $p < 0.05$ ) between boys and girls that can be frequently observed in the non-overweight group of children were not determined in the overweight group of children ( $p \geq 0.131$ ). Overweight boys performed worse in a higher number of skills’ critical features than overweight girls did when compared to non-overweight groups. With weight gain, boys might experience a more significant decline in FMS proficiency than girls do because of the higher scores when non-overweight. The critical features of FMS indicate that overweightness might affect postural control and coordination, which this paper discusses.

**KEY WORDS** body composition, overweight, waist circumference, quality of movement



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CRITICAL FEATURES OF FUNDAMENTAL MOVEMENT SKILLS

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## Introduction

Fundamental movement skills (FMS) are part of the lifespan motor development that emerge in the form of immature movement patterns in early childhood, progress through a transitional phase and become efficient, mature patterns in late childhood (Gabbard, 2012; Haywood & Getchell, 2009; Robertson & Halverson, 1984). These movement skills are supposed to be the foundation for learning more complex and sport-specific skills in later periods of motor development (Seefeldt, 1980). FMS continue to change during adolescence while sport-specific movement skills are being learned simultaneously. They are usually divided into locomotor skills (running, jumping, hopping, etc.), non-locomotor/stability skills (one-leg stand, pirouettes, etc.), and manipulative/object control skills (catching, bouncing, kicking, etc.).

Every FMS has a specific movement pattern, which is a time-sequenced series of organized movements that define the skill itself (Robertson & Halverson, 1984). In scholarly literature, two approaches are commonly used to study FMS at the level of its pattern. Robertson (1977) originally developed the first approach based on stage theory, which predicts that human movement develops in an immutable stage sequence. She proposed a model in which movement was broken down into component parts. Components represented parts of movement (overarm throw in her study) that all individuals theoretically exhibit when repeatedly performing a movement task throughout their lifespan (Robertson, 1977). The approach in which stages are proposed for the components of movement rather than for the total movement (traditional stage approach) enables a more flexible and dynamic investigation of development stages. The second approach to study FMS at the level of its pattern is the use of observable behavioural components that together constitute a proficient performance of movement; the approach Okely, Booth, and Chey (2004) describe as “expert” performer. In contrast to the former approach that allows studying changes

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of movement form (pattern) sequentially over time, the latter approach enables distinguishing movers of different proficiency among each other. To draw a distinction between both approaches, the term “critical features” will be used for the parts of the movement when referring to the second approach rather than “components”, as originally described by Robertson (1977) and used in the first approach.

A number of studies examined associations between FMS proficiency, sex, and weight status in preschool and primary school children. Boys tend to be more proficient in object control skills in comparison to girls (Barnett, van Beurden, Morgan, Brooks, & Beard, 2010; Hardy, King, Farrell, Macniven, & Howlett, 2010; Spessato, Gabbard, Valentini, & Rudisill, 2012; O'Brien, Belton, & Issartel, 2016). However, findings regarding locomotor skill proficiency are not consistent. A study conducted by Robinson (2011) found that boys are better than girls in locomotor skills, and in other studies that girls are better than boys (Cliff, Okely, Smith, & McKeen, 2009; Hardy et al., 2010). There are a couple of studies that showed no difference between sex in locomotor skills (Goodway, Robinson, & Crowe, 2010; Spessato et al., 2012). Conversely, there is a high consensus in weight status affecting FMS proficiency. An inverse association between FMS competency and weight status was found (Okely et al., 2004). Overweight or obese children tend to be less competent in FMS (Logan, Scrabis-Fletcher, Modlesky, & Getchell, 2011).

In scholarly literature, many direct (e.g., skinfold, bioimpedance) and indirect (e.g., BMI) measures of body composition are used. One of the indirect measures to effectively monitor body composition during growth is the waist circumference to body height index (Taylor, Williams, Grant, Taylor, & Goulding, 2011). It has been described as a simple, accurate, and non-age-dependent measure of overweightness and obesity for the general childhood population (Yan et al., 2007). In comparison to the body mass index, it has several advantages. It considers abdominal adiposity, correlates less with age, and is more accurate in identifying overweightness and obesity (Savva et al., 2000; Yan et al., 2007). The waist-to-height ratio (WHtR) is a better marker of metabolic risk during childhood than waist circumference, and it has been suggested that a ratio higher than 0.5 in schoolchildren is related to an increased health risk (McCarthy & Ashwell, 2006; Browning, Hsieh, & Ashwell, 2010).

Despite the fact that the main purpose of the study by Okely et al. (2004) was to describe the association between FMS proficiency and two measures of body composition, it revealed a rather inconsistent trend between FMS proficiency, sex, and measures of body composition (BMI and waist circumference) that requires further investigation. The results indicated that non-overweight boys and girls were more likely to be proficient in locomotor skills than overweight boys and girls were. The data confirmed no differences in object control skills between overweight and non-overweight boys and girls. However, these results did not reveal in which critical features of locomotor and object control skills non-overweight boys and girls differ from overweight boys and girls. Because individual features of movement can indicate particular problems in a movement pattern, it would be interesting to see in which critical features the biggest difference occurs when children are overweight; this would thus enable better planning of needed interventions. Furthermore, it would be interesting to determine whether these differences are more frequent in a specific sex.

The purpose of this study was to explore differences in critical features of FMS between overweight and non-overweight children across sex. According to the previously reported data on FMS proficiency scores between overweight and non-overweight boys and girls (Okely et al., 2004), differences in critical features of locomotor skills should be observed; however, no differences in critical features of object control skills should be observed.

## Methods

### Participants

Six hundred and five children were invited to participate in the study. Of these, 322 children (a 53% response rate) aged from five to 10 years (girls  $M = 6.4$ ,  $SD = 2.2$  years; boys  $M = 6.3$ ,  $SD = 2.0$  years), who were enrolled in either a public kindergarten or public elementary school were included in the study. A total of 146 girls (45%) and 176 boys (55%) were included in the sample, which was entirely Caucasian. Children whose parents or guardians agreed with the informed consent to participate were recruited. All procedures performed in this study were conducted according to the Declaration of Helsinki principle and were approved by the local ethics committee. The kindergarten or school principals approved each of the participating institutions.

### Procedures and measures

Eight FMS were video-recorded and then assessed with a checklist for each skill. Three locomotor (LOC) skills (run, vertical jump, long jump) and five object control (OC) skills (ball catch, ball kick, ball pass, ball bounce, and forehand strike) were included in the research. These skills were selected because they form the basis for many traditional and popular sports played in Europe (e.g., gymnastics, athletics, basketball, handball, tennis). Each skill was broken down into six critical features, as in Okely et al. (2004). A panel of three experts in FMS assessed content validity; all of them taught on sport science/physical education study programmes at different universities. They reviewed and ranked the importance of the skill and identified and reviewed each skills' critical feature (Okely et al., 2004).

The defined critical features served as qualitative descriptors for skill proficiency. Each critical feature was assessed as possessed or not possessed by three assessors. The children had to demonstrate the component on at least two out of the three attempts for the component to be recorded as possessed. For each possessed component, one point was assigned. The mean sum of three assessors represented the final score. Each participant was therefore given a total score from zero to six on the ordinal scale. A score of zero represented that the participant was not proficient



in the measured skill and six that the participant was completely proficient in the measured skill. An overall motor proficiency score (MP) was obtained by summing the scores for individual LOC and OC, with a maximum score of 48 points.

Instructions included providing a verbal description and demonstration of the skill. With the instructions, we attempted to create a relevant, meaningful and motivating activity for children, and thus enable the participants an opportunity to demonstrate their proficiency in measured skills (Hands, 2002). No motivational comments were offered to participants during the execution. All children were allowed to practice before being assessed on the three test trials. Trained assessors, who had to demonstrate competency in the FMS assessment protocol prior to the study, assessed skill proficiency.

The inter-assessor reliability of the LOC and OC proficiency scores were evaluated by the proportion of agreement adjusted with Cohen's kappa. Interpreting values for kappa were <0.20 poor, 0.21-0.40 fair, 0.41-0.60 moderate, 0.61-0.80 good, and >0.80 very good (Altman, 1991). Cohen's kappa was for LOC 0.81-0.86 and OC 0.78-0.83, indicating good to very good inter-assessor reliability.

Height was measured with a stadiometer and waist circumference with a measuring tape to the nearest 0.1 cm according to the Anthropometry procedures manual (NHANES, 2007). Waist circumference was measured with anthropometric tape at the level of the iliac crest while the subject was at minimal respiration. According to the WHtR, a score lower than 0.5 was assigned to 243 (76%) children (110 girls and 133 boys) who formed a non-overweight group, and a score higher than 0.5 was assigned to 79 (24%) children (36 girls and 43 boys) who formed an overweight group.

### Statistical analysis

Different statistical approaches were selected in relation to data typology and an a priori hypothesis. The dependent variables were the overall motor proficiency score (MP), locomotor proficiency score (LOC), and object control proficiency score (OC).

Prior to the analyses, the data were screened for normality using skewness and kurtosis statistics. A skewness value greater than 1, and a standardized kurtosis value that is less than -2 or greater than +2 indicates that the distribution varies significantly from normal (Green, Salkind, & Akey, 2000). The calculated statistics suggested that the distributions of the variables were within the expected range (skewness: -0.72 to -0.39; kurtosis: -0.43 to -0.81).

A MANCOVA with 2 between-participants factors [sex (boys, girls), weight status (non-overweight, overweight)], and 1 covariate [age] was employed to find differences between sex and weight status in MP, LOC, and OC. Pillai's Trace model was used. Prior to conducting the MANCOVA, a series of Pearson correlations were performed between all of the dependent variables in order to test the MANCOVA assumption that the dependent variables would be correlated with each other in the moderate range (Meyers, Gamst, & Guarino, 2006). A meaningful pattern of correlations was observed amongst all of the dependent variables (all  $r > 0.80$ ), suggesting the appropriateness of a MANCOVA. Additionally, Leven's test was associated with a p-value of 0.143, 0.153, and 0.088 for MP, LOC, and OC, respectively. Thus, the covariance matrices between the groups were assumed to be equal for the purposes of the MANCOVA.

For significant main effects, follow-up univariate analyses of covariance (ANCOVA) were computed. A Chi-square test was used to determine differences in the proficiency of FMS components between overweight and non-overweight groups across sex. All statistical analyses were performed using IBM SPSS Statistics version 21.0, and an a priori level used to determine the statistical significance was  $p < 0.05$ .

### Results

The MANCOVA revealed statistically significant difference in sex ( $F(2,316) = 6.92$ ,  $p < 0.001$ ,  $\eta^2 = .04$ ) and WHtR ( $F(2,316) = 21.69$ ,  $p < 0.001$ ,  $\eta^2 = .12$ ) but not in interaction between sex and WHtR ( $F(2,316) = 1.59$ ,  $p = 0.21$ ,  $\eta^2 = .01$ ). Age was a significant ( $p < 0.001$ ) covariate.

Follow-up ANCOVA showed statistically significant differences between boys and girls in MP and OC scores controlling for age ( $F(1,317) = 9.89$ ,  $p < 0.001$ ,  $\eta^2 = .03$  and  $F(1,317) = 12.95$ ,  $p < 0.001$ ,  $\eta^2 = .04$ , respectively) but not for LOC ( $F(1,317) = 3.47$ ,  $p = 0.06$ ,  $\eta^2 = .01$ ). Boys were found to be more proficient in OC (Boys,  $M = 21.74$ ,  $SE = 0.39$ ; Girls,  $M = 19.68$ ,  $SE = 0.43$ ), but not in LOC (Boys,  $M = 13.87$ ,  $SE = 0.25$ ; Girls,  $M = 13.18$ ,  $SE = 0.28$ ) in comparison to girls. Overall motor proficiency showed better results for boys ( $M = 35.60$ ,  $SE = 0.59$ ) in comparison to girls ( $M = 32.85$ ,  $SE = 0.65$ ) (Table 1).

**TABLE 1** Overall motor proficiency scores, locomotor scores, and object control scores between body composition status and sex

|     | All Children (N = 322) |               | Non-overweight (N = 243) |               | Overweight (N = 79) |              |
|-----|------------------------|---------------|--------------------------|---------------|---------------------|--------------|
|     | Boys (N=176)           | Girls (N=146) | Boys (N=133)             | Girls (N=110) | Boys (N=43)         | Girls (N=36) |
| MP  | 35.60 ± .59            | 32.85 ± .65   | 39.35 ± .96              | 35.39 ± 1.08  | 31.86 ± .73         | 30.31 ± .79  |
| LOC | 13.87 ± .25            | 13.18 ± .28   | 15.15 ± .41              | 14.17 ± .46   | 12.62 ± .31         | 12.18 ± .33  |
| OC  | 21.74 ± .39            | 19.68 ± .43   | 24.23 ± .63              | 21.22 ± .70   | 19.25 ± .48         | 18.13 ± .51  |

Note. Mean ± standard error; MP: overall motor proficiency; LOC: locomotor skills; OC: object control skills.

The ANCOVA for non-overweight versus overweight on MP, LOC, and OC scores controlling for age indicated statistically significant differences ( $F(1,317) = 43.16$ ,  $p < 0.001$ ,  $\eta^2 = .12$ ;  $F(1,317) = 30.76$ ,  $p < 0.001$ ,  $\eta^2 = .09$ ; and  $F(1,317) = 41.95$ ,  $p < 0.001$ ,  $\eta^2 = .12$ , respectively). Non-overweight children showed better results in LOC (non-overweight,  $M = 14.65$ ,  $SE = 0.31$ ; overweight  $M = 12.40$ ,  $SE = 0.23$ ), OC (non-overweight,  $M = 22.72$ ,  $SE = 0.49$ ; overweight  $M = 18.69$ ,  $SE = 0.36$ ), and MP (non-overweight,  $M = 37.37$ ,  $SE = 0.74$ ; overweight  $M = 31.09$ ,  $SE = 0.55$ ) in comparison to overweight children.

Furthermore, we analysed the differences between boys and girls by weight status. The results showed a major discrepancy between overweight and non-overweight boys in MP ( $M_{diff} = 7.49$  points) and OC ( $M_{diff} = 4.98$  points) scores, but a minor discrepancy in LOC ( $M_{diff} = 2.32$  points) scores. However, results revealed a smaller discrepancy between overweight and non-overweight girls when compared to boys (5.08, 3.09, and 1.99, respectively). Consequently, the differences observed in non-overweight group between boys and girls in MP, LOC, and OC scores ( $F(1,76) = 14.77$ ,  $p < 0.001$ ,  $\eta^2 = .12$ ;  $F(1,76) = 5.08$ ,  $p = 0.026$ ,  $\eta^2 = .04$ ;  $F(1,76) = 16.82$ ,  $p < 0.001$ ,  $\eta^2 = .13$ , respectively) could not be observed in the overweight group ( $F(1,240) = 1.89$ ,  $p = 0.170$ ,  $\eta^2 = .01$ ;  $F(1,240) = .08$ ,  $p = 0.368$ ,  $\eta^2 = 0.001$ ; and  $F(1,240) = 2.30$ ,  $p = 0.131$ ,  $\eta^2 = .01$ , respectively).

TABLE 2 Differences in FMS proficiency between boys and girls across body composition

| Critical features |   | Proficient boys (%) |      | Critical features |  | Proficient boys (%) |      |
|-------------------|---|---------------------|------|-------------------|--|---------------------|------|
|                   |   | NO                  | OW   |                   |  | NO                  | OW   |
| BK                | Eyes are focused on the ball throughout the kick, $\chi^2(1) = 12.5$ , $P < 0.001$                      | 100.0               | 82.9 | BC                | Hands and fingers are opened, $\chi^2(1) = 5.1$ , $P = 0.035$                      | 88.5                | 72.3 |
| BK                | Kicking leg follows through towards the target after the ball contact, $\chi^2(1) = 12.2$ , $P < 0.001$ | 93.8                | 72.1 | BK                | Bent knee during the backswing of the kicking leg, $\chi^2(1) = 4.8$ , $P = 0.032$ | 84.6                | 68.1 |
| RUN               | Body is leaning slightly forward, $\chi^2(1) = 10.02$ , $P = 0.001$                                     | 93.8                | 74.8 |                   |  |                     |      |
| VJ                | Crouch with knees bent and arms behind body, $\chi^2(1) = 7.34$ , $P = 0.008$                           | 84.6                | 65.8 |                   |  |                     |      |
| VJ                | Balanced landing with no more than one step in any direction, $\chi^2(1) = 15.3$ , $P < 0.001$          | 90.8                | 64.0 |                   |  |                     |      |
| BP                | Step towards the target with optional leg after the pass, $\chi^2(1) = 23.14$ , $P < 0.001$             | 75.4                | 37.8 |                   |  |                     |      |
| BB                | Eyes focused forward throughout the bounce, $\chi^2(1) = 11.06$ , $P = 0.001$                           | 60.0                | 34.2 |                   |  |                     |      |
| BB                | Contact the ball at about hip height, $\chi^2(1) = 22.90$ , $P < 0.001$                                 | 76.9                | 39.6 |                   |  |                     |      |
| BB                | Hips and knees slightly flexed during the bounce, $\chi^2(1) = 10.68$ , $P = 0.001$                     | 73.8                | 48.6 |                   |  |                     |      |
| LJ                | Controlled landing with bent knees to absorb force of landing, $\chi^2(1) = 7.37$ , $P = 0.007$         | 73.8                | 53.2 |                   |  |                     |      |
| FS                | Eyes are focused on the ball throughout the strike, $\chi^2(1) = 18.7$ , $P < 0.001$                    | 93.8                | 64.9 |                   |  |                     |      |
| FS                | Stand side-on to the target with bat held in one hand, $\chi^2(1) = 9.78$ , $P = 0.002$                 | 80.0                | 56.8 |                   |  |                     |      |
| FS                | Finish the strike in front of the body, $\chi^2(1) = 8.07$ , $P = 0.007$                                | 72.3                | 50.5 |                   |  |                     |      |

Note. NO: non-overweight; OW: overweight; BK: ball kick; RUN: run; VJ: vertical jump; BP: ball pass; BB: ball bounce; LJ: long jump; FS: forehand strike; BC: ball catch.

To indicate sex-specific discrepancy, we listed the critical features of movement in which we found differences between the overweight and non-overweight groups of children that could be attributed only to boys and girls, respectively (Table 2). The Chi square test revealed that a statistically significant number of overweight boys performed worse in 13 critical features (nine critical features of OC, four critical features of LOC) than non-overweight boys did (all  $p \leq 0.008$ ). The same test revealed differences in only two critical features (both critical features of OC) for girls (both  $p \leq 0.022$ ).

## Discussion

The main finding of the present study is that the sex differences in FMS scores frequently seen in the non-overweight group of children cannot be seen in overweight children. To examine this, we assessed 322 children's FMS proficiency. LOC, OC, and MP scores, as well as a waist-to-height ratio, were assigned to the individual child. The differences were checked across sex and weight status, and age was used as a covariate.

The results of our study concerning sex and weight status differences of all measured participants are in accordance with previously reported results. Boys in our study were found to be more proficient in MP and OC (Barnett et al., 2010; Hardy et al., 2010; Spessato et al., 2012), but not in LOC (Goodway et al., 2010; Spessato et al., 2012). Additionally, the results of our study are in accordance with recent literature that examined non-overweight children and found that they perform FMS better than their overweight counterparts do (Logan et al., 2011). Non-overweight children in our study showed better results in MP, LOC, and OC than overweight children did. The findings are also consistent with studies that used other measurements of body composition, such as waist circumference and BMI (Okely et al., 2004).

However, when sex differences across weight status were compared, we detected that the differences in MP, LOC, and OC were not evident in the overweight group. Overweight boys did not show better performances in MP and OC, nor in LOC, in comparison to overweight girls. Overweight boys experienced a more significant discrepancy in MP, OC, and LOC scores when compared to non-overweight boys in comparison to girls. Thus, the FMS proficiency of overweight boys became, particularly in OC, more similar to the girls. Additionally, overweight boys performed FMS on average worse than non-overweight girls did.

Furthermore, critical features of individual FMS were analysed to understand the background of why the sex differences in LOC and OC scores that were detected in non-overweight children, could not be detected in overweight children. The results showed the discrepancy between overweight and non-overweight boys in a higher number of critical features than between overweight and non-overweight girls. In contrast to non-overweight boys, overweight boys' bodies were not leaning slightly forward when running, their hips and knees were not slightly flexed during the ball bounce, and they did not stand side-on to the target with racket held in one hand for a forehand strike. This might suggest a lack of postural control in overweight boys. It seems that the internal representation of the movement that aids in detecting movement errors is hindered in overweight boys in a way appropriate posture cannot be achieved. One explanation could be that they are directing their attention to other critical features of the movement (e.g., contact the ball at about hip height). This could also explain why overweight boys were unable to maintain sight on the reference points such as on the ball/racket throughout the kick/strike and forward throughout the ball bounce. Another explanation could be that because of their overweightness boys are searching for other motor solutions that enable the execution of the movement. However, these solutions might not be in line with proficient execution. For example, when running, overweight boys tend to lean their body slightly backward, which is incorrect execution but enables them to lift their knees in the phase of the front swing. If they leant slightly forward, it would have made the lift of the knees more difficult or even impossible most probably because of weak hip flexors and abdominal muscles in relation to their heavy legs. Previous research showed that obese children are functionally disadvantaged compared to children of healthy body mass when required to move their larger body mass against gravity, and even when required to perform fundamental daily living activities (Riddiford-Harland, Steele, & Baur, 2006). The latter could also be the reason that overweight boys lacked proficiency in critical features that might indicate problems in motor control and co-ordination such as: kicking leg follows through towards the target after the ball contact, balanced and controlled landing with bent knees, contact the ball at about hip height in ball bounce, finish the forehand strike in front of the body, crouch with knees bent and arms behind body, and step towards the target with optional leg after the pass. In FMS, body segments have to be moved in the corresponding time sequence to achieve proficient execution. It seems that overweightness in boys hinders them in applying muscle force in the appropriate time window, and thus makes the optimal performance of movement for them impossible.

