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SportMont

ORIGINAL SCIENTIFIC PAPER

# Comparison of Ventilatory and Blood Lactate Thresholds in Elite Soccer Players

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**Abstract**

Despite a long research history, the lactate threshold continues to be a widely controversial field. Notwithstanding the controversies and influence of multiple determinants, the estimation of lactate threshold in sports has been considered one of the essential parameters in the prescription of training intensity, load monitoring, and performance prediction. The study aimed to compare the anaerobic ventilatory and lactate thresholds as determined by different methods in elite soccer players. The study consisted of twenty-five division 1 elite soccer players. The players were separated into two groups based on their run times on the treadmill. Group 1 (age 24.38±7.33 years, height 180.33±7.03 cm, weight 75.53±7.68 kg) consisted of players who completed more than 17 minutes on the treadmill, while group 2 (age 25.11±6.07 years, height 182.11±10.03 cm, weight 79.72±7.54 kg) consisted of those who completed less than 17 minutes. The players completed an incremental maximal cardiopulmonary exercise testing from which ventilatory thresholds were determined. Furthermore, measurements of blood samples were obtained every 3 minutes after completing each stage of the test, with a total of 141 measurements completed. Multivariate tests indicated no significant differences in the speeds calculated with ventilatory and lactate threshold methods. These findings suggest that the anaerobic ventilatory threshold (VT2) can be used as an alternative to the invasive lactate threshold measurements. Therefore, identifying a threshold point without utilizing an invasive procedure enhances the potential application of the VT2 or respiratory compensation point.

***Keywords:*** *Respiratory compensation, visual inspection, logarithmic transformations, maximum distance method, fixed blood lactate*

## Introduction

Soccer is classified as a high-intensity intermittent team sport (Bradley et al., 2009) that requires high levels of cardiovascular fitness, strength, and power (Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005). Elite soccer players cover about 10 km in 90 minutes during competitive games, with a mean intensity of about 75% of maximal oxygen uptake (VO2max) (Bangsbo, Mohr, & Krustrup, 2006).). Research demonstrated that low-intensity activity accounted for 85.4% of the total game time, while high intensity running and sprinting accounted for 6.4% and 0.6% of the total game time, respectively (Bradley et al., 2009). Researchers have suggested that distances covered during high-intensity running are indicative of physical performance in soccer due to their relationship with training status (Krustrup et al., 2005). Furthermore, research demonstrated a noteworthy contribution of the aerobic energy system during soccer games and a considerable stimulation of the anaerobic energy system as indicated by the high blood lactate concentrations (Krustrup et al., 2003). Consequently, variables such as VO2max, ventilatory threshold (VT), lactate threshold (LT), and blood lactate values are essential measurements for soccer players.

During an incremental exercise activity, an increase in load results in increased energy demands that derive from an immediate energy supply through the anaerobic glycolytic system (Hargreaves & Spriet, 2020). This results in the continuous

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production of lactate (lactate appearance in the blood) accompanied by increased lactate clearance (disappearance from the blood) by various lactate shuttling mechanisms (Hargreaves & Spriet, 2020). As the intensity of exercise increases, the rate of conversion of pyruvate to lactate increases rapidly as opposed to the rate of clearance (Karlsson & Jacobs, 1982). As a result, there is a disproportionate nonlinear increase in blood lactate accumulation, termed as the onset of blood lactate accumulation (Karlsson & Jacobs, 1982). During incremental exercise testing, the first lactate breakpoint in low intensity is known as the aerobic threshold (LT1), while the second rise in blood lactate is known as the anaerobic threshold (LT2). Identifying LT aids not only in the evaluation of performance but also in the prescription of exercise training intensities. Additionally, it has been proposed that the LT reflects the training status of elite soccer players and, therefore, can be used for the routine assessment of aerobic fitness in soccer players (Ziogas, Patras, Stergiou, & Georgoulis, 2011). Evidently, running performance in sports that heavily depend on an aerobic component, such as soccer, is not only associated with high levels of VO2max but also with other performance indices such as LT and its associated running velocities (Ziogas et al., 2011; Marcos, Koulla, & Anthos, 2018).

Incremental exercise testing is a common procedure for determining those physiological characteristics. Several methods have been proposed to determine LT over the years, among which the cut-off point of 4 mmol/l of blood lactate concentration (Kindermann, Simon, & Keul, 1979), the visual inspection (VI) (Davis Rozenek, DeCicco, Carizzi, & Pham 2007), the utilization of logarithmic transformations (Log-log T) (Beaver, Wasserman, & Whipp, 1985), and the various curve fitting procedures such as the maximum distance (DMax) method (Newell et al., 2007). However, no generally accepted fitting procedure has been established for LT assessments in professional soccer players as LT can be influenced by several factors, including the different testing modalities and methods. Additionally, although the LT methods are commonly used to set up individual training intensities, the relationship between lactate-based parameters and ventilatory thresholds (VTs) is still unclear. In VT1, the VO2 and carbon dioxide production increase proportionally, while HCO3- acts to buffer the lactic acid concentration in blood (Cerezuela-Espejo, Courel-Ibáñez, Morán-Navarro, Martínez-Cava, & Pallarés, 1992), while in VT2, the failure of bicarbonate buffering and the consecutive fall in blood pH result in blood lactate accumulation to rise considerably (Meyer, Faude, Scharhag, Urhausen, & Kindermann, 2004). A recent investigation indicated that ventilatory thresholds (VT1 and VT2) could be effective in setting up individual exercise intensity programs for endurance sports considering the individual metabolic responses (Wolpern, Burgos, Janot, & Dalleck, 2015). Interestingly, research on cyclists demonstrated that lactate threshold tests could be a valid and reliable alternative to ventilatory thresholds to identify the body's workloads when switching from aerobic to anaerobic metabolism (Pallarés, Morán-Navarro, Ortega, Fernández-Elías, & Mora-Rodriguez, 2016). More specifically, high reliability and validity were indicated between VT1 and LT as well as between VT2 and LT +2 mMol·L−1 (Pallarés et al., 2016). An additional study on runners and triathletes indicated that LT and LT+3.0 mMol·L−1 were solid predictors of VT1 and VT2, respectively (Cerezuela-Espejo, Courel-Ibáñez, Morán-Navarro, Martínez-Cava, & Pallarés, 2008). The aforementioned studies suggested that gas exchange systems require expensive equipment and laboratory conditions that may not be available to different teams or athletes. Nevertheless, VT2 remains an important physiological parameter to indicate the training intensity.

While some studies examined the relationship between ventilatory and lactate exercise performance parameters in running and cycling, no previous studies examined whether the ventilatory threshold (VT2) can be used as an alternative to the invasive LT measurements in elite soccer players. Thus, this study aims to compare the ventilatory (VT2) and lactate thresholds as determined by different methods (VI, Dmax, modified Dmax, Log-log, and lactate at 4 mmol/l) in elite soccer players utilizing the modified Heck incremental maximal exercise protocol.

## Methods

### *Participants*

The study consisted of twenty-five division 1 elite soccer players (age 24.64±6.78 years, height 180.98±8.07 cm, weight 77.04±7.75 kg). The players were separated into two groups based on their treadmill run times (RT). Group 1 consisted of players (n=16, age 24.38±7.33 years, height 180.34±7.03 cm, weight 75.53±7.68 kg, RT 18.63±0.94 min) who completed more than 17 minutes on the treadmill, while group 2 consisted of those (n=9, age 25.11±6.07 years, height 182.11±10.03 cm, weight 79.72±7.54 kg, RT 15.61±0.64) who completed less than 17 minutes. The cut-off time was the average run time of the players participating in the same football league during the same season, which was demonstrated in a previously published study (Parpa & Michaelides, 2021). Goalkeepers were excluded from the study as they usually work in different intensity zones than the rest of the players (Andrasic, Cvetkovic, Jaksic, & Orlic, 2013). Players were advised to abstain from any activity the day before testing, and measurements were obtained between 8:00 am and 1:00 pm. Each player was briefed on the procedures and signed an informed consent before data collection. Ethical guidelines were followed according to the Helsinki Declaration's ethical standards, and the study was approved by the University's ethics committee board (reference number STEMH 541, 2021).

## Procedures

### *Cardiopulmonary exercise testing*

The players completed an incremental maximal cardiopulmonary exercise testing (CPET) until they reached exhaustion on a treadmill (h/p/Cosmos Quasar med, H-P-Cosmos Sports & Medical GmbH, Nussdorf-Traunstein, Germany). A breath-by-breath analysis was performed on the Cosmed Quark CPET (Rome, Italy) system. Laboratory conditions were kept constant, with the temperature at 22±1°C and relative humidity at 50%. The players were tested utilizing the modified Heck incremental maximal protocol, which was previously used to test soccer players (Parpa & Michaelides, 2022). The test came to an end when the participant reached volitional fatigue or when there was no variation among the VO2 levels while the workload increased. The VO2max was detected after having the results filtered to identify the highest value for an average of 10 seconds.

### *Determination of Ventilatory Threshold and Respiratory Compensation Point*

The ventilatory threshold (VT1) and respiratory compensation point (RC) or VT2 were determined using different criteria. The VT1 was determined through the V-Slope meth-

od, the point at which the increase in the rate of elimination of carbon dioxide (VV̇ CO2) is greater than the increase in V̇O2. The VT1 point was verified at the nadir of the VE/VV̇ O2 curve. The RC or VT2 point was determined at the nadir of the VE/V̇ CO2 curve (Beaver, Wasserman, & Whipp, 1986; Takano, 2020). Blood sampling

The Nova blood lactate plus analyzer, which provides a valid and reliable measurement of blood lactate concentration (Hart, Drevets, Alford, Salacinski, & Hunt, 2013) (Nova Biomedical, Waltham, MA 02454), was used following the manufacturer's instructions to measure blood lactate during an incremental exercise testing. Lactate plus single-use test strip was touched to a drop of blood taken via finger prick (0.7 microliters) to initiate the test. The blood lactate values were available on-screen in 13 seconds. Measurements of blood samples were obtained every 3 minutes after completing each stage of the test, with a total of 141 measurements completed. If a stage was not completed, the final blood sample was obtained upon the completion of the test. The lactate measurements were used to identify lactate thresholds through VI, Dmax, modified Dmax, Log-log, and lactate at 4 mmol/l methods, utilizing the Lactate-E version 2.0 software (Galway, Ireland), which was validated in previous studies (Newell et al., 2007).

*Statistical Analyses*

SPSS 26.0 for Windows (SPSS Inc., Chicago) was used to analyze the results. First, normality and homogeneity of variances were examined and verified using the Shapiro-Wilk and the Brown and Forsythe tests, respectively. In addition, the mean and SD were calculated for all parameters. An independent t-test was utilized to compare the two groups with respect to anthropometric characteristics, run times, and heart rates. Finally, a split-plot ANOVA (Mixed design two-way repeated-measures ANOVA) was utilized to assess between and within-group differences. The between subjects' factor had two levels (group 1 and 2 based on run times), and the within-subjects factor had six levels (VT2, V1, Dmax, modified Dmax, Log-Log, and FBLA at 4mmol/l). For all statistical analyses, significance was accepted at $p<0.05$.

## Results

The anthropometric characteristics and RT of the two groups of soccer players are presented in Table 1. Heart rates at different running speeds and heart rates based on the lactate threshold methods are presented in Table 2. No significant differences between the groups were identified regarding the anthropometric characteristics and heart rates (Tables 1 and 2). However, the two groups were significantly different with regard to performance based on RT [($t(23)=8.56$, $p<0.00$, Cohen's $d=3.76$)], and that was the reason they were divided into the two groups. In addition, the speeds for the ventilatory and lactate threshold methods of the two groups are presented in Table 3. Results indicated significant differences between the two groups for the speeds calculated with the VT2 and LT methods except for the Log-Log method (Table 3). Furthermore, multivariate tests indicated no significant differences in the speeds calculated with VT2 and LT methods for groups 1 and 2. A borderline significant difference in the speed calculated for group 1 was indicated between VT2 and Log-Log (15.00±1.46 km/h vs. 13.53±1.59 km/h, $p=0.062$, partial $\eta2= 0.55$) and VT2 and FBLA at 4mmol/l method (15.00±1.46 km/h vs. 13.66±1.07, $p=0.054$, partial $\eta2= 0.55$) (Table 3). Lastly, for group 2, no significant differences were identified between the VT2 and LT methods, with the only difference being identified between V1 and Dmax methods ($p=0.043$, partial $\eta2= 0.87$) (Table 3).

**Table 1.** Anthropometric characteristics and run time (RT)

| | **Group 1 (n=16)** | **Group 2 (n=9)** |
|---|---|---|
| | Mean ± SD | Mean ± SD |
| Age (yrs.) | 24.38±7.33 | 25.11±6.07 |
| Height (cm) | 180.33±7.03 | 182.11±10.03 |
| Weight (kg) | 75.53±7.68 | 79.72±7.54 |
| RT (min) | 18.63±0.94 | 15.61±0.64** |

*Note: **p<0.01 denotes a significant difference between the groups.

**Table 2.** Heart rate at different running speeds and heart rate based on the different lactate threshold methods.

| | **Group 1 (n=16)** | **Group 2 (n=9)** |
|---|---|---|
| | Mean ± SD | Mean ± SD |
| Heart rate at 12km/h | 171.81±11.86 | 171.33±11.44 |
| Heart rate at 14km/h | 181.81±10.09 | 180.89±10.23 |
| Heart rate at 16km/h | 190.44±9.70 | 188.33±8.41 |
| Heart rate at 18km/h | 195.63±10.49 | |
| HR at V1 | 180.81±12.25 | 175.21±8.92 |
| HR at Log-Log | 175.96±16.53 | 174.83±14.99 |
| HR at Dmax | 179.91±12.02 | 172.87±9.01 |
| HR at Modified Dmax | 179.42±12.02 | 173.20±7.73 |
| HR at FBLA | 177.14±11.92 | 169.69±8.29 |

*Note: HR at V1: Heart rate based on visual inspection method, HR at Log-Log: Heart rate based on logarithmic method, HR at Dmax: Heart rate based on Maximum distance method, HR at FBLA: Heart rate based on Fixed blood lactate accumulation.

**Table 3.** Differences in speeds between the two groups and the different methods.

| | Group 1 (n=16) | | | | Group 2 (n=9) | | | |
|---|---|---|---|---|---|---|---|---|
| | **Mean ± SD** | **95% CI for mean** | **p** | **partial η2** | **Mean ± SD** | **95% CI for mean** | **p** | **partial η2** |
| VT2 speed (km/h) | 15.00±1.46 †§ | 14.22-15.78 | | | 13.33±1.41* | 12.25-14.42 | | |
| V1 speed (km/h) | 14.35±1.38 | 13.62-15.08 | | | 13.27±0.77* ‡ | 12.67-13.86 | | |
| Dmax speed (km/h) | 14.24±1.03 | 13.69-14.79 | | | 12.90±0.64** ‡ | 12.41-13.40 | 0.043 | 0.87 |
| Modified Dmax speed (km/h) | 14.14±1.18 | 13.51-14.76 | | | 12.92±0.74* | 12.35-13.50 | | |
| Log-Log LT speed (km/h) | 13.53±1.59 † | 12.68-14.38 | 0.062 | 0.55 | 13.27±1.73 | 11.94-14.60 | | |
| FBLA(4mmol.l) speed (km/h) | 13.66±1.07 § | 13.09-14.24 | 0.054 | 0.55 | 12.38±1.34* | 11.35-13.41 | | |

*Note: VT2: ventilatory threshold 2, V1: visual inspection method, Log-Log: logarithmic method, Dmax: Maximum distance method, FBLA: Fixed blood lactate accumulation, *p<0.05, **p<0.001 denotes a significant difference between the two groups, † denotes a borderline significant difference between VT2 and Log-Log LT for group 1, § denotes a borderline significant difference between VT2 and FBLA for group 1 and ‡ denotes a significant difference between V1 and DMax for group 2.

## Discussion

Despite a long research history, the lactate threshold continues to be a widely controversial field. Specific practical difficulties and controversies still exist in LT estimation due to the terminology used and the multiple proposed estimation methods. Notwithstanding the controversies and influence of multiple determinants, estimation of LT in sports has been considered one of the essential parameters in the prescription of training intensity, load monitoring (Sparks Coetzee, & Gabbett, 2016) as well as prediction of performance (Edwards, Clark, & Macfadyen, 2003; Forsyth, Burt, Ridley, & Mann, 2017). Thus, this study aimed to compare the ventilatory anaerobic threshold (VT2) that is used as an indirect marker of LT to the lactate thresholds that derive from the invasive methodology.

This study indicated that the threshold speeds based on the ventilatory anaerobic threshold (VT2) were 15.00±1.46 km/h and 13.33±1.41 km/h for groups 1 and 2, respectively (Table 3). The speeds as determined by the V1, Dmax, modified Dmax, Log-log, and FBLA methods ranged between 13.66 and 14.35 km/h for group 1, while for group 2, they ranged between 12.38 and 13.27 km/h. Similarly, a study of professional German soccer players indicated that at a fixed lactate of 4 mmol/l, the running speed was 15km/h (Altmann, Kuberczyk, Ringhof, Neumann, & Woll, 2018), while in general, a running speed of 14.4km/h at the 4mmol/l is used by sports coaches as the cut-off point (Foehrenbach, Buschmann, Liesen, Hollmann, & Mader, 1986). Concurrently, lower running speeds were indicated in another study on soccer players, where the running speed at the level of the 4 millimolar lactate threshold for first league players was 12.6km/h, while second league players reached the highest running speed at 11.8km/h (Andrzejewski, Chmura, Dybek, & Pluta, 2012). The speeds demonstrated in our study with the FBLA (Lactate=4mmol/l) method were 13.66 km/h and 12.38 km/h for groups 1 and 2, respectively. Furthermore, the higher lactate production at lower running speeds for the second league players demonstrated in the aforementioned study was similar to the results of our study, where players with lower performance demonstrated increased lactate levels at lower running velocities. It should be noted that the FBLA is calculated using inverse prediction and is a marker that represents a ceiling value for lactate (Newell et al., 2007). The main criticism of the FBLA marker is the considerable variability at higher workloads (Newell et al., 2007).

Of note, our study demonstrated no significant differences in the speeds calculated with VT2 and LT methods for groups 1 and 2, suggesting that the VT2 may be used as an alternative to the LT methods for the identification of exercise intensities at which soccer players should train. Another study in soccer players that only examined the agreement between the LT methods but not the association between the VT2 and LT methods indicated poor agreement between VI, Dmax, modified Dmax, and log-log methods for LT measurement in professional soccer players (Cerda-Kohler et al., 2016). Similarly, our results indicated a significant difference between V1 and Dmax methods only for group 2. Furthermore, in agreement with the results of the aforementioned study was the finding that the speed at LT was the lowest with the Log-Log method for group 1, indicating a borderline difference with the VT2 method. It should be noted that the Log-Log method is criticized for taking logarithms of both the lactate and workload, and it assumes that the increase in lactate post LT is exponential. This is difficult to justify as using an exponential function in the model suggests that the rate of change in lactate depends on the amount of lactate (Newell et al., 2007). Despite the criticism for the Log-Log method, our results indicated that even though the speeds at VT2 are slightly higher than those identified with the lactate methods, they are not significantly different. Therefore, the ventilatory threshold speeds can be used as an alternative to the speeds indicated with the LT methods and can be used interchangeably in professional soccer players. Furthermore, these results are comparable to the research on cyclists that demonstrated that lactate threshold tests could be a valid and reliable alternative to ventilatory thresholds (Pallarés et al., 2016).

Last but not least, in a study by Ziogas and Colleagues, the Dmax method was considered the most valid measure of velocity at LT (Ziogas et al., 2011). In their study, the velocities indicated by the Dmax method were 13.2, 12.6, and 12.3 km/h for divisions A, B, and C, respectively (Ziogas et al., 2011). Our

study's speeds at LT with the Dmax method were 14.24 km/h for group 1 and 12.90 km/h for group 2, which are similar to the findings of the previously mentioned study. Notably, the Dmax method is dependent on both the initial and final lactate reading, and therefore the initial and final workloads at which the data are collected directly influence this marker (Newell et al., 2007) and thus, this may partially explain the differences between players of different divisions as well as players with significant differences in performance.

In conclusion, the intensities identified with the VT2 are not significantly different from those indicated with the LT measurements in professional soccer players. These findings suggest that VT2 can be used as an alternative to the LT measurements and therefore being able to identify a threshold point without utilizing an invasive procedure enhances the potential application of VT2 or respiratory compensation point. Our results may aid coaches and trainers in the prescription of exercise intensities, especially in the pre-season period, to optimize performance in professional soccer players and verify the effectiveness of their training routines. Furthermore, these results may be combined with video tracking and GPS data to determine fatigue and maximize performance in elite soccer players. Concurrently, VT2 may be used as an alternative to the invasive LT measurements due to its lower cost.

*Limitations*

A major limitation of this study is the small sample size. Nevertheless, this may serve as a pilot study demonstrating the potential use of VT2 as an alternative to the LT invasive measurements. Therefore, future studies with a larger sample size are needed to confirm the results of this study. Also, further research is encouraged to clarify the validity of these results in soccer players of different age groups, divisions, playing positions, and female soccer players.

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**Conflict of Interest**
The author declares that there is no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

# Match Running Performance in UEFA Champions League: Do More Successful Teams Really Run Less?

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**Abstract**

It is often hypothesized that more successful teams from elite football competitions achieve lower match running performance (MRP) than less successful teams. However, the results of previous studies investigating the associations between MRP and different success indicators are inconsistent. The main objective of this study was to identify the association between teams' MRP and the UEFA club coefficient as an indicator of long-term success in highest-level football. Individual MRPs (n=547) of 378 outfield players were jointly evaluated into the team MRP and used as cases in this study. All data were collected by the semi-automatic optical video system InStat Fitness from matches (n=20) of the UEFA Champions League group stage (UCL) in the 2020/2021 season. MRP variables included total distance covered and distance covered in different speed zones: walking (<7.1 km/h), jogging (7.2–14.3 km/h), running (14.4–19.7 km/h), high-speed running (19.8–5.1 km/h), and sprinting (>25.2 km/h). Pearson's correlation coefficient was used to identify the association between the teams' MRP and the UEFA club coefficient. Results indicated that the UEFA club coefficient was positively and negatively associated with sprinting and jogging distance covered, respectively. These findings show that teams with a higher UEFA club coefficient performed a lower amount of running at low intensity and a greater amount of running at maximal intensity, suggesting that teams are achieving greater long-term success in highest-level football play at a higher game pace.

***Keywords:*** *physical performance, success, association, elite soccer, UEFA club coefficient*

## Introduction

Football is a highly complex sport characterized by high physical demands (Modric, Versic, Sekulic, & Liposek, 2019: Freire et al., 2022). To understand such demands, global (GPS) and local (LPS) positioning systems or optical tracking systems are most commonly used to analyse match running performance (MRP) such as total distance covered, distance covered in different speed zones, accelerations, and decelerations (Modric, Versic, & Sekulic, 2021). Thus, today is well-known that elite football players can cover 9–13km during a match, accounting for approximately 10% of that distance in high-speed running zone and 1-4% in the sprinting zone (Gomez-Piqueras, Gonzalez-Villora, Castellano, & Teoldo, 2019; Modric, Versic, & Sekulic, 2021).

It is often hypothesized that MRP, particularly high-intensity running (>5.5 m/s), is an important determinant of success in football. However, the results of studies that investigated the association between MRP and success in football are not consistent. For example, some studies showed that winning outcomes resulted in a lower amount of high-intensity running (Moalla et al., 2018), while other studies indicate no association between match outcome (i.e., win, draw, lose) and high-intensity running (Barrera, Sarmento, Clemente, Field, & Figueiredo, 2021). Furthermore, some research reported that lower-ranked teams perform more high-intensity running than their counterparts on better teams (Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009). On the contrary, other research has revealed no differences in high-intensity running

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irrespective of final competition position (Hoppe, Slomka, Baumgart, Weber, & Freiwald, 2015).

Considering that the authors of these studies drew their conclusions by analyzing teams that belong to a single country, these inconsistencies may be characterized by the geographical, cultural, historical, and social aspects of the observed competition (Sarmento et al., 2013; Sapp, Spangenburg, & Hagberg, 2018;). Therefore, an analysis of football competitions involving teams from different countries might be more appropriate to draw conclusions about the association between team success and MRP. Moreover, it has been suggested that future studies analyze top-level football competitions to clarify the association between running performance and success in football (Hoppe, Slomka, Baumgart, Weber, & Freiwald, 2015). Undoubtedly, the most elite and the most prestigious football competition involving teams from different countries is the UEFA Champions League (UCL) (Lago-Peñas, Lago-Ballesteros, & Rey, 2011).

Moreover, success in the studies mentioned above was exclusively evaluated by final ranking or match outcome (Di Salvo et al., 2009; Hoppe et al., 2015; Moalla et al., 2018; Barrera et al., 2021). Although such indicators provide a valuable measure of success in a single match or over one season, we believe that final ranking or match outcome does not provide a real measure of success in football. Namely, it is well-known that "better" teams do not always win in football (Hargreaves, 2009), so it is logical that the winning outcome is not always a valid discriminator between more successful and less successful teams. On the other hand, team success in one season can be a result of different circumstances, such as the form of the key players or injury rates (Ruiz, Power, Wei, & Lucey, 2017). Therefore, we believe that evaluation of success utilizing long-term success indicators may provide a real measure of team success in football.

One of the success indicators considering the teams' long-term success (i.e., a period of 5 years) is the UEFA club coefficient. However, considering no study to investigate the association between MRP and success by utilizing the UEFA club coefficient, the knowledge on MRP of teams achieving long-term success in football is limited. Furthermore, despite the aforementioned importance of analyzing top-level competitions involving teams from different countries to clarify the association between MRP and success in football (Hoppe et al., 2015), such studies are also lacking. Taking together, linking match MRP of teams that competed in UCL with UEFA club coefficient in a new study seems reasonable. Therefore, the main objective of this study was to identify the associations between teams' MRP and the UEFA club coefficient as an indicator of long-term success in highest-level football. In addition, we evaluated the association between MRP and success by utilizing other success indicators (e.g., match outcome and final position on the table).

## Methods

*Participants and Design*

In total, 547 individual match observations of 378 outfield players were used. One hundred twenty-eight of them were central midfielders (CM), 63 were central defenders (CD), 62 were forwards (FW), 63 were fullbacks (FB), and 62 were wide midfielders (WM). The players were members of 24 teams that competed in the group stage of the UCL in the 2020/21 season. All MRP data were obtained from 20 matches from groups A (n=3), B (n=3), C (n=4), E (n=4), F (n=3), and G (n=3). Individual players' performances were jointly evaluated into the teams' performance and used as cases in this study. The investigation was approved by the ethical board of the Faculty of Kinesiology, University of Split (approval number: 2181-205-02-05-19-0020, 1 September 2019).

## Procedures

The MRP data were collected using a semi-automatic optical tracking system InStat Fitness (Instat Limited, Limerick, Republic of Ireland). The reliability of this tracking system has been demonstrated, as the tracking system has passed the official Fédération Internationale de Football Association (FIFA) test protocol for Electronic & Performance Tracking Systems (EPTS) (a report is available on: https://www.fifa.com/technical/football-technology/resource-hub?id=a-ca57303eb0449f2835ac891b1beeb24). The of this tracking system has appeared in previous research (Modric et al., 2021). The MRP variables included total distance covered (m) and distance in five speed categories: walking (<7.1 km/h), jogging (7.2–14.3 km/h), running (14.4–19.7 km/h), high-speed running (19.8–25.1 km/h), and maximal sprinting (>25.2 km/h).

Success in this study was evaluated using three different success indicators: (i) UEFA club coefficient which is based on the results of clubs competing in the UEFA Champions League, UEFA Europa League, and UEFA Europa Conference League season during the previous five seasons. Points awarded each season are in accordance with the relevant competition regulations for that specific season (UEFA, 2022) (ii) final position on the table at the end of the group stage of UCL (1st, 2nd, 3rd, and 4th position), and (iii) match outcome (win, draw, lost).

*Statistical Analyses*

The Kolmogorov–Smirnov test revealed that all data were normally distributed (all K-S $p>0.05$). Homogeneity was evaluated using Levene's test, and data are presented as means ± standard deviations. K-means cluster analysis method was used to classify teams into the (i) teams with smaller UEFA club coefficient (mean: 31.58±12.46) and (ii) teams with greater UEFA club coefficient (mean: 87.89±16.66) (Liu, Yi, Giménez, Gómez, & Lago-Peñas, 2015). Spearman's correlations were used to identify the association between MRP, and match outcome and final position on the table. To identify the associations between MRP and UEFA club coefficient, Pearson's correlation coefficients were calculated with the r coefficient classification as previously suggested: $r\leq0.35$ indicates a low or weak correlation, $r=0.36$ to 0.67 indicates a modest or moderate correlation, $r=0.68$ to 1.0 indicates a strong or high correlation, and $r>0.90$ indicates a very high correlation (Taylor, 1990). For all analyses, Statistica (Version 13; TIBCO Software, Palo Alto, CA, USA) was used. A significance level of $p<0.05$ was applied.