In contrast to many critical features that differ between overweight and non-overweight boys, girls showed proficiency difference only in two critical features: hands and fingers were not opened in ball catch, and the knee was not bent during the backswing of the kicking leg in ball kick. These critical features point out a lack of postural control and coordination, as described in boys but to a lesser extent. This can indicate that girls' motor proficiency does not drop as much with overweightness as boys' motor proficiency does. Considering the girls in our study had lower motor proficiency scores in the non-overweight group, they have less room to drop. Boys that scored higher in the non-overweight group have more room to drop.

There are limitations to our study and care should be taken in the generalization of the results, since the number of participants in the age subgroups was relatively small. Additionally, because the data were gathered from a cross-sectional study, we cannot infer the causal direction. Nevertheless, the results indicate a distinct problem of FMS proficiency at the level of critical features in overweight children and boys in particular. The data acquired in our study limit us from making inferences about the origin of the problem. To explain why there is a more significant discrepancy in FMS proficiency between critical features of overweight and non-overweight boys compared to girls further research is needed. Additionally, only a sample of FMS that have been found to be relevant in common sports was selected in the present study. Therefore, the FMS measures do not provide an overall evaluation of a child's FMS proficiency.

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# Burnout and Coping Strategies among Private Fitness Centre Employees

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**ABSTRACT** This study aimed to examine the relationships between burnout and coping strategies among private health and fitness centre employees. Using a stratified random sampling method, a sample of 205 employees (50.7% males and 49.3% females) (51.2% full time and 48.8% part-time) completed the Maslach Burnout Inventory-General Survey (MBI-GS) and Ways of Coping Survey questionnaires. Statistical analysis showed that passive coping was associated with higher levels of depersonalization and lack of personal accomplishment while active coping has a possible negative effect on the development of burnout.

**KEY WORDS** emotional exhaustion, cynicism, personal accomplishment, coping



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BURNOUT AND COPING STRATEGIES

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## Introduction

In psychology, when referring to a syndrome, a set of clues and symptoms that characterize a particular mal-function is meant (Shirom, 2005). Occupational Exhaustion Syndrome or Burnout Syndrome (BS) consists of three dimensions: emotional exhaustion, depersonalization or cynicism, and reduced personal accomplishment (Maslach, Schaufeli, & Leiter, 2001). In the past, it was considered to be primarily associated with social service professionals (Grünfeld et al., 2000). However, as the research interest went on to other occupational sectors, results showed that other occupational groups could also be affected (Maslach & Schaufeli, 1993). The cost of tackling BS is substantial, both for employees and employers or even for national economies. Indicatively, as a result of BS, the cost for the US economy is about \$300 billion per year due to sick leave absenteeism, long-term or permanent disability requiring compensation, and staff retirement as a result of work-related resignation; in the UK, lost labour hours and reduced productivity due to workers' dissatisfaction with work cost the economy 46 billion British pounds (Leiter & Maslach, 2007). Survey results in many developed countries show high rates of BS occurrence, in proportion to their workforce. Thus, 4-7% of the workforce in the Netherlands shows symptoms of advanced BS, 7.4% in Sweden, a similar rate in Finland and slightly higher in Denmark (up to 10%) (Kristensen, Borritz, Villadsen, & Christensen, 2005; Schaufeli & Enzmann, 1998).

The ways in which an employee can avoid developing BS are found in the coping strategies for addressing stressful stimuli. This theory is based on the studies of Lazarus and Folkman (1984) and Lazarus (1991); both agree that there are two ways of coping with stressful stimuli. The first one is adopting a passive attitude, without any reaction. It is the so-called emotional way in which a person attempts, with various techniques such as avoidance, escape, or wishful thinking, to alleviate the negative effect of the stressful stimuli and the negative emotions evolved. The individual tries to feel transiently better, without making an effort to deal with, to manage, or to resolve the stressful situation. Such a situation, however, perpetuates the stress conditions and leads to the development of BS.

The second way refers to active and dynamic strategies for addressing stressful stimuli. By applying a similar strategy, the individual acts systematically to deal with it and to solve it as promptly as possible. In such situations, the person collects information about the situation she/he has to manage, organizes and systemizes it, plans an action with its alternatives, implements it, and attempts in every possible way to attain its solution.

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This way of acting reduces the chances of developing BS, exhaustion and cynicism, while also enhancing the self-efficacy and the sense of occupational satisfaction of the individual.

In general, problem-oriented active coping strategies are more effective in dealing with stressful emotions than emotional, passive-oriented coping strategies are. This is because emotionally oriented strategies include tactics, such as taking distance from a stressful situation, avoiding it, and seeking external support, with the ultimate goal of simply reducing the emotional impact of the stressful stimuli. In contrast, strategies that focus on the problem include collecting information about the problem, preparing a response plan, finding alternatives, and adhering to the action plan. Several research studies' results showed that the problem-oriented strategy seems to have a protective effect against BS due to its de-stressing character and a positive effect on personal occupational achievements and the sense of high professional ability, while passive coping strategies made a substantial contribution to the emergence of burnout and cynicism while presenting a positive correlation of exhaustion on depersonalization (Wiese, Rothmann, & Storm, 2003).

If chronic exposure to stress is the result of a person's choice of passive strategies to deal with stressful situations while choosing active strategies reduces the risk of developing BS, then there may be a solution for avoiding the occurrence of BS: the proper training for employees to choose the correct strategies for dealing with stressful situations.

Among other occupational areas, researchers' interest turned to sport. Research has examined physical education teachers, coaches, or even athletes and business executives (Caccese & Mayerberg, 1984; Kelley, Eklund, Ritter, & Taylor, 1999; Koustelios & Tsigilis, 2005; Koustelios, 2001; Kubayi, 2018; Martin, Kelley, & Dias, 1999; Tsigilis, Zournatzi, & Koustelios, 2011).

Nevertheless, to date, there is no known literature concerning the existence of burnout among private sport and fitness centres sector employees and their coping strategies. The present study seeks to explore the connection between BS and the coping strategies used in the context of the private sports sector services.

## Methods

### Participants

Participants were 205 employees of private fitness centres from the region of Attica, Greece, 104 (50.7%) men and 101 (49.3%) women, of whom 105 (51.2%) were working full time and 100 (48.8%) part-time. With regard to the age of the participants, 82.9% (81 men and 89 women) belong to the 18-37 age group, and 17.1% (23 men and 12 women) are aged 38 to 67 years.

### Measures

#### *Maslach Burnout Inventory-General Survey (MBI-GS)*

For the purpose of the present study, the Maslach Burnout Inventory-General Survey (MBI - GS) (Maslach, Jackson, & Leiter, 1996) was used, in its Greek version (Αντωνίου & Ξένου, 2008). It consists of 16 questions, five of which refer to emotional exhaustion, six questions refer to depersonalization, while the last five refer to personal achievements. Respondents expressed their opinion on a seven-point Likert scale, in which "1 = never" and "7 = every day". The credibility of internal consistency was found to be satisfactory for Emotional Exhaustion  $\alpha = 0.83$ , Depersonalization  $\alpha = 0.71$ , and Personal Accomplishments  $\alpha = 0.81$ .

#### *Coping Strategies Questionnaire*

The Coping Strategies Questionnaire consists of 25 sentences. It is designed to measure both positive and negative strategies used by an individual to overcome different stressful situations. Respondents are asked to evaluate the 25 stress-response strategies using a four-dimensional Likert type scale (from "1 = I have not used it" to "4 = I have used it very often"). Stress management strategies are divided into the following subclasses and are similar to those proposed by Lazarus and Folkman (1984).

The Positive Approach includes eight questions that evaluate the person's attempt to re-evaluate stressful situations in a positive way and to design techniques to solve the problem ("I concentrated on what I had to do next", "I was trying to see the optimistic side of things", "I was altering something to make a positive turn", "I stood on my feet, and I fought for what I wanted", "I used past experiences", "I was doubling my efforts", "I got alternatives to a problem", "I made a plan of action and I implemented"). The reliability Cronbach index was  $\alpha = 0.74$ .

Assertive Problem Solving, with 5 questions, evaluates the individual's attempt to achieve a solution by confidently addressing the situation or the person who creates it ("I was trying to address the responsible person to change my mind", "I was out the anger in the person responsible for the problem", "I did something risky to change the problem", "I rushed to other people", "I did something I did not think would work, but at least I did something"). The reliability Cronbach index was  $\alpha = 0.60$ .

Avoidance/Escape includes eight questions and is related to avoiding the stressful stimuli, reducing or ignoring their true meaning ("I continued as if nothing had happened", "I was trying to forget the whole thing", "I kept my feelings away", "I was trying to feel better by eating or taking medication", "I avoided being with people", "I refused to think about it", "I did not mind the situation", "I refused to think about what had happened"). The reliability Cronbach index was  $\alpha = 0.64$ .

Wishful Thinking includes four questions and evaluates the person's tendency to overcome the problems by wishing a miracle ("I was hoping for a miracle", "I accepted the fate, sometimes I have bad luck", "I wished the situation to end in some way", "I thought things could evolve"). The reliability Cronbach index was  $\alpha = 0.60$ .

A demographic variables questionnaire concerning gender, age, type of employment, work status, and other factors was also distributed.

#### Data collection and analysis

Participants were chosen following a combination of stage and random sampling methods; with reference to four out of the eight administrative districts of the Attica Region, 25 out of the 35 municipalities in the four administrative districts, 101 out of 201 private gyms in preselected municipalities were initially identified. The questionnaires were delivered and collected within 15 days. The questionnaire package also included a cover letter informing prospective participants of the purposes of the survey, the optional and voluntarily nature of their participation, and the anonymity of their responses. The statistical analysis was completed using the SPSS 19 statistical package for social sciences (SPSS Inc., Chicago IL, USA) and included descriptive statistics with means (M.) and standard deviations (S.D.), simple regression analysis ANOVA, and stepwise multiple regressions using the enter method.

#### Results

According to the results of the analysis of variance of the Coping Strategies Questionnaire, males are more assertive than females are in coping with stressful situations, whereas females resort more than males in Wishing  $F(1, 204) = 3.20$ ,  $p = 0.05$ . No differences were found related to the participants' working status (see Table 1).

TABLE 1 Means of the respondents in the questionnaire Coping Strategies as regards the employees' gender

| Coping Strategies         | Gender |         |       |        |
|---------------------------|--------|---------|-------|--------|
|                           | Males  | Females | Total | F      |
|                           | M.     | M.      | M.    |        |
| Positive Approach         | 1.94   | 1.98    | 1.96  | 0.28   |
| Assertive Problem Solving | 0.89   | 1.03    | 0.96  | 3.32 * |
| Avoidance / escape        | 1.11   | 1.05    | 1.08  | 0.73   |
| Wishful Thinking          | 1.28   | 1.11    | 1.20  | 4.59 * |

Note. \* $p < 0.05$ . \*\* $p < 0.01$ . \*\*\* $p < 0.001$ .

In order to examine the statistical prediction of the coping strategies for addressing stressful situations (dependent variables) of the participants from the factors of the MBI-GS Questionnaire (independent variables), four hierarchical regressions were performed using the enter method.

In the first step, gender was introduced, in the second working status, and in the third one the BS factors (emotional exhaustion, depersonalization and personal accomplishment). Table 2 presents the prediction of the Positive Approach from BS subscales. The results show that Personal Accomplishment positively predicts the Positive Approach,  $\beta = 0.18$ ,  $t = 2.43$ ,  $p < 0.05$   $R^2 = 3.4\%$ .

TABLE 2 Regression analysis of the Positive Approach strategy from gender, work status and MBI-GS factors

| Predictors              | Positive Approach |        |       |      |
|-------------------------|-------------------|--------|-------|------|
|                         | $\beta$           | t      | $R^2$ | F    |
| Gender                  | 0.04              | 0.54   | 0.001 | 0.28 |
| Work Status             | -0.05             | -0.71  | 0.005 | 1.1  |
| Burnout                 |                   |        |       |      |
| Emotional exhaustion    | -0.01             | -0.16  | 0.034 | 2.38 |
| Depersonalization       | -0.05             | -0.60  |       |      |
| Personal accomplishment | 0.18              | 2.43 * |       |      |

Note. \* $p < 0.05$ . \*\* $p < 0.01$ . \*\*\* $p < 0.001$ .

Table 3 presents the prediction of Assertive Problem Solving from the MBI-GS questionnaire factors. The results show that males are more assertive for a problem's solution than females are,  $\beta = 0.13$ ,  $t = 2.02$ ,  $p < 0.05$   $R^2 = 1.6\%$ . Emotional Exhaustion  $\beta = 0.22$ ,  $t = 3.23$ ,  $p < .0$  and Depersonalization  $\beta = .21$ ,  $t = 3.14$ ,  $p < 0.01$  contribute positively to the Assertive Problem Solving, while the contribution of Personal Accomplishment is negative  $\beta = -0.21$ ,  $t = -3.20$ ,  $p < 0.01$ . The overall contribution of the prediction of the Assertive Problem Solving strategy from the MBI-GS questionnaire is  $R^2 = 17\%$ .

**TABLE 3** Regression analysis of the Assertive Problem Solving from gender, work status and MBI-GS questionnaire factors

| Predictors              | Assertive Problem Solving |        |                |           |
|-------------------------|---------------------------|--------|----------------|-----------|
|                         | $\beta$                   | t      | R <sup>2</sup> | F         |
| Gender                  | 13.00 *                   | 2.02   | 0.016          | 3.32      |
| Work Status             | 0.05                      | 0.79   | 0.009          | 1.85      |
| Burnout                 |                           |        | 0.17           | 13.95 *** |
| Emotional exhaustion    | 0.22 **                   | 3.23   |                |           |
| Depersonalization       | 0.21 **                   | 3.14   |                |           |
| Personal accomplishment | - 0.21 **                 | - 3.20 |                |           |

Note. \* $p < 0.05$ . \*\* $p < 0.01$ . \*\*\* $p < 0.001$ .

The prediction of Avoidance / Escape coping strategy is shown in Table 4. Depersonalization  $\beta = 0.18$ ,  $t = 2.55$ ,  $p < 0.01$  contributes positively to the Avoidance/Escape coping strategy, while the contribution of Personal Accomplishment is negative  $\beta = -0.16$ ,  $t = 2.29$ ,  $p < 0.01$ . The overall contribution of the prediction of this coping strategy from the MBI-GS questionnaire is  $R^2 = 9\%$ .

**TABLE 4** Regression analysis of Avoidance/Escape strategy from gender, work status and MBI-GS questionnaire factors

| Predictors              | Avoidance / Escape |        |                |          |
|-------------------------|--------------------|--------|----------------|----------|
|                         | $\beta$            | t      | R <sup>2</sup> | F        |
| Gender                  | - 0.05             | - 0.78 | 0.004          | 0.73     |
| Work Status             | 0.09               | 1.27   | 0.014          | 2.83     |
| Burnout                 |                    |        | 0.09           | 6.88 *** |
| Emotional exhaustion    | 0.13               | 1.77   |                |          |
| Depersonalization       | 0.18 **            | 2.55   |                |          |
| Personal accomplishment | - 0.16 **          | - 2.29 |                |          |

Note. \* $p < 0.05$ . \*\* $p < 0.01$ . \*\*\* $p < 0.001$ .

Concerning the prediction of the Wishful Thinking strategy from the MBI-GS factors, results are presented in Table 5. Females are associated with a higher level of using the Wishful Thinking strategy to manage a stressful situation  $\beta = -0.14$ ,  $t = -2.03$ ,  $p < 0.05$ ,  $R^2 = 2.2\%$ . Emotional Exhaustion  $\beta = 0.20$ ,  $t = 2.84$ ,  $p < 0.01$  and depersonalization  $\beta = 0.14$ ,  $t = 1.91$ ,  $p < 0.05$  contribute positively to the use of Wishful Thinking as a stress management strategy, while the contribution of personal accomplishments is negative  $\beta = -0.13$ ,  $t = -1.93$ ,  $p < 0.05$ . The overall contribution of predicting the use of Wishful Thinking from the MBI-GS questionnaire factor is  $R^2 = 9\%$ .

**TABLE 5** Regression analysis of Wishful Thinking strategy from gender, work status and MBI-GS questionnaire factors

| Predictors              | Wishing  |        |                |          |
|-------------------------|----------|--------|----------------|----------|
|                         | $\beta$  | t      | R <sup>2</sup> | F        |
| Gender                  | - 0.14 * | - 2.03 | 0.022          | 4.59 *   |
| Work Status             | 0.10     | 1.53   | 0.018          | 3.76 *   |
| Burnout                 |          |        | 0.09           | 6.98 *** |
| Emotional exhaustion    | 0.20 **  | 2.84   |                |          |
| Depersonalization       | 0.14 *   | 1.91   |                |          |
| Personal accomplishment | - 0.13 * | - 1.93 |                |          |

Note. \* $p < 0.05$ . \*\* $p < 0.01$ . \*\*\* $p < 0.001$ .

## Discussion

The aim of the present study was twofold. Initially, the choices of coping strategies towards stressful situations were examined, with references to the factors of gender and work status in the private fitness centre employees. The results showed that male employees make statistically significant higher use of Assertive Problem-Solving strategy than their female counterparts do. In contrast, female employees make statistically significant use of the Wishful Thinking strategy at higher levels than their male colleagues do. There was no statistical significance found between genders concerning the Positive Approach or the Avoidance/Escape coping strategies' use.

The second aim of the study was to examine the prediction of coping strategies from the Burnout factors through the MBI-GS questionnaire. The results showed that Personal Accomplishments predicts the Positive Approach strategy up to 3.4%. Burnout variables in total explain 17% of the Assertive Problem Solving strategy. In more detail, Emotional Exhaustion and Depersonalization contribute positively while Personal Accomplishments contribute negatively. Concerning the coping strategy of Avoidance/Escape,

both Depersonalization and Personal Accomplishments contribute positively with an overall explanation of up to 9%. Finally, Emotional Exhaustion and Depersonalization contribute positively, while Personal Accomplishment contributes negatively to the Wishful Thinking strategy with a total of 9% of explanation BS factors.

The results point towards two directions. The first direction concerns the gender factor. Female employees make use of passive coping strategies while male employees use more active ones. The second direction shows that passive strategies are closely connected and can be predicted by BS factors and they are positively connected with Emotional Exhaustion and Depersonalization, while active coping strategies are positively connected and predicted by Personal Accomplishment. Interpreting the abovementioned point, an employee using passive strategies cannot manage stressful situations successfully and may already have or is about to develop BS. That means that female employees may be at greater risk, and they need more help than their male counterparts do. In contrast, an employee with high levels of Personal Accomplishments regularly uses active strategies, which means that he/she can respond successfully to a stressful situation while maintaining low stress levels.

In conclusion, this study gives a first class opportunity to the management of the private sport sector by using the coping strategies choices' of their employees as an indicator, as a diagnostic tool, and as a deterrence tool. Management should be able to recognize the signs of their employees' coping strategies choices and should be able to train and guide them to use active coping strategies to manage stressful situations more efficiently. Proper active coping strategies on behalf of the employees will reduce the stress effects of stressful situations and will work as a precaution measure towards the appearance of Burnout Syndrome. Future research should also have more extensive samples, from different employee groups of the sport service sector, even in a longitudinal perspective for more reliable and generalized results.

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# The Effects of High-Intensity Interval Training on Skeletal Muscle Morphological Changes and Denervation Gene Expression of Aged Rats

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**ABSTRACT** Muscle denervation is one of the most critical pathological factors involved in muscle atrophy as a result of ageing. This study aims to investigate the chronic effect of high-intensity interval training (HIIT) on cross-sectional areas and muscle denervation genes, interpreted in the plantaris muscle atrophy of aged rats. Twenty-eight aged and young rats were divided into four different groups, including exercise and control. The training protocol included six weeks of HIIT. Animals were sacrificed 48 hours after the last training session, and the plantaris muscle was removed. To measure Gadd45a mRNA and NCAM1mRNA, we used a real-time PCR technique. The cross-sectional area was measured with photomicrography using an H&E technique. The results showed that ageing significantly decreased NCAM1 mRNA in the aged control group ( $p=0.0001$ ) and exercise leads to a significant increase (interaction effect) of it ( $p=0.003$ ). Gadd45a mRNA was significantly increased due to ageing ( $p=0.009$ ), and exercise resulted in a significant decrease in that in the aged exercise group ( $p=0.04$ ). The cross-sectional area in the aged control group was significantly smaller than in the young control group ( $p=0.046$ ). In contrast to young groups, exercise could increase the cross-sectional area in the aged exercise group compared with the aged control group, but it was not significant ( $p=0.069$ ). It seems that HIIT could improve ageing-induced muscular atrophy, although denervation-involved gene modification leads to an increase in the muscular cross-sectional area; therefore, it improves muscular atrophy due to ageing.