## Results

The average total distance covered of teams that competed in UCL was 116,271±4376 m, while average walking and jogging distances were 38,875±1243 m and 47,404 m, respectively. Teams' from UCL averagely achieved 20,396±1441 m in the running zone, 8176±915 m in high-speed running, and 1399±307 m in sprinting (Table 1).

**Table 1.** Descriptive statistics for running performances of teams that competed in UEFA Champions League.

| | Mean | Minimum | Maximum | SD |
|---|---|---|---|---|
| Total distance (m) | 116,271 | 105,653 | 125,258 | 4376 |
| Walking (m) | 38,875 | 36,509 | 41,644 | 1243 |
| Jogging (m) | 47,404 | 41,182 | 55,065 | 3148 |
| Running (m) | 20,396 | 17,783 | 23,494 | 1441 |
| High speed running (m) | 8176 | 6032 | 10,131 | 915 |
| Sprinting (m) | 1399 | 933 | 2260 | 307 |

Tables 2 and 3 present descriptive statistics and associations between MRP and different success indicators. UEFA club coefficient was positively and negatively associated with sprinting (r=0.39, p=0.01) and jogging (r=–0.36, p=0.02) distance, respectively. The average jogging distance for teams with greater and smaller UEFA club coefficients was 46,675±2687 m and 48,000±3426 m, respectively. The average sprinting distance for teams with greater and smaller UEFA club coefficient was 1486±288 and 1327±310 m, respectively.

The final position on the table was negatively associated with sprinting distance covered (r=-0.34, p=0.03). The average sprinting distance for teams that finished at 1st, 2nd, 3rd, and 4th position in the group was 1517±376 m, 1563±288 m, 1320±282 m, and 1270±236 m, respectively. No significant associations between match outcome and MRP variables were evidenced (all p>0.05).

**Table 2.** Descriptive statistics for running performances of teams that competed in UEFA Champions League according to the different success indicators.

| | | Total distance (m) | Walking (m) | Jogging (m) | Running (m) | High speed running (m) | Sprinting (m) |
|---|---|---|---|---|---|---|---|
| | | Mean±SD | Mean±SD | Mean±SD | Mean±SD | Mean±SD | Mean±SD |
| UEFA club coefficient | S | 116,953±4936 | 38,772±1138 | 48,000±3426 | 20,606±1651 | 8276±964 | 1327±310 |
| | G | 115,438±3535 | 39,002±1383 | 46,675±2687 | 20,139±1127 | 8053±863 | 1486±288 |
| Match outcome | L | 115,563±5307 | 38,834±1339 | 47,504±4025 | 20,040±1745 | 7959±910 | 1246±296 |
| | D | 116,055±4152 | 38,893±1270 | 46,800±2661 | 20,435±1474 | 8429±1014 | 1534±289 |
| | W | 117,309±3662 | 38,897±1211 | 48,050±2737 | 20,734±1003 | 8093±779 | 1395±284 |
| Final position in the group | 1st | 115,856±3842 | 39,931±1177 | 46,013±3022 | 20,020±1467 | 8155±1190 | 1517±376 |
| | 2nd | 116,001±4451 | 37,970±999 | 47,471±2529 | 20,835±1448 | 8189±896 | 1563±288 |
| | 3rd | 117,679±4360 | 38,782±1293 | 48,346±3311 | 20,888±1415 | 8368±607 | 1320±282 |
| | 4th | 115,460±4891 | 38,935±925 | 47,417±3523 | 19,867±1359 | 8002±1039 | 1270±236 |

S – smaller, G – greater; L – lost, D – draw, W – win

**Table 3.** Correlations between running performance and different success indicators.

| | UEFA club coefficient | Final position on the table | Match outcome |
|---|---|---|---|
| | r (p) | r (p) | r (p) |
| Total distance | -0.22 (0.17) | 0.02 (0.92) | 0.19 (0.25) |
| Walking | 0.14 (0.38) | -0.05 (0.74) | 0.03 (0.87) |
| Jogging | -0.36 (0.02) | 0.15 (0.35) | 0.11 (0.50) |
| Running | -0.16 (0.33) | -0.07 (0.68) | 0.19 (0.25) |
| High speed running | 0.07 (0.68) | -0.03 (0.83) | 0.09 (0.57) |
| Sprinting | 0.39 (0.01) | -0.34 (0.03) | 0.23 (0.16) |

## Discussion

This is one of the first studies investigating the association between teams' MRP and various success indicators, including the UEFA club coefficient as an indicator of long-term success. UEFA club coefficient was positively and negatively associated with sprinting and jogging distance covered, respectively. The final position on the table was negatively associated with sprinting, while match outcome was not associated with MRP. These findings indicate that teams are achieving greater long-term success in highest-level football play at a higher game pace.

The total distance covered by the teams that competed in the UCL group stage in the 2020/21 season was 116,271 m, which is approximately 5% higher than the overall distances achieved in previous seasons. In particular, the total distance covered in the 2014/15 and 2015/16 seasons was 113,451 m

and 107,843 m, respectively (Windt, Ekstrand, Khan, McCall, & Zumbo, 2018). On the other hand, the results of our study show that the average distance covered at moderate intensities (i.e., running zone) was 20,396 m, which is in line with the results from previous seasons (21,765 m and 19,924 m, respectively) (Windt et al., 2018). Interestingly, the high-intensity distance covered by UCL teams in the 2020/21 season was 9575 m, which is ~7% lower than in the 2014/15 season, and ~10% greater than in the 2015/16 season (10,285 and 8760 m, respectively) (Windt et al., 2018).

Considering the results of previous research which reported that MRP in elite football tend to increase over the seasons, especially in terms of high-intensity running, such findings may seem surprising (Barnes, Archer, Hogg, Bush, & Bradley, 2014). However, MRP is generally highly variable and depends on many factors such as match location, opponents' level, match outcome, team's tactical formation or playing style (Lago-Peñas, 2012; Modric, Versic, & Sekulic, 2020). In addition, UCL is a specific competition in which different teams from various countries compete in each season. For example, in the 2020/21 season, 17 clubs that competed in the group stage did not compete in the 2014/15 season group stage. As the UCL group stage consists of 32 clubs, it is obvious that more than one-half of the clubs were different in the observed seasons. Given the fact that clubs come from different countries are characterized by different geographical, cultural, historical and social aspects (Sarmento et al., 2013; Sapp, Spangenburg, & Hagberg, 2018), variation in MRP during different seasons in UCL is actually logical and expected.

In scientific community and media, it is often postulated that high level of match MRP is important for achieving success in professional football teams (Hoppe et al., 2015). This postulation is partly in the line with our findings. Namely, results from our study indicated significant association between specific MRP variables and UEFA club coefficient. In particular, positive and negative correlations were found between UEFA club coefficient and sprinting and jogging distance covered, respectively (both moderate correlations). Most specifically, during UCL group stage matches, teams with a greater UEFA club coefficient accumulated ~12% greater amount of sprinting distance (1486 m) and ~3% lower amount of jogging distance (46,675 m) than teams with smaller UEFA club coefficient (1327 and 48,000 m, respectively). These findings indicate that teams are achieving greater long-term success in highest-level football play at a higher game pace.

Additionally, our results indicated a significant association between the final position on the table at the end of the UCL group stage and sprinting distance covered. Despite the relatively weak association, descriptive parameters show that sprinting distance of teams that finished in 1st position was approximately 20% greater compared to the teams which finished at the last position (i.e., 4th) at the end of the group stage of UCL (1517 and 1270 m, respectively). Such results are consistent with our previous conclusions that more successful teams play at a slightly higher game pace than less successful teams while supporting earlier considerations about the importance of MRP in elite football (Longo et al., 2019; Longo et al., 2021). However, it is interesting to note that our results did not indicate an association between MRP and match outcome. Considering our previous conclusions (i.e., that more successful teams played at a higher game pace), such results may seem controversial. However, as "better" teams do not always win in football (Hargreaves, 2009), we believe that match outcome is not always a valid indicator of success and, therefore, cannot be comparable to the long-term indicators of success such as position on the table or UEFA club coefficient.

The present investigation has some limitations that should be considered. First, we did not analyze all matches from the group stage of the UCL (i.e., we only noted 20 randomly selected matches). However, this is a widespread obstacle in studies involving players who compete at the highest level of football (Bradley et al., 2011; Modric et al., 2021; Modric, Versic & Jelicic; 2022). Furthermore, the current study did not consider contextual factors, such as team and opposition quality or match location, which may affect MRP. However, differences in teams' and opponents' quality in UCL is most likely lower than in national competitions, and consequently, influence on MRP may be negligible. Additionally, all observed matches were played without audience or with limited capacity in the stands due to the COVID-19 pandemic (Link, & Anzer, 2022); therefore, the influence of match location (i.e., home advantage) may be insignificant. On the other hand, this study has several strengths. Specifically, this is one of the first studies to investigate the association between MRP and UEFA club coefficient, providing new knowledge on MRP of teams achieving long-term success in football. In addition, the data analyzed in this study included the MRP of most elite football teams worldwide, enabling detailed insight into the running characteristic of teams competing in the highest-level football. Finally, the findings from this study can be used by football coaches in decision-making processes for structuring the elements of training.

In conclusion, the main findings of this study show that teams with greater UEFA club coefficient cover less distance in jogging and more distance in sprinting, indicating that teams achieving greater long-term success in highest-level football play at a higher game pace. As playing at a high game pace requires the players' high conditioning level, it becomes clear that achieving long-term success in highest-level football requires the players' conditioning to be at the highest possible level. From the practical perspective, this should be accomplished by the implementation of exercises that provoke running at maximal intensity (i.e., over 7 m/s) in the training process. Finally, to better understand the association between long-term success and MRP, future research should utilize a larger sample and analyse a greater number of MRP variables (i.e., accelerations, decelerations, metabolic power), considering a range of contextual factors which may affect MRP.

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**Conflict of interest**

The authors report no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

# Factors Determining the Choice of Healthy Diet by Kazakh Athletes of Various Sports

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**Abstract**

According to the World Health Organization (WHO), 40-60% of human health depends on a lifestyle in which 25-30% is devoted to a rational diet. Therefore, by meeting physiological needs in accordance with a rational diet, athletes can adapt more quickly to the applied physical load and achieve better sport results. The aim of the study was to describe and compare the factors that determine the healthy diet of athletes of various sports. The study, which aimed to assess the factors determining healthy diet, involved 157 students of physical education and sports studies from the University of Almaty. Respondents were divided into 3 groups - sports games (volleyball, football, basketball, tennis) (n=85), endurance sports (long distance running, skiing, road cycling, triathlon (n=22), and combat sports (wrestling, judo, karate, boxing) (n=50). The questionnaire by Steptoe et al. (1995) was employed to establish the opinion of the investigated subjects on the factors that determine healthy and rational dietary choices of student athletes. Our research has shown that among the factors that determine the healthy diet of athletes of various sports, the main ones are health, the character of the chosen sport, and the athlete's body composition. Factors such as current trends, the popularity of the food consumed, and the influence of family and friends are less important. The athletes we studied noted their efforts to eat and live healthy, most of them were satisfied with their health and their body mass. A greater variety in respondents' responses was observed when assessing the composition of food supplements, the impact of discount special offers on product selection. The responses received on adherence to the diet indicate that the athletes studied do not always observe the correct diet.

***Keywords:*** *athletes, students, sports, health, rational, healthy nutrition*

## Introduction

The choice of rational and healthy diet for athletes is determined by many factors, one of the most important being the motivation to consume health-friendly foods, taking into account the specifics of the chosen sport. Other factors influencing diet and habits include national traditions, family members, friends, current trends, and popularity (Azizbekian et al., 2010). The choice of a healthy diet for elite athletes also depends on the nature and duration of physical exercise, the amount of energy spent, the time required for recovery, and preferences of food (Pasalic et al., 2012; Jeukendrup, 2017).

Most authors point out that the relationship between nutrition and health is particularly close, because a rational diet determines the proper functioning of all body systems and organs (Vorobyeva et al., 2011; Likus et al., 2013). Sports medicine doctors and coaches need to be well aware that strengthening of health requires a regular, healthy, and balanced diet first and foremost (Lisicki, 2010; Nazni & Vimala, 2010). According to the World Health Organization (WHO), 40-60% of human health depends on a lifestyle, 25-30% of which is

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devoted to a rational diet. Therefore, by meeting physiological needs, adhering to the principles of rational and proper nutrition, athletes can adapt to the experienced physical loads more quickly and achieve better sports performance (Boguszewski et al., 2013; Turner, 2018). Therefore, data on the factors that determine a healthy diet are needed to properly organize the training of athletes, maintain high working capacity, and control the course of recovery processes (Szygula et al., 2009; Ubeda et al., 2010; Tutelyan et al., 2011). Many athletes, striving for high sport results, are also students. The study years is a phase of a young person's social life, characterized by a heavy mental load, lifestyle changes, and a change in diet. Therefore, the diet of physically active students striving for high sport results is receiving a lot of attention from researchers (Papadaki et al., 2007; Skibniewska et al., 2009; El Ansari et al., 2011; Dobrovolskij & Stukas, 2012; Otaraly et al., 2020).

If a person engages in active sports during the study years, the physiological needs of the body increase significantly. The constant lack of time can disrupt the diet or make it inferior (Satalic et al., 2007). Sports science extensively studies the role of nutrition in the promotion of the adaptation of athletes' bodies to physical exertion, increasing work capacity, and the speed of recovery after physical exertion. An important role in promoting these processes is played by a rational diet and the use of various food supplements (Jeukendrup, 2017).

The theory of balanced nutrition includes the general principles of nutrition, and the specifics of nutrition depend on the type of sport, the type of physical activity in which a person is engaged, lifestyle, and occupational activity (Crosland, 2007). For example, the nutritional habits of an endurance athlete, the composition of the food ration is significantly different from the diet of speed and strength athletes. The former need to get more carbohydrates and fats in their diet, while the latter need more protein. Endurance athletes need to replenish their energy reserves even during physical exertion. Players' physical activity is characterized by a more rapid change in intensity, so their energy spending is lower, and the main source of energy during physical activity is carbohydrates (Burke et al., 2011).

Although research data on the nutrition of athletes is sufficient, information on the determinants of a healthy diet is still lacking. In Kazakhstan, the issue has also not been sufficiently addressed. An analysis of the literature on the nutrition of Kazakh athletes shows that their eating habits are often improper due to too little consumption of vegetables and fruits, products are often chosen based on taste without paying enough attention to their usefulness (Mustafin, 2012), therefore the expected impact of the training effect may not be achieved, even if the volume and intensity of exercise is chosen correctly. Therefore, in order to achieve high sports results, the nutrition must be adapted to the needs of the specific sport. This problem has not been sufficiently studied in the scientific research of the said country. We have tried to reduce this insufficiency in our work (Yerzhanova et al., 2020; Milašius et al., 2021). The relevance of this study is related to the insufficiently solved problem of the rational nutrition of Kazakh athletes. We believe that the data of this study will help determine the factors of rational and healthy nutrition choice by Kazakh athletes from various sports groups.

The aim of the study is to describe and compare the factors that determine the choice of healthy diet by athletes of various sports.

## Methods

### *Participants*

The cross-sectional study, which aimed to assess the factors determining healthy diet, involved students of physical education and sports studies at the University of Almaty. Respondents were divided into 3 groups – game sports (volleyball, football, basketball, and tennis) (n=85), endurance sports (long distance running, skiing, road cycling, and triathlon) (n=22), and combat sports (wrestling, judo, karate, and boxing) (n=50). The athletes under study were divided into sports groups using the classification of the World Sport Encyklopedia (2003). The average age of the subjects in the game sports group was 19.5±0.9 years, height - 186.4±2.7 cm, weight - 75.6±3.36 kg, body mass index (BMI) - 21.8±2.5 kg/m2. The average age of endurance training subjects was 20.6±0.97 years, height - 175.8±2.4 cm, weight - 66.5±0.9 kg, BMI - 21.5±2.3 kg/m2. The average age of the combat sports subjects was 20.4±0.6 years, height - 174.7±2.09 cm, weight - 71.0±3.19 kg, BMI - 23.3±2.4 kg/m2.

The research was approved by the Ethics Committee of the Al-Farabi University of Kazakhstan (18.05.2018, No. A-043), as well as the voluntary and written consent of the subjects was obtained. The confidentiality of the study data was ensured.

### *Measurments*

In order to find out the opinion of the students about the factors that determine the choice of healthy and rational diet, Steptoe et al. (1995) questionnaire was used. Each respondent filled out the questionnaire directly in writing. The content of the questionnaire included questions on students' socio-demographic situation (gender, age), physical development (height, body mass, BMI), the extent of the respondents' physical activity, their diet, and self-assessment of health.

### *Statistics*

Traditional methods of mathematical statistics were used for the analysis of the research data - arithmetic means (X) and their mean deviations (S) were calculated. The $\chi 2$ (Chi-square) criterion was applied for the reliability of the data difference. The change in research data was statistically significant at $p<0.05$.

## Results

Analysing the respondents' responses on the factors determining the percentage distribution of healthy diet choices, it should be noted that the athletes of various sports we interviewed by us stated that such choice is determined by their health status. 63.55% of players, 54.54% of endurance sports athletes, and 86.0% of combat sports athletes answered this question in the affirmative (Table 1). Assessing the subjects' responses on the influence of sports activities on healthy eating choices, a reliable difference between the players' responses and the responses of combat sports athletes ($p=0.001$) was observed, while endurance sport athletes' responses stating that athletic activity has or does not have effect were distributed evenly (50% each).

A statistically significant response to the question of whether diet has an effect on body composition was obtained from the players ($\chi 2=21.80$, $p=0.001$). However, half of the studied endurance sports athletes tended to state that body composition may influence food choice or either may or may not influence it ($\chi 2=8.237$, $p=0.016$). When asked whether current trends and the product popularity influence the choice of food consumed, no statistically significant results in the re-

**Table 1.** Percentage distribution of responses to the question 'Factors determining the choice of a healthy diet'.

| No. | Factors | Game sports n=85 | Endurance sports n=22 | Combat sports n=50 |
|---|---|---|---|---|
| Healthy nutrition | | | | |
| 1 | Affects | 63.55 | 54.54 | 86 |
| 2 | Both yes and no | 30.58 | 45.46 | 12 |
| 3 | Does not affect | 5.87 | 0 | 2 |
| | | χ2=84.835; df=3; p=0.001 | χ2=0.182; df=1; p=0.670 | χ2=63.160; df=2; p=0.001 |
| Sports activity | | | | |
| 1 | Affects | 55.30 | 50 | 64 |
| 2 | Both yes and no | 40 | 50 | 34 |
| 3 | Does not affect | 4.70 | 0 | 2 |
| | | χ2=34.329; df=2; p=0.001 | χ2=0.000; df=1; p=1.000 | χ2=28.840; df=2; p=0.001 |
| Body composition | | | | |
| 1 | Affects | 36.47 | 50 | 56 |
| 2 | Both yes and no | 56.47 | 45.45 | 40 |
| 3 | Does not affect | 7.06 | 4.55 | 4 |
| | | χ2=31.506; df=2; p=0.001 | χ2=8.273; df=2; p=0.016 | χ2=21.280; df=2; p=0.001 |
| Current trends, popularity | | | | |
| 1 | Affects | 28.24 | 31.83 | 26 |
| 2 | Both yes and no | 42.35 | 40.90 | 40 |
| 3 | Does not affect | 29.41 | 27.27 | 34 |
| | | χ2=3.129; df=2; p=0.209 | χ2=0.636; df=2; p=0.727 | χ2=1.480; df=2; p=0.477 |
| Family members, friends | | | | |
| 1 | Affects | 68.26 | 40.90 | 46 |
| 2 | Both yes and no | 23.52 | 36.36 | 32 |
| 3 | Does not affect | 8.22 | 22.74 | 22 |
| | | χ2=93.871; df=3; p=0.001 | χ2=1.182; df=2; p=0.554 | χ2=4.360; df=2; p=0.113 |

sponses were obtained, but the responses of all three groups of athletes showed a prevalence of the response 'both yes and no' (Table 1).

Family members and friends often have a great influence on nutrition. 68.25% of the players we surveyed pointed out the influence of this factor (χ2=93.871, p=0.001). The respons-

**Table 2.** Percentage of respondents' responses to the question 'I agree with the statement'.

| No. | Factors | Game sports n=85 | Endurance sports n=22 | Combat sports n=50 |
|---|---|---|---|---|
| I always try to eat healthy | | | | |
| 1 | Agree | 71.78 | 63.65 | 76 |
| 2 | Both agree and disagree | 27.05 | 27.27 | 24 |
| 3 | Disagree | 1.17 | 4.54 | 0 |
| 4 | Don't know | 0 | 4.54 | 0 |
| | | χ2=65.035; df=2; p=0.001 | χ2=20.545 df=3; p=0.001 | χ2=13.520; df=1; p=0.001 |
| I live a healthy lifestyle | | | | |
| 1 | Agree | 58.84 | 54.55 | 68 |
| 2 | Both agree and disagree | 37.64 | 45.45 | 32 |
| 3 | Disagree | 2.35 | 0 | 0 |
| 4 | Don't know | 1.17 | 0 | 0 |
| | | χ2=81.071; df=3; p=0.001 | χ2=0.182; df=1; p=0.670 | χ2=6.480; df=1; p=0.011 |

*(continued on next page)*

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**Table 2.** Percentage of respondents' responses to the question 'I agree with the statement'.

| No. | Factors | Game sports n=85 | Endurance sports n=22 | Combat sports n=50 |
|---|---|---|---|---|
| I am satisfied with my health | | | | |
| 1 | Agree | 67.07 | 50 | 68 |
| 2 | Both agree and disagree | 31.76 | 40.91 | 30 |
| 3 | Disagree | 1.17 | 9.09 | 2 |
| 4 | Don't know | 0 | 0 | 0 |
| | | $\chi2=55.435$; df=2; p=0.001 | $\chi2=6.091$; df=2; p=0.048 | $\chi2=32.920$; df=2; p=0.001 |
| I am satisfied with my body mass | | | | |
| 1 | Agree | 43.52 | 31.83 | 58 |
| 2 | Both agree and disagree | 42.35 | 54.54 | 38 |
| 3 | Disagree | 14.13 | 9.09 | 4 |
| 4 | Don't know | 0 | 4.54 | 0 |
| | | $\chi2=14.141$; df=2; p=0.001 | $\chi2=14.000$; df=3; p=0.003 | $\chi2=22.360$; df=2; p=0.001 |
| The composition of food is important to me | | | | |
| 1 | Agree | 32.94 | 45.45 | 58 |
| 2 | Both agree and disagree | 61.19 | 40.92 | 42 |
| 3 | Disagree | 4.70 | 9.09 | 0 |
| 4 | Don't know | 1.17 | 4.54 | 0 |
| | | $\chi2=79.941$; df=3; p=0.001 | $\chi2=11.818$; df=3; p=0.008 | $\chi2=1.280$; df=1; p=0.258 |
| My food choices are influenced by discounts and special offers | | | | |
| 1 | Agree | 21.19 | 31.81 | 42 |
| 2 | Both agree and disagree | 57.64 | 31.81 | 36 |
| 3 | Disagree | 20 | 18.19 | 16 |
| 4 | Don't know | 1.17 | 18.19 | 6 |
| | | $\chi2=56.882$; df=3; p=0.001 | $\chi2=1.636$; df=3; p=0.651 | $\chi2=17.040$; df=3; p=0.001 |
| It is important to me that the food is of natural origin | | | | |
| 1 | Agree | 68.25 | 63.63 | 76 |
| 2 | Both agree and disagree | 24.70 | 18.19 | 20 |
| 3 | Disagree | 7.05 | 9.09 | 4 |
| 4 | Don't know | 0 | 9.09 | 0 |
| | | $\chi2=50.565$; df=2; p=0.001 | $\chi2=18.000$; df=3; p=0.001 | $\chi2=42.880$; df=2; p=0.001 |
| I often follow a diet | | | | |
| 1 | Agree | 30.58 | 45.45 | 36 |
| 2 | Both agree and disagree | 38.84 | 36.36 | 42 |
| 3 | Disagree | 25.88 | 13.65 | 18 |
| 4 | Don't know | 4.70 | 4.54 | 4 |
| | | $\chi2=21.588$; df=3; p=0.001 | $\chi2=9.636$; df=3; p=0.022 | $\chi2=18.000$; df=3; p=0.001 |

es of endurance sports and combat sports athletes were evenly distributed across the three choices (p=0.554; p=0.113).

Results of various sports athletes' responses on their dietary habits showed their attempts to eat healthy (p=0.000). Also, the majority of respondents stated that they try to maintain a healthy lifestyle, but only the players' answer 'agree' was statistically reliable ($\chi2$=81.071, p=0.001) (Table 2).

Responses from all studied athletes had statistical reliability addressing satisfaction of their health. Same results were obtained for players and combat sports athletes' responses in terms of body mass, but most endurance sports' athletes did not always agree with this statement. 54.54% of these athletes chose the answer 'both agree and disagree' because increased body mass in endurance sports is a limiting factor in sports performance ($\chi2$= 4,000, p=0.003).

The composition of food supplements is important for a rational diet. We found that 61.19% ($\chi2$=79.941, p=0.001) of game sports athletes answered 'yes and no' to the question about the composition of food products, while 45.45% of endurance sports athletes and 58% of combat sports athletes preferred the answer 'yes'.

There was no unambiguous answer to the question concerning the influence of discounts of food supplements on food choices. 57.17% of the game sports athletes chose 'Both agree and disagree' answer to this question, and 31.81% of the endurance sports athletes and 42.0% of the representatives of combat sports chose the answer – 'Agree'. A significant number of respondents stated that the food should be fresh (p=0.001). Variety of answers, from 'yes' to 'no', were provided to the question of whether athletes often follow a diet, but prevalence was observed in 'yes' and 'yes and no' responses.

## Discussion

Although scientific literature provided enough information on the nutrition of athletes of various mastery level, the issues of nutrition of athletes in Kazakhstan are not sufficiently reviewed yet. Identification of the factors that determine the rational diet of athletes can help to train them better (Nowacka et al., 2016). We have to agree with the opinion of T. Lisicki (2010) that the years during which the study was conducted are a social stage of a young person's life, associated with many challenges, including the formation of new lifestyle and eating habits, and increased physical activity, which must be compensated by a full-fledged diet. However, as Edwards & Meiselman, (2003), Papadaki et al. (2007), and Skibinewska et al. (2009) point out, during this period, quite a number of factors appear that lead to the emergence of negative lifestyle and eating habits. It can be noted that more than half of the subjects of all sports groups stated that a healthy diet is one of the main factors for successful sports activities and maintaining a suitable body composition.

The athletes, whom we studied, enrolled into university physical education and sports program, consider health, the nature of physical activity, and the composition of the body being the main factors that determine the choice of a healthy diet. Responses on factors such as current trends and the popularity of dietary supplements consumed, as well as the opinions of family members and friends, were distributed over a wider range of responses (26.0-68.26%). The subjects indicated that the least influencing factor on choosing a healthy diet is the current trends of nutrition, the popularity of products, and the greatest influencing factor is family members and friends, this was indicated by the subjects of all sports groups (game sports - 68.26%, p=0.001), endurance sports - 40.9%, p=0.554, combat sports - 46.0%, p=0.113). Such position has been shared by other researchers examining this issue (Iglesias-Gutiérrez et al., 2008; Partida et al., 2018).

Scientists, while studying the nutrition and lifestyle of students and physically active individuals, are studying factors that can determine their eating habits and lifestyle. The authors, who studied the nutritional characteristics of students in Poland, Bulgaria, Denmark, and Germany, found that students living with their parents eat more properly than students living separately from their parents (El Ansari et al., 2011). Kresic et al. (2009), who studied the features of nutrition and knowledge, found that a healthy lifestyle determines the female sexuality, older age, nutrition at home, and a sufficient knowledge about nutrition. Croatian students, who have adequate knowledge of nutrition, are 12 times more likely to have a healthy diet than students who do not. In our work, we did not set the task of comparing the quality of nutrition of students living with parents and living in a dormitory, however, while processing the research data, we noticed that this factor was more clearly manifested in students living with their parents. We found similar data in the work of Urmanowska-Zyto et al. (2004) as well.

Knowledge about rational nutrition acquired during studies at the university can help a person to choose correctly the factors that determine a healthy and rational diet. Analysing the data of the questionnaire survey, we found that the majority of the subjects (68.25-76.0%) state that it is important for them that food products are natural (p=0.001), and discount special offer do not play a significant role in their choice. After gaining this knowledge, athletes pay attention to the relationship between health and the choice of product composition when choosing foods. The data from our study is in line with the opinion of many authors (Shriver et al., 2013; Zapolska et al., 2014; Kowalczuk-Vasilev et al., 2018). We managed to find other works on this topic (Kolodinsky et al., 2007; Kresic et al., 2009; Bojanic et al., 2015) that present data on the level of knowledge and literacy of student athletes. Based on the results of their research, the authors conclude that the knowledge of professional athletes of the Balkan countries in the field of nutrition is at a satisfactory level. According to Bojanic et al. (2015) proper knowledge about rational nutrition is determined by other factors, such as health, healthy lifestyle, and diet. Scientists researching nutrition about the lifestyle of students are studying the factors that can determine their eating habits. Romaguera et al. (2011), while assessing the factors that determine the healthy lifestyle of Spanish students, found that the most effective factor is physical activity. The results of our study showed that when assessing their body mass, about 85% of respondents were satisfied or not completely satisfied with their body mass. As a rule, other authors studying the issues of athletes' nutrition also pay attention to this issue (Satalic et al., 2007; Tengvall & Ellegard, 2007; Chourdakis et al., 2010; Gazibara et al., 2013).

Athletes' rational and healthy diet requires a certain regime, at the same time it must meet the requirements of the training process. The answers of the respondents of all groups about whether they often follow a diet were almost equally distributed for each answer option - "agree", "both agree and

disagree". Proper nutrition determines the necessary adaptation of the body to physical activity and helps to achieve the highest sports results (Kouloutbani et al., 2012).

After summarizing the results of our study, we can recommend athletes and coaches to take into account the following main factors of healthy nutrition - the nature of sports activities, the diet, the composition of food products, and their energy value. Although our research data in many cases matches that of authors from other countries who studied the factors of healthy eating choices of athletes, our research data also has specific features that can be used to mark respondents' answers about the composition of food products, the influence of prices and discount special offers when choosing seafood products. However, the collection, application, and interpretation of such data face certain limitations. A valid questionnaire and objective answers for the subjects must be selected, research results must be properly processed, and objective conclusions must be drawn. Based on the data of Small et al. (2013), we believe that in order to properly assess the factors that determine the choice of a healthy diet, the students who are involved in the study should be divided into groups - those who live at home with their parents and those who live separately in a dormitory.

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The authors declare that there are no conflict of interest

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## Conclusions

Our research has shown that among the factors that determine the healthy diet of athletes of various sports the main ones are health, the character of the chosen sport, and body composition. Factors such as current trends, the popularity. Based on the data of M. Small et al. (2013), we believe that in order to properly assess the factors that determine the choice of a healthy diet, the students who are involved in the study should be divided into groups - those who live at home with their parents and those who live separately in a dormitory of the food consumed, and the influence of family and friends are less important. The studied athletes noted their efforts to eat healthy and live a healthy life, most of them were satisfied with their health and their body mass. A greater variety of respondents' responses was observed when assessing the composition of food supplements and the effect of discount special offers on product selection. The responses received about the adherence to the diet regime indicate that the studied athletes do not always adhere to this regime. Although the data of our study basically matches the data of many authors, but in some aspects our data has their own specificities, which are characteristic of this country. The data of our study partially helps to solve the problem - it characterizes the factors that determine the choice of a healthy diet.

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SportMont

ORIGINAL SCIENTIFIC PAPER

# Within-season Adaptations in Physical, Physiological and Technical-tactical Performance of Experimented Futsal Players

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**Abstract**

This study analysed the seasonal variations in futsal players' physical, physiological, and technical–tactical performance. Eight senior futsal players from the same team were monitored at three time points in the season (beginning of the preseason, middle of the first half of the season, and middle of the second half of the season). A progressive and intermittent shuttle-running test (the futsal intermittent endurance test) was applied to collect the following variables: maximum velocity, distance covered, total distance covered, test duration, initial heart rate, peak heart rate, peak blood lactate concentration, and rating of perceived exertion. In addition, different match-performance variables were assessed during a simulated futsal match (goals scored, shots on goal, successful passes, balls lost, balls recovered, and goals conceded). Results indicated that the physiological variables of initial heart rate ($p<.001$, $\eta 2=.862$) and peak blood lactate concentration ($p=.001$, $\eta 2=.640$) significantly varied over the course of the season. However, no significant differences were found in the physical and technical–tactical variables. This study has implications for sport practitioners; specifically, it emphasizes that preseason and in-season training load periodization enhances the physiological fitness of top-level futsal players, although their physical and technical–tactical performance remained relatively stable.

***Keywords:*** *workload, heart rate, lactic acid, team sports, season variance*

## Introduction

Scholars have shown increasing interest in investigating futsal-related topics as a means of generating scientific and applied knowledge for coaches and practitioners (Spyrou et al., 2020). One of the most prevalent topics of investigation involves analyzing the physical demands of match play. Futsal has been described as a strenuous sport and is characterized by intermittent and high-intensity efforts and frequent multidirectional sprints, jumps, and impacts, requiring substantial energy from the aerobic and anaerobic systems (Barbero-Alvarez et al., 2008; Castagna et al., 2009; Moore et al., 2014; Ribeiro et al., 2020; Spyrou et al., 2020). A special feature of futsal is the unlimited number of player substitutions, which contributes to maintaining match intensity and pace at a high level and ultimately increases the match's physical demands (Castagna et al., 2009; Ribeiro et al., 2021). Therefore, understanding how to maintain or improve the physical parameters of players is a critical issue, as futsal players should be able to successfully perform during a long competitive season of roughly 8–9 months.

Futsal preseason features high training loads, which are intended to develop several physical capacities concomitantly and elevate player performance levels (Miloski et al., 2016; Rabelo et al., 2016; Lago-Fuentes et al., 2020). By contrast,

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the in-season period is mainly devoted to technical–tactical content, with maintenance of a generally stable training load (Miloski et al., 2016; Rabelo et al., 2016; Lago-Fuentes et al., 2020; Mateus et al., 2021). This logical variation of training scope might lead to seasonal changes in players' fitness and technical–tactical performance. Accordingly, the analysis of seasonal variations in player performance customarily involves three key periods of the season: preseason, midseason, and end of season (Clark et al., 2008; Oliveira et al., 2013). Studies have clearly demonstrated that the physical capacities that determine performance are improved over the preseason and are generally maintained throughout the competitive season (Oliveira et al., 2013; Miloski et al., 2016). Further, occasionally, declines in some of these capacities may be observed towards the end of the season (Clark et al., 2008; Mara et al., 2015).

Although variations in the fitness components are acknowledged, the evidence on how technical–tactical skills change over the course of a competitive season of futsal is inadequate. The existence of such a gap in the literature is somewhat surprising, given that physical fitness is just one of several variables that influence players' performance; the combination of different performance variables is widely recognized as the determinant of successful performance (Travassos et al., 2012; Mohammed et al., 2014). In line with this reasoning, a crucial feature of players' overall performance is the link between their physical fitness and technical–tactical skills (Mohammed et al., 2014; Moore et al., 2014; Milanez et al., 2020). For instance, a lower activity profile resulting from a lack of conditioning has been associated with more technical errors (Rampinini et al., 200; Milanez et al., 2020). Furthermore, players with poor physical fitness face difficulties in continually performing explosive movements, which leads to predictable game play and a consequent inability to disrupt opponents' tactics (Sampaio et al., 2014; Coutinho et al., 2018).

To better understand futsal players' development under such demanding training and competitive scenarios, longitudinal coverage of the physical adaptations and match-related technical performance variations throughout the competitive season would therefore be a fruitful approach. As previously mentioned, the literature has mainly been devoted to studying physical fitness over the course of a season while neglecting possible indirect and interactive effects on technical–tactical performance. Pursuing such a line of investigation may provide a deeper understanding of the interaction between physical and tactical–technical performance and thus empower coaches and practitioners to implement critical adaptations to their training programs, thereby increasing their effectiveness. Therefore, the present study is a first attempt to explore the seasonal variations in futsal players' physical, physiological, and technical–tactical performance. We hypothesized that significant improvements in physical and physiological variables would be initially observed during the preseason and then stabilize over the season (Oliveira et al., 2013; Miloski et al., 2016). Additionally, we envisioned that a training environment aimed at improving individual and collective performance would enhance players' technical–tactical performance (Travassos et al., 2012a; Travassos et al., 2012b; Oppici et al., 2018).

## Materials and Methods

### *Participants*

Eight experienced outfield futsal players volunteered to participate in the study (age, 24.5±5.17 years; height, 175±6.12 cm; weight, 69.7±8.4 kg). Criteria for inclusion were applied to ensure players had previous experience in playing futsal in national championship leagues (i.e. minimum experience of 5 years), and participants were exposed to four training sessions per week (lasting approximately 100 min each). No players presented a history of injury or muscle disorders in previous 6 months. All players were informed of the study purpose and potential risks before giving their written informed consent for participation. The study protocol conformed to the recommendations of the Declaration of Helsinki and was approved by and followed the guidelines of the local institutional research ethics committee (CEUBI-Pj-2018-029).

### *Design and procedures*

Evaluation procedures were distributed across three time points within a competitive season (M1, beginning of the preseason; M2, middle of the first half of the season; M3, middle of the second half of the season). The selection of the timing for testing followed previous research (Oliveira et al., 2013) and was arranged for the convenience of the team's coach. Participants were randomly assigned to perform physical and match testing on different days. Physical measures were assessed in the second training session of a weekly microcycle that did not include any formal competition, and match-related variables were assessed on the following day. All the tests were completed on the same day of the week (i.e. physical: Tuesday; technical: Wednesday), at the same time of day (6:00–8:00 p.m.), and at an indoor facility where the players typically engaged in their weekly training. On testing days, subjects completed an individual warm-up consisting of jogging, static and dynamic stretching, short sprints, and general exercises involving ball control.

### *Measurements*

Physical performance was evaluated using the futsal intermittent endurance test (FIET), which entails shuttle running performed at progressively increasing speed until exhaustion (Castagna & Barbero-Alvarez, 2010). The test comprises three shuttle-running bouts of 45 m (3×15 m) interspersed with 10 s of active recovery. After each 8×45 m, the players were allowed to rest for 30 s. For the FIET, the initial speed was 9 km/h, and speed increments during the first 9×45-m bouts were 0.33 km/h, successively shifting to 0.20 km/h every 45 m until exhaustion (Castagna & Barbero-Alvarez, 2010). The test ends when participants do not reach the finish line before the timer sounds in two consecutive runs.

One week before testing, participants were familiarized with the testing equipment and procedures. Physical performance was determined on the basis of the following measures directly retrieved from the shuttle-running test: (i) maximum velocity reached (km/h), (ii) total distance covered (m), and (iii) test duration. Additionally, we evaluated (iv) initial heart rate (bpm) and (v) peak heart rate (bpm) using the Polar system (Polar Team System, Polar Electro, Kempele, Finland), (vi) peak blood lactate concentration (mmol/L) using a Lactate Pro 2 analyser (Arkray, Kyoto, Japan), and the (vii) rating of perceived exertion using the Borg Scale, with scores ranging from 6 to 20 (Borg, 1982).

Players' technical–tactical performance was evaluated by conducting a simulated futsal match (GK+4 vs. 4+GK) on a regular-sized futsal pitch. The match was 10 min in duration, interspersed with a 5-min recovery period. To ensure the

teams were evenly matched, the players were divided on the basis of their skills, according to the coach's perception of their passing ability, ball control, shooting, and game knowledge. All the match situations were video recorded (a pair of cameras was positioned on each side of the goals) and downloaded to a computer to register the match performance statistics by using a video analysis system (PickleSports, Portugal). This software allows for the selection of key performance indicators and the generation of detailed performance statistics regarding individuals' and team performances. The match performance indicators were goals scored, shots on goal, successful passes, balls lost, balls recovered, and goals conceded (Santos et al., 2020).

*Statistical analysis*

First, a Shapiro–Wilk test was used to confirm the normal distribution of data ($p>0.05$). Descriptive statistics (mean, standard deviation, and 95% confidence interval) were reported. A univariate one-way repeated-measures analysis of variance (ANOVA) was then conducted to compare the effect of the timing of testing on the physical, physiological, and match performance indicators. No violations of the assumption of sphericity were detected. Effect sizes were computed on the basis of partial eta-squared ($\eta 2$) values and interpreted in accordance with Ferguson (2009): without effect if $0<\eta 2<0.04$, minimum effect if $0.04<\eta 2<0.25$, moderate effect if $0.25<\eta 2<0.64$, and strong effect if $\eta 2>0.64$. Whenever data were (i) significant ($p\leq 0.05$) with a medium/moderate or large/strong effect size ($\eta 2>0.25$), this was reported as a 'meaningful variation', and where the data were (ii) significant ($\leq 0.05$) with a small effect size ($\eta 2\leq 0.25$), it was reported as a 'significant variation'. Post hoc Bonferroni's tests were used to make a pairwise comparison between the levels of the within-participant factor, namely the timing of testing (Winter, 2008). All the analyses were conducted using SPSS (version 23.0. Armonk, NY: IBM Corp), with the significance level being set at $p<0.05$.

## Results

No significant differences were found for the physical-related variables between the different time points of evaluation (maximum velocity, $F(2,14)=1.21$, $p=.328$, $\eta 2=.147$; total distance covered, $F(2,14)=1.61$, $p=.235$, $\eta 2=.187$; and test duration, $F(2,14)=1.89$, $p=.187$, $\eta 2=.213$).

However, the analysis of physiological variables revealed significant differences in initial heart rate between the different time points of evaluation ($F(2,14)=43.77$, $p<.001$, $\eta 2=.862$). A posteriori comparison indicated that participants exhibited a larger initial heart rate at M1 (61.5±3.21) that significantly decreased over time (M2, 57.38±3.25; M3, 55.13±1.06). Significant differences were also observed in peak blood lactate concentration between the different time points of evaluation ($F(2,14)=12.45$, $p=.001$, $\eta 2=.640$). A posteriori comparison demonstrated that participants exhibited a high peak blood lactate concentration at M1 that significantly decreased at M2 (M1, 11.49±1.82; M2, 6.99±1.95) and then stabilized with no differences between the second and third time points (M3, 9.13±2.51). Further analysis revealed no significant differences in peak heart rate ($F(2,14)=1.85$, $p=.194$, $\eta 2=.209$ ) or perceived exertion ($F(2,14)=2.00$, $p=.172$, $\eta 2=.222$; Fig. 1).

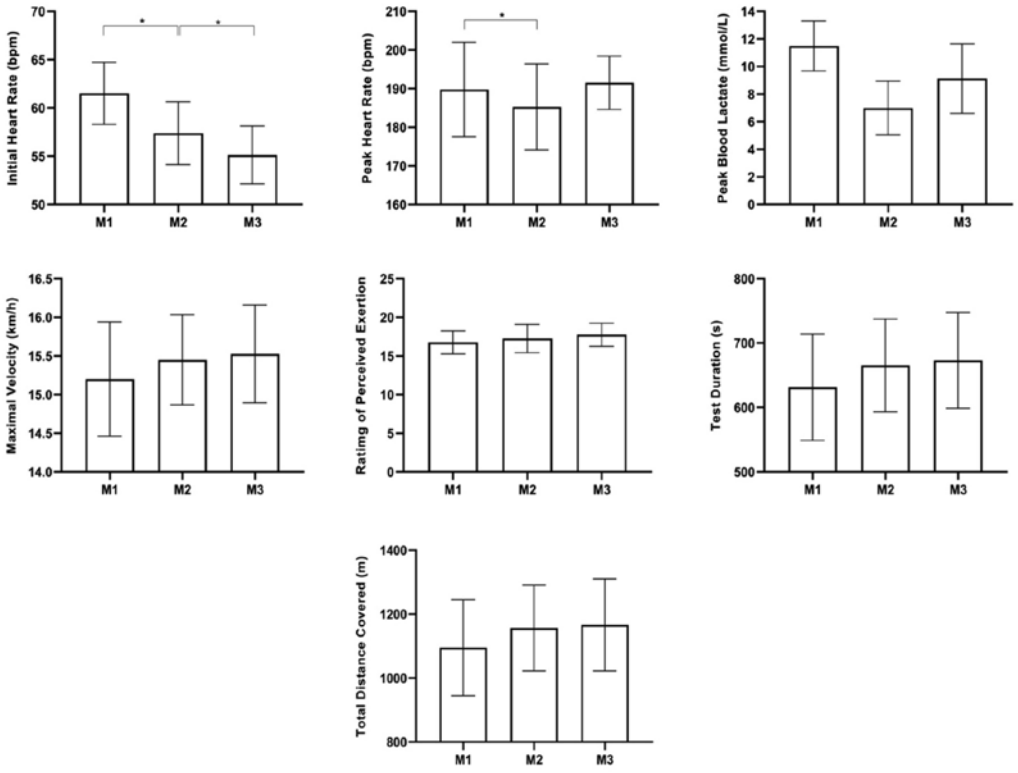


FIGURE 1. Descriptive values (mean and standard deviation) of physical and physiological variables.

With regard to players' technical–tactical performance, no significant differences were observed across the variables of goals scored ($F(2,14)=0.13$, $p=.876$, $\eta 2=.019$), shots on goal ($F(2,14)=1.94$, $p=.180$, $\eta 2=.217$), successful passes ($F(2,14)=1.67$, $p=.224$, $\eta 2=.192$), balls lost ($F(2,14)=0.86$, $p=.444$, $\eta 2=.109$), balls recovered ($F(2,14)=1.64$, $p=.23$, $\eta 2=.190$), and goals conceded ($F(2,14)=0.88$, $p=.44$, $\eta 2=.111$).

**Table 1.** Mean and standard deviation of physical, physiological and match-related performance variables

| Variables | Moment 1 | Moment 2 | Moment 3 |
|---|---|---|---|
| Maximal velocity reached | 15.20(0.69) | 15.45(0.55) | 15.53(0.59) |
| Total distance covered | 1095(140.51) | 1156.88(125.82) | 1166.25(134.53) |
| Test duration | 631.38(82.49) | 665.25(72.21) | 673.13(74.53) |
| Initial heart rate | 61.50(3) | 57.38(3.04) | 55.13(2.80) |
| Peak heart rate | 189.75(11.40) | 185.25(10.43) | 191.50(6.44) |
| Peak blood lactate concentration | 11.49(1.70) | 6.99(1.83) | 9.13(2.35) |
| Rating of perceived exertion | 16.75(1.39) | 17.25(1.71) | 17.75(1.39) |
| Goals scored | 0.88(1.05) | 0.63(1.11) | 0.75(0.66) |
| Shots on goal | 3.13(1.62) | 4.75(2.49) | 2.75(1.64) |
| Successful passes | 15.50(4.56) | 19(3.61) | 19.13(5.06) |
| Ball lost | 5.00(2.45) | 3(1) | 2.88(1.62) |
| Ball recovery | 2(1.12) | 2.13(1.76) | 3.25(0.97) |
| Goals conceded | 3(1) | 2.50(0.50) | 3(1) |

## Discussion

This study examined futsal players seasonal physical, physiological, and technical–tactical adaptations at three different time points in the season (i.e. beginning of the preseason, middle of the first half of the season, and middle of the second half of the season). The results demonstrated that certain physiological variables such as initial heart rate and peak blood lactate concentration, which were evaluated through the FIET test, significantly varied through the season. The players' initial heart rate progressively decreased from the first to the last time point of evaluation, and the blood lactate concentration significantly decreased from the first to the second time point but then stabilized.

Amongst the physiological variables, only initial heart rate and peak blood lactate concentration exhibited significant variations, presenting higher values at the preseason time point compared to the in-season time points. This evidence may reflect the relatively poor fitness level of players of team sports that typically feature a preseason period. In fact, at the beginning of the season, coaching staffs tend to follow a periodization strategy where training loads tend to be higher for conditioning purposes. Previous research has corroborated this convention, reporting significant differences in the total weekly training load between the first and subsequent microcycles of professional female and male futsal teams (Miloski et al., 2012; Lago-Fuentes et al., 2020). For instance, Miloski et al. (2012) found larger training load (i.e. total weekly training load), monotony, and strain values in the preparatory period than in the competitive period. These training load dynamics are designed to induce an imbalance in the players' homeostasis to improve their physical fitness and enable them to achieve the desired performance level in competitions.

Initial heart rate values in the FIET progressively decreased over the season. Futsal has been consistently characterized as a high-intensity match sport that places heavy demands on both the aerobic and anaerobic systems. Additionally, players are required to perform high-intensity movements such as sprinting and tackling on an intermittent basis (Naser et al., 2017). Players covered almost a quarter of the total distance in the FIET at high intensity. The high-intensity and intermittent match profile is further supported by a work-to-rest ratio of approximately 1:1 (Barbero-Alvarez et al., 2008). That the initial heart rate in the FIET decreased from 61.5 bpm to 55.1 bpm from the initial to the last time point of evaluation may suggest that the training program induced relevant cardiorespiratory and mitochondrial adaptations, both at central and peripheral levels. A wealth of evidence indicates that the aerobic system provides the main source of energy (Makaje et al., 2012) and also contributes to removing blood lactate, which is critical, given the metabolic acidosis effects of high-intensity exercise and its detrimental influence on player performance (Glänzel et al., 2020). Therefore, the observed decrease in initial heart rate within the season may signal optimization of the aerobic system as a result of the training process.

In the present study, blood lactate concentration significantly decreased from the preseason to the middle of the first half of the season and then stabilized in the middle of the second half of the season. Blood lactate concentration is a solid indicator of the contribution of anaerobic glycolysis to overall performance in team sports (Krustrup et al., 2006). Previous research has reported peak BLac values of 12.6±2.3 mmol/L and 12±2.9 mmol/L, respectively, for the FIET and treadmill protocols (Castagna & Barbero-Alvarez, 2010). Our results accord with the findings of Castagna and Barbero-Alvarez (2010), especially the values observed in the preseason (11.49±1.82 mmol/L). Existing research has also provided additional insights into blood lactate variation during an official futsal match, with the results demonstrating that the BLac concentration of futsal players tends to rise from the beginning of a match to half-time and then stabilizes at the end of the match (Arslanoğlu et al., 2014). The present study corroborates previous research by highlighting the high-intensity nature of a futsal match and the predominant role of anaerobic metabolism. This study provides additional insight into how the BLac concentration of futsal players tends to stabilize throughout the season, which can be interpreted as a physiological adaption to training stimuli. In particular, improved capacity of the aerobic system to remove blood lactate may have contributed to the lower values observed at the second and third evaluations. Although tentative, such evidence was ascertained while not jeopardizing the capacity of the anaerobic pathway to support player performance given the high-in-

tensity and intermittent physiological profile of futsal match play.

Surprisingly, no significant improvement in distance covered and test duration variables was observed. In this context, Oliveira et al. (2013) documented performance improvements in the repeated sprint ability (RSA) and Yo-Yo intermittent recovery test from the preseason to the in-season period. Worth noting is the fact that the FIET is a futsal-oriented high-intensity test, whereas the RSA and Yo-Yo are not. Hence, additional evidence is needed to determine the within-season sensitivity of both specific and general physical fitness tests to the performance of elite futsal players.

In futsal matches, players experience an informationally rich and time-contrived environment that requires accurate decision-making regarding when and where to move, pass, shoot, and recover ball possession (Travassos, Araújo, et al., 2012; Travassos, Duarte, et al., 2012). Furthermore, players with poor physical fitness struggle to consistently perform explosive actions and consequently technical–tactical performance is also impacted (Milanez et al., 2020; Rampinini et al., 2008). Unexpectedly, in the present study, the match performance variables did not change between the time points in analysis. Possibly, as a result of their high expertise, the participating players may have a superior level of technical and tactical skills that is not directly affected by their physical fitness. In addition, the stability observed in the physical-related variables may also suggest that the players experienced a degree of change in their physiological capacity to perform while co-adapting their perceptual and motor behaviours. Further research is required to understand the relationship between the different physical, physiological, and technical–tactical components and the specific thresholds that may generate bidirectional impacts on performance.

Our study has some limitations that should be noted. Due to the small sample size and the specificity of the players' technical–tactical performance evaluation task, further research involving larger cohorts is needed to clarify the within-season variations in match performance and whether they are closely related to physical variables. Further research should also be conducted over the course of a season by considering players' performance in competitive matches. Furthermore, future studies should incorporate a wide range of variables (session rating of perceived exertion, distance covered, accelerations, decelerations, speed thresholds, collective variables) to provide a comprehensive understanding of performance fluctuations across a season.

The results obtained in this study may provide guidance for the monitorization of futsal players performance across the season. In particular, sport coaches and practitioners may utilize heart rate and peak blood lactate measures as potential indicators of fitness levels, especially at the preseason time point. By this means, a solid performance basis may be created to sustain an optimal level of performance over the in-season period. In addition, the design of periodization strategies may be critically informed by a multidimensional spawn of information involving physical, physiological, and technical–tactical measures in order to induce favourable performance adaptations.

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**Conflicts of Interest**
The authors declare no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

# Lifestyle Changes During COVID-19 of University Staff in Indonesia: A Cross-Sectional Survey

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**Abstract**

Among the lecturers and staff at the university are experiencing stress disorders, especially during the COVID-19 pandemic. We aimed to determine the prevalence of cardiovascular risk factors, physical activity, and dietary adherence among lectures and staff associated with the national survey. A cross-sectional study with a web-based questionnaire presented anonymous demographic data, cardiovascular risk factors, physical activity, dietary intake, and healthy lifestyle barriers. A total of 1,862 lecturers and staff who met the following criteria for participation, having reached the age of majority at 25, were accepted into the study, gave informed consent online, and responded to a survey. BMI in the staff and lecturers group was overweight and obese, slightly lower for lecturers (25.9 kg/m2) compared to staff (27.4 kg/m2) with adjustments for age and gender. There was no significant difference ($p>0.05$) in the prevalence of obesity between staff and faculty regardless of age or gender. The short IPAQ questionnaire revealed that around 68.7% of lecturers did PA category 2 or 3 and 28.3% of lecturers did PA category 3. Muscle strengthening exercises were carried out in each group by 24.5% of lecturers and 21.4% of staff. Lecturers (74.2%) feel responsible for their health. Most of the participants expressed that their working hours prevented them from staying fit. Physical activity and low intake of vegetables and fruits due to lack of managerial support, fitness facilities, and long working hours are obstacles to a healthy lifestyle. Very few lecturers and staff can follow an active lifestyle every day of the week and tend to engage in physical activity for longer periods within days or regulate food intake during the COVID-19 pandemic.

***Keywords:*** *lifestyle, cardiovascular, physical activity, covid-19*

## Introduction

The fourth leading cause of death worldwide is physical inactivity and it is one of the main risk factors for non-communicable diseases (World Health Organization, 2010). WHO recommendations make it clear that physical activity for adults aged 19-64 should strive to be active every day, taking part in at least 150 minutes/week of moderate-intensity aerobic activity, 75 minutes of vigorous intensity, or a combination of both, with additional muscle-strengthening activity on 2 or more days per week. 33.5% in Indonesia are deemed to be physically inactive (World Health Organization, 2010). Low levels of physical activity can lead to high body fat and appetite dysregulation (Kovacheva & Tsen, 2018).

Lifestyle is a complex foundation that plays a central role in the state of health of an individual. Lifestyle is based on the habits, behavior, attitudes, activities, and decisions of a person, or a group of people, related to various situations in society or during work, and daily activities, and which can be modified (Health and Safety Executive, 2017). Lifestyle includes several behaviors such as type of diet/nutrition, physical activity, drinking alcohol, smoking and/or taking other drugs, responsibility for health, recreational activities, interpersonal rela-

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tionships, sexual practices, activities related to work/career, and patterns consumption (Ramírez & Agredo, 2012).

Lifestyle can affect health diseases, which can be interpreted as identification and priority for all professionals including lecturers and staff. WHO explains that crawling non-communicable diseases (NCDs) can significantly be overcome by modifying lifestyle and related risk factors (World Health Organization, 2010), which prioritizes physical activity, controlling their body weight and healthy eating patterns, limiting tobacco and intake of alcohol and also keep blood pressure and plasma lipid levels within normal limits. The majority of Indonesians, or 78.9 percent of the population, engage in physical exercise, compared to only 21.1 percent of those who engage in less physical activity. In contrast, when looking at smoking behaviors, 27.2 percent of people in Indonesia who are 15 years old currently smoke, 4.9 percent of people who used to smoke, and 67.8 percent of people do not (Kesehatan et al., 2019).

Coronavirus disease 2019 or what is now known as COVID-19 is a severe acute respiratory syndrome caused by SARS coronavirus 2 (SARS-CoV-2) (Wang et al., 2020). To contain the spread of the new COVID-19, in early March 2020, the Government of Indonesia decided to take action to ban mass gatherings that were enforced throughout the national territory.

This new condition can interfere with a healthy and varied diet and regular physical activity. For example, decreased consumption of fresh food, especially fish and vegetables, and fruits due to limited access to grocery stores. This has resulted in preferring foods that are processed in a fast manner, such as snacks, junk food, eating cereals that are high in sugar, fat, and salt. In addition, emotional and psychological responses to the COVID-19 outbreak (Wang et al., 2020), resulted in lifestyle changes due to control measures with the consequences of persistent changes in unhealthy behavior.