**KEY WORDS** high-intensity interval training, muscular atrophy, muscle denervation, ageing, gadd45a protein, ncaml protein



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HIIT EFFECTS ON DENERVATION IN THE SKELETAL MUSCLE OF AGED RATS

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## Introduction

Ageing deteriorates muscle strength and mass (known by the term “sarcopenia”). This leads to a reduced functional capacity as well as an increased risk of chronic metabolic diseases (Kurokawa, Mimori, Tanaka, Kohriyama, & Nakamura, 1999). Sarcopenia can be found particularly in muscle fibre research shows that fast twitch fibres are most affected as a result of ageing (Snijders, Verdijk, & van Loon, 2009). Diminished numbers of motoneurons due to ageing could reduce the number and size of muscle fibres. This can cause impaired muscle functions, such as maximum power, power, and rate of force development (RFD), which play significant roles in routine activities (Aagaard, Suetta, Caserotti, Magnusson, & Kjaer, 2010). Evidence suggests that motoneuron failure is one of the causes of sarcopenia, and this is because of its connection to muscle fibres. Therefore, the loss of motoneurons is the first incidence in fast twitch muscles damage during ageing (Drey et al., 2014). However, the number and size of motoneurons do not change in the spinal cord during the whole life, but this does happen in neuromuscular junctions (Chai, Vukovic, Dunlop, Grounds, & Shavlakadze, 2011). During ageing, motoneurons' capability is subjected to be shrunk, and muscle fibres

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and motoneurons connections would become thinner; this ultimately leads to muscular atrophy (Gyorkos & Spitsbergen, 2014). Therefore, recognizing the mechanisms involved in neuromuscular degeneration, and the interventions that can reverse these mechanisms is essential.

There is strong evidence showing that, after denervation, acetylcholine receptors, as well as NCAM1 (Knudsen, McElwee, & Myers, 1990; Walsh, Hobbs, Wells, Slater, & Fazeli, 2000) and Gadd45 $\alpha$ , which induce atrophy (Barns et al., 2014; Bongers et al., 2013), are increased. In contrast, it has been shown that exercise not only create a non-surgical and non-pharmacological protective mechanism against diseases and musculoskeletal disabilities, but it is also assumed to be a way of maintaining the function and structure of synapses and regenerating damaged neurons (Gyorkos & Spitsbergen, 2014; Smith & Mulligan, 2014). In addition to endurance/aerobic training (Samiei, Behpour, Tadibi, & Fathi, 2018), studies show HIIT exercises have many benefits, including improving glucose levels in diabetic subjects (Rahmaty, Gaeini, Dolatshahi, & Choobineh, 2018), reducing inflammation in adipose tissue (Alizadeh, Asad, Faramarzi, & Afroundeh, 2017), and increasing prolonged motoneuron maintenance and neuromuscular junctions (M. R. Deschenes et al., 1993) and has led to neuronal sprouting and proliferation in both healthy and unhealthy subjects (Sabatier, Redmon, Schwartz, & English, 2008). Therefore, the purpose of this study is to investigate the effect of six weeks of HIIT on NCAM1 and Gadd45 $\alpha$  gene expression in order to observe denervation in the plantaris muscle of aged rats. In addition, because the role of exercise to modify these factors in the neuromuscular junction has not been studied yet, and in order to ensure that NCAM1 and Gadd45 $\alpha$  are reliable factors, the effect of exercise on changes in the muscular cross-sectional area will also be identified.

## Methods

### Animals

Experiment protocols for rats were planned according to the policies of the Iranian Convention for the Protection of Vertebrate Animals, and the Ethics Committee of the School of Medicine Sciences, Tarbiat Modares University (TMU), authorized the protocol. Twenty-four male Wistar rats (aged 4-5 months), obtained from Iran Pasteur Institute were collected in the current study. They dwelled in a standard temperature room and 12-h light and dark periods with unlimited access to water and food. They were maintained in the Animal House in the School of Medical Sciences of TMU. Animals (5 in each group) were randomly divided into four groups: Aged Control (AC) Aged Training (AT), Young Control (YC), and Young Training (YT).

### Training protocol

The training groups performed five sessions each week of HIIT for six weeks, and 48 hours after the last training session, the training groups did not perform any exercise until they were sacrificed. After the animals were sacrificed, the left foot plantaris muscle was frozen immediately in liquid nitrogen for cellular and molecular testing, and then stored in a refrigerator for 80 days. The right leg muscle was used for conducting a 10-25% formalin test for histochemical experiments. In the current study, the plantaris muscle was chosen because it is predominantly composed of (II-60%) muscle fibres of type II (Michael R Deschenes, Roby, & Glass, 2011).

At the beginning, in order to reduce stress as well as create familiarity with running on a treadmill, the subjects ran on a training programme for a week at speeds of 10 to 18 metres per minute (m/min) for ten minutes. Then, 48 hours after the last familiarization session, an exhausting test was performed, starting at a speed of 10 m/min and increased by 3 m for every three minutes (Thomas, Bishop, Moore-Morris, & Mercier, 2007).

TABLE 1 Training protocol

| Week | Sets | Rest & Exercise Ratio | Exercise Intensity | Rest Intensity | Average Speed in Week | Time of Training (minutes) | Days per week |
|------|------|-----------------------|--------------------|----------------|-----------------------|----------------------------|---------------|
| 1    | 5    | 2:2                   | 80%                | 60%            | 70%                   | 90                         | 5             |
| 2    | 6    | 2:2                   | 80%                | 60%            | 70%                   | 110                        | 5             |
| 3    | 7    | 2:2                   | 90%                | 50%            | 70%                   | 130                        | 5             |
| 4    | 8    | 2:2                   | 100%               | 50%            | 75%                   | 150                        | 5             |
| 5    | 8    | 2:2                   | 100%               | 50%            | 75%                   | 150                        | 5             |
| 6    | 8    | 2:2                   | 100%               | 50%            | 75%                   | 150                        | 5             |

The time to fatigue was determined by the inability of the rats to run on the treadmill. After determining the maximum speed, the training groups participated in a six-week HIIT programme (Tables 1 and 2).

TABLE 2 Maximum speed and training session intervals

| Groups | Speed level     | Week 1 <sup>st</sup> & 2 <sup>nd</sup> | Week 3 <sup>rd</sup> | Week 4 <sup>th</sup> | Week 6 <sup>th</sup> & 7 <sup>th</sup> |
|--------|-----------------|--|----------------------|----------------------|--|
| YT     | Max Speed       | 40                                     | 44                   | 44                   | 47                                     |
|        | Sprint Interval | 32                                     | 40                   | 44                   | 47                                     |
|        | Rest Interval   | 24                                     | 22                   | 22                   | 24                                     |
| AT     | Max Speed       | 34                                     | 37                   | 37                   | 40                                     |
|        | Sprint Interval | 27                                     | 33                   | 37                   | 40                                     |
|        | Rest Interval   | 20                                     | 19                   | 19                   | 40                                     |

Note. YT: Young Training; AC: Aged Control; AT: Aged Training.

### Moulding and cutting of muscle

Forty-eight hours after fixing the tissues in formalin, the samples were distilled from alcohol into different degrees of purity (70, 80, 90, and 100), the stopping time of each one in alcohol containers was calculated for two hours. In the next step, a microplate was used to cut them, and 5 microns of each sample were placed in the required measurements. The slides then were placed in a hot bath for at least 60 °C to melt the paraffin from the tissue section; in addition to this, the tissue was stuck to the lamina. Removed sections were then transferred to the slide, and after removing paraffin in an oven at 120 ° for 10 minutes and washing steps in alcohol of different purities, immunohistochemical staining and H & E were performed.

### H & E staining and cross-sectional measurements

To measure the cross-sectional area (CSA) of the muscle, muscle samples were fixed in 10% formalin and then moulded into paraffin. The fixed organ tissues were then embedded in paraffin. The paraffinized tissue specimens were cut into 5 µm-thick slices and were stained with hematoxylin and eosin (H&E) for histopathological observation using a previously established procedure (Carleton, Drury, & Wallington, 1967). Photomicrographs were captured using a normal spectra fluorescent microscope (Olympus DP 72) at 6100× magnification with an attached digital camera (Olympus, Tokyo, Japan).

### Real-time PCR

Total RNA was extracted from the plantaris muscle samples by exerting QIAzol<sup>®</sup> Lysis Reagent (Qiagen) according to the manufacturer's recommendations. RNA concentrations were defined by the rate of absorbance at 260 nm. RNA purity also was determined by absorbance ratio at 260 and 280 nm, and with a Nano-Drop Machine. Acceptable purification in 260/280 nm absorbance ratio above 1.8. RNA was reverse-transcribed into complementary DNA (cDNA) using a Revert Aid first standard cDNA Synthesis Kit (Thermo Scientific, Fermentas K1622, United States) using an accepted protocol including reverse transcription at 25 °C for five minutes, then inactivated reverse transcriptase at 42 °C for 60 minutes, and finally refrigeration at 70 °C for five minutes, with storage at -20 °C.

For real-time PCR, primers were designed using NCBI and gene runner software and synthesized by Cinnagen Company (Iran). The primer sequences are shown in Table 3. Gene expression measurement was done with Master Mix and SYBR Green in an Applied Biosystems, StepOne<sup>™</sup> thermal cycler. The thermal cycle protocol was divided into protocols including one cycle at 95 °C in 10 min, followed by 40 cycles at 95 °C for 15 s, and 60 °C for 30 s. PCR amplification also was performed with duplication in a total reaction volume in 20 µl. The reaction mixture had three µl diluted templates, 10 µl SYBR Premix Ex Taq<sup>™</sup> Kit (Perfect Real Time, Takara Code RR041A, Japan), and two µl primers. Amplification specificity was monitored using the analysis of the melting curve. Genes' relative expression were normalized by subtracting the housekeeping levels of the mean of glyceraldehyde 3-phosphate dehydrogenase (Gapdh) 2-ΔΔCT, which was amplified as a housekeeping gene. All data are represented as fold changes from the weight-bearing group (Livak & Schmittgen, 2001).

TABLE 3 Sequences of the primer designed in this study

| Primer | sequences                        |
|--------|----------------------------------|
| NCAM1  | forward 5'CCAGTACATTGAGCACCTAC3' |
|        | reverse 5'GCAAATGATCTACTGGGTG3'  |
| Gadd4a | forward 5'TAACTGTCGGCGTGACGAG3'  |
|        | reverse 5'GCAACAGAAAGCACGAATGA3' |
| Gapdh  | forward 5'GACATGCCGCTGGAGAAA3'   |
|        | reverse 5'AGCCCAGGATGCCCTTTAGT3' |

### Statistical Analysis

All statistical analyses were done using SPSS software (version 20, SPSS Inc., Chicago, IL, USA). The normal assumption was examined using a one-sample Kolmogorov-Smirnov test. Two-way ANOVA tests were used to compare groups regarding under study variables, and the significant level was determined at  $p < 0.05$ .

## Results

### Body mass

Changes in body mass before and after exercise are shown in Table 3. The results of the t-test for intra-group comparison of body mass changes showed that the weight of both young groups increased significantly at the end of six weeks compared to the baseline measurements ( $p = 0.001$ ). However, the control group and the aged training group showed a non-significant increase compared to the pre-test data ( $p = 0.655$ ,  $p = 0.83$ , respectively) (Table 4).

TABLE 4 Weight changes in the experimental groups

| Variable  | Group | Pre - test     | Post - test      |
|-----------|-------|----------------|------------------|
| Body Mass | YC    | 314.15 ± 17.63 | 370.23 ± 18.52 * |
|           | YT    | 299.82 ± 10.54 | 347.03 ± 17.15 * |
|           | AC    | 386.02 ± 9.55  | 390.37 ± 55.09   |
|           | AT    | 407.23 ± 11.51 | 400.35 ± 1.76    |

Note. YC: Young Contro;; YT: Young Training; AC: Aged Control; AT: Aged Training; \*: Significant Difference to pre-test ( $p = 0.001$ ).

### Plantaris muscle weight

The results of one-way ANOVA to compare absolute weight and relative weight (muscle/body mass ratio) of the plantaris muscle showed a significant difference between groups ( $p=0.001$ ;  $p=0.001$ ). Therefore, Tukey's post hoc test showed that the absolute and relative weight of the plantaris muscle in aged rats was significantly lower than young groups ( $p=0.002$ ,  $p=0.001$ ) (Table 5). HIIT significantly decreased muscle weight in young rats ( $P = 0.99$ ), but the relative ratio was increased, although the difference was not statistically significant between these two groups ( $p=0.466$ ). In comparison with the young groups, HIIT increased both muscle weight ( $p=0.106$ ) and relative weight ( $p=0.425$ ) in the aged training group.

TABLE 5 The average of relative and absolute plantaris weight

| Variable               | YC                   | YT                    | AC                    | AT                  |
|------------------------|----------------------|-----------------------|-----------------------|---------------------|
| Plantaris Weight (mg)  | $0.3949 \pm 0.024$   | $0.378 \pm 0.033$     | $0.321 \pm 0.048^*$   | $0.364 \pm 0.039$   |
| Relative Weight (mg/g) | $0.00106 \pm 0.0007$ | $0.00115 \pm 0.00078$ | $0.00083 \pm 0.00016$ | $0.0009 \pm 0.0007$ |

Note. YC: Young Control; YT: Young Training; AC: Aged Control; AT: Aged Training; \*: Significant Difference to YT ( $p < 0.05$ ).

### Cross section area (CSA) of muscle fibres

The results of one-way analysis of variance analysis showed a significant difference between groups ( $P = 0.032$ ). Tukey's post hoc test showed that the cross-sectional area of the muscle fibres in the control aged group was significantly less than in young groups ( $P = 0.046$ ) (Figure 1 A and C). Compared to the young groups, there was a non-significant decrease in the cross-sectional area of the trained rats as opposed to the control ( $P = 0.53$ ) (Figure 1 -A and -B).

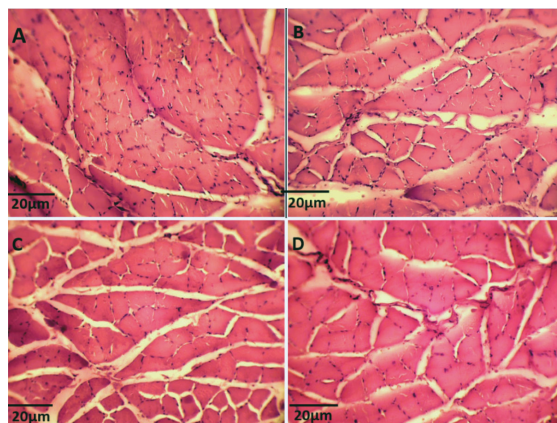


FIGURE 1 Plantaris Micrograph Photo. (A): Young Control; (B): Young Training; (C): Aged Control; (D): Aged Training.

Unlike with the young groups, exercise significantly increased the size of muscle fibres in the aged training group ( $P = 0.69$ ) (Fig. 1 -C and -D), but still less than in the young groups according to the data (Table 6).

TABLE 6 Cross section area (CSA) of muscle fibres

| Variable              | YC                 | YT                | AC                 | AT                 |
|-----------------------|--------------------|-------------------|--------------------|--------------------|
| CSA ( $\mu\text{m}$ ) | $308.47 \pm 60.32$ | $297.1 \pm 46.94$ | $260.46 \pm 60.32$ | $273.74 \pm 31.04$ |

Note. CSA: Cross Section Area; YC: Young Control; YT: Young Training; AC: Aged Control; AT: Aged Training; \*: Significant Difference to YC ( $p < 0.05$ ).

### mRNA expression of Gadd45a

The results show that HIIT has significantly reduced Gadd45a expression in the plantaris muscle of aged rats ( $p=0.041$ ). Ageing resulted in a significant increase in this gene ( $p=0.0001$ ), but in the young group, exercise did not show a significant effect on Gadd45a expression ( $p=0.465$ ) (Figure 2).

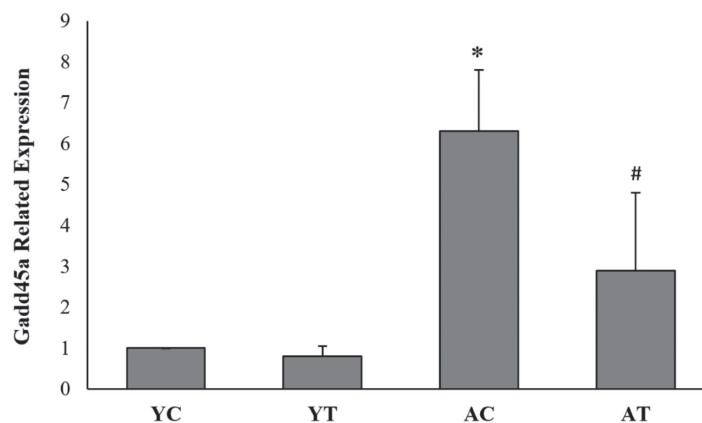


FIGURE 2 Related Expression mRNA Gadd45a. YC: Young Control; YT: Young Training; AC: Aged Control; AT: Aged Training; \*: Significant Difference to YC. #: Significant Difference to AC.

**mRNA expression of NCAM1**

In contrast, HIIT significantly increased NCAM1 mRNA expression in the plantaris muscle of aged rats ( $P = 0.001$ ). Moreover, ageing resulted in a significant decrease in this gene ( $P = 0.0040$ ), but in the YT group, exercise did not show a significant effect on NCAM1 mRNA expression ( $P = 0.315$ ) (Figure 3).

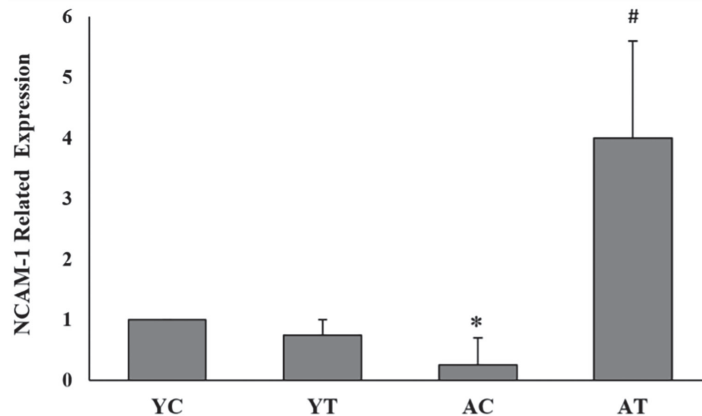


FIGURE 3 Related Expression mRNA NCAM-1. YC: Young Control; YT: Young Training; AC: Aged Control; AT: Aged Training; \*: Significant Difference to YC. #: Significant Difference to AC.

**Discussion**

The findings have shown that consistent with previous research results, ageing significantly reduced the weight of the plantaris muscle and diminished the cross section area and relative muscle weight. In contrast, the results have shown that six weeks of HIIT almost reduced the size of the plantaris muscle in young rats. This reduction in muscle fibres after exercise could be advantageous because it has been reported that change of muscle fibres size after endurance training reduces the distance between muscle fibres and blood capillaries, where gas exchange should occur (Hoppeler, Howald, & Cerretelli, 1990). Unlike young rats, the aged group showed an increase in muscle weight and size after training. This difference between the aged and young groups muscles' response to exercise can be due to differences in their compatibility capacity. Since ageing causes atrophy in muscle fibres, this kind of muscle fibres has a higher potential for hypertrophy, even in response to endurance exercises that usually do not lead to hypertrophy (Michael R Deschenes, Hurst, Ramser, & Sherman, 2013). To support this claim, reference can be made to Cogan's study, in which it was reported that endurance training leads to muscle fibroblastic hypertrophy in human subjects (Coggan et al., 1992).

During embryonic growth, acetylcholine receptors are expressed with fetal isoforms by muscle fibres before becoming neurons. The high volume of receptors makes fibres extremely sensitive to acetylcholine. After neurotization, a significant decrease in acetylcholine receptors expression occurs except for the muscular cells' area, which is assumed to be a communication site between nerves and muscle (Cohen et al., 2007). Loss of the nervous system is concurrent with the expression of all subtypes of acetylcholine receptors. In addition, it over-expresses Gadd45 subcategories.

Regarding this evidence, our results showed that there was a significant increase in Gadd45a expression in aged plantaris muscle compared to young muscle. Gadd45a also shows an almost twofold increase from 15 to 24 months and then a decrement with age (Barns et al., 2014). Studies have shown that the nervous system's response to damage caused by peripheral nerve suppression is different in healthy rats and NCAM-free mice; therefore, peripheral axons of motor neurons are reshaped after surgical abnormalities in normal healthy rats, but axon growth is impaired and defective in NCAM-free mice (Grumbles, Almeida, & Thomas, 2008). A study done on surgically debilitated young and aged mice showed that a muscle twitch after nerve rupture in young mice resulted in a 33% increase in NCAM (Biral et al., 2008).

In comparison to aged rats, axonal growth defects are associated with no significant change in NCAM; this could be attributed to the inability to regenerate peripheral nerves in aged subjects in the absence of NCAM changes (Gatchalian, Schachner, & Sanes, 1989). In addition, physical activity as a non-pharmacological intervention has great importance in the function and structure maintenance of synapses and recovering damaged neurons. Studies that examine the effect of exercise on muscle show that endurance exercise improves the reabsorbed muscle fibres (English, Cucoranu, Mulligan, & Sabatier, 2009; Krakowiak et al., 2015) and the number of myelin axons after peripheral nerve damage (Asensio-Pinilla, Udina, Jaramillo, & Navarro, 2009; Bobinski, Martins, Bratti, & Mazzardo-Martins, 2011). HIIT also increases neuromuscular stability and prolongs neuronal growth more than low-intensity exercises do (M. R. Deschenes et al., 1993; Sabatier et al., 2008). The amount of muscular activity directly affects NMJ size (M. R. Deschenes et al., 1993): it can be concluded that the amount of involved muscle during an exercise activity significantly influences NMJ structures. For example, it has been shown that in comparison to plantaris and EDL muscles, followed by exercise activity, the changes only applied to the plantaris muscle (Alshuaib & Fahim, 1990).