Many studies have been conducted on the effects of the pandemic on the health of the general public since it was declared to exist, but few have looked at how it has affected professors and staff. Numerous research has examined its impact on certain lifestyle factors, including mental health (Husky et al., 2020; Son et al., 2020), physical activity (Huber et al., 2020; Romero-Blanco et al., 2020a), food (Duong et al., 2020), sleep (Romero-Blanco et al., 2020b; Son et al., 2020), or a combination of these factors (Amatori et al., 2020). Few research, however, has examined important aspects of health determinants such as social and family ties, drug use, and work satisfaction. We haven't come across any research that assesses changes in general function experienced by university faculty and staff in Indonesia during the COVID-19 pandemic concerning cardiovascular risk factor status, measuring adherence to dietary recommendations, or tracking physical activity. By evaluating individual and institutional factors that are thought to be barriers to leading a healthy lifestyle, the study's objectives included determining cardiovascular risk factor status, monitoring adherence to dietary recommendations and physical activity guidelines, and making comparisons between lecturers and staff at the university. Accordingly, we conducted a study aimed to determine the prevalence of cardiovascular risk factors, physical activity, and dietary adherence among lectures and staff associated with the national survey.

## Methods

### *Design*

The Department of Physical Education of the Universitas Tanjungpura conducted this observational, descriptive, and survey study. A web poll using Microsoft Forms was utilized to gather information on the collegiate population of Indonesia during the COVID-19 pandemic.

A digital platform, available from any device with an internet connection, including smartphones, desktops, and tablets, was used to survey from July to August 2020. Institutional emails, corporate and private social networks (Twitter, Facebook, and Instagram), and WhatsApp were all used to spread the word about the poll. According to earlier studies (di Renzo et al., 2020), this approach is effective for achieving the research goals since it makes it easier to disseminate the survey questionnaire during a time when there are a lot of territorial restrictions because of the pandemic.

According to other studies (di Renzo et al., 2020), this is a multicenter cross-sectional study that is entirely based on a self-suggested questionnaire. This approach is effective for the research goals because it makes it easier to disseminate the survey questionnaire during a time when there are many territorial restrictions because of the pandemic.

### *Participants*

University lecturers and staff primarily based totally in and around Pontianak agreed to take part in this examination which had been West Pontianak, East Pontianak, Southeast Pontianak, South Pontianak, and The city of Pontianak. According to the following eligibility requirements, participants were admitted to the study: Inclusion criteria: the age of majority is 25; become a lecturer and staff at an Indonesian university and submit informed permission online. Exclusion criteria: having a severe impairment or disorder that constrained or limited one's way of life.

A total of 1862 staff and faculty approved participation in the survey. Respondents were almost equally divided between the staff group (n=929, 31.4±21) and the lecturer group (n=933, 32.3±23). Participants were aged between 25 and 50 years. The proportions of men and women did not differ between groups of staff and lecturers. Of these, 1862 staff and faculty completed the first two sections of the survey, while 1711 of them completed all five sections of the questionnaire. Outcomes for demographic and risk factors with medical conditions were analyzed and reported by all participants (n=1862), whereas responses related to diet, PA, and healthy lifestyle barriers were analyzed for those who completed the entire survey (n=1711).

All groups of workers without delay hired via way of means of the trusts had been covered withinside the survey. Ethics approval (EC/UNTAN/20520) or waiver turned into acquired from the Universitas Tanjungpura. The Checklist for Reporting Results of Internet E-Surveys (CHERRIES) turned into followed for improvement and reporting of the survey (Eysenbach, 2004). The group of workers needed to provide their consent to the questionnaire earlier than they may continue further, which turned into duly recorded. At the quit of this duration, the facts from the online questionnaire had been extracted for analysis.

### *Data Collection*

The COVID-19 pandemic-related state of panic that Indonesia had at the time the study was conducted made it hard to administer the questionnaire in person. Through a website created for conducting surveys, the questionnaire was delivered digitally (Microsoft Forms). By preventing the

potential bias of feeling assessed by the person delivering the questionnaire, this structure supported the participants' genuineness. To learn how the participants' lifestyles have changed.

*Survey questionnaire design*

The survey became anonymous, and no identifiable non-public info have been amassed from the respondents. The questions have been advanced to check the compliance in opposition to the overall fitness steerage posted through the WHO (Wood et al., 2005). There have been 5 sections inside the questionnaire. Body mass index (BMI) same to or extra than 25 kg/m2 became classified as overweight, even as same to or extra than 30 kg/m2 became labeled as obese (WHO, 2020). Self-reported height and weight were used to compute the BMI (kg/m2). The BMI of each participant was computed by dividing their weight (kg) by their height (m2). The questions about eating regimen have been acquired from the Leeds brief shape meals frequency questionnaire (SFFFQ) (Cleghorn et al., 2016), which has 20 meals frequency questions, the responses to that are used to calculate meals institution or nutrient- unique day by day consumption and an eating regimen nice score (DQS) in 5 domains (intake of fruit, vegetables, oily fish, fats, and non-milk extrinsic sugars (NMESs) and a complete score. A DQS of 12 or extra is taken into consideration to symbolize a healthful eating regimen. The PA questions protected the same old brief inter-country-wide bodily interest questionnaire (IPAQ) (Mehta et al., 2018).

To evaluate the responses, a Likert-type scale was used, which assigns a score between 0 and 4, where a score of 4 equates to always or almost often, depending on the type of topic asked. The scale reflects the degree of opinion or behavior on each question posed. The maximum possible score is 100, and the data are interpreted for healthy lifestyles in general as follows: a lifestyle is considered fantastic if it scores 85 to 100 points, good if it scores 70 to 84, average if it scores 60 to 69, low if it scores 40 to 59, and dangerous if it scores up to 39 points. Through the use of Spearman's test-retest correlation, the questionnaire's reliability in its validated version in Indonesia was found to be quite high (p=0.01, r=0.81).

*Statistical analysis*

Survey reaction costs have been assessed as view charge, participation charge, and crowning glory charge according to the CHERRIES tick list for the entire look at a cohort (Eysenbach, 2004). Proportions and chances are used to explain all specific data. The chi-rectangular take a look at became used to examine the gender of the staff, even as the Mann–Whitney take a look at became used to examine the age class among groups. All questionnaire outcomes have been transformed into binary final results measures. Logistic regression became used to examine the consequences among medical and non-medical groups. The analyses have been adjusted for age institution and sex. All statistical evaluation became done with the use of SPSS version 23 (SPSS inc., Chicago, IL, USA). For all statistical analyses, significance was accepted at $p<0.05$.

**Table 1.** List of national standards/guidance on body mass index, diet, and physical activity as outcome measures.

| Standard guidance/indicator | |
|---|---|
| Body mass index (WHO, 2020) | 25-30 kg/m2 |
| Dietary intake (Department of Health, 2011) | Daily consumption of at least five portions of fruit and vegetables |
| | Weekly intake of at least two portions of fish, one of which should be oily (one portion of oily fish 1⁄4 140 g) |
| | Fats to form not more than 30% of daily energy intake (≤85 g) |
| | Less intake of added sugars or non-milk extrinsic sugars forming no more than 11% of daily energy intake (≤60 g) |
| Physical activity (Department of Health, 2011) | 150 Minutes of moderate intensity activity in bouts of 10 minutes or more, or 75 minutes of vigorous intensity activity each week, and |
| | undertake physical activity to improve muscle strength at least two days a week |

## Results

BMI in the staff and lecturers group was overweight and obese, slightly lower for lecturers (25.9 kg/m2) compared to staff (27.4 kg/m2) with adjustments for age and gender. There was no significant difference ($p>0.05$) in the prevalence of obesity between staff and faculty regardless of age or gender (Table 2).

Most reported suffering from stress-related conditions, especially among staff groups (Table 2). Based on the SFFFQ, the recommendations for five servings of fruit or vegetables a day are met, consume one or more servings of oily fish per week, and meet the recommended intake for fat (≤85 g/day) and NMES (≤60 g/day) with no difference in intake between staff and lecturers (table 2). The short IPAQ questionnaire revealed that around 68.7% of lecturers did PA category 2 or 3

**Table 2.** Prevalence of cardiovascular risk factors, medical conditions, and adherence among lecturers and staff to nutritional and physical activity guidelines.

| | All (%) | Lecturer (%) | Staff (%) | OR (95% CI) | P value | National data (%) |
|---|---|---|---|---|---|---|
| Cardiovascular risk factors (n=1862) | | | | | | |
| Overweight | 872 (46.8) | 427 (45.7) | 474 (51) | 0.88 (0.68, 1.12) | 0.59 | 59 |
| Obese | 373 (20) | 178 (19) | 186 (20) | 0.80 (0.58, 1.08) | 0.16 | 31 |

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**Table 2.** Prevalence of cardiovascular risk factors, medical conditions, and adherence among lecturers and staff to nutritional and physical activity guidelines.

| | All (%) | Lecturer (%) | Staff (%) | OR (95% CI) | P value | National data (%) |
|---|---|---|---|---|---|---|
| Hypertension | 252 (13.5) | 82 (8.7) | 121 (13) | 0.54 (0.38, 0.790 | 0.004 | 20.1 |
| Diabetes | 103 (5.5) | 28 (3) | 38 (4) | 0.86 (0.48, 1.79) | 0.89 | 6 |
| Abnormal cholesterol | 291 (15.6) | 110 (11.7) | 147 (15.8) | 0.79 (0.49, 1.20) | 0.18 | 49 |
| Current smoker | 202 (10.8) | 84 (8.9) | 133 (14.3) | 0.58 (0.38, 0.87) | 0.03 | 19.9 |
| Cardiovascular medical conditions and stress (n=1862) | | | | | | |
| MI | 17 (0.9) | 6 (0.6) | 7 (0.7) | 0.68 (0.14, 2.27) | 0.578 | 1.9 |
| PVD | 19 (1) | 21 (2.2) | 24 (2.5) | 0.69 (0.19, 2.2) | 0.676 | NA |
| Stroke | 10 (0.5) | 7 (0.7) | 13 (1.3) | 0.38 (0.05, 1.46) | 0.193 | 1.3 |
| Stress | 587 (31.5) | 257 (27.5) | 332 (35.7) | 0.59 (0.47, 0.79) | 0.002 | 1.9 |
| Dietary intake (n=1711) | | | | | | |
| Met 5-a-day F&V | 334 (18.4) | 138 (14.7) | 148 (15.9) | 0.85 (0.57, 1.17) | 0.59 | 19 |
| Oily fish > 1/week | 897 (49.4) | 499 (53.4) | 435 (46.8) | 1.32 (1.23, 1.65) | 0.006 | NA |
| Fat intake <85 g/day | 223 (12.3) | 128 (13.7) | 105 (11.3) | 1.28 (0.68, 1.82) | 0.41 | NA |
| NMESs <60 g/day | 272 (15) | 163 (17.4) | 180 (19.3) | 1.13 (0.69, 1.32) | 0.69 | NA |
| Physical activity (n=1711) | | | | | | |
| IPAQ category 2 or 3 | 986 (57.6) | 641 (68.7) | 607 (65.3) | 1.16 (0.79, 1.47) | 0.39 | 58 |
| IPAQ category 3 | 360 (21) | 267 (28.3) | 221 (23.7) | 1.24 (1.11, 1.69) | 0.06 | NA |
| Muscle strength exercise | 308 (18) | 229 (24.5) | 199 (21.4) | 1.08 (0.68, 1.44) | 0.18 | NA |
| Attitudes and barriers (n=1711) | | | | | | |
| Responsible towards health | 1161 (67.8) | 693 (74.2) | 580 (62.4) | 1.47 (1.18, 2.12) | 0.002 | NA |
| Working hours as a barrier | 912 (53.3) | 522 (55.9) | 441 (47.4) | 1.78 (1.34, 2.24) | <0.002 | NA |
| A full-time job as a barrier | 300 (17.5) | 175 (18.7) | 143 (15.3) | 1.62 (1.12, 2.12) | 0.01 | NA |
| Lack of healthy options in the canteen | 514 (30) | 309 (33.1) | 154 (16.5) | 2.13 (1.49, 2.68) | <0.002 | NA |
| Lack of fitness facilities | 1145 (66.9) | 694 (74.3) | 609 (65.5) | 1.39 (1.03, 1.89) | 0.002 | NA |
| Lack of support from manager | 724 (42.3) | 412 (44.1) | 411 (44.2) | 0.87 (0.67, 1.19) | 0.89 | NA |

CI: confidence interval; MI: myocardial infarction; PVD: peripheral vascular disease; F&V: fruit and vegetables; NMESs: non-extrinsic milk sugars; IPAQ: International Physical Activity Questionnaire; NA: not available as proportions similar to the study.

and 28.3% of lecturers did PA category 3. Muscle strengthening exercises were carried out in each group by 24.5% of lecturers and 21.4% of staff (Table 2).

Lecturers (74.2%) feel responsible for their health. Most of the participants expressed that their working hours prevented them from staying fit. Lack of fitness facilities (66.9%), managerial support (42.3%), and healthy food choices in the canteen (30%) were also considered barriers to a healthy lifestyle.

## Discussion

This large-scale cross-sectional study at four universities in Indonesia explains the prevalence of cardiovascular risk and lifestyle during the current COVID-19 pandemic by describing it in terms of physical activity and food intake among lecturers and employees. It can be explained from our findings that half of the staff were obese or overweight without adhering to the recommended physical activity and dietary guidelines, which showed no significant difference between faculty and staff.

The findings showed that despite other risk factors being the same, smoking and high blood pressure were less prevalent among lecturers and staff. The majority of lecturers and employees show an attitude that they feel they own and enjoy and are responsible for their health, but many lecturers and employees consider the lack of fitness facilities, working hours, and managerial attitudes that do not support a healthy lifestyle.

The survey results explained that although the prevalence of diabetes and obesity among lecturers was the same as that of employees, it was lower than the adult population in Indonesia. At the national level, the problem of being overweight and diabetes also occurs as an international health problem. Surveys on cardiovascular health and lifestyle have been reported but to a lesser extent, performed mostly by physicians including cardiologists, who provide the same or even slightly better lifestyle outcomes and risk factors compared to their general population (Borgan et al., 2015; McGrady et al., 2007; Pardo et al., 2014; Temporelli et al., 2013).

Our survey results also show the same thing as other countries in terms of BMI range ≥25 kg/m2 (WHO, 2020). The prevalence of smoking is much lower at the University due to the no-smoking policy in the University area as well

as awareness of the harmful effects of smoking (Frazer et al., 2016). Our study explains that the high prevalence of stress and depression is in line with previous studies and surveys (Health and Safety Executive, 2017), where the results show an increased prevalence of coronary heart disease and type 2 diabetes. Our survey results also reveal that the consumption of vegetables and five servings of fruit in both the faculty and staff groups is significantly lower than that of the same age group in the nationally reported survey (Public Health England, 2016). Our survey results show that there is no significant difference between lecturers and staff with low adherence with an NMES intake of less than 60 g/day and total fat less than 85 g/day, according to national data.

The factors causing the low intake include low personal food intake habits which are also supported by long working hours and a lack of choices for vegetable and fruit intake. The recommended physical activity indicates that the lecturer does not show better appraisal results than the staff, it also shows conformity with that reported in the general population (Taylor, 2014), physical activity has shown many cardiovascular benefits that can be done both at work and in leisure time (Lear et al., 2017). The results of the survey on low muscle strengthening exercises are better than the same age population but have not been reported in national reports.

Several lifestyle problems between lecturers and staff, one of which is due to lack of time or being too busy, major obstacles (Morrow et al., 2011). Physical activity can improve cardiovascular health and reduce the stress that occurs between lecturers and staff due to a bad lifestyle.

*Limitations*

This study demonstrates that the university population's healthy lifestyles may be compromised in the event of future COVID-19 pandemic outbreaks or other pandemics around the world. Limitations and sources of bias often occur when cross-sectional surveys display self-reported data because they are anonymous, making it impossible to compare respondents with non-respondents (Fowler, 2014). This cross-sectional survey's sample size was relatively large and exceeded the starting point of the sample size calculation. The study's comparison of outcome factor measurement before and during the epidemic is a crucial component. Sampling via web-based surveys is often error-prone and response rates are low. However, because some of the differences that were discovered are clinically slight, general comments and interpretations of the current data should be used with caution. The self-reported data, which raises the possibility of reporting bias, was one of the study's major shortcomings. Efforts have been made to obtain the maximum response rate by sending a minimum of two emails provided by human resources departments at all Universities for six weeks which are used by faculty and staff so that it can be ascertained that the sample is representative of the faculty distribution and staff. Selection bias can occur due to the lack of participation of lecturers and employees who are not guided by healthy and unhealthy lifestyles. Participation in these surveys is voluntary and therefore no attempt is made to enforce it from self-reported samples and data which may result in a lack of understanding of body weight and risk factors, physical activity, or diet-related questions. The absence of reporting information on the participants' socioeconomic level, which could be crucial for the research, is another problem.

## Conclusion

The research revealed that COVID-19 confinement harmed the healthy lifestyles of university lecturers and personnel in Indonesia. Very few lecturers and staff can adhere to an active lifestyle every day of the week and tend to do physical activity for a longer period in a few days or regulate dietary intake during the COVID-19 pandemic. To try to lessen its effects, modified strategies should be established. Restrictions may be a protective factor because they reduced aspects of drug and poisonous substance usage. In this regard, the research has shown the need for developing interventions that encourage the population of Indonesian universities to adopt healthy lifestyles while under COVID-19 quarantine.

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**Conflict of Interest**

The authors declare that there are no conflicts of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

# The Impact of Morphological Characteristics and Motoric Skills in Young Football Players' Selection

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**Abstract**

This research aims at showing the impact of basic morphological characteristics and specific motoric skills in the selection of young football players, specifically in showing the differences between FC Prishtina's U17 first and second teams. 30 football players participated in this study and were divided into two teams: a first team (n=15) and a second team (n=15). The competitive season performance of football players served as the selection criterion. It was always based on the eye of the coaches. The morphological measurements (body weight and height; BMI) and the assessment of specific motoric skills (speed, agility, and others) were done at the beginning of the competitive season. The research results through T-test analysis have proven differences between the first and second teams (in favor of the first team) in specific motoric skills: sprint 10 m, sprint 30m, specific endurance 300 m, agility without ball 20 m, agility with ball 20 m, but no significant differences between teams in morphological characteristics (body weight and height, BMI). So, based on this study, we can affirm that the selection of more qualitative football players (for the first team) is significantly influenced by specific motor skills (speed, agility, and specific endurance) but not by morphological characteristics (body weight and height, BMI).

***Keywords:*** *football player selection, speed, agility, body weight, and height*

## Introduction

The most popular sport in the world, football, offers the most opportunities to advance to the professional ranks. In order to overcome the challenges of modern football, players must be highly prepared, technically proficient, and tactically evolved (Bjelica et al., 2019; Sermaxhaj, 2021c).

Talent identification is one of the most important steps in the preparatory process of football players with a potential to play at high levels (Waldron & Worsfold, 2010; Hirose & Seki, 2015; Sarmento et al., 2018). The talent preparation process (development) necessitates multidisciplinary knowledge of anthropologic status (morphologic, motoric, technical-tactic, functional, psychologic, etc.) from the selectionist, as well as continuous assessment knowledge during the growth and development period (Huijgen et al., 2014).

Regardless of age or maturity level, the majority of studies show that good players have advantages in technical, tactical, body construction, motoric, and psychological skills (Sarmento et al., 2018). To prove the differences between levels, different morphologic status aspects of football players have been researched. Numerous studies have revealed insignificant differences among football players from various regions (Gardasevic et al., 2020; Sermaxhaj et al., 2021a). Young football players' morphological characteristics may influence their opportunities and competitive spirit as they strive to advance to higher levels (le Gall F, et al., 2010). Young football players' motoric and functional skill capacities vary fundamentally as a result of variations in morphologic status during growth and development (Vänttinen et al., 2011; Leäo et al., 2017).

Conditional preparation is fundamental to the execution of all technical-tactical elements and is responsible for dis-

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tinguishing between higher and lower-level football players (Jovanovic et al., 2011; Sermaxhaj et al., 2015). Research done with the goal of selecting young football players has shown that running speed and technical demonstration were more important in the selection of U13 and U14 football players, whereas specific endurance (cardiovascular and respiratory system) was more important in the selection of U15 and U16 football players (Reilly et al., 2000). Speed with direction change and speed in linear direction can be used as assessments for identifying new football players' talents, whereas muscular force changes during the growth phase are not relevant in football player selection between the ages of 12 and 14 (Hirose & Seki, 2015). Motoric skills until the age of 12–14 are developed to a large extent as a result of the sensitive period. After the age of 14–15, a motoric skill progression happens as a result of rapid muscle development (Bugarski et al., 2013). According to research, motoric skills in general can develop until the age of 16–17, after which the space for motoric skill development is minimal (Bugarski et al., 2013).

Professional football players run 10 to 12 km during a game, with 89% of those km being low-to moderate-intensity runs and only 11% being high-intensity runs (Bradley et al., 2019). The success of high-intensity activities, football game success, and the distinction between professional and amateur football players all depend more on motoric skills such as speed, agility, and specific endurance (Gil et al., 2007; Gonaus & Muller, 2012; Sermaxhaj et al., 2015; Emmonds et al., 2016; Murr et al., 2018).

Football players are selected based on the coach's subjective opinion (coach's eye, motoric performance assessments, and multidimensional data) of which ones, after five years (from the ages of 14 to 19), will progress to the professional level and which ones will remain at the amateur level. The study has shown that the coach's eye has been more predictive than motoric performances and multidimensional assessments, but the three factors coach's eye, motoric and multidimensional assessments together have provided a greater prediction (Huijgen et al., 2014; Sieghartsleitner et al., 2019). In order to recognize the differences between high and low levels of football players based on direct motoric skills assessments, it is crucial for us as sports researchers to do research on the athletes' motoric skills, in this case, the motoric skills of football players.

Based on the abovementioned studies, the aim of this research is to prove the differences between the first team (Superior League) football players and the second team (Regional League) ones in morphological characteristics (body weight and height, BMI) and motoric skills (speed, agility, and specific endurance). Through this research, we will try to answer the question: why do a group of football players belong to the first team and the other group to the second team? We will try to find the answer through morphological characteristics (body weight and height) and motoric skills (speed, agility, and specific endurance) measurements of U17 football players of FC Prishtina club.

## Methods

The research was conducted with U17 football players from FC Prishtina Academy. All participants in the research were preliminarily notified of the morphological and motoric skill measurement procedures. Before participating in the study, football players underwent a medical check-up at the sports medicine center in Prishtina. The check-up cleared all the football players for participating in the study. In accordance with the Declaration of Helsinki, the local university ethics committee approved the study (1964).

*Participants*

The sample for this research included 30 U17 football players from FC Prishtina club. The football players' sample was divided into the first team (n=15) and the second team (n=15). Based on the performances the football players had shown during the preparatory time in the regular sessions and games, the coach's eye was the primary criterion for selecting players for the first and second teams. According to the coaches, the first team, which would compete in the Superior League for U17 Kosova, was selected after the preparatory period with more talented football players, while the second team, which would compete in regular matches in the Regional League for U17 for the municipality of Prishtina, was selected with less talented football players. The coaches at this age have consistently trained both teams four times per week during the preparatory period.

*Morphological measurements*

Morphological measurements were conducted in the college of sports "Universi" in Prishtina. Body weight and BMI (Body Mass Index = kg/m2) were measured and calculated electronically with "In Body 720" (InBody, Seoul, Korea) (Gil et al., 2007; Vänttinen et al., 2011; Sermaxhaj et al., 2021b), whereas body height was measured sequentially with a Martin anthropometer with an accuracy of 0.1 cm (Marfell-Jones et al., 2006).

*Motor skills assessments*

Variable assessments of specific motoric skills were conducted in the field with artificial grass of FC Prishtina Sport Center, where the U17 football players also conduct their regular training sessions. After 20 minutes of warm-up, all participants (players) in this study underwent testing variables of motoric skills: speed (10 m and 30 m), agility (20 m running zig-zag with and without the ball), and specific endurance (300 m shuttle tempo test).

The sprint tests (10 m and 30 m) consisted of a 30 m track with 10 m split time recording. The photocells were placed at starting positions at 10 m and 30 m in the finish line test. Testing was completed from a standing start, with the front foot placed 30 cm behind the photocell's starting line. The test was conducted with Powertimer 300 (Newtest Oy, Tyrnävä, Finland) photocells with a precise time of 0.01 sec. (Sander et al., 2013; Sermaxhaj et al., 2017; Sermaxhaj, 2022).

The agility test of 20 m running zig-zag with and without the ball was completed from a standing start, with the front foot placed 30 cm behind the photocells' starting line. The photocells were placed at the starting position and finish line test. This test was measured with the Powertimer 300 testing system (Newtest Oy, Tyrnävä, Finland), with an exact time of 0.01sec (Enoksen et al., 2009; Sermaxhaj et al., 2021b).

The specific endurance 300 m test was conducted by running the 1.20 m wide and 50 m long path. Players ran with a high tempo the distance of 2x10 m, 2x20 m, 2x30 m, 2x40 m, and 2x50 m going and coming (a total of 300 m). The time was measured from the moment of the departure signal until the runner crossed the target vertical line with his chest. The play-

ers made only one attempt, and they scored with an accuracy of 0.1 seconds (Verheijen, 1997; Sermaxhaj & Telai, 2014).

*Statistical analysis*

Data analyses were performed using SPSS version 22.0 (BMI, Armonk, USA). Minimal (Min), maximal (Max), arithmetic means (Mean), standard deviations (SD), results of morphological characteristics (body height, body weight, BMI), and motoric skills (speed 10 m, 30 m, agility 20 m zig zag with and without ball, specific endurance 300 m) were calculated for both teams. To determine the difference between the first team (Superior League) and second team (Regional Team) of U17 football players, each variable was independently examined using the T-test method. We highlight, using the T-Test method, how frequently the variance between arithmetic means exceeds their standard errors. The level of significance was set at $p<0.05$. A T-test with a value of $t>1.96$ (equal or bigger) and a significant level $p<.05$ (smaller) shows that the difference between both groups is significant in a variable.

## Results

The two tables below show the results that were achieved. The parameters of morphological variables are shown in Table 1, whereas those of specific motoric variables are shown in Table 2. It was shown from table No. 1 using the T-test method that there were no significant differences between the first team (Superior League) and second team (Regional League) of U17 football players in the three variables of morphological characteristics (weight, height, and BMI). This significant lack of morphological difference shows the team's homogeneity and membership in the same demographics, including age, gender, nationality, and socioeconomic conditions.

**Table 1.** Descriptive statistics (Minimal – maximal results and arithmetic means ± Standard deviations) and T-Test (t= score, p=value) for all tests of morphological variables between the first team (n=15) and second team (n=15) football players aged U17.

| Variable | Firs team U17<br>Min. – Max.<br>(Mean±SD) | Second team U17<br>Min. – Max.<br>(Mean±SD) | t | p |
|---|---|---|---|---|
| Body mass (kg) | 57.00 - 79.00 (65.23 ± 6.55) | 52.00 - 74.00 (65.00 ± 6.17) | -.100 | .921 |
| Body height (cm) | 169.00 - 189.00 (177.93 ± 6.10) | 160.00 - 183.00 (175.72 ± 5.52) | -1.512 | .242 |
| BMI (Body mass index) | 17.92 -23.72 (20.59 ± 1.64) | 16.79 - 23.39 (21.30 ± 1.93) | 1.092 | .284 |

Note: Min=minimal result, Max=maximal result, Mean=arithmetic mean, SD=Standard Deviation, t= score, p=p value

Table No. 2 and the T-test method showed that there were statistically significant differences between the first team of U17 football players (Superior League) and the second team (Regional League) in all assessments (variables) of specific motoric skills, with the first team being statistically significantly better. Sprint run 10 m (p=.004), sprint run 30m (p=.008), run of fast specific endurance 300 m (p=.005), run 20 m zig-zag (p=.004), run 20m zig-zag with ball (p=.003); The results of specific motoric variables in a football game favor the first team (Superior League) of FC Prishtina U17 football players over the second team (Regional League).

**Table 2.** Descriptive statistics (Minimal – maximal results and arithmetic means ± Standard deviations) and T-Test (t=score, p=value) for all tests of motor specific skills between first the team (n=15) and second team (n=15) soccer players U17.

| Variable | First team U17<br>Min. – Max.<br>(Mean±SD) | Second team U17<br>Min. – Max.<br>(Mean±SD) | t | p |
|---|---|---|---|---|
| Speed 10m | 1.69 - 1.98 (1.84 ± .06) | 1.78 - 2.09 (1.93 ± .09) | 3.183 | .004 |
| Speed 30 m | 4.25 - 4.66 (4.42 ± .13) | 4.32 - 5.22 (4.61 ± .21) | 2.871 | .008 |
| Agility 20m zig- zag | 6.07 - 6.62 (6.25 ± .14) | 6.06 - 7.00 (6.51 ± .26) | 3.222 | .004 |
| Agility 20m zig- zag with ball | 7.25 - 7.75 (7.47 ± .13) | 6.90 - 8.72 (7.86 ± .45) | 3.193 | .003 |
| Specific endurance 300m | 55.78 - 61.13 (57.78 ± 1.82) | 56.00 - 66.06 (60.39 ± 2.82) | 1.892 | .005 |

Note: Min=minimal result, Max=maximal result, Mean=arithmetic mean, SD=Standard Deviation, t= score, p=p value

## Discussion

One of the most hotly debated topics, not only among football game professionals but also among the general public, is football player selection: which performances (determining factors) make the difference between professional and amateur football players, or even competition within a club where one football player is part of the first team and the other part of the second team (Murr et al., 2018; Sarmento et al., 2018). The selection of football players in the first and second teams was conducted by the eye of the coach based on their performance during the preparatory phase (regular training sessions and testing games). This is consistent with the findings of this study, which reveals that U17 football players from FC Prishtina's first team in the Superior League performed better on all motoric skill tests than players from the second team (Regional League).

The results of this research have proven that in morphological characteristics (body weight and height, BMI) between the first and second teams of U17 football players, there are no significant differences. Other authors have found similar results where insignificant differences in morphological aspects are shown (Jukic et al., 2019), as well as insignificant differences in morphological characteristics between football players from different places and ranges (Emmonds et al., 2016; Bjelica et al., 2019; Sermaxhaj et al., 2021a). Although numerous studies have been conducted to determine whether morphological charac-

teristics (weight and height) have an impact on football player selection, only a few have proven that morphological characteristics have an impact (le Gall et al., 2010; Murr et al., 2018).

This research has shown a significant difference in favor of the first team in motoric specific skills such as starting speed, accelerating speed, specific endurance and agility (the speed of acceleration and stopping with change of direction with or without the ball). There is similar research where the results of the research have proven that specific motoric skills were determined for football player selection (Waldron & Worsfold, 2010; Gonaus & Muller, 2012; Bidaurrazaga et al., 2015b; Murr et al., 2018). The collected data prove that football players of higher professional levels differ from those of lower levels, especially in specific skills of the football game (Waldron & Worsfold, 2010; Sermaxhaj et al., 2015).

Coaches are continuously searching for effective methods to improve the current practices in the identification and development of young football players with a promising potential to reach high levels of football. In this regard, there is a constant conflict between coaches and scientific researchers on the method of football player selection and talent development (Unnithan et al., 2012; Pankhurst & Collins, 2013). The research suggests to coaches and scouts that football player selection should be based on technical and tactical skills, as well as the evaluation of morphological and physiological factors proportionate to the player's age (Sarmento et al., 2018). There is a severe lack of research on the role of psychological and environmental factors in the identification and development of talents (Sarmento et al., 2018).

Based on the findings of this study and with regard to the selection of football players, we can draw the conclusion that certain motoric skills have a significant impact on player selection. Football games are tests on tests, and the assessments made by coaches, scouts, and player action analysts during games through video recordings have a significant impact on the selection of football players. There were thus fewer selection errors when players were selected using the coach's eye, through video analysis of players' activities, and by multidimensional assessment of the anthropologic status of the football player.

This study shows that the young football players (U17) chosen from the coaches' eyes correspond with the positive outcomes that the football players of the first team have shown when compared to the second team in the specific motor skills (starting speed, accelerating speed, specific endurance), and agility (the speed of acceleration and stopping with change of direction with or without the ball). We propose that additional pertinent skills, like technical, tactical, and mental components, be examined in order to reduce the errors made during the selection of young football players. In this way, one may identify the factors that affect the selection of football players at various levels.

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**Author contributions**

Fitim Arifi, Musa Selimi, and Iber Alaj reviewed previous studies and discussed the findings; Sami Sermaxhaj collected the data, carried out statistical analyses, and produced the manuscript; Fitim Arifi designed the study, discussed the data, and revised the manuscript; whereas Jeton Havolli did the presentation of the results and discussed them.

**Conflicts of interest**

The authors declare that they have no financial or other conflicts of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

# Relative Age Effect in Senior Football Leagues in Former Yugoslav Republics

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**Abstract**

The relative age effect is considered to be the main cause of the uneven distribution of birthdates in sports teams, particularly in football. The aim of this paper is to examine the presence of the relative age effect in the leagues of the former Yugoslav republics and the differences in birthdates distribution between the leagues. To test hypotheses, we used publicly available information obtained from official websites, which regarded players who played in the analyzed leagues during the 2020/2021 season. The absolute results indicate that in five of the six observed leagues, the greatest number of players were born in the first quartal of the year. A more detailed observation of each league individually found a significant relative age effect among players who play in the Serbian, Croatian and Slovenian leagues, but not in Northern Macedonia, Montenegro, and Bosnia, and Herzegovina. Also, the results show that the quarterly distribution of analyzed leagues does not differ significantly. The results of this paper should serve the purpose of raising awareness about the presence of the relative age effect in regional football. All this should affect the creation of an environment in which all football players would have an equal chance for development and progress, reduce the chances of overlooking potential talents and ultimately raise the quality of football in the region.

***Keywords:*** *birth date, distribution, selection, maturity, football*

## Introduction

The generally accepted categorization by chronological age in sport aims to enable parity in competition and create a conducive environment for the development of young athletes (Musch & Grondin, 2001). However, in this setting, the differences between members of the same group can be more than eleven months (between those born at the beginning and those born before the end of the year), taking into account that the annual division is usually in question. These inequalities consequently have a potentially significant impact on the process of talent identification in sport (Wattie, Cobley, & Baker, 2008).

To explain the differences between subjects of the same chronological age, ie group, the term relative age is used. The relative age effect is considered to be the "main culprit" for the uneven distribution of the date of birth, which is characterized by a significant deviation from the expected distribution within the same chronological group. It is typical for this distribution that within the observed group we have a larger number of subjects born at the beginning compared to the end of the year (Cobley et al., 2009; Delorme, Boiché, & Raspaud, 2010).

One of the explanations for such phenomena would be that children born relatively earlier are at a higher degree of biological maturation than relatively younger ones. Consequently, the older ones (born in January, February, and March) are more physically dominant and better coordinated than the younger ones (born in October, November, and December), and thus perform with more success. With success come awards as well as increased self-confidence, which certainly has a positive effect on the retention of this group of relatively older individuals in the sport (Vaeyens, Philippaerts, & Malina, 2005; de la Rubia, Lorenzo-Calvo, & Lorenzo, 2020).

The presence of the mentioned effect is especially pro-

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nounced in sports games, where physical characteristics have a direct impact on the outcome of activities. The authors have particularly established the existence of this phenomenon in hockey (Bezuglov et al., 2020), youth basketball (Arrieta et al., 2016), baseball (Nakata & Sakamoto, 2013), volleyball (Campos et al., 2016), handball (Wrang et al., 2018; de la Rubia et al., 2020) and tennis (Edgar & O'Donoghue, 2005).

The earliest research of the presence of the relative age effect in football appeared in the early 1990s. Barnsley et al. (1992) observed a distribution of date of birth in the sample of players participating in the 1990 World Cup in Italy and the World Championships held a year earlier in the category of players under the age of 17, which deviated significantly from the expected normal distribution. The authors also point out the astonishing fact that in the competition of football players under the age of 20, as many as 46.87% were born in the first and only 7.64% in the last quartal of the "football year" (Barnsley et al., 1992). According to the regulations of the time, the "football year" was considered to be the period from August 1 to July 31. Using the same reference period (August-July), a similar asymmetry was noted by Helsen, Starkes, and Van Winckel (1998) by observing the birth dates of young Belgian players, and by Verhulst (1992) who analyzed the birthdates of players who played in the first and second level of the competition in Belgium, Netherlands, and France.

In 1997, instead of August 1, FIFA set January 1 as the beginning of the selection period in the youth categories, and by doing harmonized "football" with the calendar year. Examining the impact of the change on the distribution of birth dates, Helsen et al. (2000) noted that after only two years of implementing this regulation, the proportion of players born at the beginning of the selection period was as high as before the change.

Observing the trends over the years, no decrease in the percentage of relatively older players in the total population of players who participated in world championships for under-17s was found. The consistency of this distribution in the period from 1997 to 2007 is shown in the results of research conducted by Williams (2010). The author also emphasizes that out of the total number of surveyed football players, as many as 40% were born in the first quartal of the year, compared to a noticeably smaller number, namely 16%, in the last one. A slight increase in the representation of relatively earlier births (born in the first quartal) from 29.3% to 31.9% was revealed by comparing the 2000/01 and 2010/11 competition seasons within the ten European senior professional leagues (Helsen et al., 2012). A special contribution to the influence of relative age in senior football was shown in the study by Yagüe et al. (2018), which showed that the relative age effect is present in a significant way in the top ten UEFA leagues in the 2016-17 seasons, regardless of team competitive ranking. On the other hand, Ramos-Filho and Ferreira (2020) found a reverse relative age effect, which means that players born at the end of the year reach the adult category with better performance qualities. Finally, Brustio et al. (2018) have showed that relative age effect exists in all ages and in seniors too in Italian football, but the effect size of this trend decreased as the age increased. The aforementioned indicates that the prevalence of this phenomenon has not decreased over the years, despite the great interest of the scientific and professional public.

In the former Yugoslavia, football enjoys the status of one of the most popular sports, and it would be important to determine the presence of the relative age effect and its impact on the selection of football players from the region. Although this topic has been the subject of interest of the professional public around the world for many years, to our knowledge no one has so far dealt with a comprehensive analysis of the distribution of birthdates among football players playing in the former Yugoslavia leagues. Therefore, the aim of this paper is to examine the presence of the relative age effect in the leagues of the former Yugoslavia as well as its impact on player selection.

## Methods

### *Subjects*

The subjects in this study are football players who played in the leagues of the former Yugoslav Republics during the 2020/2021 season. The leagues covered by the analysis are: Linglong Tire Super League (Serbia), Croatia Telekom First Division (Croatia), First Telemach League Slovenia (Slovenia), Telekom 1. CFL (Montenegro), First MFL (Northern Macedonia) and MTel Premier League (Bosnia and Herzegovina). The total sample is 1900 distributed in 74 teams competing in the 6 mentioned leagues. This research was conducted in accordance with ethical standards derived from the Declaration of Helsinki adopted in 1964 and revised in 2013 and approved by the Singidunum University Ethics Committee (no. 82-1, decision made on 31st January 2022).

### *Data collection*

Two variables were used in the preparation of this paper, namely the date of birth (more specifically the quarter in the year when the subject was born) and the league in which the subject played in the 2020/21 season. Players' birthdates were classified into one of 4 quarters (Helsen et al., 2012; Romann & Fuchslocher, 2013). Players born between January 1 and March 31 are ranked in the first quarter (Q1). By the same principle, players born between April 1 and June 30 are placed in the second quarter (Q2). The third quarter consisted of players born between July 1 and September 30 (Q3), while the last, fourth quarter consisted of players with birth dates between October 1 and December 31 (Q4).

The website https://www.transfermarkt.com/ was used to search and collect the data required for this paper, while the information was checked and supplemented through the official websites of the leagues: Serbia (https://superliga.rs/), Croatia (https://prvahnl.hr/), Slovenia (https://www.nzs.si/prvaliga/), Montenegro (https://fscg.me/takmicenja/telekom-1-cfl/), Northern Macedonia (https://ffm.mk/prva-mfl), Bosnia and Herzegovina (https://www.nfsbih.ba/takmicenja/nogomet-muskarci/m-tel-premijer-liga-bih/). When it was available for additional verification of the authenticity of the data, the websites of the clubs were also consulted. The names, surnames, date, and year of birth of the players are taken from the team lists via the above-mentioned websites. It is considered that a player qualifies as a subject if he is in the match protocol at least once during the season. Players who made no appearance in the squad were not taken into consideration.

### *Statistical analysis*

For the purposes of this paper, descriptive and comparative statistics were processed. Comparative analysis was performed using the Chi-square test for distribution ($\chi 2$) and the Pearson Chi-square test for independence. This analysis checked the homogeneity of the distribution based on the comparison of

the observed and expected quarterly distribution of the birth dates. A large number of studies advocate the theory that the percentage of births during each quarter of the year is similar, i.e. 25% (Cobley et al., 2009; Campos et al., 2017), so in this paper this value is taken as the expected theoretical distribution. The effect of relative age was diagnosed when the observed distribution was statistically significantly different from the expected theoretical distribution.

To analyze the relationship between leagues and quarterly distribution, Pearson Chi-square test for independence was used. Specifically, if there is statistical significance it can be argued that the league has an impact on the quarterly distribution, but if not, then it can be said that the quarterly distribution is independent of the leagues. All tests were conducted using SPSS (v. 20, IBM Co., Chicago, IL, USA), and Microsoft Office Excel 2010. The obtained results were considered statistically significant when $p<0.05$.

## Results

The absolute results shown in Table 1 and Figure 1 indicate that in five of the six observed leagues, the largest number of players were born in the first quartal of the year. The only competition in which this was not the case was the League of Northern Macedonia, where most players were born in the second quarter – 28.46%. On the other hand, the lowest number of births is in the fourth quarter in all but the Montenegrin football league, where we can notice that those players born in the third quartal are less represented – 22.42%. Also, compared to other leagues, Montenegro has the highest percentage (23.32%) of football players born in the period of October - December (Q4). If we look at the total sample of 1900 respondents, we can see a trend that shows a decrease in the number of players by quarters from the beginning to the end of the year (first 30.58%, second 26.42%, third 23.16%, and fourth 19.84%; Figure 1).

**Table 1.** Absolute quarterly distribution of birth dates by leagues for the 2020/2021 season with corresponding χ2 test for distribution

| Country | Number of players | Q1 | Q2 | Q3 | Q4 | χ2 |
|---|---|---|---|---|---|---|
| Serbia | 576 | 175 | 155 | 133 | 113 | 15.03* |
| Croatia | 280 | 94 | 73 | 66 | 47 | 16.14* |
| Slovenia | 259 | 88 | 66 | 55 | 50 | 13.20* |
| Montenegro | 223 | 64 | 57 | 50 | 52 | 2.09 |
| Northern Macedonia | 260 | 70 | 74 | 67 | 49 | 5.63 |
| Bosnia and Heztegovina | 302 | 90 | 77 | 69 | 66 | 4.57 |
| Total | 1900 | 581 | 502 | 440 | 377 | 47.99* |

(* statistically significant differences between observed and expected quarterly distribution; $p<0.01$)

Figure 1 shows the distribution of birth dates by quarter of all six leagues presented here, but in addition it shows the statistical significance of differences in relation to the theoretically expected homogeneous distribution of both the whole sample and each category individually. The analysis of the entire sample shows a distorted distribution that differs significantly from the expected uniform ($p<0.001$), where we note that 581 of 1900 total subjects were born between January and March (30.58%).

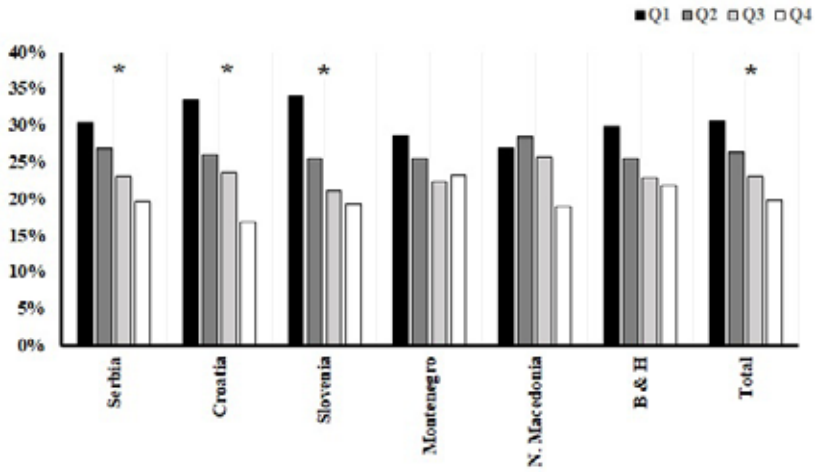


FIGURE 1. Relative quarterly distribution of birth dates by leagues for the 2020/2021 season (* statistically significant differences between observed and expected quarterly distribution $p<0.01$; N. Macedonia - Northern Macedonia, B & H – Bosnia and Herzegovina)

A more detailed observation of each league individually, which is shown in Figure 1, found a significant relative age effect among players who play in the Serbian ($p=0.002$), Croatian ($p=0.001$), and Slovenian leagues ($p=0.004$). The exceptions were competitions in Northern Macedonia ($p=0.131$), Montenegro ($p=0.553$), and Bosnia and Herzegovina ($p=0.206$), where there was no statistically significant difference between the observed and expected quarterly distribution, i.e. the relative age effect was not pronounced.

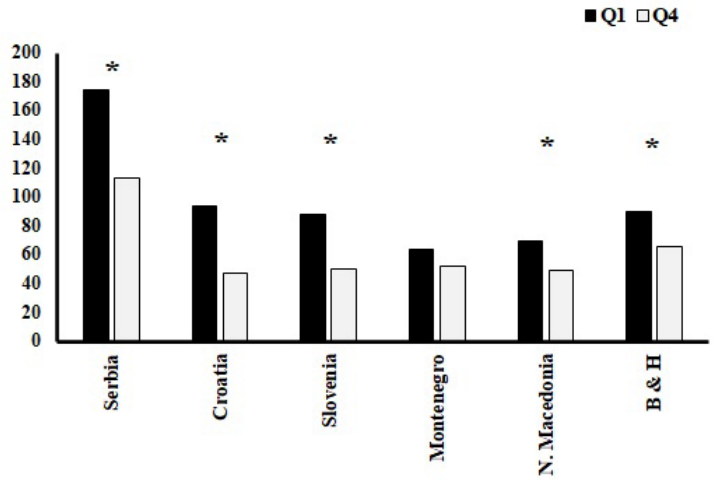


FIGURE 2. Differences in the number of players born in the first (Q1) and fourth quarter (Q4) (* statistically significant differences between observed and expected quarter distribution p<0.01; N. Macedonia - Northern Macedonia, B & H – Bosnia and Herzegovina)

An additional comparison of Q1 and Q4 (Figure 2) indicates a significantly higher number of players born in the first quarter in 5 of the 6 leagues analyzed (Serbia p<0.001; Croatia p<0.001; Slovenia p<0.001; Bosnia and Herzegovina p=0.003; Northern Macedonia p=0.003). The only league in which it was not statistically significant, although there was a difference in favor of the Q1 is the Montenegrin league (p=0.096).

**Table 2.** Differences in quarterly distribution between leagues (p values)

| | Serbia | Croatia | Slovenia | Montenegro | Northern Macedonia | Bosnia and Herzegovina |
|---|---|---|---|---|---|---|
| Serbia | 1 | 0.685 | 0.764 | 0.715 | 0.687 | 0.882 |
| Croatia | | 1 | 0.843 | 0.294 | 0.418 | 0.453 |
| Slovenia | | | 1 | 0.563 | 0.296 | 0.713 |
| Montenegro | | | | 1 | 0.529 | 0.980 |
| Northern Macedonia | | | | | 1 | 0.578 |
| Bosnia and Herzegovina | | | | | | 1 |

Table 2 shows that the quarterly distribution of analyzed leagues does not differ significantly ($\chi2=8.72$, $p=0.892$). According to the Pearson $\chi2$ test for independence results, based on the differences between the two leagues observed separately, we didn't find any significant correlation between a quarterly distribution and any of the evaluated leagues ($\chi2=0.186$-$3.696$; $p=0.294$-$0.980$).

## Discussion

The main goal of this study was to examine the significance of the relative age effect in football leagues from the former Yugoslav Republics during the 2020/2021 season. The effect of relative age was observed in Serbian, Croatian and Slovenian League, but not in the leagues of Montenegro, Northern Macedonia, and Bosnia and Herzegovina.

Some of the possible explanations according to which the relative age effect is present only in certain competitions could be that the quality of football and competitions in Serbian, Croatian and Slovenian leagues is higher compared to other analyzed countries because great competition in a particular sport can be the cause of the relative age effect (Musch & Grondin, 2001). Similar results are shown in the papers of other authors who have dealt with this topic. A significant relative age effect in European professional football is shown in many European leagues during the 2010/2011 season (England, Germany, Belgium, Netherlands, Spain, France, Italy, Denmark and Sweden; Helsen et al., 2012). The only league not revealed in that season was Portugal (Helsen et al., 2012). Examining the ten best European leagues for the 2016/2017 season, Yagüe et al (2018) indicate that the relative age effect was not significant only in the Belgian league, while it was pronounced in all other leagues (England, Italy, Turkey, Austria, Netherlands, Portugal, Spain, France, Germany). Also, Padron-Cabo et al. (2016) point to the pronounced effect in the national leagues of Spain, Italy, Germany, France, Portugal, Netherlands, Belgium, Ukraine, South Africa, Australia, Mexico and Brazil, while it was not recorded in England and South Korea.

Certainly, the causes of the obtained results should be sought in the selection of players at younger ages. The prevalence of the relative age effect indicates the phenomenon that among young players who are classified according to chronological age, football players born at the very beginning of the year are more often selected than their relatively younger teammates. This is indicated by the results of studies in youth football in Switzerland (Romann & Fuchslocher, 2013), Turkiye (Mulazimoglu, 2014), Spain (Del Campo et al., 2010), Norway (Sæther, 2016), and Germany (Augste & Lames, 2010). However, Brustio et al. (2018) have shown that relative age effect exists in senior age in Italian football too, but it is significantly smaller because maturation status has a

smaller impact on the physical performance of adult players. Also, the influence of player migrations between sports teams has a great influence on the mentioned effects.

Therefore, we can conclude that the selection in which one of the basic criteria is physical characteristics can have a far-reaching negative impact that would later be reflected through less representation of relatively younger players in senior football. To a certain extent, the results of this paper speak in favor of that, because by comparing the number of players born in the first and fourth quarter, it was determined that in five of six leagues significantly more players were born in the first quarter. Although it is known that these initial developmental benefits are neutralized after the end of the maturation period and should not significantly affect the distribution in senior categories, observing the results of this study we can say that this is not entirely true. The reason for this phenomenon could be the current process of identifying and selecting talents in football, which is not fully objective and comprehensive, and as such causes the loss of potential talent (Jiménez & Pain, 2008).

Although scientific literature suggests some solutions to the problem of the relative age effect (shortening the age categories to 6 months, creating teams from players who have strong technical and tactical characteristics but are currently lagging behind their peers in physical development, rotation of administrative periods of age categories), perhaps the most important segment in solving this problem would be the continuous education of coaches who work with young categories in these formative years (Helsen et al., 2012). During the selection, coaches should pay more attention to the technical and tactical skills of football players and less to physical characteristics such as height and strength. Furthermore, shifting the focus from victory and short-term success to the process of player development should be the ultimate goal of coaches in youth categories.

All of this should affect the creation of an environment in which all football players would have an equal chance for development and progress, reduce the chances of overlooking potential talents, and ultimately help improve the quality of football in the region.

The results of this paper should serve the purpose of raising awareness of the presence of the relative age effect in regional football, which, although not observed in all analyzed competitions, is in the majority. It could be said that the major limitation of the existing study is the fact that it covers only one season. As the migration of players in the region is very frequent, a longer period of time is needed in order for us to be able to draw valid conclusions. Therefore, it is recommended that any future research should try to cover longer periods of time that would offer a better insight into whether trends observed in this study are constant or isolated. Also, future research should cover the area of the number of games played, since this research included players who appeared only once in match protocol during the season.

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**Conflict of Interest**
The author declares that there is no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

# Somatotype Characteristics of Elite Young Athletes from the Republic of Kosovo

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**Abstract**

A large number of published studies have established the somatotype characteristics of athletes from different sports. The research goal is to establish and compare the anthropometric characteristics, body composition, and somatotype components of Kosovo's young elite athletes. The research was conducted on 255 young athletes aged 18, divided into 92 footballers, 83 basket players, and 80 handball players. The obtained results show numerous relations and differences between the tested young athletes. The research results suggest that footballers are shorter and lighter than basketball and handball players; have lower BMI than handball players. Handball players are shorter than basketball players, and have greater BMI than basketball players and footballers. Footballers, compared to handball players have a greater bone-component and less fat-component percentage. Basketball players possess greater bone-component percentage values than handball players. Footballers have a dominant mesomorph component. Their somatotype category is balanced mesomorph. Handball players are established to have a common mesomorph athletic type with a characteristic skeleton's longitudinal dimension. The ectomorph body type is dominant in basketball players – a mesomorph- body type with a characteristic skeleton's longitudinal dimension and balanced correlation between the bone and muscle tissue. Therefore, these findings may give coaches from the region better working knowledge and suggest to them to follow recent selection process methods and be more diligent during the process of talent scouting.

***Keywords:*** *sport, youth, talent scouting, different sports activity, male athletes*

## Introduction

Amongst the important components of the anthropologic characteristics without a doubt are the anthropometric characteristics. They have been studied for a long time by sports scientists. It is a well-known fact that a large number of anthropometric characteristics are genetically determined. It is extremely difficult to influence by training the longitudinal and transversal measures (Norton & Olds, 2001). Nevertheless, it is the morphologic structure that directly influences the athlete's performance and they are very important in planning an effective training program.

Football is a team sport which is played on an open field of great dimensions, and therefore it requires a high standard of physical conditioning, it is also based on a large number of movements, and a series of moderate activities that periodically replace high-intensity activities, leading towards significant metabolic heat production, and an intensity of 75-90% of the maximum heart rate, or 70-80% of the maximum oxygen consumption (Sæther, 2017; Amani, Sadeghi, & Afsharnezhad, 2018). On the other hand, handball is played in the field of smaller dimensions, however, it is considered as one of the fastest team sports and also requires great durability and strength due to constant contact with the opponent's body and specific maneuvers such as jumping, pressurizing, blocking and shooting on goal (Bilge, 2013; Masanovic, Milosevic, & Corluka, 2018). The characteristics of the activities that volleyball players perform during training and matches are different from those of football and handball. There is no contact in

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volleyball because two teams of six players are separated by a net. In this game, movement patterns differ significantly from those in football and handball, as this game includes a large number of spiking, jumping, power hitting, blocking, and setting that is mainly based on a high level of strength and power (Marques & Marinho, 2009; Palao, Lopez-Martinez, Valades, & Hernandez, 2019).

Although there is a lot of research in the world in conjunction with the anthropometric characteristics and body composition of athletes, in the Republic of Kosovo there are few studies that deal with this issue. Therefore, this research was conducted in order to determine the anthropometric characteristics, body composition, and somatotypes components of young elite athletes from Kosovo who are involved in team sports, such as: football, basketball, and handball and to determine the differences between athletes.

## Methods

*Subjects*

The research was conducted in the Laboratory of Functional Testing, Department of Physiology and Anthropology at the Medical Faculty in Kosovo, where all the athletes from the Republic of Kosovo are bound to have a regular medical-sports examination for two times a year at least. The current research involved an analytic-comparative design in order to evaluate the anthropometric characteristics of elite Kosovo athletes from several sports fields. The data extracted from the athletes who have played in the first national league and have been subject of routine sports medical examinations over the three-year period (2019–2021) were analyzed in this study. Prior to the initiation of the tests, the purpose and procedures were explained to all the athletes. Data were confidential and data protection was observed.

The research was conducted on a sample of 255 young elite athletes aged 18. The sample was divided into three (3) groups as follows: 92 football players, 83 basketball players, and 80 handball players from the Kosovo Junior Premier League. The respondents were tackled according to the recommendations of the Declaration of Helsinki (revision of Edinburgh 2000). The protocols were approved by the Ethics Committee (Number 549, 10.05.2021) at the Ss. Cyril and Methodius University of Skopje.

*Protocols and equipment*

All measures were undertaken by highly qualified and experienced persons. The height and weight were taken by a stadiometer (Seca, Leicester, UK) and electronic scale (HD-351, Tanita, Illinois, USA). Skinfolds were measured by John Bull calipers. The volumes were estimated with a standard elastic band, while the diameters – with a slide caliper (GPMc).

Besides the height and weight, the following anthropometric measures (Lohman et al., 1988) were estimated: four diameters (elbow, wrist, knee, and ankle); five circumferences (upper arm, both relaxed and flexed, forearm, the calf, and the thigh) as well as seven skin folds (biceps, triceps, forearm, and thigh calf, subscapular and supra-iliac). Anthropometric parameters were analyzed by a special software program that utilizes all Mateigka's formulas intended for calculations of all body components (Cattrysse et al., 2002). Somatotyping components (endomorphy – mesomorphy - ectomorphy) were calculated according to Carter and Heath method (1990), using the somatotype software (Somatotype V.1_2_5).

*Statistical analysis*

The players' anthropometric measures, body, and somatotype components were analyzed descriptively (i.e. mean and standard deviations). In addition, a one-way analysis of variance (ANOVA) was undertaken in order to evaluate the differences in the dependent measures based on played positions. In case the result was significant, Tukey HSD post hoc analysis was carried out to determine specific substantial differences among the groups. A probability level of 0.05 or less was taken in order to indicate statistical significance. All data were analyzed using the Statistical Package for the Social Sciences (SPSS, SPSS Inc., Chicago, IL, USA, version 22.0).