In conclusion, the results of this study revealed an increased Gadd45a level and a decreased level of NCAM1 in the plantaris muscles of aged rats, which was associated with a decrease in the muscle's cross-sectional area. Therefore, we can argue that as the process of sarcopenia develops from type 2 or fast muscle fibres, there is a relationship between the amount of muscle fibres and musculoskeletal system health. In this regard, the benefits of higher intensity exercises to various physical systems in different populations, such as athletes, patients, and the elderly, are well-defined (Madden, 2018; Ramírez-Vélez et al., 2016). Elderly people also may benefit from high-intensity exercises to improve their musculoskeletal health, in order to reduce the effects of ageing on muscle mass, and ultimately prevent their disabilities in doing routine activities and preventing metabolic diseases.

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# How Grit is Related to Objectively Measured Moderate-to-Vigorous Physical Activity in School Student

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**ABSTRACT** This study aimed to estimate parameters of the model in which perseverance of effort and consistency of interest of grit scale are related directly to objectively measured physical activity (PA) and indirectly via PA intention in school students (N = 209) aged 12 to 14 years. The Grit Scale was used to estimate the consistency of interests and perseverance of efforts. The measure for intention consisted of two items from the Theory of Planned Behaviour Questionnaire. Actigraph was used to measure moderate-to-vigorous physical activity (MVPA) during seven consecutive days. A well-fitting structural equation model ( $\chi^2 = 46.169$ ,  $df = 31$ ; CFI = .958; RMSEA = .053) demonstrated the significant direct effect ( $\beta = .286$ ,  $p < .001$ ) from perseverance of efforts on intention to be physical active. Physical activity intention mediated the effect of the perseverance of efforts on moderate-to-vigorous physical activity (MVPA), but not the effect of consistency of interest. The total effect from the consistency of interest on MVPA was significant, but the perseverance of efforts was not. The dimension of the perseverance of efforts between groups with high and low MVPA was not statistically significantly different, whereas the intention was significantly higher in the high-MVPA group. The consistency of the interest dimension in the high MVPA group was significantly higher than in low group only at  $p < .1$  level. The findings of the study may be used by physical education teachers for the promotion of physical activity, highlighting the role of consistency of interest on MVPA.

**KEY WORDS** grit, intention, moderate-to-vigorous physical activity, school students



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GRIT, INTENTION, AND PHYSICAL ACTIVITY

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## Introduction

A large number of studies based on self-determination theory (SDT; Deci & Ryan, 1985) and theory of planned behaviour (TPB; Ajzen, 1985) have shown how cognitive factors are related to physical activity in leisure time (see for review Hagger & Chatzisarantis, 2016). However, less is known about whether non-cognitive factors like personality traits have the potential to influence physical activity. One of the personality traits that has been of interest recently is grit. Duckworth Matthews, and Kelly (2007) have defined grit as the perseverance of effort and passion for long term goals. According to this definition, grit entails the capacity to sustain effort and interest in an activity over a period of years. One of the goals of contemporary physical education is also to prepare students for long lasting physical activity. Although several researchers (Cosgrove, Chen, & Castelli, 2018; Larkin, O'Connor, & Williams, 2016) have demonstrated the positive effect of grit on different behavioural domains, including education (Sturman & Zappala-Piemme, 2017; Light & Nencka, 2019; Collaco, 2018; Wang & Baker, 2018), there is limited understanding of the impact of personality trait, such as grit, on student engagement and outcomes in respect of physical activity (Wang & Degol, 2014). Moreover, there is a lack of studies that have examined the independent effects of grit on physical education outcomes, such as objectively measured leisure-time physical activity. The current research aimed to estimate parameters of the model in which perseverance of effort and consistency of interest as two subscales of grit were proposed to be related directly to objectively measured moderate-to-vigorous physical activity (MVPA) and indirectly via physical activity intention in a sample of school students.

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Grit is operationalized as a construct consisting of two domains: perseverance of effort and consistency of interest (Duckworth & Quinn, 2009). Perseverance of effort is viewed as the tendency to overcome initial failures to achieve long-term goals, while consistency of interest focuses on an individuals' tendency to pursue the same goals over time. Studies have shown that grit is associated with achievement motivation (Duckworth & Eskreis-Winkler, 2013), educational attainment (Duckworth & Quinn, 2009; Collaco, 2018), and professional achievement (e.g., Vallerand, Houlfort & Forest, 2014). A recent meta-analysis by Credé, Tynan, and Harms (2016) demonstrated that grit was correlated at about 0.16 and 0.17 with GPA (Grade Point Average) at the high school and college levels, respectively. The perseverance factor was related to academic performance at a higher level (0.26) than the consistency factor (0.10) was. The perseverance of effort was also more strongly related to the well-being than the consistency of effort was (Disabato, Goodman, & Kashdan, 2019). It was also found that grit predicts retention in a challenging three-week military training course (Eskreis-Winkler, Shulman, Beal, & Duckworth, 2014). In the sport domain, Larkin, O'Connaor, and Williams (2016) exploring the influence of grit level on perceptual-cognitive skills tests demonstrated that grittier soccer players performed better than less gritty players on the assessment of decision making. Grittier players also dedicated more time to sport activities compared with less gritty players. Reed, Pritschet and Cutton (2012) examining the relationships of grit and conscientiousness dimension with respect to the different exercise intensity in the four stages of exercise behaviour (precontemplation; preparation; action, and maintenance) found that grit significantly predicted the high intensity and moderate intensity exercise stages while the conscientiousness did not. Based on the preceding, it can be assumed that the grit dimensions may have a different relationship with leisure-time physical activity.

There are many mechanisms that may explain the association between grit and different behavioural outcomes (Collaco, 2018). One widely used theory to explain behavioural outcomes is the theory of planned behaviour (Ajzen, 1985), according to which intention is the most proximal variable related to the self-reported physical activity in leisure time contexts (see, for review, Hagger and Chatzisarantis, 2016). To investigate the coincidence of behavioural intent and actual behaviour, or the mismatch, McBroom and Reid (1992) have categorized the actual behaviour into four types. Learners who intend to act will do so, and those who do not intend to do a certain behaviour will not do it. In such a case, the intentions and actions of the students are consistent; there is no discrepancy. Also, it may be that there is an intention to behave but not behave like this. There may also be a case in which there is no intention to operate, but in practice, it is done. Sheeran (2002) has stated that people may have incomplete control over whether they can engage in the behaviours they intend. Therefore, it is rational to assume that there may be unknown factors, such as personality traits, that can influence intention. To the best of our knowledge, only Wang and Degol (2014), have studied the relationship between learners' intention to complete a massive open online course (MOOC) and their actual completion status. The authors found that grit and goal orientation were associated with course completion, but grit predicted course completion independently from the intention to complete.

We can perhaps better understand why some of the students are more active than others by comparing their grit. In this case, we are interested in whether and how the students' grit dimensions (perseverance of effort and consistency of interest) are related to intention to be engagement in physical activities beyond compulsory school physical education. In previous studies, effort and interest have been found to be essential components of motivation (Ntoumanis, 2001; Standage, Duda, & Ntoumanis, 2006) that in turn are related to intention and latter with the behavioural outcome (Hagger & Chatzisarantis, 2016). The results of Ntoumanis (2001) showed that motivation was a strong predictor of perceived effort as students experiencing excitement and fun in physical education are likely to exert high effort to learn a new skill.

The dimensions of grit, the perseverance of effort and consistency of interest, have not been widely studied in the context of physical activity. Specifically, unanswered questions remain regarding the relationships between objectively measured MVPA and dimensions of grit. Based on SDT, Duckworth (2016) noted that for individuals to remain committed and driven towards their long-term goals, they must first to have an interest in that activity, specifically, that inspires individuals towards their lifelong allegiance, despite setbacks, mistakes, obstacles and alternatives. Therefore, we hypothesized that consistency of interest would relate more positively than the perseverance of effort to MVPA in leisure time. We also hypothesized that students with high MVPA would have a higher level of grit dimensions and behavioural intention compared to students with low MVPA.

## Methods

### *Research Participants and Design*

The participants were school children; 59 boys (M age = 13.07, SD = .99) and 150 girls (M age = 13.26, SD = .95) from Estonia. Students were enrolled in physical education as a compulsory lesson twice per week. Permission to carry out the study was obtained from the head teacher, and ethical approval was granted from the university ethics committee. Next, consent from class teachers was obtained in lieu of parental consent. The purpose of the study was explained, and the guidelines for completing the questionnaire were provided. The questionnaire took approximately 5-10 minutes to complete. The students were assured that their responses would remain confidential. The data were collected at two points in time. First, the participants completed the self-reported questionnaires about grit scale and intention. Second, five weeks later, the MVPA for the seven following days was recorded by accelerometers



### Measures

The Grit Scale. The present study included the eight-item short Grit Scale (Duckworth & Quinn, 2009) to assess learners' consistency of interests and perseverance of efforts. Consistency of interests was measured with four items, such as "I have difficulty maintaining my focus on projects that take more than a few months to complete". These items were a reverse-coded. Perseverance of effort was measured with items such as "I'm a hard worker." The grit scores were calculated by averaging across items on a scale of 1 to 5. The measure of intentions comprised two items from Theory of Planned Behavior Questionnaire (Ajzen, 1985) ("I intend to do active sports and/or vigorous physical activities during my leisure time in the next 5 weeks" and "I plan to do active sports and/or vigorous physical activities during my leisure time in the next 5 weeks") rated on seven-point scales anchored by 1 ("strongly agree") to 7 ("strongly disagree").

Objective measure of physical activity. Actigraph GT3X (ActiGraph LLC, Pensacola, FL) was used to measure MVPA. The participants had to wear the accelerometer on their waist for seven consecutive days, and to remove the device for sleeping and water activities (e.g., bathing, swimming). The data files were downloaded using ActiLife software 6.13.3. The sampling interval was set at 15 s. Accelerometer data were considered valid if over 600 min (10 hours) of recorded data per day at least four days out of seven were present. Zero counts of consecutive 60 min were classified as non-wear time. The PA intensity level in the accelerometers was measured using the cut-off points of Evenson, Catellier, Gill, Ondrak, and McMurray (2008), which have been used to evaluate the level of PA during adolescence (Hinckson et al., 2017).

Translation procedures. Standardized back-translation techniques (Brislin, 1986) were used to translate the English version questionnaire into Estonian. The first step consisted in having the items translated by a bilingual translator into Estonian and then translated back by independent bilingual translators who had no access to the original questionnaires. The back-translation procedure was repeated iteratively until the original and back-translated English versions of the questionnaires were virtually identical.

### Data analyses

Data analyses were conducted using SPSS 23 and AMOS 23 software. First, descriptive statistics for all study variables were calculated. Second, confirmatory factor analyses (CFA) was used to test the factorial validity of the grit scale and measurement model of the study variables. Third, the structural equation model (SEM) for predicting the objectively measured physical activity was used. Finally, the independent t-test was used to compare the group with low and high physical activity regarding grit dimensions and intention.

TABLE 1 Descriptive statistics of the items of grit scales and intention

| Subscale                | Items   | Mean $\pm$ SD    | Skewness | Kurtosis | $\rho$ |
|-------------------------|---|------------------|----------|----------|--------|
| Perseverance of efforts |   |                  |          |          | 0.784  |
| Grit1                   | I have overcome setbacks to conquer an important challenge.   | 3.21 $\pm$ .653  | -0.453   | 0.216    |        |
| Grit6                   | I am a hard worker.   | 3.09 $\pm$ .761  | -0.675   | 0.405    |        |
| Grit9                   | I finish whatever I begin.  | 2.86 $\pm$ .794  | -0.271   | -0.394   |        |
| Grit12                  | I am diligent.  | 3.14 $\pm$ .733  | -0.749   | 0.748    |        |
| Consistency of interest |   |                  |          |          | 0.668  |
| Grit 2                  | New ideas and projects sometimes distract me from previous ones.  | 2.22 $\pm$ .748  | -0.288   | 0.335    |        |
| Grit5                   | I have been obsessed with a certain idea or project for a short time but later lost interest.               | 2.65 $\pm$ .848  | -0.458   | -0.341   |        |
| Grit8                   | I have difficulty maintaining my focus on projects that take more than a few months to complete.            | 2.69 $\pm$ .823  | -0.151   | -0.497   |        |
| Grit7                   | I often set a goal but later choose to pursue a different one.  | 2.56 $\pm$ .830  | -0.208   | -0.484   |        |
| Int1                    | I intend to do active sports and/or vigorous physical activities during my leisure time in the next 5 weeks | 5.96 $\pm$ 1.168 | -1.187   | 1.409    |        |
| Int2                    | I plan to do active sports and/or vigorous physical activities during my leisure time in the next 5 weeks.  | 5.92 $\pm$ 1.210 | -1.149   | 1.019    |        |

Note: SD = standard deviation;  $\rho$  = composite coefficient. Consistency of interest item describes are shown after reverse coding. Composite coefficient with three items was 0.740.

Scale reliability was calculated based on the composite reliability index for each subscale that reflects the proportion of shared variance to error variance in a construct (Li, Rosenthal & Rubin, 1996). The bootstrap-generated bias-corrected confidence approach was used to investigate the direct and indirect relationships between study variables (Byrne, 2010; Preacher & Hayes, 2008).

The adequacy of the CFA and SEM models was evaluated by using multiple goodness-of-fit indexes: comparative fit index (CFI), the non-normed fit index (NNFI), normed fit index (NFI), and the root mean square error of approximation (RMSEA). A cut-off value greater than .95 for the CFI, NFI, and NNFI, and a cut-off value less than or equal to .08 for the RMSEA indicated adequate model fit (Hu & Bentler, 1999).

To compare the influence of the grit dimensions and physical activity intention on moderate-to-vigorous physical activity, the participants were divided into two groups based on one standard deviation of the mean MVPA value. The high moderate-to-vigorous physical activity group was formed with one standard deviation above and low group with one standard deviation below the mean value.

## Results

The mean scores, standard deviations, skewness, and kurtosis for each of the three subscale scores are presented in Table 1. Univariate skewness and kurtosis values indicated to the normal distribution of the observed variable. The composite reliability coefficients for the perseverance of efforts, consistency of interest, and intention were 0.784, 0.668, and 0.895, respectively.

The discriminant validity CFA model for grit with two latent factors and eight items (Table 2, Model 1) met the criterion for fit. However, considering the confidence interval values for RMSEA, and low factor loading (0.38) for one item “New ideas and projects sometimes distract me from previous ones” from the consistency of interest scale, it was decided to remove it. After removing the item with low factor loading, the composite reliability coefficient of this scale increased from 0.668 to 0.740. The exclusion of this item also resulted in improved psychometric parameters (Table 2, Model 2).

**TABLE 2** Goodness-of-fit statistics for confirmatory factor analyses and structural equation models

| Models  | $\chi^2$ | d.f. | CFI   | NNFI  | NFI   | RMSEA | CI95RMSEA     |
|---------|----------|------|-------|-------|-------|-------|---------------|
| Model 1 | 37.019   | 19   | 0.956 | 0.916 | 0.936 | 0.068 | 0.034 - 0.100 |
| Model 2 | 21.112   | 13   | 0.979 | 0.965 | 0.947 | 0.055 | 0.000 - 0.096 |
| Model 3 | 30.488   | 24   | 0.990 | 0.984 | 0.953 | 0.036 | 0.000 - 0.070 |
| Model 4 | 46.169   | 31   | 0.971 | 0.958 | 0.927 | 0.053 | 0.021 - 0.080 |

Note: Model 1 = discriminant validity of Short Grit Scale (GRI-S) with two factors and 8 items; Model 2 = discriminant validity of modified Short Grit Scale (GRI-S) with two factors and 7 items; Model 3 = measurement model with all study variable; Model 4 = structural equation model;  $\chi^2$  = chi-square; d.f. = degrees of freedom; CFI = comparative fit index; NNFI = non-normed fit index; NFI = normed fit index; and RMSEA = root-mean squared error of approximation; CI95RMSEA = 95% confidence interval of RMSEA.

The results from the CFA revealed that the measurement model based on nine observed measures and three latent constructs was appropriate (Table 2, Model 3); each factor was adequately explained by its respective set of indicator items. In addition, factor correlations among the constructs were significantly different from a unified state according to the criteria specified by Bagozzi and Kimmel (1995), supporting the discriminant validity of the constructs.

**TABLE 3** Standardized parameter estimates and variability statistics for the model of the effect of students' perceptions of the dimensions of grit on moderate-to-vigorous physical activity with intention as a mediator

| Independent variable    | Dependent variable | Mediator  | β       | 95% CI |       |
|-------------------------|--------------------|-----------|---------|--------|-------|
|                         |                    |           |         | LL     | UL    |
| Direct effects          |                    |           |         |        |       |
| Perseverance of efforts | Intention          | -         | 0.286** | 0.086  | 0.480 |
| Consistency of interest | Intention          | -         | 0.153   | -0.045 | 0.337 |
| Perseverance of efforts | % in MVPA          | -         | -0.023  | -0.194 | 0.135 |
| Consistency of interest | % in MVPA          | -         | 0.162*  | -0.025 | 0.327 |
| Intention               | % in MVPA          | -         | 0.149*  | -0.032 | 0.318 |
| Indirect effects        |                    |           |         |        |       |
| Perseverance of efforts | % in MVPA          | Intention | 0.042*  | 0.002  | 0.113 |
| Consistency of interest | % in MVPA          | Intention | 0.023   | -0.003 | 0.081 |
| Total effects           |                    |           |         |        |       |
| Perseverance of efforts | % in MVPA          | -         | 0.020   | -0.144 | 0.176 |
| Consistency of interest | % in MVPA          | -         | 0.185*  | 0.002  | 0.346 |

Note: CI = 95% confidence intervals of parameter estimates; LL = Lower limit of 95% CI; UL = Upper limit of 95% CI. \* $p < 0.05$ ; \*\* $p < 0.001$ ; % in MVPA = moderate-to-vigorous physical activity.

The results of the structural model for the full sample demonstrated a good fit to the data (Table 3, Model 4). The results of the SEM model presented in Figure 1 revealed a significant direct effect ( $\beta = .286, p < .001$ ) from the perseverance of efforts on the intention to be physically active. Consistency of interest and intention to be physically active were not directly related to the MVPA. However, the intention to be physically active mediated the effect of the perseverance of efforts on MPVA whereas consistency of interest did not. It was notable that the total effect from the consistency of interest was significant.

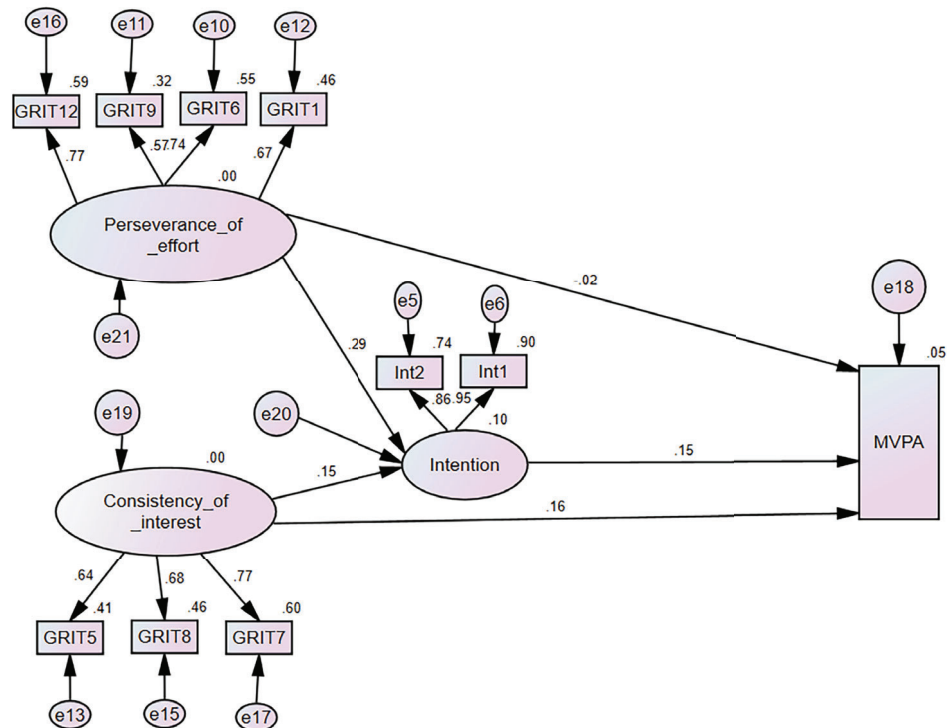


FIGURE 1 Structural model predicting moderate-to-vigorous physical activity regarding the dimensions of grit and intention. Abbreviations in boxes are measured variables; e10, e12, e11, e16, e13, e15, e17, and e18 are error terms associated with each measured variable. MVPA = moderate-to-vigorous physical activity.

The differences related to the dimensions of the grit and intention in groups with high and low MVPA are presented in Table 4. The dimension of the perseverance of efforts between groups with high and low MVPA activity was not statistically significant, whereas the intention was. The consistency of the interest dimension in the high MVPA group was significantly higher than in the low group only at the  $p < 0.1$  level.