## Results

The inspection of Table 1 shows that the football players are shorter and possess less body weight than basketball and handball players ($p<0.001$). Their body mass index (BMI) is statistically significantly lesser than that of handball players ($p<0.001$), but no statistically significant differences were established in the body mass index (BMI) between the football and basketball players. The handball players are statistically significantly shorter than the basketball players ($p<0.001$), and their body mass index (BMI) is statistically and significantly greater than that of the basketball and football players ($p<0.001$).

**Table 1.** Descriptive statistics for height, body weight, and BMI

| | Soccer X±SD | | Basketball X±SD | | Handball X±SD | | F | Sig |
|---|---|---|---|---|---|---|---|---|
| Height | 178.42 | 5.98 | 192.10 | 8.82 | 182.50 | 6.81 | 80.31 | .000 |
| Weight | 71.07 | 7.06 | 82.98 | 11.68 | 83.58 | 13.00 | 38.03 | .000 |
| BMI | 22.29 | 1.49 | 22.43 | 1.90 | 25.09 | 3.61 | 26.50 | .000 |

The inspection of Table 2 shows that the football players have statistically and significantly lower values of the diameters of the arm, elbow, and ankle in comparison with the basketball and handball players ($p<0.01$). No significant and statistical presence of differences in the diameter of the knee joints in the football, basketball and handball players were established. In addition, no statistical and significant differences were established in the diameter of the hand, knee, elbow and ankle joints during the comparison between basketball and handball players. The football players have statistically significantly less volume of the upper arm, upper arm flex, thigh, forearm, and calf compared to those of the basketball and handball players ($p<0.01$). The basketball players have statistically significantly less volumes of the upper arm, upper arm flex and forearm as compared to those of the handball players ($p<0.01$). No statistical and significant differences were established between the basketball and handball players in the volumes of their thighs and calves.

**Table 2.** Diameters and circumferences – mean (X) ± standard deviation (SD) of athletes

| | Soccer X±SD | | Basketball X±SD | | Handball X±SD | | F | Sig |
|---|---|---|---|---|---|---|---|---|
| DIAMETERS | | | | | | | | |
| Wrist | 55.46 | 3.21 | 57.83 | 4.14 | 57.18 | 3.68 | 9.82 | .000 |
| Knee | 101.67 | 8.77 | 103.28 | 6.54 | 104.03 | 7.44 | 2.13 | .121 |
| Elbow | 78.82 | 4.99 | 82.36 | 6.09 | 81.78 | 5.82 | 10.07 | .000 |
| Ankle | 71.96 | 3.98 | 75.60 | 5.06 | 75.13 | 7.05 | 11.71 | .000 |
| CIRCUMFERENCES | | | | | | | | |
| Upper arm | 275.71 | 20.10 | 290.84 | 24.64 | 303.56 | 29.64 | 27.04 | .000 |
| Upper arm flex | 306.03 | 21.52 | 322.59 | 24.09 | 335.75 | 30.19 | 29.77 | .000 |
| Thigh | 553.04 | 37.61 | 576.51 | 41.27 | 590.75 | 51.67 | 16.51 | .000 |
| Forearm | 258.53 | 16.13 | 270.78 | 18.17 | 281.10 | 22.21 | 30.85 | .000 |
| Calf | 365.49 | 23.82 | 378.19 | 28.92 | 387.00 | 32.10 | 12.63 | .000 |

The inspection of Table 3 shows that the football players have statistically significantly lower values of all skinfolds compared to those of the handball players ($p<0.001$). The basketball players have statistically significantly lower values of the skinfolds of forearm, triceps, thigh, calf and supra-iliac than those of handball players ($p<0.01$).

**Table 3.** Individual skinfolds – mean (X) ± standard deviation (SD) of seven sites of athletes

| | Soccer X±SD | | Basketball X±SD | | Handball X±SD | | F | Sig |
|---|---|---|---|---|---|---|---|---|
| Biceps | 4.60 | 1.15 | 5.44 | 4.63 | 6.09 | 2.37 | 5.23 | .006 |
| Forearm | 6.17 | 1.55 | 6.34 | 1.82 | 7.84 | 2.43 | 18.40 | .000 |
| Triceps | 8.43 | 2.60 | 9.30 | 3.10 | 11.08 | 4.00 | 14.60 | .000 |
| Thigh | 12.46 | 4.33 | 14.02 | 4.92 | 17.61 | 6.69 | 20.46 | .000 |
| Subscapular | 9.04 | 2.07 | 11.92 | 15.32 | 13.26 | 6.24 | 4.50 | .012 |
| Calf | 9.94 | 3.63 | 10.96 | 3.09 | 13.52 | 4.97 | 18.36 | .000 |
| Supra-iliac | 7.47 | 2.41 | 8.56 | 3.77 | 11.64 | 7.00 | 17.74 | .000 |

According to the values of the arithmetic means and the level of statistical significance in Table 4, it is evident that the football players have statistically and significantly lower absolute values of the muscle, bone and fat components compared to the basketball and handball players ($p<0.01$). The basketball players have statistically and significantly lower absolute values of the muscle and fat components, and greater absolute values of the bone component as compared to those of the handball players ($p<0.01$). As for the percentage differences of the body composition component (Table 4), it can be established that the football players have a greater percentage of the bone component, and lesser percentage of the fat component compared to those of the handball players ($p<0.01$). No statistical and significant differences were established between the football and basketball players with regard to the percentage values of the muscle, bone and fat components. The basketball players have statistically and significantly greater percentage values of the bone component in comparison with those of the handball players. No statistical and significant differences were established between the basketball and handball players in the percentage values of the muscle and fat components.

**Table 4.** Body composition of athletes – the mean (X) ± standard deviation (SD) of the fat, bone and muscle weights (kg) and percentages are shown

| | Soccer X±SD | | Basketball X±SD | | Handball X±SD | | F | Sig |
|---|---|---|---|---|---|---|---|---|
| MMA | 49.79 | 8.24 | 54.92 | 9.76 | 58.09 | 11.69 | 15.42 | .000 |
| MMkg | 38.08 | 4.86 | 44.71 | 7.22 | 44.92 | 7.65 | 30.38 | .000 |
| MM% | 53.52 | 3.50 | 53.80 | 2.91 | 53.70 | 2.98 | 30.38 | .000 |
| BMkg | 12.74 | 1.56 | 14.75 | 2.03 | 13.92 | 1.87 | 26.97 | .000 |
| BM% | 17.96 | 1.77 | 17.84 | 1.51 | 16.82 | 2.00 | 10.41 | .000 |
| FMkg | 10.27 | 1.61 | 13.13 | 6.14 | 14.10 | 4.46 | 21.80 | .000 |
| FM% | 14.40 | 1.30 | 15.63 | 5.81 | 16.58 | 2.92 | 17.85 | .000 |
| LBM | 60.80 | 5.81 | 69.85 | 10.16 | 69.47 | 9.28 | 31.78 | .000 |

The inspection of Table 5 shows that the average values of mesomorph and endomorph components (components that refer to the total muscle and bone mass) are statistically greater with the handball players than those of football and basketball players ($p<0.001$). The high values of endomorph and mesomorph components reflect the big body structure of

the handball players. The football players have statistically significantly higher average values of the mesomorph component in comparison with the basketball players (p<0.001). As it was expected, the average values of the ectomorph component are significantly lower with the handball players than with those of football and basketball players (p<0.001). The basketball players have statistically significantly higher average values of ectomorph component than those of the football players (p<0.001).

**Table 5.** Scores - mean (X) ± standard deviation (SD) of the three components of the somatotype

| | Soccer X±SD | | Basketball X±SD | | Handball X±SD | | F | Sig |
|---|---|---|---|---|---|---|---|---|
| Endomorphic | 2.3 | 0.6 | 2.5 | 1.2 | 3.3 | 1.4 | 18.51 | .000 |
| Mesomorphic | 4.7 | 1.1 | 3.8 | 1.4 | 5.4 | 1.6 | 27.40 | .000 |
| Ectomorphic | 3.0 | 0.7 | 3.7 | 1.1 | 2.2 | 1.3 | 44.75 | .000 |

## Discussion

The former research suggests that anthropometric characteristics and body composition can be taken into consideration during the selection of athletes in many sports (Hasan et al., 2007; Ziv & Lidor, 2009). The research results show the existence of differences in the anthropometric characteristics, body composition, and somatotype components between athletes of different sports fields (Hoare, 2000). In the current research, the subject of study was only the anthropometric characteristics, body composition, and somatotype components of young Kosovo elite athletes in the football, basketball, and handball sports games, and the obtained results were mutually compared. The results confirmed the recent studies that point the differences between the body height of football, basketball, and handball players (Jeukendrup & Gleeson, 2009; Ramos-Campo et al., 2014). So the selection criteria, the different types of games, and the game rules between these sports can explain the observed difference. If we analyze the official data, it is evident that the average height of the football players who took part in the Junior World football competition in India in year 2017 was 176.01 cm (Bjelica, Masanovic, & Krivokapic, 2000), while the average height of the representatives of Britain and Spain who played in the Final of the mentioned competition was 179.1 and 178.6 cm (Bjelica, Masanovic, & Krivokapic, 2000). Based on the mentioned data, it can be concluded that the young Kosovo football players have similar body height to the players of the European and South American teams (Chuman et al., 2013; Bjelica et al., 2019; Gardasevic et al., 2019). Different studies show that soccer players in national and international competitions vary in body weight, height, and BMI depending on the geographical location, ethnic and cultural influences or the different styles of the soccer game, diet habits, and similar. Professionals, namely elite football players in Europe, in Middle East, and South America have an average body height in the range of 176.0-183.0 cm., and a weight of generally less than <80 kg (within the range of 65.6-78.7 kg.) and BMI ranging between 23.00-24.45 kg/m$^2$ (Reeves et al., 1999; Bandyopadhyay, 2007).

On the other hand, the basketball players have the tendency to be tall athletes, since they manipulate with the ball above their heads (Gaurav & Singh, 2010), and their height helps them to reach the basket easier or to block the opposite player. The taller players in basketball are in advantage since their height works for them towards making a short shot (Rašidagić et al., 2020). For example, the average height of players who played in the World Competition of Basketball 2016 year in Saragossa, Spain, was 195.56 cm. Similarly, the average height of the basketball national representations which participated in the half-final were the following according to the accessible data: USA (198.17 cm), Turky (195.75 cm), Latvia (198.17 cm) and Spain (195.92 cm) (Bjelica, Masanovic & Krivokapic, 2000). That proves that young Kosovo players have less body height than the best world's teams. The research results suggest that Kosovo coaches should be more diligent and keep pace with the contemporary selection methods while identifying talented basketball players. Namely, recent research points out that a great percentage (about 28%) of the total population of that area of Europe – the West Balkan – are tall 190 cm, and over. (Milašinović et al., 2017; Popovic, 2017; Ćorluka et al., 2018). Likewise, it is expected for the basketball players to be heavier than the football players due to greater height, and the basketball players' height has increased over the last 20-30 years. It can be a result of an improved diet, especially in the professional basketball, as well as due to the diet supplements. The handball players have a greater BMI than the basketball, and football players, and have less body height than the basketball players. These differences can derive from the differences in the game structure and the rules that are specific for the handball game. The review of the obtained results shows that Kosovo young handball players have less body height than that of the European players in the World Championship held in Russia 2015 year. For example, the average height of the French representation, which won the Championship in Russia in year 2015 was 191.8 cm, while the Korean handball players, who took the 13th place, had the average height of 183.4 cm. The Polish handball players, who took 19th place, had the average height of 190.1 cm, and the Japanese representation, who were placed 20, had the average height of 181.7 cm (Bjelica, Masanovic, & Krivokapic, 2000). The representations from Africa and Asia have relatively shorter players than most of the European teams (Táborský, 2007), but none of these representations presented notable results. The former researches suggest that persons doing sports and those engaged in sports activities, have namely put their bones under pressure and hits, and have better health of the bones than the persons of sedentary life (Bedogni et al., 2002). Zouch et al. (2008) and its established that the bone mass was greater with those bones that had had greater loading as a result of direction changing, which takes place in such sports as football, handball and basketball. Ubago-Guisado et al. (2015) also describe soccer, basketball and handball as the sports of high impact, which demonstrate higher values of bone mass in comparison to other sports. Furthermore, the research results show that skinfolds and the mass component percentage of the handball players is higher in comparison with that of football players. No statistical and significant differences were established in the mass component percentage values between the basketball and handball players. These differences can be explained due to the specifics and structure of the handball game, which is performed with a number of contacts with the

opposite players – fighting for a better position, actions that involve pushing, opposing, and swirling – briefly, great static tensions in very short and dynamic actions, and the relatively great total body mass enables the handball players to perform these tasks (Buchheit et al., 2009). Consequently, it is now well established that elite handball players need to be tall and have body mass (Nikolaidis & Ingebrigtsen, 2013). The quantity of body fat component is important from the point of the physiology, the greater percentage of the body fat is correlated with the physical characteristics of an athlete, especially in those of movements in which the body changes its place, or different body parts move in the space (Gil et al., 2007). The fat component percentage of Macedonian football players ranges from 14% of basketball players 15% and handball players about 16% (Gontarev et al., 2016; Gotarev et al., 2017). The average values of the body fat percentage in our study population were found at the higher zone of the optimal level (5–15%) delineated by Heyward and Wagner (Heyward & Wagne, 2004) for a physically active male population. In addition, it is very important to remember that the football, basketball, and handball players need to have a certain percentage of body fat in order to perform well enough and achieve their full playing potential. The person with a little amount of body fat is endangered of having some risks (Milosevic et al., 2015). A greater drop of fat level can lead to some complications and contra-indications. Adipose tissue is a complex, essential, and highly active metabolic and endocrine organ that, through secreting adipokines, plays a very complex role (Kershaw & Flier, 2004). The role of adipokines (leptin, adiponectin, and interleukin 6) in proliferation, in hematopoiesis, and reproduction, is large just as in the regulation of immune function, angiogenesis, and bone development (Kershaw & Flier, 2004). Since they have anti-diabetic, anti-inflammatory and anti-atherogenic properties, their absence would make the organism weak (Fischer, 2006; Silva et al., 2016), which means that a deficiency in the adipose tissue can have as harmful consequences as its excess.

The mesomorph component dominates in football players and their somatotype category is the balanced mesomorph (Rienzi et al., 2000; Casajús, 2001). The obtained type with the handball players is the common mesomorph athletic type with an emphasized longitudinal dimension of the skeleton, a balanced correlation of the bone and muscle tissue, and somewhat higher values of the fat tissue and endomorphic component. The dominant component with the basketball players is the ecto-mesomorph type with an emphasized longitudinal dimension of the skeleton and balanced relation of the bone and muscle tissue. The data obtained in this research shows a high degree of similarity (results are very similar) with the research by Pireva (2019).

The limitation of this study consists in the fact that not all young football players, handball and basketball players who play for Kosovo Junior Prime League were taken into consideration, which fact does not allow us to make an overall generalization in our conclusions. In addition, there was no consideration with regards to the specificities of the player's positions which are specific in each sport. In future research works, more sophisticated equipment could be used such as (DEXA and similar), which would provide more precise data about the body composition of young Kosovo athletes.

## Conclusion

The importance of anthropometric characteristics and body composition has a direct influence on the athlete's performance, and above all, they are important in planning an effective training program during the whole season and at all levels of competition. This is mostly due to the fact that describing anthropometric characteristics and body compositions of athletes and detecting possible differences in relation to competition levels may give coaches a better working knowledge of the studied groups of athletes. The obtained results can be used as a normative anthropometric index in the regular sports medical inspections of top young athletes. The data can also be used as a standard for comparison of anthropometric characteristics, body composition, and somatotype components of elite young athletes from different countries. The present research results show that football players are shorter and have less body weight than those of basketball and handball players. Their body mass index (BMI) is statistically and significantly lesser than that of the handball players. The handball players are statistically and significantly shorter than the basketball players, and their body mass index is statistically and significantly greater in comparison with that of the basketball and football players. Football players have a greater bone component percentage and less fat component percentage than handball players. The basketball players have statistically and significantly greater percentage values of the bone component than that of handball players. The dominant component of the football players is mesomorph, and their somatotype category is a balanced mesomorph. The handball players were established to obtain a common mesomorph athletic type with an emphasized longitudinal dimension of the skeleton. The dominant body type of the basketball players was obtained to be ectomorph with an emphasized longitudinal dimension of the skeleton, and balanced relation between the bone and muscle tissue.

The difference in body height is a result of the selection process. Hence, it is of great importance to have a particular focus on these variables. On the other hand, the part subscribed to the body weight can mainly be provoked by nutrition habits. Finally, the differences in bone content of the body is a logical consequence of the specific movement models of each sports discipline.

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**Conflict of Interest**
The authors declared that there no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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ORIGINAL SCIENTIFIC PAPER

# Linear Discriminant Analysis of Various Physiological and Psychological Parameters among Indian Elite Male Athletes of Different Types of Sports

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**Abstract**

The aim of this study was to categorize various physical, physiological, and psychological variables that discriminated among Indian elite male athletes participating in endurance sports (Group A, n=34, age=16.88±2.44 years), combat sports (Group B, n=35, age=17.40±1.37 years) and skill sports (Group C, n=34, age= 8.91±2.24 years) and non-athletic control group (Group D, N=33, years=18.48±2.03 years). Physical parameters included height, body weight, body fat percentage, lean body mass, muscle content, and total water content. Physiological parameters included heart rate variability and maximal aerobic power (VO2 max) measured using the Astrand protocol. Various psychological parameters were evaluated using Big Five Inventory and State-Trait Anxiety Inventory questionnaires. Discriminant analysis revealed three significant functions (P<0.05) contributing 65.7%, 25.8%, and 8.5% respectively to the model. After cross-validation, the resulting equation correctly classified 72.8% of endurance, combat, skill athletes, and control group. Total thirteen variables significantly (P<0.05) contributed to the discriminant analysis. The interpretation of the acquired discriminant functions was also based on the examination of the structure coefficients greater than 0.30. The athletes and control were discriminated mainly on VO2 max (structure coefficient, SC=0.741) in Function 1, body weight (SC=0.424), Lean body mass (SC=0.430), and muscle content (SC=0.574). This model substantiates the fact that elite male athletes show physical and physiological differences because of the different training regimens in their respective sports that conditioned them differently. In conclusion, these discriminant models could help in athlete's induction, talent identification process and improving training programs.

***Keywords:*** *maximal aerobic power, linear discriminant analysis, endurance sports, combat sports, skill sports, psychological variables*

## Introduction

Physical and physiological parameters have marked differences between athletes training for different sporting events and between different playing positions in team events (Matković et al., 2003). Understanding body composition of an athlete is important since it provides information on adaptations to training regimens and nutritional status. Different components of body composition, like fat mass, fat-free mass, and total body water, need to be studied since each component varies independently (Andreoli et al., 2003). Aerobic capacity is accepted as a major component of assessing the physical capacity of an athlete (Rankovic et al., 2010). The demand of oxygen differs from one sport to another sports (Singh and Patel, 2014). In football, hockey, basketball, and handball, technical and tactical skills as well as the physical performance capacity of the players are the most important factors that contribute to the success of a team in competitions. Combat sports that are shorter in duration and are comprised primarily of grappling

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or wrestling tend to require relatively lower aerobic capacity. Nevertheless, a greater aerobic capacity has been related to a higher standard of performance in boxing, wrestling, and judo too (James et al., 2016).

Heart rate variability (HRV) which is an indicator of cardiovascular autonomic regulation is an important determinant of training adaptations (Plews, Laursen, Stanley, Kilding, & Buchheit, 2013). In athletes, the autonomic balance is altered in response to varying intensities, and duration of the training, as measured by changes in HRV variables. Well-trained athletes have an elevated parasympathetic dominance as compared to non-athletes; confirming that athletic conditioning improves the autonomic control of the cardiovascular system (Dong, 2016). Combat sports athletes replicate high-intensity training and experience significant stress from losing weight before the match. This could have negative effects on the autonomic nervous function of combat sports athletes. According to an earlier study about on the heart rate variability of young archery athletes, experienced athletes had superior LF and RMSSD values during competition than beginners. This means that the parasympathetic nervous system of experienced archers is more dominant than beginners (Carrillo et al., 2011). In another study on the effects of heart rate variability on the performance of elite shooting athletes, the high-performance group had a lower SDNN than the low-performance group (Jon, 2015).

Physical capacity is not the only determining factor for success in sports, psychological capacity is equally important. Research has proved that personality differences were found between athletes and non-athletes, and also between individual- and team-sport athletes. It has been found that more successful athletes are significantly more agreeable, conscientious, and more emotionally stable than less successful athletes (Steca, Baretta, Greco, D'Addario, & Monzani, 2018). Optimal level of anxiety is also said to be beneficial for desired performance in sports. A statistically significant difference was found between the trait anxiety of athletes participating in different sports such as taekwondo and wrestling (Sanioglu, Ulker, & Tanis, 2017).

Many sports are based on a multifaceted, multi-dimensional performance profile (Buekers, Borry, & Rowe, 2015). There were promising efforts to discriminate various sports by means of their profile of sports-specific performance prerequisites. Leone, Lariviere & Comtois (2002) could differentiate 88% of athletes from four different sports (figure skating, swimming, tennis, and volleyball) by means of a discriminant analysis including anthropometric and motor characteristics. Even more promising were the findings of Pion, Fransen, Lenoir & Segere (2014) in elite male U18 athletes, as the investigators found a 100% correct classification within the more interconnected martial arts disciplines of judo, karate, and taekwondo. However, there is a lack of research exploring the discriminative value of different physiological and psychological performance fundamentals for Indian male elite athletes over a variety of different sports disciplines. Thus, the aim of this study was to investigate whether Indian male athletes participating in three different types of sports (endurance, combat, and skill) illustrate a sport-specific physiological, and psychological profile which is in line with the specific necessities of each sport that might serve as scientific knowledge backdrop for sports specific talent identification purposes.

## Materials and Methods

### *Participants*

The sample consisted of 136 male participants, divided into 4 groups. Group A (n=34, age=16.88±2.44 years, height=172.33±9.22 cm, weight=63.73±7.75 kg) included elite male athletes belonging to endurance sports such as middle and long-distance athletics, swimming, and cycling, Group B (n=35, age=17.40±1.37 years, height=170.66±10.01 cm, weight=71.06±15.98 kg) included elites male athletes belonging to combat sports such as wrestling and judo, Group C (n=34, age=18.91±2.24 years, height=173.99±5.96 cm, weight=69.66±10.69 kg) elites male athletes belonging to skill games such as archery and Group D (n=33, age=18.48±2.03 years, height=165.49±9.24 cm, weight=54.35±7.77 kg) included non-athletic population. Athletes were all selected from various schemes of Sports Authority of India (SAI), Northern Region and control group was composed of healthy university students who didn't participate in any sports. The athletes had a history of participation in at least national-level competitive events with a minimum of 2 years formal training and were in pre- competitive phase during the conduction of the test. Subjects, who were healthy, with no history of any hereditary or cardio-respiratory diseases, were selected for the study. Prior to that, a full explanation of the purposes, procedures, and potential risks and benefits of the assessments were offered to all players, and their written consents were acquired. The present study was conducted following guidelines as laid down in the Declaration of Helsinki, and ethical clearance was also obtained from the Institutional Ethical Committee (approval number SU/2021/092(30) dated 06.01.2021) before a performance of any tests on human subjects.

### *Procedure*

All subjects were assessed for various physical, physiological, and psychological variables at Human Performance Laboratory, SAI, and conducted during morning hours on a similar day. They underwent heart rate variability assessment first and then physical and questionnaire-based psychological assessments were done followed by sub-maximal exercise testing with the help of bicycle ergometer after familiarizing them with the exercise protocol. The subjects had a light meal at least 2 hours before the exercise test. The training was relatively common to all the athletes of the study besides the skill training. Their medical history and training duration was evaluated by a preset questionnaire.

### *Physiological and Psychological measurements*

The height and weight were measured using a digital measuring station (SECA 284; SECA, Hamburg, Germany). Heart Rate Variability (HRV) was measured using Physiological Monitoring System (Zephyr Technology Corporation, Annapolis, MD, US) (Kim et al., 2013). The chest strap was tied across the chest of the subject such that center of the electrode was directly beneath the subject's armpit. The subject was seated in a comfortable armchair located in a quiet laboratory and was asked to remain as still as possible for the duration of the recording. The readings were taken for a duration of 10 min, out of which the last 5 min readings were considered for analysis. The values of the RR intervals were analysed using Kubios Software (Version 2.2, Kuopio, Finland) (Tarvainen, Niskanen, Lipponen, Ranta-

Aho, & Karjalainen, 2014). Body composition analysis was done using Body Composition Analyser (BCA) (Model mBCA 515, SECA, Hamburg, Germany) (Lahav, Goldstein, & Gepner, 2021). The subjects were instructed to come for the test fasting and with an empty bladder, and all metal accessories, coins and mobile phones removed from the body. The subjects were made to stand on the platform with electrodes such that, their heels were placed central to the smaller posterior electrode, and the forefoot was placed central to larger anterior electrode. The subjects were asked to touch the electrodes in such a way that the electrode separator was located between middle and ring fingers. Aerobic capacity of the subjects was measured using the Astrand protocol on a bicycle ergometer (Monark LC7). The subject cycled for 6 minutes at a workload chosen to try and elicit a steady-state heart rate between 125 and 170 bpm. Recording of the heart rate was done every minute during the test. If the heart rate at 5 and 6 minutes was not within 5 beats/min, the test was continued for one extra minute. The steady-state heart rate and workload recorded were put in the equation to determine an estimation of VO2max (Macsween, 2001). For the characterisation of the personality type Big Five Inventory was used, which is a 44-item inventory that measures an individual on the dimensions of personality namely, extraversion, agreeableness, openness, neuroticism and conscientiousness (Goldberg, 1993).The State-Trait Anxiety Inventory (STAI) was used for the measurement of trait and state anxiety levels (Spielberg, Gorsuch, Lushene, & Vagg, Jacobs, 1983).

Although most of the tests administered are very standardized and well-documented assessments, test-retest reliability on the specific subject pool utilized in the present study could not be acquired. To counteract this possible problem, all testers were methodically trained and familiarized with proper test administration prior to actual data collection. All tests were DONE by the same tester to keep away from inter-tester errors. The discriminant analysis is considered to be robust with these variables (Norusis, 1993).

*Statistical Analysis*

Data analysis was done using the statistical program for social sciences (SPSS) version 25 SPSS (Inc., Chicago, IL, USA). In this study, the study variables were assessed by a two-tailed probability value of $p<0.05$ for significance. The data were tested for assumptions of normality using the Shapiro-Wilk test. Homogeneity of between groups variance-covariance matrix was checked using the Box M test. Discriminant analysis was employed on 18 variables measured, which included various physical, physiological and psychological parameters, to develop a model to predict membership of each athlete and non-athlete in the four groups (sports and non-sports). A discriminant analysis using the Wilks A was performed to determine the ability to discriminate between the four groups using the 18 selected variables ($p<0.05$). The interpretation of the acquired discriminant functions was based on the assessment of the structure coefficients greater than 0.30, meaning that variables with higher absolute values have a foremost contribution to discriminate among groups (Tabachnick & Fidell, 2000). Validation of discriminant models was carried out using the leave-one-out method of cross-validation (Norusis, 1993). Cross-validation analysis is required in order to comprehend the usefulness of discriminant functions when classifying new data. This method involves producing the discriminant function on all but one of the participants (n-1) and then testing for the group membership of that contributor. The process is repeated for each participant (n times) and the percentage of correct classifications created through averaging for the n trials.

## Results

Means and standard deviations for the four groups of athletes and control are presented in Table 1. The global test for equality of the mean vectors for the four groups was significant (Wilk's Lambda, $P<0.01$), which showed that the groups were different in all variables except in fat (%), Conscientiousness, Agreeableness, Open-mindedness, and trait anxiety which yielded a statistically non-significant result (Table 2).