TABLE 4 Mean differences in the grit dimensions and physical activity intention among groups with low and high moderate-to-vigorous physical activity

| Study variables         | Group with low MVPA (n = 42) | Group with high MVPA (n = 46) | t value | P - value |
|-------------------------|------------------------------|-------------------------------|---------|-----------|
|                         | Mean $\pm$ SD                | Mean $\pm$ SD                 |         |           |
| Consistency of interest | 2.59 $\pm$ .78               | 2.84 $\pm$ .67                | -1.640  | 0.105     |
| Perseverance of efforts | 3.04 $\pm$ .66               | 3.20 $\pm$ .63                | -1.166  | 0.247     |
| Intention               | 5.48 $\pm$ 1.28              | 6.19 $\pm$ 1.05               | -2.900  | 0.005     |

## Discussion

The current research aimed to estimate how the perseverance of effort and consistency of interest as two subscales of grit are related to objectively measured moderate MVPA and whether these relationships are mediated by the physical activity intention.

Prior to testing hypotheses, we needed to confirm the validity of the psychological measures constructs for use with the current Estonian sample. At first, the results of CFA of the grit scale with eight items for both subscales indicated to the room of improvement. The factor loading of the item “New ideas and projects sometimes distract me from previous ones” was below an acceptable value (Tabachnick & Fidell, 2007); with the elimination of that item, the composite reliability coefficient of the scale increased. Also, the psychometric parameters were better for seven than for eight items. Disabato et al. (2019) also noted the need for an overview of the items of the consistency of interest scale. For instance, they proposed the item “I become interested in new pursuits every few months”. However, in general, the two factor model of grit, with eight items has been confirmed by several studies (Duckworth & Quinn, 2009; Collaco, 2018; Wang & Baker, 2018; Wang & Diegol, 2014).

The proposed model showed that the consistency of interest was strongly directly related to MVPA and indirectly via physical activity intention. This is inconsistent with several previous studies, in which the role of the perseverance of effort in academic performance is emphasized (Collaco, 2018; Wang & Diego, 2014). The results of this study are not congruent with those of the study of Disabato et al. (2019), in which perseverance of effort was more strongly related to life satisfaction than the consistency of interest. Obviously, to encourage physical activity, it is important that the activity for students would be of constant interest and offer an enjoyable experience. In contrast, the persistence of efforts may seem to be irrelevant to certain activities, such as MVPA. Consequently, to be moderately to vigorously physically active does not need so much effort than interest for that activity.

However, Disabato et al. (2019) have noted that maintaining consistent interests over some time does not specify whether or not interests are involved. It may be that the high level of continuity of interest is less focused on engaging in activities because they do not want to try new things. Nevertheless, this is not a case for long-lasting physical activity in which the focus is mainly on engagement. Such a statement can be confirmed by the findings that the total effect from the consistency of interest was significant, but the perseverance of efforts was not.

The comparison of low and high physical activity groups regarding grit dimensions and intention revealed that a statistically significant difference was found only in intention. Students who scored higher on the MVPA reported higher scores in intention than lower active students did. Although the scores of the consistent of interest as well in the perseverance of effort were higher in a group with high MVPA compared to the group with low MVPA, the differences were not significant at a more conservative level ( $p < 0.05$ ). To some extent, the results corroborate the finding obtained in the previous study by Larkin et al. (2015) who found that gritty soccer players invested more time within specific soccer activities.

The study was correlational in nature; therefore, cause and effect could not be followed. In this study, the dimensions of grit predicted directly and indirectly via physical activity intention objectively measured MVPA for a short period. Therefore, there is an urgent need to verify it for a much longer period. It should also be mentioned that this study looked at grit and intention relationships with MVPA, but including other psychological variables, such as attitude, perceived behavioural control, and motivation, may shed additional light on these connections.

In conclusion, our study has demonstrated that students' consistency of interest, but not perseverance of effort were significantly directly related to MVPA. The present research makes a unique contribution to the literature, providing the initial evidence about the relationships between grit and MVPA. These results also suggest that grit should be more widely considered by physical education teachers for promotion students' long-lasting physical activity.

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# Research Quality Evaluation in Social Sciences: The Case of Criteria on the Conditions and Requirements for Academic Promotion in Serbia, Slovenia and Montenegro

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**ABSTRACT** The primary goal of the present paper is to analyse and compare the criteria on the conditions and requirements for academic promotion in three countries: Serbia, Slovenia and Montenegro. The University of Novi Sad, the University of Ljubljana, and the University of Montenegro were selected to be subjects in this study. The sources used for the analyses in this study were the official criteria on the condition and requirements for academic promotion at the abovementioned universities. The authors used a descriptive method with the consulting of competent sources and personal experiences. First, it is interesting to note that the universities in Serbia and Slovenia follow official documents at two levels: one at the national level issued by the relevant higher education council/agency and the second at the university level issued by the senate of each university, whose criteria are more strict in terms of quantitative requirements. However, this is not the case in Montenegro, where universities follow only the national criteria in the research quality evaluation. In each country, evaluation exercises usually recognize three fields, one of which is social sciences and humanities, which is concerned with an entire range of interdisciplinary and multidisciplinary scientific areas. Comparing the minimum standards for the appointment of university teachers, it is essential to highlight that Slovenian regulations are the most demanding, especially with regards to quantitative criteria, while Serbian and Montenegrin criteria are similar to each other; however, it is necessary to highlight that Montenegrin regulations contain some unusual criteria, such as the requirement that scientific research work must be achieved through one single-author paper published in an international journal for promotion to academic titles at all three levels (assistant, associate and full professor) in social sciences and humanities; however, this is not the case in other academic fields.

**KEY WORDS** evaluation, research, social, science, Yugoslavia



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RESEARCH QUALITY EVALUATION IN SOCIAL SCIENCES

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## Introduction

The evaluation of the quality of scientific research has always been a crucial issue in the development process of every society (Aksnes & Tøxt, 2004; Peruginelli, & Faro, 2018; Zuccala, 2018). Investing in scientific research has opened up new opportunities for every society and, through innovative products and services it has produced, has influenced every facet of global society. Since the time of the ancient civilizations, such as Greece and Rome, people have recognized the benefits of the results of scientific research. Even then, they carried out, in a very skilful way, the evaluation of the quality of research because they were aware that such activities would raise the process of it to a much higher level.

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Today, with the explosion of digitization, new forms of research data exchange have begun to appear. The processes of research itself are changing rapidly, multidisciplinary approaches are emerging, and new research projects do not resemble those of ancient Greece and Rome – they do not even look like research projects that were carried out only a decade or two ago (Harzing & Alakangas, 2016; Harzing, 2019; Moed, Burger, Frankfort, & Van Raan, 1985; Narin & Hamilton, 1996). Contemporary research projects are based on the increasing specialization in the field of digitization, and such a specialization significantly changes the work of researchers, not only those from natural and technical sciences, but also those from the social sciences and humanities (Jokic, Mervar, & Mateljan, 2019; Singleton, Straits, & Straits, 1993). Nowadays, researchers in the field of, for example, sport sciences, even though they are fundamentally oriented towards social sciences, must possess skills and knowledge, not only from practical areas of sports science, such as physical activity and sports, but also from areas such as computer science, knowledge of specific foreign language and skills of handling the various hardware and software that are necessary to conduct research in the best possible way (Popovic, 2018; Thelwall, 2018).

It is necessary that the aforementioned matter be taken responsibly in the evaluation process. The results of scientific research represent an output that is of interest to a broad community (Abramo, Cicero, & D'Angelo, 2012), and not only researchers who implement and read them but all interested parties, primarily other researchers, research organizations and research financiers (Lohr, 2004). In order for the research to be of high quality and serve the purpose for which it was launched, it is necessary to make this process as open and transparent as possible. Also, the process of evaluating the quality of research must be free of any agenda that could jeopardize the freedom of thought and creativity of researchers (Peruginelli & Faro, 2018).

Even though the modern era offers many opportunities for the further development of science, it still has significant deficiencies, which are reflected in an unfair evaluation of research (Elango, Kozak, & Rajendran, 2019), which is the primary source of frustration and potential threats to the further development of science. Therefore, it is challenging to obtain a generally accepted solution (Allen, Jones, Dolby, Lynn, & Walport, 2009). Strongly opposed specific structures, on the one hand, support a traditional approach of evaluating research through a qualitative assessment of personal or institutional reputation, the relevance of projects, the prestige of journals, and similar factors, while on the other, there are those who support an alternative approach to the evaluation of research (Peruginelli, & Faro, 2018), which is gaining increasing attention from the scientific public, because it is based on seemingly objective quantitative indicators, such as the number of citations, various bibliometric factors, and the journal impact factor (Chandler, 2019). Since there was no consensus, in some countries, written standards have begun to appear, which represent predetermined rules, and the research results are being evaluated according to them.

As the aforementioned rules represented an agreement between varying members of the scientific community, which aimed to establish criteria for the evaluation of scientific research, it was expected that they would differ among the social communities, depending on the needs and willingness of individual communities to compromise (Abramo, D'Angelo, & Reale, 2019; Vieira, Cabral, & Gomes, 2014). However, a gap remains between scientific fields, as it was difficult to determine the same criteria that would meet the primary needs for the evaluation of research in various fundamental scientific fields. The results of the research in the natural-mathematical and technical fields could not be evaluated in the same way as the results from the social sciences and humanities (Taubes, 1993), primarily because of the particular traditions and nature of research within those fields. For this reason, specific criteria for the evaluation of research in various fundamental scientific areas began to appear.

Recognition of scientific quality is not only necessary for the further motivation of each researcher to deal with science, but also the necessary key to open the door towards new research projects so that the research process never stops (Abramo, D'Angelo, & Rosati, 2015). Furthermore, it is essential that researchers not be exclusively focused on the set criteria. They should turn to the essential goals of their research activities and concentrate on, first of all, attracting certain monetary funds from public institutions, domestic and international donors, necessary for the unhindered testing of set research questions, then creating and supporting a scientific authority in their social community and internationally, i.e., obtaining specific tangible and intangible merits for themselves and for the organization for which they work (Seglen, 1998).

The criteria above, in the form of specific measuring instruments, have found wide application at higher education institutions around the world, where the rules are clearly set for the further promotion of teaching and research personnel (Abramo, 2018). Many debates on this topic are on-going, and the above-mentioned instruments are always the subject of criticism and pressure from certain structures to be changed. Consequently, the most critical topics in the research quality evaluation in the social sciences are the choices and definitions of criteria evaluation; the main goal of the present paper is thus to analyse and compare the criteria on the conditions and requirements for academic promotion in three countries: Serbia, Slovenia and Montenegro, which were jointly developed within the former Yugoslavia, and have continued their journeys since the beginning of the 1990s.

## Methods

The University of Novi Sad, the University of Ljubljana, and the University of Montenegro were selected to be subjects in this study. The University of Novi Sad was established in 1960: It is located in Novi Sad, the second biggest city in Serbia, and has over 50,000 students and 5,000 employees (University of Novi Sad, 2019). The University of Ljubljana was established in 1919. It is located in Ljubljana, the capital of Slovenia and has over 40,000 students and 5,600 employees (University of Ljubljana, 2019). The University of Montenegro was established in 1974. It is located in Podgorica, the capital of Montenegro and has over 21,000 students and 1,200 employees (University of Montenegro, 2019).

TABLE 1 Criteria on the condition and requirements for academic promotion in social sciences at the national level

|                     | University of Novi Sad   | University of Ljubljana   | University of Montenegro  |
|---------------------|--|---|---|
| Assistant Professor | <ol style="list-style-type: none"> <li>1) Paper published in journal recognized by M20 category or three papers from M51 category*</li> <li>2) Positive evaluation of pedagogical skills by institution</li> <li>3) Professional and academic contribution at national and international levels</li> </ol>   | <ol style="list-style-type: none"> <li>1) Success at resolving academic problems</li> <li>2) International activity</li> <li>3) at least three papers published as first or lead author of which at least one paper has been published in journals indexed in the SSCI, the SCI with IF&gt;0 or the AHCI</li> </ol>   | <ol style="list-style-type: none"> <li>1) Single-authored paper published in journal indexed in SSCI or A&amp;HCI</li> <li>2) Positive evaluation of pedagogical skills by institution</li> <li>3) One presentation at international conference</li> </ol>  |
| Associate Professor | <ol style="list-style-type: none"> <li>1) Two papers published in journal recognized as in M20 category or five papers from M51 category*</li> <li>2) Positive evaluation of pedagogical skills by institution</li> <li>3) Coordination of or membership in project</li> <li>4) University textbook</li> <li>5) Professional and academic contribution at national and international level</li> </ol>  | <ol style="list-style-type: none"> <li>1) independent academic work in the field</li> <li>2) worked in a professional environment</li> <li>3) international publicity of the work</li> <li>4) research or teaching work at a foreign university or research institution for an uninterrupted period of at least three months</li> <li>5) co-mentor for at least one completed doctoral dissertation or has otherwise contributed relevantly to the education of professionals in the field</li> <li>6) at least seven papers (at least four since the last appointment) of which is the first or lead author; of these at least three papers must be published in journals indexed in the SSCI, the SCI with IF&gt;0 or the AHCI</li> </ol> | <ol style="list-style-type: none"> <li>1) Two papers, one single-authored paper published in journal indexed in SSCI or A&amp;HCI</li> <li>2) Positive evaluation of pedagogical skills by institution &amp; student survey</li> <li>3) Two presentations at international conference</li> </ol>  |
| Full Professor      | <ol style="list-style-type: none"> <li>1) Paper published in journal recognized as in M21-23 category*</li> <li>2) Paper published in journal recognized as in M24 category*</li> <li>3) Five papers published in journal recognized as in M51 category*</li> <li>4) Positive evaluation of pedagogical skills by institution</li> <li>5) Ten citations (excluding auto citations)</li> <li>6) Invited speech at the international conference</li> <li>7) University textbook</li> <li>8) Memberships in three postgraduate juries</li> <li>9) Contribution for your colleagues development</li> <li>10) Professional and academic contribution at national and international level</li> </ol> | <ol style="list-style-type: none"> <li>1) independent academic work in the field</li> <li>2) research or teaching work at a foreign university or research institution for an uninterrupted period of at least three months</li> <li>3) mentor for at least one or co-mentor for at least two completed doctoral dissertations</li> <li>4) published scholarly works (monograph, book, textbook)</li> <li>5) led the research projects in the field</li> <li>6) at least 14 papers (at least seven since the last appointment) of which is the first or lead author; of these at least six papers must be published in journals indexed in the SSCI, the SCI with IF&gt;0 or the AHCI</li> </ol>  | <ol style="list-style-type: none"> <li>1) Two papers, while one single-authored paper, published in journal indexed in SSCI or A&amp;HCI</li> <li>2) Positive evaluation of pedagogical skills by institution &amp; student survey</li> <li>3) University textbook</li> <li>4) Three presentations at international conferences</li> <li>5) Membership in national or international projects</li> </ol> |

Note. \*M20 category include papers published in journals indexed in SCI, SSCI, SCIE or A&HCI (M21=Q1; M22=Q2; M23=Q3&Q4; M24=list of journals recognized by Ministry); M51 category include papers published in national journals.

The sources used for the analyses in this study were the following documents:

1. Minimum standards for the appointment of university teachers issued by National Council for Higher Education of the Republic of Serbia (Minimum standards for the appointment of university teachers, 2016), and Minimum standards for the appointment of university teachers at University of Novi Sad issued by the Senate of the University of Novi Sad (Minimum standards for the appointment of university teachers at University of Novi Sad, 2018),
2. Minimum standards for the appointment of higher education teachers, researchers and faculty assistants at higher education institutions issued by the Council of the Slovenian Quality Assurance Agency for Higher Education in Slovenia (Minimum Standards for the Appointment of Higher Education Teachers, Researchers and Faculty Assistants at Higher Education Institutions, 2010) and Criteria for appointment to the titles of university teacher, researcher and associate at the University of Ljubljana issued by the Senate of the University of Ljubljana (Criteria for Appointment to the Titles of University Teacher, Researcher and Associate at the University of Ljubljana, 2011),
3. Criteria on the conditions and requirements for promotion to academic titles issued by the Council for Higher Education in Montenegro (Criteria on the Conditions and Requirements for Promotion to Academic Titles, 2016).

The authors used a descriptive method with the consulting of competent sources and personal experience to analyse and compare the criteria on the condition and requirements for academic promotion in three countries: Serbia, Slovenia, and Montenegro.

## Results

First, it is interesting to note that the universities in Serbia and in Slovenia follow the official documents at two levels: one at the national level issued by a higher education council/agency, and the second, at the university level issued by the senate of each university, whose criteria are stricter in terms of quantitative requirements. However, this is not the case in Montenegro, where universities follow only the national criteria in the research quality evaluation. In Montenegro and Serbia, evaluation exercises usually recognized three fields, one of which is the social sciences and humanities, which cover a vast range of interdisciplinary and multidisciplinary scientific areas. In contrast, in Slovenia, evaluation exercises recognized two fields, which means it separates the field of arts from the rest of the academic fields.

The results of this study are presented in two tables. Table 1 describes the criteria for the conditions and requirements for academic promotion in social sciences at the national level; Table 2 describes the criteria for the conditions and requirements for academic promotion in the social sciences at the institutional level. Even though all the criteria seem similar at first glance, the qualitative and quantitative differences reflect the differences in quality that are visible on the prestigious world rankings of universities. Specifically, the smallest differences in quantitative requirements, which clearly exist between the analysed universities, cause significant differences in ranking at the global level (Academic Ranking of World Universities, 2018). If, for example, a university has a requirement that an academic have one paper published in journals indexed in SCI/SSCI/SCIE/AHCI, and the university has 1000 employed teachers or researchers, this is reflected in 1000 published papers. This detail significantly raises the rating of each university, and any realistic scaling is multiply beneficial for both individuals and for the institution.

It is interesting that at the University of Ljubljana, which has been among the top 500 ranked universities in the Shanghai university ranking list for years, quantitative requirements were significantly higher compared to the other two analysed universities, which, at the overall institutional level, were not included on this list. In contrast, the University of Novi Sad has more transparent and more precise criteria, especially regarding the social sciences, and the results are expected to be better. For example, one of the faculties that belong to the social group, the Faculty of Sport and Physical Education from the university above, was ranked among the top 500 universities in the Shanghai University ranking list within its specific field (Shanghai Ranking's Global Ranking of Sport Science Schools and Departments, 2018). The University of Montenegro still lacks the aforementioned acknowledgements for social sciences, mostly because some quantitative requirements have been established in the latest criteria that are not in line with any good European example. It is noteworthy that a scientist in the social sciences is required to publish a paper as an autonomous author. For example, in sports science, such a requirement is against the basic principles, based on which scientists have grown and developed into serious scientific workers, through collaborative work.

Furthermore, there is another limitation, which states that a prospective paper needs to be published exclusively in a journal indexed in the SSCI index. This requirement significantly reduces the number of available journals, especially for scientists coming from multidisciplinary areas, such as sport science, but also tourism, architecture, and other fields. Sport scientists are usually unable to publish the results of their research in "strictly social" journals, primarily because of the multidisciplinary nature of their research; sometimes they encounter a situation in which academic promotions are brought into question because of the reckless criteria established by the Council for Higher Education of Montenegro, but obviously without the extensive and careful analysis that the social sciences need.

Based on everything previously said, it is clear that the research quality evaluation is one of the crucial issues that can significantly improve the quality of research, but also the rating and visibility of both scientists and institutions at the international level. Therefore, it is necessary to carefully and critically analyse the current criteria, because that is the first step in the process of determining criteria that would, in the best manner, serve to upgrade scientific research, especially in the social sciences, and not to the interests of individuals and institutions, as seems to be the case in determining the analysed criteria in Montenegro.



TABLE 2 Criteria on the condition and requirements for academic promotion in social sciences at the institutional level

|                     | University of Novi Sad  | University of Ljubljana   | University of Montenegro   |
|---------------------|---|---|--|
| Assistant Professor | <ol style="list-style-type: none"> <li>1) Paper published in journal recognized as in M20 category (first or corresponding author) or three papers from M51 category (history and law)*</li> <li>2) Positive evaluation of pedagogical skills by institution</li> <li>3) Professional and academic contribution at national and international levels</li> </ol>   | <ol style="list-style-type: none"> <li>1) Success at resolving academic problems</li> <li>2) International activity</li> <li>3) At least three papers published as first or lead author of which at least one paper has been published in journals indexed in the SSCI, the SCI with IF&gt;0 or the AHCI</li> </ol>   | <ol style="list-style-type: none"> <li>1) Single-authored paper published in journal indexed in SSCI or A&amp;HCI</li> <li>2) Positive evaluation of pedagogical skills by institution</li> <li>3) One presentation at international conference</li> </ol>   |
| Associate Professor | <ol style="list-style-type: none"> <li>1) Two papers published in journal recognized by M20 category (first or corresponding author at least at one paper) or six papers from M51 category (history and law)*</li> <li>2) Positive evaluation of pedagogical skills by institution</li> <li>3) Coordination of or membership in project</li> <li>4) University textbook</li> <li>5) Professional and academic contribution at national and international levels</li> </ol>  | <ol style="list-style-type: none"> <li>1) independent academic work in the field</li> <li>2) worked in a professional environment</li> <li>3) international publicity of the work</li> <li>4) research or teaching work at a foreign university or research institution for an uninterrupted period of at least three months</li> <li>5) co-mentor for at least one completed doctoral dissertation or has otherwise contributed relevantly to the education of professionals in the field</li> <li>6) mentorship of a postgraduate student; at least one student paper that received the award; and two professional specialisations</li> <li>7) management of a research project</li> <li>8) at least seven papers (at least four since the last appointment) of which is the first or lead author; of these at least three papers must be published in journals indexed in the SSCI, the SCI with IF&gt;0 or the AHCI</li> </ol> | <ol style="list-style-type: none"> <li>1) Two papers, one single-authored paper published in journal indexed in SSCI or A&amp;HCI</li> <li>2) Positive evaluation of pedagogical skills by institution &amp; student survey</li> <li>3) Two presentations at international conferences</li> </ol>  |
| Full Professor      | <ol style="list-style-type: none"> <li>1) Paper published in journal recognized as in M21–23 category*</li> <li>2) Paper published in journal recognized as in M24 category*</li> <li>3) Five papers published in journal recognized as in M51 category*</li> <li>4) Positive evaluation of pedagogical skills by institution</li> <li>5) Ten citations (excluding auto citations)</li> <li>6) Invited speech at the international conference</li> <li>7) University textbook</li> <li>8) Memberships in three postgraduate juries</li> <li>9) Contribution for colleagues' development</li> <li>10) Professional and academic contribution at national and international levels</li> </ol> | <ol style="list-style-type: none"> <li>1) independent academic work in the field</li> <li>2) research or teaching work at a foreign university or research institution for an uninterrupted period of at least three months</li> <li>3) mentor for at least one or co-mentor for at least two completed doctoral dissertations</li> <li>4) published scholarly works (monograph, book, textbook)</li> <li>5) led the research projects in the field</li> <li>6) at least 14 papers (at least seven since the last appointment) of which is the first or lead author; of these at least six papers must be published in journals indexed in the SSCI, the SCI with IF&gt;0 or the AHCI</li> </ol>  | <ol style="list-style-type: none"> <li>1) Two papers, while one single-authored paper, published in journal indexed in SSCI or A&amp;HCI</li> <li>2) Positive evaluation of pedagogical skills by institution &amp; student survey</li> <li>3) University textbook</li> <li>4) Three presentations at international conferences</li> <li>5) Membership in national or international project</li> </ol> |

Note. \*M20 category include papers published in journals indexed in SCI, SSCI, SCIE or A&HCI (M21=Q1; M22=Q2; M23=Q3&Q4; M24=list of journals recognized by Ministry); M51 category include papers published in national journals.