**Table 1:** Descriptive results from the physical, physiological and psychological variables of elite male athletes of different sports (values are mean± SD**)**

| Variables | Group A Endurance (n=34) | Group B Combat (n=35) | Group C Skill (n=34) | Group D Control (n=34) |
|---|---|---|---|---|
| Age (years) | 16.88±2.44 | 17.40±1.37 | 18.91±2.24 | 18.48±2.03 |
| Training (years) | 4.5±2.6 | 4.9±1.7 | 5.5±2.1 | NA |
| Height (cm) | 172.33±9.22 | 170.66±10.01 | 173.99±5.96 | 165.49±9.24 |
| Weight (kg) | 63.73±7.75 | 71.06±15.98 | 69.66±10.69 | 54.35±7.77 |
| Fat (%) | 13.50±5.34 | 14.38±5.67 | 16.29±6.36 | 15.07±6.25 |
| Lean body mass (kg) | 55.35±6.59 | 59.87±9.79 | 57.48±6.01 | 46.15±7.33 |
| Muscle content (kg) | 25.40±3.76 | 29.94±5.60 | 28.04±3.52 | 21.56±3.87 |
| Total body water (%) | 61.98±5.91 | 62.45±3.87 | 60.50±4.48 | 57.27±7.58 |
| VO2 max (ml/min/kg) | 59.22±5.59 | 51.33±6.14 | 43.27±6.16 | 41.29±4.28 |
| SDNN | 87.99±38.84 | 119.06±88.08 | 82.13±40.37 | 74.08±36.31 |
| pNN50 (%) | 28.90±17.25 | 23.14±19.41 | 14.96±13.20 | 25.38±18.82 |
| LF/HF | 2.28±1.51 | 5.28±8.35 | 1.95±1.45 | 2.36±1.85 |
| Extraversion | 28.88±3.71 | 29.51±3.92 | 27.44±3.43 | 26.96±2.67 |
| Conscientiousness | 35.58±4.86 | 34.82±3.84 | 34.58±4.40 | 33.18±5.12 |

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**Table 1:** Descriptive results from the physical, physiological and psychological variables of elite male athletes of different sports (values are mean± SD**)**

| Variables | Group A Endurance (n=34) | Group B Combat (n=35) | Group C Skill (n=34) | Group D Control (n=34) |
|---|---|---|---|---|
| Agreeableness | 35.82±4.86 | 36.02±3.30 | 34.29±5.49 | 36.72±3.33 |
| Neuroticism | 22.05±5.54 | 25.91±5.58 | 23.14±4.28 | 24.60±6.71 |
| Open mindedness | 37.88±2.91 | 37.42±3.79 | 37.29±4.03 | 38.54±3.82 |
| State anxiety | 32.94±7.06 | 39.97±9.39 | 38.29±10.04 | 38.30±7.09 |
| Trait anxiety | 41.17±8.12 | 43.45±8.85 | 42.88±10.38 | 40.87±8.73 |

* - significant at the level of <0.05;** - Significant at the level of <0.01, SDNN – Standard Deviation of NN intervals, pNN50 – Percentage of consecutive NN interval difference greater than 50 msec, LF – Low Frequency, HF – High Frequency, LF/HF – Ratio of Low Frequency over High Frequency, NA=Not applicable

**Table 2:** Test of equality of group means

| Variables | Wilk's Lambda | F | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Age (years) | 0.862 | 7.063 | 3 | 132 | 0.000 |
| Height (cm) | 0.882 | 5.881 | 3 | 132 | 0.001 |
| Weight (kg) | 0.738 | 12.632 | 3 | 132 | 0.000 |
| Fat (%) | 0.970 | 1.352 | 3 | 132 | 0.260* |
| Lean body mass (kg) | 0.677 | 20.954 | 3 | 132 | 0.000 |
| Total body water (%) | 0.883 | 5.812 | 3 | 132 | 0.001 |
| Muscle content (kg) | 0.645 | 24.236 | 3 | 132 | 0.000 |
| VO2 max (ml/min/kg) | 0.379 | 72.117 | 3 | 132 | 0.000 |
| SDNN | 0.911 | 4.296 | 3 | 132 | 0.006 |
| pNN50 (%) | 0.918 | 3.953 | 3 | 132 | 0.010 |
| LF/HF | 0.913 | 4.189 | 3 | 132 | 0.007 |
| Extraversion | 0.916 | 4.009 | 3 | 132 | 0.009 |
| Conscientiousness | 0.964 | 1.652 | 3 | 132 | 0.180* |
| Agreeableness | 0.959 | 1.867 | 3 | 132 | 0.138* |
| Neuroticism | 0.934 | 3.124 | 3 | 132 | 0.028 |
| Open mindedness | 0.982 | 0.794 | 3 | 132 | 0.499* |
| State anxiety | 0.909 | 4.411 | 3 | 132 | 0.005 |
| Trait anxiety | 0.985 | 0.663 | 3 | 132 | 0.576* |

*statistically non-significant, SDNN – Standard Deviation of NN intervals, pNN50 – Percentage of consecutive NN interval difference greater than 50 msec, LF – Low Frequency, HF – High Frequency; LF/HF – Ratio of Low Frequency over High Frequency

The structure coefficients enumerate the potential of each variable to maximize differences between means amongst the endurance (Group A), combat (Group B), skill (Group C), athletes and control (Group D). The larger the enormity of the coefficients, the greater the contribution of that variable to the discriminant function. Multiple discriminant analyses revealed three significant functions (Table 3). Function 1 reflect an emphasis on VO2 max, function 2 on body weight, lean body mass, and muscle content while function 3 is on height, body weight, lean body mass, muscle content, pNN50, LF/HF, agreeableness and neuroticism (Table 3). Based on values of Wilk's Lambda, discriminant

**Table 3:** Discriminant function coefficients and tests of statistical significance

| Variables | Structure matrix coefficient | | | Standardized discriminant functions | | |
|---|---|---|---|---|---|---|
| | Function 1 | Function 2 | Function 3 | Function 1 | Function 2 | Function 3 |
| Age (years) | -0.217 | 0.088 | -0.242* | -0.442 | -0.070 | -0.201 |
| Height (cm) | 0.116 | 0.092 | -0.491* | -0.348 | -0.665 | -0.501 |
| Weight (kg) | 0.187 | 0.424* | -0.416 | 0.165 | 1.129 | 0.475 |
| Fat (%) | -0.080 | 0.069 | -0.146* | 0.038 | -0.379 | -0.334 |
| Lean body mass (kg) | 0.276 | 0.430* | -0.419 | 0.621 | -0.741 | -0.612 |

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**Table 3:** Discriminant function coefficients and tests of statistical significance

| Variables | Structure matrix coefficient | | | Standardized discriminant functions | | |
|---|---|---|---|---|---|---|
| | Function 1 | Function 2 | Function 3 | Function 1 | Function 2 | Function 3 |
| Total body water (%) | 0.198 | 0.128 | -0.119 | 0.223 | 0.216 | -0.266 |
| Muscle content (kg) | 0.232 | 0.574* | -0.339 | 0.039 | 0.907 | 0.192 |
| VO2 max (ml/min/kg) | 0.741* | -0.319 | 0.080 | 0.951 | -0.337 | 0.082 |
| SDNN | 0.118 | 0.207* | 0.182 | -0.165 | 0.470 | 0.039 |
| pNN50 (%) | 0.079 | -0.184 | 0.314* | 0.029 | -0.219 | 0.351 |
| LF/HF | 0.075 | 0.205 | 0.306* | 0.250 | 0.195 | 0.226 |
| Extraversion | 0.166* | 0.092 | 0.125 | -0.107 | -0.001 | 0.142 |
| Conscientiousness | 0.107 | 0.003 | -0.124* | 0.029 | -0.003 | -0.068 |
| Agreeableness | -0.003 | -0.067 | 0.322* | 0.038 | -0.027 | 0.502 |
| Neuroticism | -0.034 | 0.175 | 0.308* | -0.132 | 0.029 | 0.659 |
| Open mindedness | -0.034 | -0.092 | 0.126* | 0.073 | -0.068 | 0.004 |
| State anxiety | -0.094 | 0.250* | 0.147 | 0.026 | 0.346 | 0.220 |
| Trait anxiety | 0.016 | 0.113* | -0.039 | 0.071 | 0.005 | -0.360 |
| Wilk's Lambda | 0.093 | 0.351 | 0.735 | | | |
| Chi square | 294.420 | 129.676 | 38.217 | | | |
| P | 0.000 | 0.000 | 0.001 | | | |
| Eigenvalue | 2.776 | 1.091 | 0.361 | | | |
| % of Variance | 65.7 | 25.8 | 8.5 | | | |
| Canonical correlation | 0.857 | 0.722 | 0.515 | | | |

SDNN – Standard Deviation of NN intervals, pNN50 – Percentage of consecutive NN interval difference greater than 50 msec, LF – Low Frequency, HF – High Frequency, LF/HF – Ratio of Low Frequency over High Frequency

function 1 accounted for 65.7% of the variance, discriminant function 2 accounted for 25.8% of the variance, while discriminant function 3 accounted for 8.5% of the remaining variance among groups respectively.

Table 3 also provides a standardized discriminant function coefficient, an index of the importance of each predictor like the standardized regression coefficient (beta's) did in multiple regression. The sign indicates the direction of

**Table 4:** Functions at group centroids

| Groups | Function | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Endurance (A) | 1.968 | -1.255 | -.161 |
| Combat (B) | 1.115 | 1.332 | .512 |
| Skill (C) | -.996 | .579 | -.901 |
| Control (D) | -2.184 | -.716 | .551 |

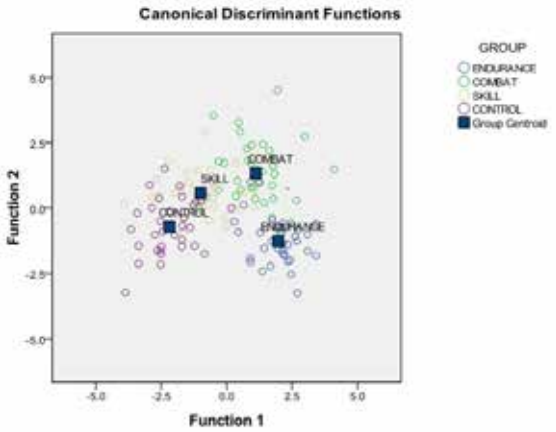


FIGURE 1. Plot of the individual and group differences between elite male athletes of different sports and control group resulting from different physical, physiological and psychological tests.

the relationship. The interpretation of the obtained discriminant functions was based on the examination of the structure coefficients greater than 0.30. VO2 max and muscle content are the strongest predictors of Function 1 and 2 respectively while state anxiety and extraversion are the least successful predictors of Function 1 and 2 respectively.

Based on these scores, group membership could be predicted according to the closeness of these respective group centroid values (mean group values) (Table 4). It is then possible to determine correct classifications. In our study, the endurance group has a mean of 1.968; the combat group has 1.115, skill group has -0.996 while control group has -2.184 in Function 1 while the endurance group has a mean of -1.255; combat group has 1.332, skill group has 0.579 while control group has -0.716 in Function 2 (Figure 1). Cases with scores near to a centroid are predicted as belonging to that group.

The original classification summary shows 81.6% of the cases correctly classified in their respective sports (table 5). The leave-one-out test summarizes the ability of the discriminant functions to correctly classify the athletes in their respective sports (see Table 5). This analysis provided an overall percentage of successful classification of 85.3% for the endurance players, 68.6% for the combat players, 64.7% for the skill players, and 72.7 % for the control group. Notably, almost all players were correctly classified on the basis of their physiological and psychological variables.

**Table 5:** Classification matrix for the sports according to physical, physiological and psychological variables of the discriminant functions

| | | **Classification Results[b,c]** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Predicted Group Membership** | | | | | |
| | | Group | Endurance | Combat | Skill | Control | Total |
| Original | % | Endurance | 88.2 | 8.8 | 2.9 | .0 | 100.0 |
| | | Combat | 11.4 | 74.3 | 11.4 | 2.9 | 100.0 |
| | | Skill | .0 | 11.8 | 85.3 | 2.9 | 100.0 |
| | | Control | .0 | .0 | 21.2 | 78.8 | 100.0 |
| Cross-validated[a] | % | Endurance | 85.3 | 8.8 | 5.9 | .0 | 100.0 |
| | | Combat | 17.1 | 68.6 | 11.4 | 2.9 | 100.0 |
| | | Skill | 2.9 | 14.7 | 64.7 | 17.6 | 100.0 |
| | | Control | .0 | .0 | 27.3 | 72.7 | 100.0 |

a. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case. b. 81.6% of original grouped cases correctly classified. c. 72.8% of cross-validated grouped cases correctly classified.

## Discussion

The aim of this study was to explore the discriminating power of selected physiological, physical, and psychological variables among 136 Indian male participants of different sports (Endurance=34, Combat=35, Skill games=34), and control group (n=33). Most of the variability among groups was reported by the first discriminant function (65.7%) which reflected variations in physical, physiological, and psychological variables between endurance and other groups of athletes as well as a control group. Endurance players obtained the highest mean value of maximum aerobic capacity (VO2 max among the four groups as is also evident by the demand of the sport. VO2 max is a significant contributor in the model with a structure coefficient of 0.741 in Function 1 and plays an important role in discriminating endurance players from combat and skill players. VO2max is an important variable that sets the upper limit for endurance performance. Endurance training causes an increase in mitochondrial enzyme activities, which improves performance by enhancing fat oxidation and decreasing lactic acid accumulation at a given VO2 (Bassett & Howley, 2000). Upper limits for absolute VO2max have been reported in rowers and cross-country skiers are 7.0–7.5 L·min−1 in males and 5.0–5.5 L·min−1 in females and for relative VO2max in cyclists, runners, and cross-country skiers up to ~90 mL·kg−1·min−1 in males and ~80 mL·kg−1·min−1 in females (Haugen, Paulsen, Seiler, & Sandbakk, 2018), which is quite higher than the values of VO2max obtained for the endurance group in the present study. The mean value of vO-2max for the wrestlers in this study was found to be higher than the results obtained for the U.S. Freestyle Wrestling team (41.2 ml/kg/min) evaluated using a cycle ergometer (Callan et al., 2000) and lower than the values of VO2max (51.9 ± 4.3, n=15) obtained in elite Chilean wrestlers (Venegas-Cárdenas et al., 2019). In a study conducted in Malaysia, the mean value of VO2max obtained in archers (n=12) was 45.1 ± 3.3 ml/kg/min by MSFT (Multi Stage Fitness Test) (Lau, Ghafar, Hashim, & Zulkifli, 2020) which is found to be higher than the value of VO2 max obtained for male elite archers in this study.

The results in Table 1 also revealed that the combat players (wrestlers, judoists) are the heaviest among the four groups, having the highest mean value of body weight, lean body mass, and muscle content. The findings of this study also showed that weight, lean body mass, and muscle content are significant contributors to the discriminant model with a structure coefficient of 0.424, 0.430, and 0.574 in function 2 respectively (Table 3). The results of this study are new insights into the understanding of combat sports like wrestling and judo. Garcia-Pallares, Lopez-Gullon, Bonete, & Izquierdo (2012) have examined the body composition of elite wrestlers and proved that international-level wrestlers had greater fat-free mass (FFM) and less fat tissue. As in all weight-category sports, body weight, and body composition play a major role in judo, and reducing substantial amounts of weight within a short time is a usual part of the competition. It has also been proven that the anaerobic power of judo athletes is influenced by an increase in lean body mass while maintaining the initial level of adipose tissue (Kim et al., 2011).

Skill games like archery and combat sports have complete-

ly different characteristics. Greater parasympathetic activity and a balance between both systems of the autonomic nervous system are beneficial to the performance of archers (Lo, Huang, & Hung, 2008). In a comparative study conducted on archers and boxers, it was found that boxers showed sympathetic dominance whereas parasympathetic dominance was found in archers (Aggarwala, Vij, & Dhingra, 2016). In the present study, we have found significant differences in LF/HF ratio ($p<0.05$) between the combat group and remaining three groups (endurance, skill, and control). Different sports activities have different effects on HRV, likely due to different demands of training — such as strength versus endurance, continuous versus interval, and ratio of training to competition. In this study, the highest HRV values were found in cyclists and canoe and kayak paddlers, while the lowest in runners (Merkely et al., 2016).

The general profile of sportsmen in terms of personality is low neuroticism, high extraversion, and conscientiousness, as well as average openness to experience and agreeableness (Anghel, Banica, & Ionescu, 2009). Similar findings were obtained in the present study; however, significant differences were seen only in the personality types of extraversion and neuroticism (Table 2). Anxiety is multidimensional in that it can be divided into different categories, including trait and state anxiety. Trait anxiety is characterized by an inherent inclination to perceive certain stimuli as threatening and in turn to respond with increased state anxiety when a particular stimulus is present. Conversely, state anxiety involves increased levels of physiological arousal, apprehension, fear, and tension. Both trait and state anxiety have cognitive and somatic elements, creating four distinct types of anxiety: cognitive trait anxiety, cognitive state anxiety, somatic trait anxiety, and somatic state anxiety (Cox, 2007). In the case of state anxiety, lowest values were found in athletes involved in endurance sports and the highest in combat sports. Research suggests that elite players exhibit lower state anxiety (Fernandez et al., 2009). Elite competitors, who were defined according to their professional status, interpreted worry symptoms as less debilitative, and somatic anxiety responses as more facilitative than their non-elite counterparts who competed at semi-professional levels or lower (Neil, Mellalieu, & Hanton, 2006). For trait anxiety, no significant differences were seen between the four groups. For future research, it is suggested to involve a greater number of athletes for every discipline to understand the differences in the psychological process to a greater extent.

A study done by Leone et al (2002) revealed that in the discriminant analysis, the anthropometric variables contributed more to the model than the bio-motor variables. This study is in the agreement of the fact that physical and maximal aerobic capacity contributed more than heart rate variability and psychological factors to characterize and distinguish male athletes participating in different sports. There are clear training effects between sports. Success in many different sporting activities would most likely be reliant in part on aerobic power and body composition. In summary, the results showed that after cross validation 72.8% of cases were correctly classified, with 85.3% being correctly classified for the endurance players, 68.6% being correctly classified for the combat players, 64.7% being correctly classified for the skill players and 72.7 % being correctly classified for the control group.

Our study has several limitations. The current sample of athletes was drawn from only one region of the country and therefore generalizability is questionable. Another limitation was the difficulty for the investigators to control for different physiological status and factors that may influence the results of the tests. This study recommends, for wider generalization of results, the replica of the study may be extended to other regions. Coaching as an intervention for non-sports persons should be conducted to see its effects on different variables of physical fitness and adjustment. A third limitation is the focus solely on male athletes. The fourth limitation is that the heart rate variability was measured at rest, not during competition in this study. Therefore, further research on the heart rate variability measurement during exercise using wearable equipment is needed.

## Conclusions

In summary, we present a model that could be used to predict the sports of an athlete from a number of physical variables like body weight, lean body mass, and muscle content as well as physiological variable like maximal aerobic capacity. This information might be employed to familiarize the training of athletes towards a specific sport and could also be of use in improving performance in deficit areas. In this work, however, there are also a number of strengths to be highlighted. First, the data provided in this study help to fill some important gaps in the literature providing a better understanding of the physiological characteristics that discriminate athletes into different sports. Second, our findings may have an important impact on the classification system.

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**Conflict of Interest**
The author declares that there is no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

# Predicting Maximal Aerobic Capacity based on Self-Reported Physical Activity Levels among Adolescents

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**Abstract**

Growing evidence has indicated a positive association between physical activity and cardiorespiratory fitness (i.e., maximal aerobic capacity or $VO_2$ max). Limited evidence, however, is available among adolescents. This research aimed to predict $VO_2$ max based on the physical activity level and estimate the discriminant capacity of the physical activity levels on the $VO_2$ max status among adolescents. This research was a cross-sectional study in 141 adolescents (age 19±1 year old, 83% male). The $VO_2$ max was assessed using the 1-mile run test. Physical activity was measured using the International Physical activity Questionnaire-Long Form. Multiple linear regression was conducted to predict the $VO_2$ max using physical activity level data (in metabolic equivalent of tasks (Mets/week), sex, and body mass index (BMI). The discriminant capacity of the total and domain-specific physical activity in discriminating high and low $VO_2$ max was estimated with the area under the curve (AUC). The Youden Index determined cut-off points, sensitivity, and specificity. Multiple regression analysis revealed a significant predicting equation of $VO_2$ based on total physical activities, BMI, and sex. The equation explained a significant proportion of $VO_2$ max variances. The total and domain-specific physical activity significantly discriminated low and high $VO_2$ max status, while the highest AUC was based on total physical activity, followed by other physical activity domains. A cut-off of total physical activity levels for predicting the $VO_2$ max was successfully generated, with high sensitivity and specificity. Adequate evidence, thus, supports the prediction of $VO_2$ max based on self-reported physical activity levels among adolescents..

***Keywords:*** *physical activity, cardiorespiratory fitness, equation*

## Introduction

Physical activity levels and cardiovascular fitness are useful diagnostic and prognostic health indicators in clinical settings (Arovah & Heesch, 2021; Myers et al., 2021), including adolescents (Raghuveer et al., 2020). Cardiorespiratory fitness is also a significant predictor of aerobic performance; thus, it is important in talent scouting, athletic training programming, and evaluation (Manari et al., 2016). Therefore, routine physical activity and cardiorespiratory fitness assessments among adolescents are recommended in clinical and population settings.

The standard assessments of cardiorespiratory fitness, usually measured as maximal oxygen capacity (VO2 max), involve direct and indirect measurements. However, both maximal and submaximal tests require in-person assessment and are relatively time-consuming, cost-prohibitive, and impractical in many settings (Schembre & Riebe, 2011). Therefore, non-exercise regression equations were developed. The non-exercise-based equation for $VO_2$ max estimation also includes variables such as physical activity levels because most of the variability in cardiorespiratory fitness is determined by genetics

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and environmental factors; it is largely influenced by physical activity levels (Ottevaere et al., 2011; Schembre & Riebe, 2011; Taylor et al., 2018).

The gold standard for measuring physical activity level is using objective physical activity assessment involving instruments which include motion sensors and calorimetry. However, self-rated physical activity reports are increasingly used because it is more practical and inexpensive. Thus, it is often more feasible in a large-scale population. The self-report physical activity assessment can be carried out using various instruments, including the International Physical Activity Questionnaire (IPAQ), which measures sedentary times (Lee et al., 2011; Lepp et al., 2013).

The IPAQ-Short Form (IPAQ-SF) has been used to predict $VO_2$ max among adults with a range of fitness levels (Schembre & Riebe, 2011). The regression equation based on the IPAQ-SF explained 43% of the variance in measured $VO_2$ max. Based on a 20% standard error, the estimated $VO_2$ max based on the submaximal test fell within acceptable error limits for 87% of individuals (Schembre & Riebe, 2011). However, research shows that it is more difficult to predict the relationship between physical activities and cardiorespiratory fitness among children and adolescents because their physical activity tends to be less systematic and consistent (Morrow Jr et al., 2013). The use of diverse methods of evaluating physical activity and cardiorespiratory fitness might also contribute to inconsistency in these estimates. More research, therefore, is required to develop regression estimation equations of physical activity levels to predict cardiovascular fitness in a specific population, including adolescents, using well-established physical activity assessments.

The development of the equation for predicting $VO_2$ max based on self-reported physical activity is expected to reduce the need for $VO_2$ max assessments that generally requires more resources. While, IPAQ-SF has been used to predict $VO_2$ max, no attempt has been made to develop the estimation equations using the IPAQ long format (IPAQ-LF), which is one of the most highly validated and utilized physical activity questionnaires (Kim et al., 2013). Moreover, IPAQ-LF provides domain-specific physical activity (i.e., work-related, recreational-based, transport-related, or household-related), which is not available in IPAQ-SF. Therefore, the development of the estimation equation using the IPAQ-LF allows exploration of the capacity of each domain-specific physical activity level to predict $VO_2$ max and estimate the cut-off of the levels for discriminating between low and high $VO_2$. This study, therefore, aimed to develop a regression equation for predicting $VO_2$ max based on the self-reported physical activity level using the IPAQ-LF and to estimate the discriminant capacity of the physical activity levels in differentiating $VO_2$ max status among adolescents. The successful demonstration of the validity and accuracy of the equation is expected to justify its use in large population-based studies involving adolescents for assessing cardiorespiratory fitness for health evaluation, talent scouting, or athletic training programming and evaluation purposes.

## Method

### *Research Design, Subject, and Setting*

This research was a cross-sectional observational study on 141 students enrolling in a sports science faculty in Indonesia in September 2019. The researcher conducted all the measurements at the faculty site with a team of experienced faculty officers. All participants were provided with informed consent, and the study protocol was approved by the Human Ethics Committee of Gadjah Mada University (Approval No. KE/0142/02/2019).

### *Instruments and Scoring*

The maximum oxygen capacity ($VO_2$ max) was measured using a 1-mile run test. The test was conducted on a 1.6 km flat running course (4x400 m track). A group of participants (up to 10 participants) was asked to complete the 1.6-km course in the shortest possible time. At the start, they were asked to line up behind the starting line and started to run on the command while the tester started the stopwatch. The testers recorded the total time to complete the course for each participant in minutes and seconds. The testers also recorded participants' weight, height, and age prior to the test. The $VO_2$ max was calculated based on the regression equation from Cureton et al. (1995). $VO_2$ max in boys was (0.21xage) - (0.84xbody mass index) - (8.41xrunning time) + (0.34x(running time)2) + 108.94, while for girls, it was (0.34x(running time)2) + 08.94 - (0.84xBMI) - (8.41xrunning time). The $VO_2$ max score was subsequently classified into high or low according to the median of the data because the data were not normally distributed, referring to the technique suggested by Manikandan (2011).

Physical activity was measured using an online International Physical Activity Questionnaire-Long Form (IPAQ-LF) questionnaire comprising 25 items. The questionnaire asks time that participants spent for walking and moderate to vigorous physical activity in the last seven days. Moderate physical activity was defined to participants as an activity that causes shortness of breath but does not disturb their ability to make a conversation. On the other hand, vigorous physical activity was defined to participants as any physical activity that creates difficulties in making conversation due to shortness of breath. All physical activities were conducted within the four domains of physical activity, which included work-related, recreational-based, transport-related, or household-related physical activities. Following the scoring guideline, the total physical activity was calculated as the metabolic equivalent of tasks (METs) per week using the formula of METs derived from walking time multiplied by 3.3, added with moderate physical activity time, which was multiplied by 4.0 and vigorous physical activity time multiplied by 8.0 from all domains (Sjostrom et al., 2005). Physical activities in METs per week were also recorded for each domain, while sedentary time was recorded as time spent in sedentary activities both on weekdays and weekends in minutes per week (Sjostrom et al., 2005).

### *Data analysis*

Descriptive analysis was conducted to describe the mean and standard deviation of age, weight, height, body mass index (BMI), 1-mile running performance, $VO_2$ max, and METs of total and domain-specific physical activity per week. The multiple linear regression was used to generate prediction equations for $VO_2$ max in 75% of randomly selected data (the derivation sample) with domain-specific physical activity or total physical activity and sedentary time as the main predictors in the initial model, while BMI and sex were assigned as covariates, using stepwise regression to obtain the final developed model. The goodness of fit and precision of the regression equations were evaluated using adjusted multiple coefficients of determination (adjusted R2) and a standard error of estimation (SEE) in the

developed model. The generated prediction models were then cross-validated by comparing the goodness of fit indices and the correlation between the predicted values and the data in the remaining 25% of data (the validation sample).

The discriminant capacity of physical activity levels (total and domain-specific) on the$VO_2$ max status (high or low status) was then calculated based on the area under the curve (AUC) on the Receiver Operating Curve (ROC). The vertical axis of the curve reflects sensitivity that, in this case, represented the proportion of participants correctly identified as having high $VO_2$ max. The horizontal axis was 1-specificity. In this case, specificity was the proportion of correctly identified participants with low $VO_2$ max based on the physical activity level. The outcome assigned in the ROC curve for physical activity was a high $VO_2$ max status, while for the sedentary activity was a low $VO_2$ max status, as it was hypothesized that it was inversely related to the level of physical performance (Carter et al., 2016). Youden's formula (sensitivity + specificity-1) to obtain the most optimal specificity and sensitivity (Martínez-Camblor & Pardo-Fernández, 2019). All analyses were conducted using Statistical Package for Social Sciences (SPSS) v. 25.0, and a significance level of 5% was used for all data analysis.

## Results

*Participants' Characteristics and the Maximum Aerobic Capacity*

A summary of the anthropometric profile and maximal aerobic capacity is presented in Table 1. As shown in Table 1, 83% of participants were male, while the average age of the total sample was 19±0.7 years old. As illustrated in the table, there were no differences in characteristics between Samples 1 and 2.

**Table 1.** Anthropometric Profiles and Maximum Aerobic Capacity

| | Total (n=141) | Derivation sample (n= 116) | Validation sample (n= 25) | p* |
|---|---|---|---|---|
| Sex | | | | |
| Men | 117 (83%) | 96 (83%) | 21 (84%) | 0.573 |
| Women | 24 (17%) | 20 (17%) | 4 (16%) | |
| Age (years) | 19.5±0.7 | 19.6±0.7 | 19.4±0.9 | 0.329 |
| Height (cm) | 167.2±7.0 | 167.4±7.3 | 165.8±5.6 | 0.312 |
| Weight (kg) | 58.9±9.8 | 59.5±10.2 | 56.4±7.3 | 0.148 |
| Body mass index | 21.0±2.5 | 21.1±2.7 | 20.5±1.9 | 0.325 |
| $VO_2$ max (mm/kg BW/min) | 48.5±4.9 | 48.4±5.0 | 48.9±4.4 | 0.635 |
| Physical activity | | 5506±2535 | 5185±2452 | 0.567 |

Note: *Height and physical activity used independent t-test. Weight, BMI, age, and $VO_2$ max = Mann Whitney.