## Discussion

As previously mentioned, a large number of debates on research evaluation are ongoing, and the current criteria are always the subject of criticism and pressure of certain structures to be changed. However, comparing the minimum standards for the appointment of university teachers, it is necessary to highlight that Slovenian regulations are the most demanding (Minimum Standards for the Appointment of Higher Education Teachers, Researchers and Faculty Assistants at Higher Education Institutions, 2010), especially with regard to their quantitative criteria, while the Montenegrin and Serbian criteria (Criteria on the Conditions and Requirements for Promotion to Academic Titles, 2016; Minimum standards for the appointment of university teachers, 2016) are quite similar; however, it is essential to highlight that Montenegrin regulations contain some unusual criteria, such as the requirement that scientific research work must be achieved through one single-authored paper published in an international journal for promotion to academic titles at all three levels (assistant, associate and full professor) in social sciences and humanities. It is essential to highlight that this is not the case in two other fields (natural and technical sciences and arts). For example, if one young researcher from the field of sports science in Montenegro wants to be promoted to assistant professor, he/she needs to publish at least one paper in the journal that is indexed in the Social Science Citation Index (SSCI) database as a single-authored paper. This is definitely against the foundational principles of science, as collaborative work is the driving force that develops the scientific process and reaches the relevant conclusions based on joint discussion.

In contrast, a young researcher can promote him/herself in Serbia much more easily from the quantitative point of view, as he/she does not need a single-authored paper, but must be the leading author of one paper published in the journal recognized as belonging to the M20 category (first or corresponding author). This means he/she might publish the paper in each database from Web of Science (SCI/SCIE/SSCI// AHCI) that has an impact factor or in the M24 category, which represents the yearly list of journals announced by the Ministry in Serbia (Minimum standards for the appointment of university teachers at University of Novi Sad, 2018).

The Slovenian example is more demanding, because the young researcher from the field of sports science needs to publish at least three papers as first or lead author, of which at least one paper is in journals indexed in the SSCI, the SCI with IF>0 or the AHCI (Criteria for Appointment to the Titles of University Teacher, Researcher and Associate at the University of Ljubljana, 2011). The Slovenian regulations purposely excluded the SCIE database as it contains a wider range of journals, but did not make a meaningless decision to limit all the researchers from social sciences to publishing their mandatory paper in the journals indexed just in SSCI database, as is the case in Montenegro. The Montenegrin example has limited many of multidisciplinary areas within the social sciences, including sport science.

The issue mentioned in the previous paragraph is not the only one in the Montenegrin Criteria on the Conditions and Requirements for Promotion to Academic Titles, and Article 14, to be criticized. Specifically, the criteria state that the previous criteria (from 2004) prescribed for promotion to academic titles shall be applied to people who had been promoted to academic titles until the Law on Higher Education ("Official Gazette of Montenegro", no. 44/14 and 47/15) entered into force, for the subsequent promotion to an academic title. This means that it is much easier to be promoted to associate and full professor at the University of Montenegro than to assistant professor, as the requirements from the previous criteria are much easier. This fact significantly discriminates against younger researchers, mostly because they need to satisfy much stronger requirements and, theoretically, be supported by senior colleagues, who did not need to satisfy the same requirements. This fact clearly indicates that a change of criteria should be considered as quickly as possible, mostly because the current rules might discourage the young researcher and direct them out of academia. In contrast, such issues are not present in the criteria in Slovenia and Serbia, but the debates on research evaluation should be continued in all three countries; furthermore, the current criteria should be the subject of criticism, all in order to develop an international ranking of the institutions.

It is essential to highlight that the limitation of this study is reflected in the method applied. A descriptive method with consulting of competent sources and personal experience is used to analyse and compare the criteria in the selected countries. However, some more rigorously scientific methods would improve some further investigations in the area. Nevertheless, the limitations of this study are that it is analysed just mandatory requirements from the criteria in all three countries; however, the other requirements need to be reviewed carefully too, especially those contained in the methodology for the international ranking of the universities.

From all the above-mentioned in this study, it is easy to conclude that research evaluation in social sciences is an area that is still developing and it is vital to involve all stakeholders in the future that can help in any form to reach as best criteria that are in line with international standards and meet domestic needs. For the further studies, it is crucial to take into consideration the limitation of this study and carefully analyse the difference among the various field of studies, especially those of the social sciences that have some natural or technical components with their multidisciplinary approach, such as sports science, tourism, architecture, among others.

In addition, it is highly recommended to take a methodological approach that can help to improve research processes at the national level, but also improve recognition and visibility at the international level; academic ranking of global universities is the best example of this.

It is also recommended to combine qualitative and quantitative methods, to ensure that the exclusively quantitative conclusions based on statistics do not force us in the wrong direction, and to keep constant criticism

and pressure on certain structures that are making decisions in the area of research evaluation, such as national councils of higher education, senates of universities, as well as all other relevant institutions that can influence the development of this area.

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# Match Analysis in Handball: A Systematic Review

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**ABSTRACT** The main objective of this research is to focus on a systematic review of the literature on handball, to identify potential areas for future research in this specific area of specialization. The most common research topics were identified, their methodologies were described, and the evolutionary tendencies of this area of research were systematized. Within a systematic review of the Web of Science™ Core Collection, PubMed, and SportDiscus databases, according to the PRISMA guidelines, the following keywords were used: “handball”, each one associated with the terms: “match analysis”, “performance analysis”, “notational analysis”, “game analysis”, “tactical analysis”, and “patterns of play”. Of the 245 studies initially identified, 28 were fully reviewed, and their results were analysed. Studies that meet all the inclusion criteria were organized according to the research design as descriptive, comparative, or predictive. The results showed that most of the studies use the statistics available through the tournament organization; some researchers have attempted to find some association between cause and effect in different contexts. The studies focused their analysis on four main variables of performance: total shots and finals, end match outcome, Time Outs (TTOs), and the relationship between home advantage. This systematic review can provide useful information on potential lines of research for performance analysts in the field of handball match analysis.

**KEY WORDS** game analysis, performance, teams' sports, PRISMA



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MATCH ANALYSIS IN HANDBALL

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## Introduction

Handball is one of the most popular team sports in the world (Clanton & Dwight, 1996). There are six confederations and 209 affiliated countries to the IHF (International Handball Federation), with approximately 795,000 teams and 19 million players. The rising popularity of handball is aligned with a significant increase in the number of related scientific publications.

The systematic observation of the handball matches and posterior analysis of the results is referenced at the beginning of the 1970s. The French Handball Federation and a group of students from the Sports School of Cologne (Germany) observed the matches of the World Championship of 1970 and became pioneers in the observation and analysis of the match of handball (Kunst-Ghermanescu, 1976). Following several authors (Alonso, 1994; Antón García, 1992; Brčić, Viskić-Štalec, & Jaklinović-Fressl, 1997; Czerwinski, 1998; Czerwinski & Taborsky, 1996; Taborsky, 2000; Vuleta, Milanović, Sertić, & Jukić, 2000) engaged in similar studies related to performance factors and how they influence team performance and the final score in the competitions.

Nowadays, match analysis has become a subject of great interest of the performance in team sports, such as handball (A. Silva & Anzano, 2018; J. Silva, 2008; Valeria et al., 2017; Zapardiel Cortés, Ferragut Fiol, Manchado, Abalde Valeiras, & Vila Suárez, 2017), football (Kempe & Memmert, 2018; McKenna, Cowan, Stevenson, & Baker, 2018; Yang, Leicht, Lago, & Gomez, 2018), basketball (Clemente, Gonzalez-Villora, Delextrat, Martins, & Vicedo, 2017; Conte, Favero, Niederhausen, Capranica, & Tessitore, 2017) and other sports (Kempton, Sirotic, & Coutts, 2017; Sarmiento et al., 2016; Valhondo, Fernandez-Echeverria, Gonzalez-Silva, Claver, & Moreno, 2018).

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An essential factor in all sports (handball) performance is the impact that coaches have on the player's development. In this sense, performance analysis is one of the main subjects of movement and training sciences. Match analysis methods used in this field have gradually improved, and many of the most popular and original recent studies (Debanne, 2018; Dello Iacono et al., 2018; Ferrari, Vaz, Sousa, Couceiro, & Dias, 2018) in this area have involved recording performance variables during or after competitions and visual and written storage of these records using computers. When examining the literature of handball, most of the research done on this subject focuses on the physiological problems or injuries of the athletes. There are many articles in this area in comparison to match analysis (Prieto, Gómez, & Sampaio, 2015b).

The exponential growth in the number of studies about performance observation analysis and success indicators in several sports has prompted literature review studies seeking to synthesize the principal results and research methodologies of different sports, including football (Sarmiento, Anguera, Pereira, & Araújo, 2018; Sarmiento et al., 2014), volleyball (M. Silva, Marcelino, Lacerda, & João, 2016), futsal (Abras, Ferragut, & Abalde, 2016) and basketball (Courel-Ibáñez, McRobert, Toro, & Vélez, 2017). However, there is no such specific study done in this way that synthesizes the main results of observation and analysis of matches in a sport as popular as handball.

Thus, the main goal of this study was to review and organize the literature around match analysis in handball, so to understand the topics of more developed researches in this area, their methodologies, and the tendency of evolution for future projects.

## Methods

### *Search Strategy: Databases, Inclusion Criteria and Process of Selection*

A systematic review of the available literature was conducted according to PRISMA (Preferred Reporting Items for Systematic reviews and Meta-analysis) guidelines. The electronic databases Web of Science<sup>™</sup> Core Collection, PubMed, and SportDiscus were researched for relevant publications prior to the 8 of January 2019 using the keywords “handball”, each one associated with the terms: “match analysis”, “performance analysis”, “notational analysis”, “game analysis”, “tactical analysis”, and “patterns of play”.

The inclusion criteria for these articles were: (1) contain relevant data concerning technical and tactical evaluation or statistical compilation, and time-motion analysis; (2) performed by amateur and/or professional adult male handball players and (3) written in the English language. Studies were excluded if they: (1) included children or adolescents; (2) included females; (3) did not include relevant data for this study, and (4) were conference abstracts. If there was disagreement amongst authors regarding the inclusion of certain articles, a discussion was held until a consensus was found.

Two independent reviewers (WF, HS) independently screened citations and abstracts to identify articles potentially meeting the inclusion criteria. For those articles, full-text versions were retrieved and independently screened by two reviewers to determine whether they met the inclusion criteria. Disagreements about whether the inclusion criteria were met were resolved through discussion with the other authors (VV).

### *Extraction of Data*

A data extraction sheet (adapted from the Cochrane Consumers and Communication Review Group's data extraction template) was developed and tested with ten randomly-selected studies. First, one researcher extracted the data from included studies and then, a second researcher checked the extracted data. Disagreements were resolved by consensus (WF, HS).

## Results

### *Search, Selection and Inclusion of Publications*

The initial search identified 245 titles in the described database. These data were then exported to reference manager software (EndNote X8), and any duplicates (59 references) were eliminated automatically. The remaining 186 articles were then screened according to the title and abstract for relevance, resulting in another 57 studies being eliminated from the database. The full text of the remaining 129 articles was then read, and another 101 were rejected due to a lack of relevance to the purpose of this study. At the end of the screening procedure, 28 articles received further in-depth reading and analysis for the systematic review (Figure 1).

After in-depth analysis, it was decided that the most appropriate way to present the results would be to categorize them as suggested (Sarmiento et al., 2018), creating a categorization system according to two levels of analysis: a first-order level, depending on the type of analysis performed (descriptive, comparative analysis and predictivity), and a second-order level, depending on the type of variables analysed (Figure 2).

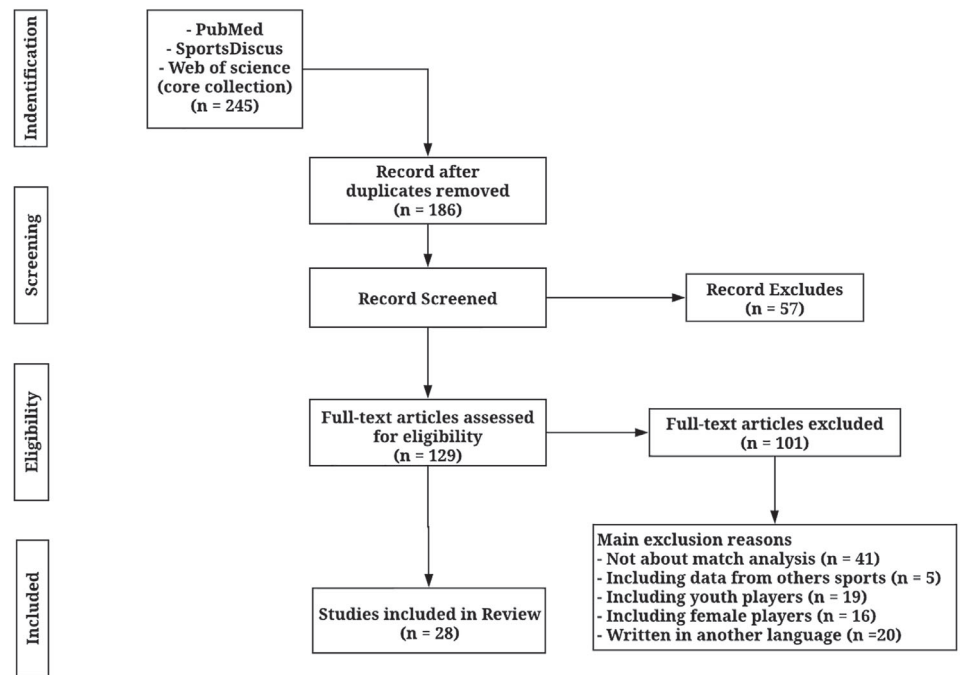


FIGURE 1 Preferred report items for systematic review flow diagram

### Major research topics

After in-depth analysis, it was decided that the most appropriate way to present the results would be to categorise them according to their subjects of: (1) descriptive analysis; (2) comparative analysis – Defensive analysis, playing position, game results; (3) contextual variables – game location, Time out; (4) Predictive analysis – Score a goal; Game result.

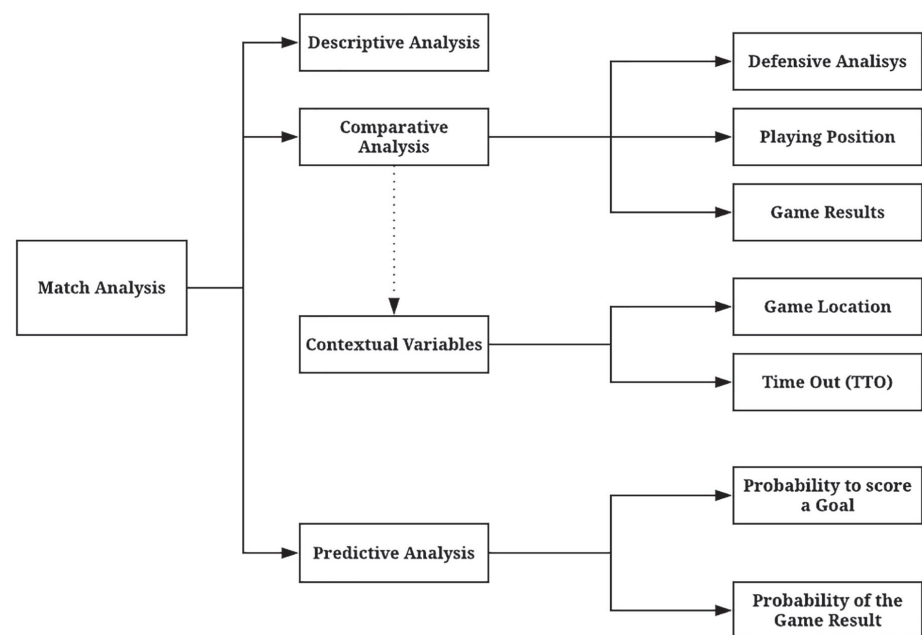


FIGURE 2 Scopes of match analysis

### Descriptive analysis

The performance variables during or after the competitions are the main topics that other authors approach (Bilge, 2012; Gutiérrez, Rojas, Ortega, Campos, & Parraga, 2011) with their written and visual storage, being the measurement and evaluation of the athletes' performance and having an important role in planning the training and competition process (Table 1).

TABLE 1 Studies with descriptive analysis

| Study                   | Sample  | Result  | Variables   |
|-------------------------|---|---|---|
| Gutiérrez et al. (2011) | 11 men took part in this study, seven Goalkeeper for handball team and four field players.  | The goalkeepers moved in the correct direction of the throw in 91.1+9.4% in situation TM2. In situation TM4, the goalkeepers made errors on 17.5+7.6% occasions (N=95) and managed to save the ball on 66.3+7.5%  | The time of play; the speed of the ball; the accuracy of the throw; speed of lateral movement; speed of lateral movement and distance travelled at the time of release of ball; speed of vertical movement and distance travelled 100ms before the launch of ball; speed of vertical displacement and distance travelled at the time of release of ball; maximum speed of the vertical component during the period of anticipation; transverse acceleration of the goalkeeper In situation TM2 the thrower made the perpendicular throw on goal with only two possibilities for the direction of the throw: the upper and lower corners of the goal on the same side as the throwing arm. In situation TM4 the thrower could throw at each of the four corners of the goal. |
| Bilge (2012)            | 72 matches<br>-Olympic Games 2004 and 2008;<br>-World Championship 2005, 2007 and 2009;<br>-European Championship of 2004, 2006, 2008 and 2010. | Average number of fast break goals per match was higher in OG and WC than in the EC.<br>Fast break efficiency rates were higher in OG and WC than in the EC.<br>The ratio of pivot position goals and fast break goals to all goals in OG and WC was higher than in EC<br>The ratio of backcourt position goals and break-through goals to all goals in OG and WC was lower than in the EC. | Average number of attacks, attack efficiency, counterattack efficiency, goalkeeper effectiveness per match, average number of disqualifications and foul per match, and differences in players by position  |

### Comparative Analysis

Based on comparative studies, five topics were created to better understand the subject: Comparative analysis based on Timeouts (TTos), (Gomes, Volossovitch, & Ferreira, 2014; Gutiérrez Aguilar, Montoya, Fernandez, & Saavedra, 2016; Guzmán, Calpe-Gomez, Grijalbo Santamaria, & Imfeld Burkhard, 2012; Prieto, Gómez, Volossovitch, & Sampaio, 2016) (Table 2).

TABLE 2 Empirical studies predominantly with comparative analysis based on TTOs

| Study                | Sample  | Statistical procedure                                      | Variables  |
|----------------------|---|--|--|
| Guzmán et al. (2012) | 1 Match in Spanish League.  | Chi - person and comparison.                               | Implementation of the action technical tactics, a result of the actions and technical tactics, intensity, behaviour is not specified, organization of the team, the decision of the arbitrator; and the "type of behaviour", composed by: feedback positive, negative, orderly instruction, encouragement, disagreement, I am sorry, consultation, call, suggested instruction, in request to timeout, aggression or insult and alert. |
| Gomes et al. (2014)  | 2178 TTOs in - 720 matches in Spanish League in seasons; 2009/2010, 2010/2011, 2011/2012. | Analysis of cluster k-means<br>The Pearson chi-square test | Goals scored and goals during allowed as last five possessions of each team before the call of the TTo. The match was classified in six episodes of 10 minutes each. The location of the match included two categories - home and away.  |

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| Study                           | Sample  | Statistical procedure  | Variables  |
|---------------------------------|---|--|--|
| Gutiérrez Aguilar et al. (2016) | 558 TTo applied:<br>- The European Championship of 2012, Serbia (156);<br>- World Championship 2013, Spain (346);<br>- 2012 Olympic Games, London (76). | The Wilcoxon tests<br>The contingency coefficient and V of Cramer.<br>The test of Mann-Whitney Test. | The end result of departure final difference (number of goals), differences in the score when requesting TTo, in favour of the team that applies a time limit, the difference in the score five minutes before the minute the TTo is requested, the modification of the defence system, substitutions of players and completion of five previous attacks and subsequent to the time at which the TTo is requested.   |
| Prieto et al. (2016)            | 64, 10% of TTos (total) in 240 matches in the Spanish league.   | Cluster Analysis of k-means;<br>Logistic regression of the linear model.                             | The number of goals scored before, and after each TTo, a ball was defined as a unit for analysis of temporal effects, the goals scored for the periods within the TTo and previous post first, third and fifth possessions of ball were recorded, the difference between the goals scored and awarded to a ball before the TTo and draw a ball after him, as differences in the goals recorded five poses of ball before the TTo and five represents the ball after the TTo. |

Regarding comparative analysis based on home advantage, the data processed allowed us to identify those critical game-related statistics that are affected by playing at home or away and how these variables might be affected depending on the particular context of the match according to team ability of both teams (Gomez, Lago-Penas, Viano, & Gonzalez-Garcia, 2014; Gutiérrez Aguilar, Fernández, & Saavedra, 2014; Krawczyk, 2015; Lago-Penas, Gomez, Viano, Gonzalez-Garcia, & Fernandez-Villarino, 2013; Oliveira, Gómez, & Sampaio, 2012; Pic, 2018) (Table 3).

TABLE 3 Empirical studies predominantly with comparative analysis based on home advantage

| Study                           | Sample   | Statistical procedure  | Variables   |
|---------------------------------|--|--|---|
| Oliveira et al. (2012)          | 480 matches in the Spanish League seasons; 2007/2008, 2008/2009.                 | ANOVA  | Efficacy of 6-meter, 7-meter and 9-meter shots and counterattacks   |
| Lago-Penas et al. (2013)        | 240 matches in the Spanish League during a season 2012/13                        | Test of Mann-Whitney   | Effectiveness and goals from 6-9m, Effectiveness and goals from attack, full and speedy effectiveness to trim the field; assists, Errors, yellow cards, suspension of 2 minutes, blocks, theft of ball, effectiveness of the networks in shoot of 6-9m, effectiveness of the networks in counter-attack, and overall effectiveness of the networks.   |
| Gomez et al. (2014)             | 365 matches Olympic Games (12), European Championship (9) between 1936 and 2011. | Tests of Wilcoxon<br>Test of Mann-Whitney U<br>The Kruskal-Wallis Test                                 | The number of matches won, the number of matches lost, the number of goals scored and allowed, the number of goals scored and allowed in a match, the sex of competitors and the league involved.   |
| Gutiérrez Aguilar et al. (2014) | 240 games in the Spanish League a season 2012/13                                 | Kaiser-Meyer-Olkin<br>As analysis of cluster of K-means<br>Post-hoc Scheffé and Bonferroni correction. | The Factor 1 (success of 6m and 7m, shots and 6m, 7m and 9m of shots without success); Factor 2 (6m and 9m of shots and bailouts succeed without success from shots 9m); Factor 3 (successful and unsuccessful), shots of counter-attack, assists and balls retrieved blocks); Factor 4 (successful and unsuccessful shots of 7m); Factor 5 (bailouts successful and unsuccessful shots of counter-attack); Factor 6 (red/yellow cards) |
| Krawczyk (2015)                 | 50 matches EHF Champions League 2012-2013  | The non-parametric Wilcoxon test   | Errors of spend, 24 and dribble the ball; errors in decision-making, started with the ball; enters the goal when penalized; Absences offensive; errors resulting from exclusion from the match; passive match; and a shortage resulting in a shot of penalty being awarded to the opponent  |
| Pic (2018)                      | 39 matches<br>14 Spanish League<br>14 German Bundesliga<br>11 French League      | T-pattern<br>Multivariate analyses   | Location; Final result; Scoreboard evolution; Zone; Attack; Defending; Time Observer  |

This review was to determine the key indicators of discrimination in a comparative analysis between winners and losers. (Foreti, Rogulj, & Papi, 2013; Gutiérrez Aguilar & Ruiz, 2013; Rogulj, 2000; Skarbalius, Pukėnas, & Vidūnaitė, 2013) (Table 4).

TABLE 4 Empirical studies with predominantly comparative analysis based on winners and losers

| Study                             | Sample   | Statistical procedure  | Variables   |
|-----------------------------------|--|--|---|
| Rogulj (2000)                     | Total of 80 matches, the World Championship 1999, in Egypt.  | ANOVA  | Number of goals scored, attack, counter-attack and quick attack and goals, goals, shots and goals from 6-meters (tips excluded), goals and shots in first line, trim and goals of tips, trim and goals from penalty 7-meters, assistance, errors, punishment of 2 minutes, stealing the ball, blocks shots defended by networks of 6-meters, tips, first line, a penalty of 6-meters, counter-attack, quick attack.   |
| Foreti et al. (2013)              | 101 matches in the World Championship handball in Croatia in 2009  | ANOVA<br>Kruskal-Wallis test.<br>Correlation coefficient of Spearman | For the construction of the model, we analyse the total of 47 indicators of situational activity on its players, being 16 in position to attack, attack of transition in 7, 9 in defence of a position in defence of transition 5 and 10 indicators of situational activity of the player<br>Activity indicators of situational attack from a defensive position, transition, transition defence, guard trans<br>In the early stages of the match, offset activity indicators were situationally analysed within 6 positions in positional attack |
| Gutiérrez Aguilar and Ruiz (2013) | Matches of the 24 teams of the world championship in Sweden - 2011.  | Data Envelopment Analysis  | Goals and shot from different distances (6-meters, 6-meters, 6-meters), situations (fast attack, counterattack and organized attack)  |
| Skarbalius et al. (2013)          | 5 European Championships of Handball Sweden 2002 Slovenia (2004), Switzerland (2006), Norway (2008), Austria (2010). | ANOVA<br>Test of Tukey's post hoc                                    | Attacks, shooting, the effectiveness of guard networks, positive actions (theft, flight of 6-meters gain, blocked shots) and negative actions (2 minutes of sleep, business volumes)  |

The following studies present indication related to other comparative analyses among several indicators in a handball match analysis. (Fasold & Redlich, 2018; Gryko, Bodasiński, Bodasińska, & Zieliński, 2018; Hatzimanouil, Giatsis, Kepesidou, Kanioglou, & Loizos, 2017; Meletakos & Bayios, 2010; Meletakos, Vagenas, & Bayios, 2011; Prieto, Gómez, & Sampaio, 2015a; Prudente, Sousa, Sequeira, Lopez-Lopez, & Hernandez-Mendo, 2017) (Table 5).

TABLE 5 Empirical studies predominantly with comparative analysis

| Study                       | Sample   | Statistical procedure  | Variables  |
|-----------------------------|--|--|--|
| Meletakos and Bayios (2010) | 10.358 final scores of seven national championships in Europe;                   | Post-hoc tests<br>The k-means clustering<br>Chi-square tests             | The first group included all matches with a difference in goal two or less. These matches were categorized as matches closed, while all other matches were categorized as open matches   |
| Meletakos et al. (2011)     | 288 matches in 3 World Championships.  | MANOVA<br>Univariate F-tests   | Shot at 6-meters from the pivot, shot from the wings, shots at 6-meters by first-line players, 7-meter penalty shots, counterattack, fast attack, percentage of shots and effectiveness.   |
| Prieto et al. (2015a)       | 60 matches, 280 exclusions, in the Spanish league, season 2011-2012              | -Analysis of linear and multiple logistic<br>Analysis of cluster k-means | Match status, location, quality of opposition, and match situational variables were incorporated in the analysis   |
| Hatzimanouil et al. (2017)  | 44 matches, League of Greece seasons 2013-2014, 2014-2015.                       | The Kruskal-Wallis test.<br>Mann Whitney U Test.                         | Compare the differences between playing six positions (left side, left, centre, right player attacking player, the right wing and the player in line) about places out, goals and saves  |
| Prudente et al. (2017)      | 16 matches, European Championship 2012 preliminary phase (8) the final stage (8) | Technical<br>Analysis of polar coordinates.                              | The table included as main criteria, organized defence, type of defence, the match time, score, specific positions, tactical and result of the action, from which were developed systems of category and each indicator set, covering in detail, the actions and behaviours that can occur in these situations the match |

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| Study                     | Sample  | Statistical procedure        | Variables   |
|---------------------------|---|------------------------------|---|
| Gryko et al. (2018)       | World Championships 2013 Spain (84)<br>2015 Qatar (88)  | One-way ANOVA                | Number of actions recorded, and efficiency of actions and the offensive and defensive actions taken by field players and goalkeepers  |
| Fasold and Redlich (2018) | 1000 actions in 55 matches, Germany 1st League (24), 2nd league (21), 3rd league (10), Season 15/16 | Barnard's unconditional test | Foul, cards, time-suspension followed by a penalty, signal for passive play, goal, technical mistake missed shot blocks, interceptions, offence and defence outcomes were categorized into goal and no goal actions |

### Predictive Analysis

The common goal of this type of studies is to determine more efficient ways to play. Through the use of qualitative multidimensional data instead of unidimensional data, the ability to describe the handball match is enhanced (Debanne, Laffaye, & Trouilloud, 2018; Dumangane, Rosati, & Volossovitch, 2009; Gruić, Vuleta, & Milanović, 2006; Rogulj, Srhoj, & Srhoj, 2004; Srhoj, Rogulj, & Katić, 2001) (Table 6).

TABLE 6 Empirical studies with predominantly predictive analysis

| Study                   | Sample  | Statistical procedure  | Variables   |
|-------------------------|---|--|---|
| Srhoj et al. (2001)     | 80 matches World Championship in Egypt 1999   | Regressive Analysis  | Number of goals and shots of goal position; of seven meters; of the pivot position; of the players of 1 <sup>o</sup> line; individual action of fast attack and counterattack.  |
| Rogulj et al. (2004)    | 90 matches Croatian League season 1998-1999.  | MANOVA   | Number of counterattacks; of prolonged counterattacks; short positional attacks; long positional attacks; uninterrupted attacks; single interrupt attacks; various interrupt attacks; In-game attack systems with one or two pivots; Attack organization Number of attack segments based on group cooperation; attack segments based on basic principles; Combination-based attack segments; attack segments based on group manoeuvres attack segments based on independent action; Attack direction attack segments to the right, left and centre. |
| Gruić et al. (2006)     | 60 matches World Championship in Portugal 2003  | Regressive Analysis  | Frequency of successful shots (scored goals) or missed shots, which were made by first line players, wings and pivots of their play and counter-attack positions, as well as their assists and technical errors   |
| Dumangane et al. (2009) | 224 matches of the men's world championships 2001, 2003 and 2005                                | Linear Probability Model   | Offensive actions and Goals.  |
| Debanne et al. (2018)   | 68 matches of the French league, seasons 2012-2013, 2013-2014, 2014-2015, 2015-2016, 2016-2017. | Logistic regression analyses<br>Multivariate logistic regression | The 7-meter throws; Situational Focus (when the 7-meter throw is executed during the final minute of the match); Reward Structure induced from the score difference between the teams and game location   |

The results of these types of investigations can provide valuable information for coaches that could optimize team and players' performance according to the specific variables considered.

### Discussion

The objective of this review was to identify and summarize the most detailed literature on handball match analysis. We have identified the most frequently searched topics and characterized their methods. According to the previous systematic reviews on the analysis of collective sports matches (Agras et al., 2016; Sarmiento et al., 2018; Sarmiento et al., 2014; M. Silva et al., 2016), the common purpose of revised articles in handball is to describe the activity patterns of players and teams.

### **Descriptive analysis**

Players' and teams' actions during handball matches are registered using collecting systems that have vastly improved since the first simple manual collect systems videos (Prieto, 2015). However, although this process has evolved substantially in the amount and facility of data collection, studies are usually based on the frequency of actions and percentages of different performance indicators, which only provide information on what happened at the end of a game, without revealing the process of how this result happened during the match. (Prieto et al., 2015b).

The most commonly evaluated indicators present in this studies are the numbers of attacks made, offensive efficiency, shots taken, shots efficiency, goalkeepers' efficiency, average number of disqualifications, shots taken by backline players, wings and pivots, fast-break, quick attack and positional attack and 7-meter penalties (Bilge, 2012; Gutiérrez et al., 2011). For those analysis to be effective in the future, they must provide feedback to coaches and players before and after the match (Bilge, 2012; Gutiérrez et al., 2011).

The number of scored goals by the player is the main reason for the teams' success and depends on various factors: collective actions, individual actions, or weak individual technique of the defenders, surpassed by the strength or individual techniques of the offensive players (Gutiérrez et al., 2011).

Gutiérrez et al. (2011) also consider the goalkeeper to be one of the primary indicators of defensive success; their study includes a methodology that allowed to approach the study of the anticipation of the goalkeepers through an analysis of the movement used by them to defend the ball, allowing the temporal and spatial orientations of the goalkeeper to be connected with anticipation of movement and decision making, before the shot is realized.

### **Comparative Analysis**

As researchers' objectives, the studies compare the performances of the athletes and teams, according to the final result of the match, the actions of the coaches, the location of the match, and the defensive process.

### **Time-outs (TTOs)**

Among the various options available to handball coaches to control the course of the match, the two main features are player replacement and time-out calls; in the case of handball, there are three TTO requests per match, with a maximum of two per period permitted (Gomes et al., 2014). Thereby, coaches can use time-out as a tool to influence team performance, since they can use this moment to give tactical instructions or to perform structural modifications (e.g., game system, tactical disposition of the players) (Gutiérrez Aguilar et al., 2016).

Related to the above-mentioned studies, it is vital for the coach to know when to call a TTO and the amount of feedback to be provided to the athletes (Guzmán et al., 2012). The relationship with the analysis of the TTOs requested by the coaches comes through structural changes in the match, thus exposing an external result of the request; furthermore, the quantitative analysis of the coach's verbal behaviour would aid in determining if the information on the performance variables was efficiently supplied (Guzmán et al., 2012).

When the team calls for a TTO, the tendency is to make substitutions of players and changes of defence. The number of positive actions of the team increases after requesting a TTO; a change in the defensive system alone does not change the positive action difference in a relevant way after requesting a TTO, but the effect is positive when players are replaced (Gutiérrez Aguilar et al., 2016). Also, the decision of when to call a TTO during the match can make a difference to the final result of the match as well as short-term performances of both teams (Gomes et al., 2014).

Prieto et al. (2016) state that TTO is used mainly by teams that are losing or that have had a negative partial on the scoreboard and want to restructure the team (Gomes et al., 2014; Gutiérrez Aguilar et al., 2016). Consequently, the losing teams, in turn, have the habit of requesting it more often than the winning teams do.

Regarding the period of play, significant positive effects were found in the medium term; for the teams that made a TTO request in the first 20 minutes of each half of the match, there was always an increase in the goals scored (Prieto et al., 2016). Gutiérrez Aguilar et al. (2016) recognized that most of the TTO were requested in the last ten minutes of each period.

Coaches must be aware of their TTO calls, when the prevailing mood following positive actions and corrective actions are considered relevant, as players always need more information, even after a successful action. A second prominent position would be provided by the increase of doubt and insecurity that generates negative actions in the coach; this may be due to the reduction of effectiveness in the information processes and decision making in negative situations (Guzmán et al., 2012).

### **Home advantage**

The domestic advantage effect is an intriguing phenomenon that has been the focus of much interest in sport research; data have enabled identifying those statistics related to the match that are affected by playing at home or away and how these variables can be attributed depending on the particular context of the match according to the capacity of both teams (Lago-Penas et al., 2013).

There is a significant direct association between the advantage of playing at home and the points obtained in a competition. In addition, there is a significant inverse association between the advantage

of playing at home and the final classification of a team (Gutiérrez Aguilar et al., 2014). Several studies have emphasized the need to adjust the team's ability to quantify the advantage of playing at home; Lago-Penas et al. (2013) consider this domestic advantage to be at the behavioural level as a psychological factor for athletes; in contrast, Pic (2018) explains that the existence of the advantage of playing at home exists mainly in the critical moments of handball games to obtain decisive success actions in favour of the home team.

The importance of these factors is reflected in the changes in team and player activities, and in the responses to game situations; the results are that home teams outnumber their opponents in terms of more aggressive defensive behaviour, such as blocked shots, highly successful defensive actions and anticipations that can generate errors of the visiting teams (Gomez et al., 2014). As a result, playing matches at home causes players to make fewer mistakes (Krawczyk, 2015), which can be explained by the increase in player motivation and which can lead to a greater level of involvement in the match and greater accuracy.

Oliveira et al. (2012) studied the home advantage phenomenon and examined the five-minute periods in which teams scored more goals. The results confirmed the existence of a home advantage (64%), which was higher in balanced matches (71%) and lower in unbalanced matches (55%) but did not show any specific five-minute period of when the home advantage appeared. The last five-minute periods of each half of the match were those in which most goals were scored, especially in the second half.

Additionally, Pic (2018) verified the existence of home advantage at critical moments (match status and game result), while Oliveira et al. (2012) concluded that home advantage in handball depends upon the quality of opponent, and it is stronger in balanced games. Moreover, the authors concluded that the differences between the final outcome and game location were only identified in 6-m shot effectiveness.

Gomez et al. (2014) argue that the effect of the advantage at home can be affected by the interpretation of the referees that in turn influence the result of the match. In fact, a referee's decisions can favour local teams in disciplinary decisions. In addition, a feature of the visiting teams is that their defensive actions are poorer, due to dysfunctional aggression, which means that defensive players fail in preventing the attackers from making contacts; the players then end up committing absences or violations.

Team coaches should be able to consciously change the style of the match and change the players when the team is making a greater number of mistakes so that the team's own errors can be eliminated and those committed by the opponent can be used (Krawczyk, 2015).

In general, the results of the reviewed studies showed that there is a home advantage effect for most measures of performance and discipline at the team level. These results indicate that strategies in handball are influenced by the location of the game and teams can change their style of play accordingly.

### **Winners and losers**

Typically, team performance indicators are provided from the comparison of winners and losers, and it is stated that no difference was found in the game style (positioned and fast breaks). It is essential to note the importance of the indicators established in goals scored, the effectiveness of total attacks and position attacks, total and long-range shooting efficiency and goalkeeper saves, as well as defensive actions that show significant differences between teams in relation to goalkeeper and defence (Skarbalius et al., 2013). The process of individual and collective defence actions as well as defensive match systems can become the main weapon of a team and can compensate for deficiencies in the offensive compartment (Gutiérrez Aguilar & Ruiz, 2013).

Rogulj (2000) had the goal of determining which offensive and defensive collective tactics related to the duration of the match, the continuity, the systems, and the game structure that better differentiate between winning teams and losing teams. In his study, he used 27 performance indicators related to the competitive success situation of the teams. The main results revealed that winning teams were more efficient in fast transitions and individual action of progressing in attack. On the defensive end, winning teams were more efficient in executing defensive elements, and the losing teams committed several mistakes and executed inefficient shots in most of the fields' positions.

By involving a number of indicators of non-standard situational activity of the match, Foreti et al. (2013) present a contribution to defining the parameters of the situational efficiency of the players in a specific game position in handball. Understanding the importance and contribution of specific moments of the match to the final outcome can be very fruitful for coaches, in order to better perform their intervention. In this sense, individual performance indicators, such as attack efficiency, shots from the wings and 7m penalties have a tendency to be considered as key indicators of the match standard (Skarbalius et al., 2013).

Data Envelopment Analysis (DEA) is widely used by researchers for the purposes of measuring productivity and relative performance. In particular, it is a non-parametric technique that allows comparing input and output data without statistical order assumptions (Charnes, Cooper, & Rhodes, 1978). Gutiérrez Aguilar and Ruiz (2013) evaluate the cross-efficiency to measure the performance of each team, obtaining the performance classification of the teams that can be compared with the final classification of the tournament and, therefore, are able to establish a comparison between the performance of the match and the competitive

performance of each team according to their level. The results identified 9 efficient teams and 15 inefficient teams. The efficient teams achieved the efficiency both through different patterns of the game and very specialized patterns of the game (e.g., good performance in the number of goals scored from 6m). Concerning the inefficient teams, the DEA model identifies areas of potential improvement in each team (e.g., need to improve the efficacy of goals scored from the 9m and 6m).

#### *Other comparative studies*

In addition to the comparative studies that focused their analysis based on specific variables of players or teams at various competitive levels, there were a number of studies that focused their analysis on other aspects, though less numerous.

The intensity and workload, intensity load, and volume load of a handball game are dynamically heterogeneous due to the very nature of this team sport, in which two opposing teams alternately assume the roles of attacker or defender. A complex system in sport, especially in team matches, consists of structural and functionally heterogeneous components that interact with different intensities and encompass different space-temporal scales (Prudente et al., 2017). Analysts and coaches use performance indicators to evaluate the performance of an individual, a team or elements of a team, comparably using opponents, other athletes or groups of athletes or teams of peers, but often they are used in isolation as a measure of the performance of a team or individual (Prieto et al., 2015a). It allows them to choose the actions that best adapt to today's handball situations, directed directly to group tasks, such as two vs two situations within the match (Prudente et al., 2017).

The main results obtained by Meletakos and Bayios (2010); Meletakos et al. (2011) showed that the 6- and 9-metre throws had great relevance in the profile of the offensive teams. In particular, the efficiency of 6-metre throws remained constant in the three championships, while the effectiveness of 9-metre throws experienced a significant increase from 2005 to 2009. The authors argued that this was due to the increased quality of the pivots and their higher shooting efficiencies, which led the opposing teams to adopt special defensive tactics near the 6-metre line.

In identifying the offensive and defensive situations during a two-year cycle, Gryko et al. (2018) detects a change in the concept of playing in the positional attack in the 2015 championship in comparison to the 2013 championship; there were a significantly greater number of actions that led to a pitch in the region of 6 metres next to an opponent's goal area, as well as a higher level of actions and a more aggressive game by the defensive players; the European teams won more games than the teams of other continents, demonstrating a superiority in the effectiveness of the technical-tactical actions of the match.

On the influence of the defensive fouls in the handball match, Fasold and Redlich (2018), when comparing the offensive actions where they happened, concludes that neither the strategy of stopping the offensive actions by corporal contact (fouls), nor avoiding fouls and focussing only on the interception of the ball, were a favourable solutions in the successful defence in the handball, being the most effective to implement a defence strategy with zones and situations to make fouls, clearly defined among the team, since the tactical possibility of making fouls is allowed in handball.

On the excess of more aggressive faults and fouls punishable, one a factor that shows no difference in the results of the match is the exclusion of two minutes; the study by Prieto et al. (2015a) show that in the sanctioned exclusions, opposing teams take advantage of numerical superiority and improve their score performance in the match. However, the punctuation increments were smaller than might be expected from numerical superiority. Psychological theories, such as asphyxia in situations of pressure, where good performance is expected and does not occur, may contribute to explain this finding.

Finally, it is known the goalkeepers play an essential role in defence and always try to minimize the success of opposing players. Handball has some areas of its field where goalkeepers have more advantages and more opportunities to defend the shots: the corners and the area behind the nine metres. Field players in attack in these areas attempt to overcome these disadvantages; this leads these players to find another way to be more effective (more technique and stronger shots). That said, the success of one or the other ultimately depends on the level of each performer (Hatzimanouil et al., 2017).

Thus, it can encourage a reflection in terms of planning for the coaches, helping to understand better how the result and the match time influence the efficiency of the actions, taking into account the tendencies in the game evolution (Prudente et al., 2017).

#### *Predictive Analysis*

The hierarchical model of performance structure in handball is meant to describe the situational action or efficiency of handball players' performance, which in turn defines the outcome of a match and, consequently, its overall sporting achievements in a competition (Gruić et al., 2006). The results of the analysis indicated the feasibility of detecting the performance parameters in the offensive process of the teams. However, in interpreting the obtained results one must be careful; despite its relatively high statistical significance, the proportion and structure of the case samples and observed variables limit, to some extent, the virtue of the results obtained (Gruić et al., 2006; Rogulj et al., 2004).

Dumangane et al. (2009) examined whether the offensive and defensive performance of the teams influenced the probability of scoring in the match. A linear probability model was developed to estimate the probability

of scoring as a function of the previous team performance. The main results showed that the scoring probability does not appear to have been influenced by the previous offensive performance of the attacking team, but indirectly by the past offensive actions of the opposing team.

Focusing only on the offensive aspect of the game, Rogulj et al. (2004) studied 19 elements of collective attack tactics, differentiating between winning and losing teams. It was found that the winning teams made continuous and short attacks against unorganized defences and short positional attacks (less than 25 seconds). It was discovered that losing teams performed long positional attacks, one pivot attack, low tactical complexity attacks, attacks based on individual player attempts, and attacks based on group cooperation and group manoeuvres of only a few team players.

Srhoj et al. (2001) analysed the influence of 18 indicators of the positional direction of the final conduct of the attack on the final result of the match. The results of the study showed that the players in the centre position were those who performed the final conduct of the attack more frequently. The best effectiveness of the shots was presented in situations and short distance shots. The lowest effectiveness of finalization was presented in long-distance shots and shots with small angles (wings); the variables related to the indicators of general engagement of the attack activity directed to the final conduct of the attack have no significant influence on the result. This means that the resulting success is not conditioned by the quantity but by the quality of the shots.

With another perspective of match analysis in a more psychological context, the purpose of Debanne et al. (2018) study was to examine the connection between shooters' motivational orientations and their performance in a real-time environment at a crucial moment in the match and to evaluate the location effect successful seven-metre penalty throws in a handball match, evaluating performance in a real environment for understanding human psychological behaviour in a stressful context. As a consequence regarding the shooting situation of seven-metres, the authors suggest systematically perceive it critical to reduce the score difference independent of the moment of the match.

Although the literature emphasizes the importance and relevance of this type of research and despite the constant use of sophisticated analytical techniques/game analysis, there are still few available studies that have worked on developing and predictive models of sports performance in handball.

## Conclusion

Research on performance analysis in sports, match analysis, has evolved over the years, mainly due to tremendous technological advances. In the case of handball match analysis, published studies examined the performance of players and teams with different complexity perspectives. The studies are based on the actions of the players and teams, are recorded to obtain a final set of data and thus describe what happened at the end of the match, without considering how it happened.

It can be observed that most articles focused on the study of offensive actions. In turn, many of the aforementioned studies focused their analysis on four main performance variables that seem to assume a greater importance: (1) in the shots where the main action under study, in relation to which different positions of the players, distances and situations of the game; (2) the differences between winning teams and losing teams; (3) Time Outs and their importance to coaches and teams; and (4) the relation between matches as home team and visitor. Regarding the methods of analysis, articles from the static perspective were based on descriptive and comparative studies of the cumulative statistics at the end of the match. In contrast, studies using the dynamic approach have used a variety of advanced analysis techniques to evaluate the time evolution of performance during the match.

This systematic review can provide useful information on potential lines of work for performance analysts in the field of handball match analysis. The general guidelines for future work on handball match analysis include, but are not limited to, (1) comparison of winning teams throughout sporting seasons, (2) understanding the effects of major indicators in different match periods, (3) understanding evolutionary tendencies of the match during several times, (4) conducting more studies focused on the defensive profile, (5) analysing international club competitions, (6) analysing video matches and not using other reports provided by the tournament organization, (7) using standardized variables for all researchers.

In this sense, there is a need to promote the development of systems for analysing the performance of athletes and teams that allow continuous and sequential mapping of actions occurring in the game. In this way, we will facilitate a more profitable relationship between science and practice, enhancing the collaboration between coaches and scientists.

Limitations of the reviewed studies are related to the default definitions of terms and conflicting expressions of activities and actions, which make it difficult to compare a similar group of studies. The use of studies with teams of different levels and different national championships also complicate the standardization of conditioned groups, thus hindering a replication of the studies and their future comparisons.

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# The Development of an Online Surveillance of Digital Media Use in Early Childhood Questionnaire- SMALLQ™- For Singapore

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**ABSTRACT** Digital media engagement in families in Singaporean society is increasing at an unprecedented pace. Limited research in the last five years in Singapore shows that young children experience significant amounts of screen time from television, computers and other forms of mobile digital devices, even before primary school. For children, digital media use can aid with learning, but its overuse has inimical effects on learning and health. As digital media use in children increases faster than research on its impact, it is essential to develop a tool that can monitor changes in digital media habits of children over time. This study aimed to develop an online questionnaire for parents to report on the digital media habits of children. An online questionnaire bundle, Surveillance of digital-Media hAbits in earLy chiLdhood Questionnaire (SMALLQ™), organized into sections ((I) Digital-media use of parent and child, (II) Non-digital media behaviour of the child, (III) Parent and child information) was developed for the purpose of charting digital media use and changes over three years (2018, 2019, and 2020). The results showed that SMALLQ™ has face and content validity and was practicable for Singapore. Furthermore, based upon a similar methodology for developing the SMALLQ™, the development of Child-SMALQ (Surveillance of digital MediA use in chiLdhood questionnaire) and Adolescent-SMALQ (Surveillance of digital MediA use in adoLescence questionnaire) are directions for future research.

**KEY WORDS** surveillance, development, questionnaire, SMALLQ™



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DEVELOPMENT OF ONLINE SMALLQ™  
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## Introduction

Research shows that people of all ages in developed and developing countries use digital media significantly on a daily basis because of the high penetration rate of the internet, work and school culture, societal environment and the ubiquity of mobile technologies (American Academy of Pediatrics (AAP), 2011; Canadian Paediatric Society (CPS), 2017). Some scholars suggest that young children's interacting with digital media can help with learning and literacy (AAP, 2016). Other scholars opine that an early adoption of these digital media socializes young people to sedentary lifestyles, leading to obesity, an earlier onset of type II diabetes, technology addiction, displacement of other meaningful activities, such as real-time parent-child interaction, physical play and physical activity, impaired self-regulation, and delayed expressive speech, among other insidious outcomes (CPS, 2017). International organizations, such as UNESCO Bangkok (2015), advocate maximizing children's digital opportunities in an attempt to ameliorate the digital divide with caution and concern for the inimical consequences. Some health ailments have their genesis in childhood, and it is crucial to curb their entrenchment as early as possible. Digital devices (fixed screens (television, desktop computers) and mobile screens (smartphones, tablets)) originally targeted at adults are now increasingly available to pre-school children, with or without parental supervision. Research into the effects of such digital media exposure

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Conflict of interest: None declared.

on the health and development of preschool children in the context of urban areas in Asia cannot match the increased use of such parent-owned technologies. As digital media use among young people changes rapidly over time and increases with age (AAP, 2011; Bernard et al., 2017), there is a need for a common measurement tool, such as the SMALLQ™, to chart and monitor children's digital media use over different critical periods, for example, in school transitions (preschool to primary and to secondary school) as transitions from early childhood, childhood, and adolescence.

## Method

### *Ethical clearance*

Prior to the research, the authors obtained ethics clearance from the Nanyang Technological University – Institutional Review Board (IRB-2017-09-036).

### *Development and face validity of the SMALLQ™*

The questionnaire was developed in Singapore using the AMEE framework- Guide No.87 (Artino, Rochelle, Dezee, & Gehlbach, 2014). The seven-step framework is used to develop high-quality surveys that are suitable for programme evaluation and research. The seven steps include (1) literature review, (2) focus group interviews, (3) synthesis of the literature review and focus group outcomes, (4) development, modification or re-order of the questionnaire items, (5) feedback on the items through expert opinion, (6) employment of cognitive interviews to ensure that respondents understand the items as intended, and (7) pilot testing the online questionnaire. A unique feature of this process is that it blends the views of potential participants and that of experts, thereby front-loading the validity of responses via careful item selection (Artino et al., 2014).

A thorough review of media use questionnaires reported on children was made, and initial drafts of the questionnaire were produced. Some of these included items in the “Zero-to-eight Children's Media Use in America” (CommonSense, 2011) as well as the “Early Years Physical Activity Questionnaire” (Bingham et al., 2016). Initial draft questionnaire items numbered about 40 (a juxtaposition of media use and physical activity) and focused mainly on soliciting parent's response to the type of devices used to access digital media in general and did not differentiate between weekday and weekend use. Focus group discussions were conducted between the researchers and several experts in questionnaire design, early childhood specialists and stakeholders in education to gauge the relevance and appropriateness of questionnaire items. Specifically, for the development of the online SMALLQ™ in Singapore, the group included an early childhood expert, an advisor to early childhood government agency, a senior lecturer in early childhood and an associate professor who lectures in graduate courses on questionnaire development and design, a pedagogy specialist working in preschool, and five parents of children attending preschools in Singapore. They independently reviewed early versions of the questionnaire and guided the development of new questions that were contextually relevant, of concern and interest, and useful for tracking over time for Singapore. A specialist for the Qualtrics platform provided technical expertise on the functionalities, security and confidentiality of using the online platform. This eventually led to the formulation of a new online survey entitled “Surveillance of digital Media hAbits in earLy chiLdhood Questionnaire”, aptly encapsulated in the acronym “SMALLQ™”, for which a trademark application (TM120494 Class 41 under education research) was made in Singapore, in 2018. Cognitive load and the ease of understanding of the questionnaire items were tested with the focus group, and, where necessary, the questionnaire items were refined and reorganized before the final 25-item SMALLQ™ was accomplished and hosted online on the Qualtrics platform. Leadership teams and principals from the preschools, and parents of preschool children outside of this study participated in a feasibility study. Feedback on the usability of SMALLQ™ on mobile devices was solicited, and the researchers further refined the interface to improve the end-user experience (i.e., parents answering the online SMALLQ™). Four independent experts who were not involved in the research established the face validity of the SMALLQ™.

### *Surveillance of digital Media hAbits in earLy chiLdhood Questionnaire (SMALLQ™)*

The online SMALLQ™ sought information in three segments: (i) digital media use, parent benefit, concern, knowledge and practice of guidelines, outside of school on weekday and weekend; (ii) non-digital media habits: indoor and outdoor play, day time naps, non-screen reading, and drawing; (iii) parent educational attainment and household income, additional child information: height, weight, wearing spectacles or not, and night-time sleep. Specifically, the SMALLQ™ instructed respondents to provide information about:

#### *Digital media environment at home*

Parents were asked about the type of technological devices that children had access to outside of school (e.g., at home). These included fixed screens such as television, desktop computers and game consoles, mobile screens such as smartphones, tablets and other hand-held devices and technological toys.

#### *Parent digital media habits*

Parents were queried about their digital habits on a typical weekday and on a typical weekend day. The choices were segregated as use for work, entertainment, social networking and for personal development.



### ***Digital media habits of the child outside of pre-school/ kindergarten***

Parents were asked to provide details of children's digital media habits outside of pre-school/ kindergarten, on a typical weekday, and on a typical weekend day. This included the frequency, duration and purpose of digital media use (for learning, for entertainment, for communication) on fixed screens and on mobile screens.

### ***Parent perception of digital media use***

Parents were asked to indicate their perceived importance of digital media use to them and to their child using a 5-point Likert scale from "not important" to "very important". Options for the benefit to the child include "Improve knowledge and skills", "Entertainment", and "Communication". Options for the benefit to parent include "Keep child occupied", "Distract or divert the attention of the child" and "Put the child to sleep".

### ***Parent concern of child digital media use***

Parents reported their perceived concerns about digital media usage by their child on a 5-point Likert scale from "not concerned" to "seriously concerned". Options for parents include "Poor sleep", "Poor eyesight", "Lack of physical exercise or play", "Exposure to inappropriate content", "Addiction", and "Lack of parent-child interaction".

### ***Parent awareness and practice of guidelines on digital media use by children***

Parents were asked to indicate whether they are aware of the four professional guidelines on digital media use by children and if they practised those guidelines. The guidelines are (i) Limit digital media use for children younger than two years, (ii) Limit screen time to 1 hour per day for children 2-5 years, (iii) Introduce only high-quality educational programmes for children 18-24 months, and (iv) Co-watch or co-play digital media with a children.

### ***Non-digital habits of the child outside of pre-school/ kindergarten***

Parents were also asked to report about their child's physical activity and play on a typical weekday and weekend day outside of the preschool. This included the duration spent on various indoor activities (non-screen reading and drawing), indoor play and outdoor play, and an estimated apportion of time their child spent on moderate-to-vigorous activities, which caused their child to breathe harder and faster.

### ***Demographic information***

The SMALLQ™ also included demographic questions about the participants (e.g., relationship to the child, monthly household income, highest educational attainment, race) and their child (e.g., gender, age, height and weight, whether the child wore spectacles or not, sleep duration, and sleep quality).

A sample of SMALLQ™ and acknowledgement of help is shown in Annex 1.

## **Results**

In testing the online SMALLQ™, we received 137 completed surveys from teachers, parents, and school leaders of preschool centres and kindergartens in Singapore. These participants were not part of a more extensive three-year tracking study, which, commenced in 2018 and will end in 2020. The average time taken to complete the online survey in a single sitting was between 20 and 30 minutes; 66% of respondents used the QR code to access the SMALLQ™ while 34% used the anonymous internet-link. In terms of qualitative online feedback from respondents, the use of "drop-down options" for choices was preferred to the use of "slider-scales". These were noted, and amendments were made to the SMALLQ™ to enhance its utility and ease of response for participants of the survey. Overall, the qualitative comments from respondents in the pilot test were affirmative. There was agreement and concurrence among the qualitative comments of the four independent experts who commented on the SMALLQ™ and established its face and content validity.

## **Discussion**

The purpose of the pilot research was to develop an online questionnaire that holistically examines the digital media use of preschool children aged between two and six years old, indoor and outdoor play, parents digital media habits, their concerns, awareness of digital media use guidelines and their enforcement, and socioeconomic background of parents. The development of the SMALLQ™ adhered to the seven-step process described by Artino et al. (2014). The results showed that parents, teachers and school leaders who were not involved in the main study took between 20-30 minutes to complete the online SMALLQ™ in a single sitting, albeit, many did so in more than one sitting. The response rate was higher when participants completed the online SMALLQ™ as a group such as during a briefing session about the research. However, such an arrangement may not be feasible for the actual launch of the research since opportunities where parents of preschool children congregate as a group are infrequent. However, there is an advantage to the questionnaire being online since the reach to parents of children who enrolled in the preschools is greater. Feedback from users about the improving upon the functionality of the online survey such as the use of "drop-down" options instead of "slider-scales" and the merits of using both QR codes and anonymous internet-link to access the SMALLQ™, was accommodated.

In conclusion, the SMALLQ™ was adjudged to have acceptable face validity, was relevant and appropriate for use as monitoring tool of digital media use in early childhood and has the potential to be adapted for use in childhood as Child-SMALQ (surveillance of digital media use in childhood questionnaire) and in adolescence as Adolescent-SMALQ (surveillance of digital media use in adolescence questionnaire). These online questionnaires can be translated into other languages for international comparisons of digital media use among participants from early childhood, childhood, and adolescence.

### Acknowledgement

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Revised June 2019

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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 Krstrup (2008) stated that...
- ✓ Subsequent 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

- ✓ Krusturup et al. (2003) studied...
- ✓ In one study (Krusturup 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
- Krusturup, 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](http://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. <sup>a,b,c</sup>), and order the superscripts from left to right, top to bottom. Each table's first footnote must be the superscript <sup>a</sup>.

✓ <sup>a</sup>One participant was diagnosed with heat illness and n = 19.<sup>b</sup>n = 20.

Probability notes provide the reader with the results of the tests 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 below 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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and physical education  
NIKŠIĆ**



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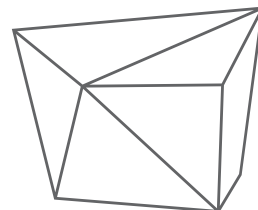




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## *University of Montenegro*

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 through a numerous EU funded scientific projects.

All over the year Institute is looking to hire 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 organizes several summer schools and workshops 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 which 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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# University of Montenegro

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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 programmes 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](http://www.ucg.ac.me) or send e-mail to [pr.centar@ac.me](mailto:pr.centar@ac.me).







# UNIVERSITY OF MONTENEGRO FACULTY OF MECHANICAL ENGINEERING Podgorica

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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 professional work.

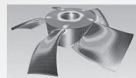
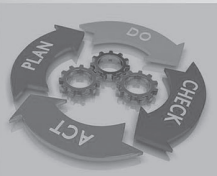
Two study programmes were accredited within the Faculty of Mechanical Engineering:

- 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.

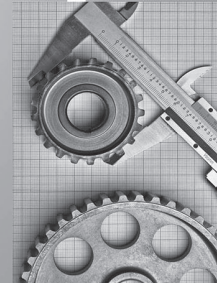
On the study program Mechanical Engineering it is possible to study next modules:

- 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:

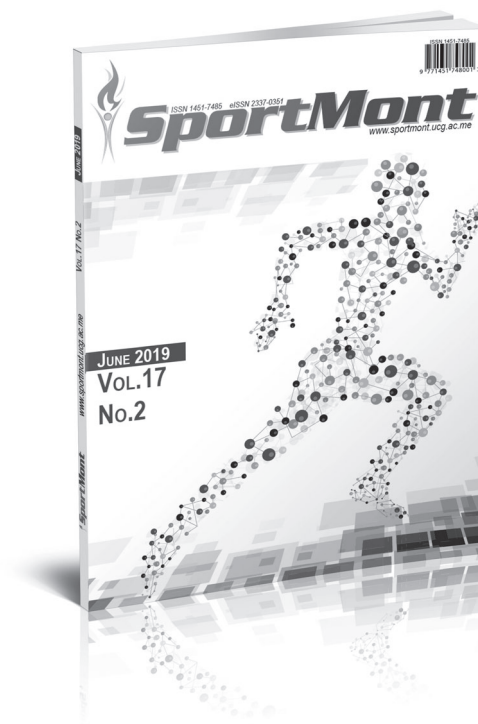
- Centre for Energetics
- Centre for Vehicles
- Centre for Quality
- Centre for Construction Mechanics
- Centre for Traffic and Mechanical Engineering Expertise
- Centre for transport machines and metal constructions
- 3D Centre
- Didactic Centre – Centre for Automation and Mechanomics training
- European 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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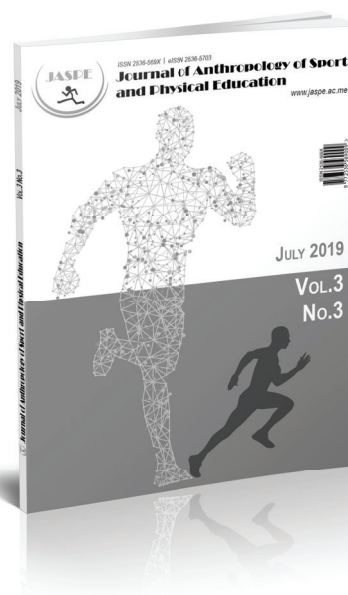
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