*Physical Activity Levels*

Figure 1 illustrates the average physical activity in the four domains (i.e., work activities, transportation, domestic, and leisure), total physical activity, and sedentary time per week, participants in high and low $VO_2$ max groups. The overall average total physical activity was 5449±2461 METs per week. As expected, participants in the high $VO_2$ group significantly reported higher physical activity levels than their counterparts (6967±1701 Mets/week vs. 3276±1597 Mets/week ($p<0.001$). Similar trends were found in the four domain-specific physical activities. In contrast, there was no difference in sedentary time reported in both groups.

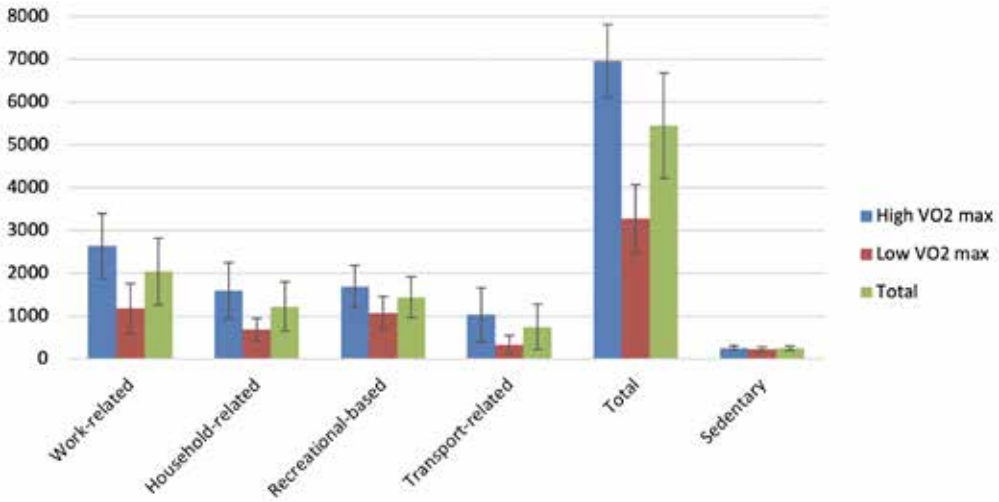


FIGURE 1. Physical Activity Levels by VO2 status in all samples (n=141)

*The Development and Cross-validation of the Regression Equation for Predicting $VO_2$ Max Status*

Table 2 summarises the intercepts, coefficients, standardized coefficients (β), the adjusted R2, and standard error of estimate (SEE) of the multiple regression equation of the model development and cross-validation. The main predictors for model A were all four domain-specific physical activity and sedentary time. In contrast, the main predictors for model B were total physical ac-

tivity and sedentary time. Sedentary time was removed in the model as it did not reach a significant level, in contrast to sex and BMI. However, the final model A was not cross-validated in the validation sample, as opposed to the final model B.

**Table 2.** The Development and Cross-validation of the Regression Equation for Predicting $VO_2$ max

| | **Initial Model (n=116)** | | | **Final Model (n=116)** | | | **Cross-validation (n=25)** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coefficient | β | p | Coefficient | β | p | Coefficient | β | p |
| Model A | | | | | | | | | |
| Intercept | 40.1 | - | <0.001 | 55.6 | - | <0.001 | 52.15 | - | <0.001 |
| Work | 0.001 | 0.47 | <0.001 | 0.001 | 0.25 | <0.001 | 0.000 | 0.09 | 0.519 |
| Transport | 0.002 | 0.39 | <0.001 | 0.001 | 0.27 | <0.001 | 0.000 | 0.10 | 0.481 |
| Household | 0.002 | 0.40 | <0.001 | 0.001 | 0.23 | <0.001 | 0.001 | 0.16 | 0.209 |
| Recretional | 0.001 | 0.23 | <0.001 | 0.001 | 0.12 | 0.007 | 0.001 | 0.18 | 0.201 |
| Male | - | - | - | 6.59 | 0.51 | <0.001 | 6.09 | 0.57 | <0.001 |
| BMI | - | - | - | -0.80 | -0.42 | <0.001 | -0.84 | -0.26 | 0.069 |
| Adjusted R2 | 0.57 | - | - | 0.80 | - | - | 0.71 | - | - |
| SEE | 3.34 | - | - | 2.35 | - | - | 2.23 | - | - |
| Model B | | | | | | | | | |
| Intercept | 39.9 | - | <0.001 | 55.1 | - | <0.001 | 53.4 | - | <0.001 |
| Physical activity | 0.002 | 0.75 | <0.001 | 0.001 | 0.44 | <0.001 | 0.001 | 0.32 | 0.020 |
| Male | - | - | - | 6.07 | 0.46 | <0.001 | 6.56 | 0.52 | 0.018 |
| BMI | - | - | - | -0.79 | -0.41 | <0.001 | -0.63 | -0.29 | <0.001 |
| Adjusted R2 | 0.57 | - | - | 0.79 | - | - | 0.75 | 0.75 | |
| SEE | 3.32 | - | - | 2.25 | - | - | 2.20 | 2.20 | |

Note: Model A= domain-specific physical activity as the main predictors, Model B = total physical activity as the main predictor, BMI= Body Mass Index, SEE= standard estimating equation

As seen in Table 2, the final model for predicting $VO_2$ max was $VO_2$ max= 55.1 + (0.002*total physical activity) - (0.41*body mass index) + (6.07*gender (male =1, female=0)). The adjusted R2 for that model indicated that 79% variances for the $VO_2$ max were explained by physical activity levels, sex, and body mass index with the standard error estimates of 2.25 ml O2/kg/minutes.

*Physical Activity Discrimination Capacity on the $VO_2$ max Status*

Based on the median $VO_2$ max, 83 (59%) participants had high $VO_2$ max, while the remaining 58 (41%) had a low $VO_2$ max. Figure 2 and Table 3 further describe the discriminatory capacity of the four physical activity domains, the total physical activity, and sedentary time on discriminating the $VO_2$ max status (i.e., high/low).

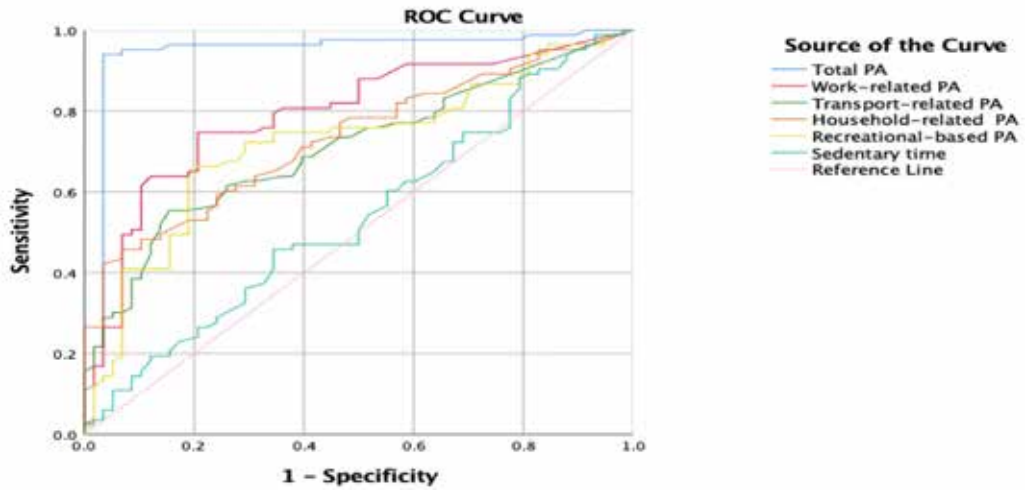


FIGURE 2. Physical Activity Capacity in Discriminating VO2 max status

Figure 2 suggested that the total physical activity had the highest discriminatory capacity, with 0.95 [95% CI 0.90-0.99], p<0.001, while sedentary time did not discriminate $VO_2$ max capacity, with the AUC of 0.54 [95% CI 0.44-0.64], p=0.437. The cut-off values for discriminating the $VO_2$ max status based on the Youden index are further illustrated in Table 3.

Consistent with the AUC, total physical activity has the highest sensitivity and specificity with a 5088 Mets/week cut-

**Table 3.** Cut off, sensitivity, and specificity of physical activity level to discriminate on $VO_2$ max status

| Domain | Cut off | Sensitivity | Specificity |
|---|---|---|---|
| Work-related (Mets/week) | 1824 | 75% | 79% |
| Transport-related (Mets/week) | 625 | 55% | 85% |
| Household-related (Mets/week) | 1320 | 48% | 90% |
| Recreational-based (Mets/week) | 1068 | 75% | 66% |
| Total physical activity (Mets/week) | 5088 | 94% | 97% |

off point with a sensitivity of 94% and specificity of 97%. The specificity for the four physical activity domains was relatively high (>66%), but the sensitivity for transports and household-related was low (<60%), thus, having the lowest diagnostic values.

## Discussion

This is the first study to develop a prediction equation of cardiorespiratory fitness (i.e., maximum oxygen capacity/$VO_2$ max) based on the physical activity levels, which were assessed using the IPAQ-LF, a validated self-reported physical activity assessment, and to estimate the discriminant capacity of physical activity in differentiating high and low $VO_2$ max among late adolescents. We found that the total physical activity with sex and body mass index adequately predict $VO_2$ max, while both total and domain-specific physical activity have the capacity to discriminate high and low $VO_2$ max.

Our prediction equation for $VO_2$ max differs from Schembre and Riebe (2011), as they used different physical activity predictors: physical activity intensity. They reported vigorous physical activity and gender as significant prediction covariates while reporting that walking and moderate-intensity physical activity did not. However, a full comparison could not be made as they did not assign total physical activity as an alternative predictor in their model. However, their reported adjusted R2 was much lower than ours (0.47 vs. 0.79), suggesting that total physical activity derived from IPAQ-LF is potentially a better predictor than vigorous physical activity derived from the IPAQ-SF.

To some extent, our findings are also in discrepancy with some findings from previous studies. For instance, a study in the middle-aged population using a direct maximal exercise test reported that total physical activity was not a significant $VO_2$ max predictor (Aadahl et al., 2007). Another prediction equation from a study using an objective physical activity measure indicated that $VO_2$ max was positively associated with leisure-based physical activity but not with occupational-based physical activity on workdays (Mundwiler et al., 2017), emphasizing the inadequate level of intensity during the occupational time to improve $VO_2$ max. This finding to some extent is in discrepancy with our finding that suggests that domain-specific physical activity did not predict $VO_2$ max. The discrepancy is possibly due to the difference in the physical activity assessment methods. Their method incorporated an accelerometer, an objective physical activity measure, which is more likely to accurately differentiate physical activity intensity levels in each domain. Based on the diversed findings, it appears that prediction equations may be population-specific and specific for different assessment methods.

Consistent with the findings from the multiple linear regression, the total physical activity demonstrates the highest prediction capacity. The cut-off for the total physical activity was 5088 Mets, which was much higher than the criteria set by the IPAQ-LF scoring for classification for a high level of physical activity (>3000 METs/week) (Sjostrom et al., 2005), suggesting that the majority of our participants were highly physically active. Although the possibility of overreporting, which is inherent in the self-reported physical activity assessment, could not be overruled, our findings support previous research stating that a high level of physical activity is required for achieving a high $VO_2$ level (Black et al., 2016; Corazza et al., 2019; Nevill et al., 2020).

The main strength of this study was the involvement of both development and validation stages in the improvement of the $VO_2$ max prediction equation, thus ensuring the external validity of the equation. We demonstrated that both domain-specific and total physical activity have the capacity to discriminate $VO_2$ max status. The equation could be used for discriminating cardiorespiratory status based on physical activity data for health evaluation, talent scouting, or athletic training programming and evaluation purposes. However, several limitations need to be acknowledged. First, the age range of our samples was limited and with a small representation of women (12.5%). Therefore, it limits the generalisability of the findings of this study to other age groups and women. Secondly, our samples were relatively physically active individuals. Further studies, thus, are required to develop prediction and discrimination capacity with adolescents with wider age ranges, more balanced sex distribution, and varied physical activity levels.

## Conclusion

This study indicates that the total physical activity derived from the IPAQ-LF, a validated physical activity instrument, significantly predicts $VO_2$ max. Both domain-specific and total physical activity levels can discriminate $VO_2$ max status with sufficient sensitivity and specificity, justifying its use to estimate $VO_2$ status among late adolescents, particularly those with similar characteristics to this study's participants.

**Acknowledgment**

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**Declaration of competing interest**

No competing interest is declared.

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SportMont

ORIGINAL SCIENTIFIC PAPER

# Learning Effectiveness and Satisfaction Self-report of College Online Physical Education (OLPE) Students in the Philippines in Time of COVID-19 Pandemic

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**Abstract**

Physical Education was among the badly hit courses as different countries implement systemic quarantine to mitigate the spread of COVID-19. The Philippines is not spared by this measure, migrating the education system to remote and online methods. Pursuing schools and instruction during a lockdown, this study intends to explore how the online learning implementation process is perceived and how different factors play in this unprecedented educational climate. One thousand four hundred four Physical Education students (N=1404) participated in an online survey using a modified OLQ-TLP questionnaire, comprising 11 categories of 42 quality indicators namely: Instruction (I), learning content (LC), course design (CD), knowledge acquisition (KA), ability to transfer (ATT), learning support (LS), social presence (SP), learning platform (LP), instructor interaction (II), learner interaction (LI) and learner satisfaction (L-Sat). Results showed student satisfaction reports outside the capital are significantly lower than their counterparts in the capital. Female students reported significantly higher satisfaction scores than males in the Instruction, Learning Content, Course Design, Knowledge Acquisition, and Ability To Transfer categories. Using One-way ANOVA, findings also revealed significantly low satisfaction reports as the students aged. Lastly, Knowledge Acquisition, Learner Interaction, and Ability To Transfer were strongly associated with overall learner satisfaction reports, validating previous reports that human-to-human interaction is a strong indicator of online learning satisfaction. While hybrid education is looming and here-to-stay post-pandemic, further studies on how students learn better outside the classroom are promoted, especially in countries with educational equity interests like the Philippines.

***Keywords:*** *online learning, physical education, learner satisfaction*

## Introduction

Coronavirus Disease 2019 (COVID-19) outbreak brought by the SARS-CoV2 has translated into a significant educational crisis with the implementation of massive closures of colleges and universities (Alvárez, 2020). The numerous announcements of schools' temporary closure have impacted around a billion learners worldwide. In the Philippines, closures have affected not only students' academic skills acquisition but aggravated the country's pre-pandemic sedentary problem. Trailing from South Korea, Philippines is among the largest proportion of children who are physically inactive having less than an hour of exercise per day, as revealed by the

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World Health Organization (2019). This report has called for the need to oversee how physical activity, being a contributor to immune health (Lowder et al., 2005; Hojman et al., 2011), can be maintained especially during the time of pandemic when movement and access were restricted with the cessation of formation institutions.

Sallis et al. (2021) recently showed how meeting physical activity (PA) guidelines can reduce the risk of having severe COVID-19 symptoms among unvaccinated adults and promoted them as support in the ongoing pandemic. Physical education beyond the walls of closed school buildings is demonstrated to be imminent by communicating and practicing the values of PE effectively (Jeong & So, 2020). Physical activity programs were seen to be inclined toward engagement, requiring effective pedagogies in dealing with the restrictions brought by COVID spread mitigation (Kopcakova et al., 2015; Jamiai, 2021). Appropriately designed program also impacts reducing health disparities caused by unequal opportunities for PA participation (Draper, Milton, & Schipperijn, 2021). The need for physical education has led the Society of Health and Physical Educators (SHAPE) America (2018) to communicate that online physical education (OLPE) should serve the same needs and achieve the same results as traditional, in-person PE in time of restrictions (Daum, 2020).

As the degree of pandemic restriction progress, rightful access to quality physical education (QPE) became a major consideration as professionals and experts see OLPE as directly identical to, and not only as an alternative to in-person instruction. UNESCO newly (in De Coning & Keim, 2021) published a statement about QPE stating that all students should have equitable access to a well-balanced and inclusive curriculum, which is the foundation of quality PE. Learning effectiveness, access, learner, and teacher satisfaction are among the quality pillars of Online Learning Consortium's framework and are highly predictive of the quality and outcome of online courses (Stickney et al., 2019). Pillars are related to student attitudes toward education experiences and achieved education outcomes.

*Challenges in Migration to OLPE*

With the developing pandemic, educational institutions worldwide have embraced the inevitable teaching using virtual and remote approaches to replace teacher interaction in receptive learning (Lee & Rha, 2009). PE teachers were not spared to using technology for remote instruction and reported learning along with its implementation (Mercier et al., 2021). Instructors across different specializations were even unprepared in dealing with this abrupt migration issue as limited tools and retooling were provided to enhance online skills, especially higher educational professionals handling undergraduate or postgraduate programs. This shift in the new mode has inevitably increased teachers' workload as institutions experienced the method for the first time (Chan et al., 2021). Without the physical presence of the PE teacher, for instance, challenges in guiding students to engage in healthy levels of PA and fitness while fostering student enjoyment of those activities remained present. This synthetic form of formation has highlighted by Buschner more than a decade ago (2006) about OLPE being "in a box" that includes sophisticated sound, lights, images, and words—but not physical education in its previous form.

While online education was regarded as feasible, some departments have not fully embraced its advantages. A cultural change crisis in the academe blossomed as some specialized subjects cannot fully maximize the new approach the same way they do in traditional face-to-face classes. The implementation of fully online courses posed a different climate due to the lack of available evidence-based best practices (Yu & Jee, 2021). The extended domains of performance-based courses such as PE allowed school and university administrators to face challenges in training and retooling their faculty in online instruction pedagogy (Moralista & Oducado, 2020).

Being in the peripheries has also influenced school's experiences with remote PE instruction (Mercier et al., 2021). Most teachers reported that OLPE was ineffective at nurturing motor skill acquisition or increasing the physical activity levels of students (Chan et al., 2021). Likewise, the majority of students reported they are more satisfied with face-to-face learning methods than with online learning, and that they see e-learning as a supplement to face-to-face instruction rather than a replacement (Jamiai, 2021). Student learning motivation was found to be unmatched with the way online classes were managed. Methods employed are largely traditional, alongside the different barriers that hinder students to participate in physical activity specifically in internet access, risk of injury, type of residence and the most dominant is, lack of resources (Surahman, 2020; Puen et al., 2021).

Paradigm shift experienced by teachers resulted in various obstacles as mentioned, shifting how students perceived learner satisfaction peri-pandemic. The impediments significantly impacted students' motivation and participation during the online learning experience and showed demands on behavioral and emotional rather than cognitive engagements (EL-Sayad, Md Saad & Thurasamy, 2021). With face-to-face classes in PE unlikely to happen soon, and the impending long-term integration of hybrid approaches post-pandemic, emphasis on human-to-human interaction activities as a feature of remote learning programs will likely to be a game changer. Physical Education, is not just a physical activity course; it encourages interaction, collaboration, and cooperative learning with supportive environments (in Lederman, 2017). Online learning classes, though remote in nature, provide students with a comfortable setting to promote responsibility, self-confidence, and positive attitudes among students (Jamiai, 2021; EL-Sayad, Md Saad & Thurasamy, 2021).

With the recent development in the country's perspective on fitness as the pandemic continues, PE is now being considered in schools as an essential subject as it addresses the prolonged sitting time of learners, aggravating the adverse effects on their health, peri-pandemic. Quality OLPE serves students to be on track with their physical activity in keeping a healthy body even they are in the comforts of their home. The quality of PE classes being held online is a recurring issue, for this will positively or negatively affect the student's well-being during the pandemic. The rationale of the study is to establish and contribute to growing data on hybrid physical activity for post-pandemic applications, as schools catch up from physical activity debt due to the pandemic. The researchers aim to determine the quality of instruction and learning in online PE is necessary. Particularly in this study, they aimed to examine how learners from higher education institutions were satisfied in the implementation of online learning, applied to physical education courses using forty-two quality indicators. With the hybrid type of education is becoming imminent post-pan-

demic, analysis of factors from this investigation may institute the foundation for the future of physical education instruction, using exclusively reports and perspectives of students.

## Methods

*Research Design*

This study utilized a descriptive, cross-sectional research design to identify the quality of online distance learning modality as perceived by the students as well as their teachers. A cross-sectional descriptive survey determines how often, broadly, or severely a particular variable occurs within a given population. It adopted a data-gathering procedure involving the use of a questionnaire, adapted to an online form.

*Sample and Data Collection*

Participants were purposively recruited to provide responses reflecting their experiences in the conduct of online PE. One thousand four hundred four (N =1404) students aged 17-25 years, from higher education institutions from the country's capital and outside the capital participated in the survey. Students were grouped into age groups of 17-19 years (N=1043) or junior group, 20-22 years (N=343) or senior group, and 23-25 years (N=18) or the residency group. Screened respondents have enrolled students who have taken a Physical Education subject such as physical fitness, dance, individual/dual sports, and team sports, in an online distance learning modality, using learning management systems including Blackboard, Canvas and Microsoft Teams.

*Procedure*

In the collection of data, pertinent requests and documents were presented to HEI program chairs, with regards to the facilitation of online survey. Upon ethical certification, dissemination of the online form was permitted and facilitated in the most standardized manner in the implementation of online Physical Education. Gathered responses for 10 days were processed, prepared quantitatively through central tendencies and statistical analysis, with the aid of visual presentations as well. For a more in-depth study, these data were linked to existing literatures and previous findings.

*Instrumentation and Data Analysis*

The research instrument was organized into two parts – pre-response section and satisfaction with online learning – using same satisfaction scales using the Online Learning Quality index based on Teachers and Learners Perceptions (OLQ-TLP).

- Pre-OLQ-TLP Section – section includes the study information consent and the privacy agreement in the first part, and demographic information form containing gender, age group, and school location.
- Modified OLQ-TLP Online Form – the researchers modified and transformed into an online form, a questionnaire used in a previous study (Gomez-Rey, Barbera & Fernandez-Navarro, 2016) measuring learning effectiveness, access, and student's satisfaction. The questionnaires have 42 quality indicators in 11 categories for students and faculty namely: instruction (I), learning content (LC), course design (CD), knowledge acquisition (KA), ability to transfer (ATT), learning support (LS), social presence (SP), learning platform (LP), instructor interaction (II), learner interaction (LI) and learner satisfaction (L-Sat). The 11 categories, covering three of the Sloan-C quality standards, were scored with a four-point Likert scale, used to calculate the OLQ-TLP index.

*Statistics*

Mean score analysis was done using a T-Test and One-way ANOVA for cross-sectional differences at $p<0.05$, and Pearson Correlation was used to explore associations in relation to learner satisfaction to online Physical Education with $p<0.05$. The statistical program SPSS 26 was used for data processing (Statistical Package for Social Sciences, v26.0, SPSS Inc., Chicago, IL, USA).

*Ethical Considerations*

Participants were informed and oriented about the nature, risks, and benefits of their voluntary participation in the study. They were advised to withdraw from the study at any time without any sanction if they decline to participate. Furthermore, all responses will be kept confidential with no personal, identifiable information associated with the respondents included in any reports of this investigation. The study was cleared by the University Research Ethics Board of Polytechnic University of the Philippines on 18 November 2021.

## Results

Figure 1 shows a visual discrepancy between the self-report of college students in the capital and outside the capital, with scores in the capital higher in all categories. Social Presence variable is seen to have the highest satisfaction scores in both

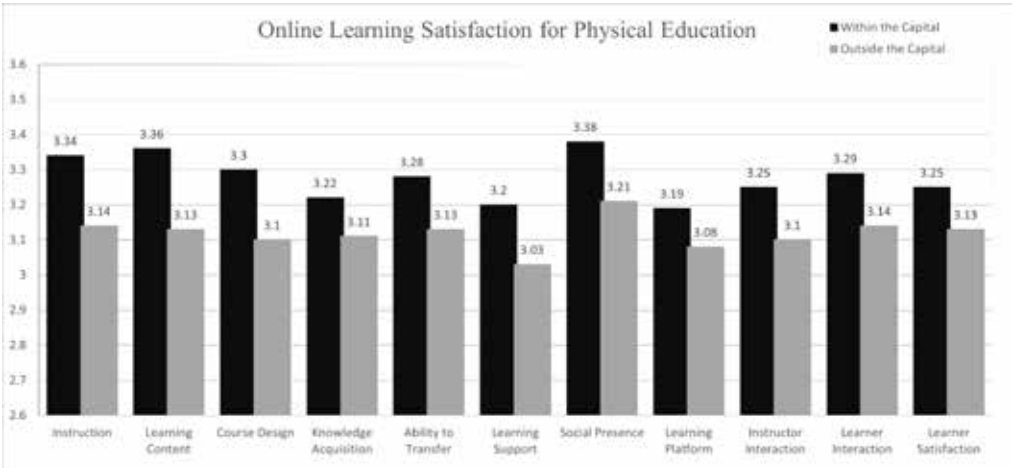


FIGURE 1. Comparing mean scores of 11 variables

location groups. Learning Support and Learning Platform of students outside the capital were reported to have the lowest mean scores with 3.03 and 3.08 respectively as presented in Table 1. Distinction between student scores is seen to be high in the Learning Content variable with a mean difference of 0.23.

Results show statistical differences between the two location groups with t scores significant at p<0.01. Presented also in Table 1, comparing student perception according to sex was also investigated and showed significant differences between males and females in the Instruction, Learning Content, Course Design, Knowledge Acquisition, and Ability To Transfer variables, with females exhibiting higher scores than males. While not presented in the table, there is a significant difference at p < 0.01 in perception among students and teachers in the capital in the category of Instruction with a t score of 2.95.

**Table 1.** Comparing differences using independent T-test

| | **Difference in Student Location (Within and Outside the Capital)** | | | **Difference in Sex** | | |
|---|---|---|---|---|---|---|
| | *p* | *t* | Mean Difference | *p* | *t* | Mean Difference |
| Instruction | 0.000 | 5.83** | 0.20 | 0.044 | -2.01* | -0.08 |
| Learning Content | 0.000 | 6.62** | 0.23 | 0.006 | -2.75** | -0.11 |
| Course Design | 0.000 | 6.09** | 0.21 | 0.032 | -2.15* | -0.08 |
| Knowledge Acquisition | 0.002 | 3.12** | 0.11 | 0.012 | -2.53* | -0.10 |
| Ability to Transfer | 0.000 | 4.41** | 0.16 | 0.043 | -2.02* | -0.08 |
| Learning Support | 0.000 | 4.12** | 0.17 | 0.119 | -1.56 | -0.07 |
| Social Presence | 0.000 | 4.81** | 0.17 | 0.114 | -1.58 | -0.06 |
| Learning Platform | 0.001 | 3.47** | 0.12 | 0.239 | -1.18 | -0.04 |
| Instructor Interaction | 0.000 | 4.23** | 0.15 | 0.260 | -1.13 | -0.04 |
| Learner Interaction | 0.000 | 4.40** | 0.15 | 0.154 | -1.43 | -0.05 |
| Learner Satisfaction | 0.001 | 3.33** | 0.12 | 0.191 | -1.31 | -0.05 |

**significant at 0.01
*significant at 0.05

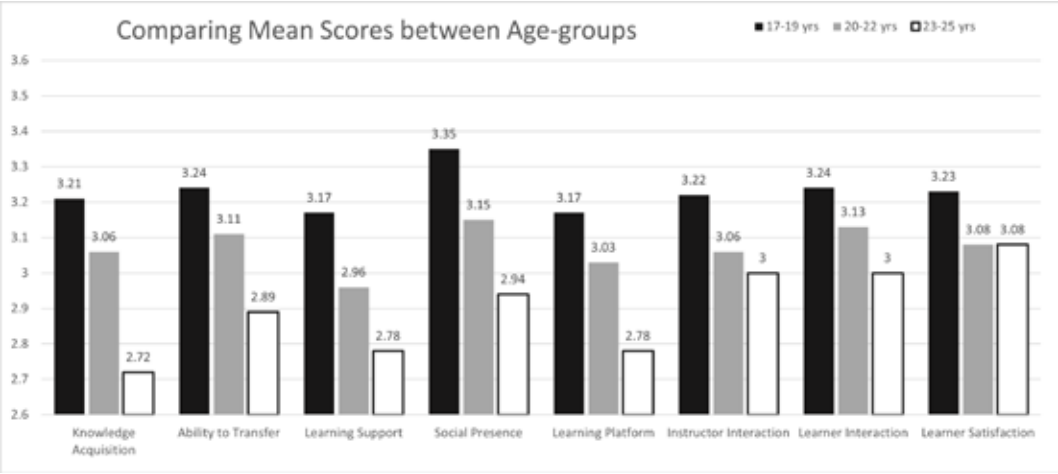


FIGURE 2. Comparison of mean scores between age groups

In the analysis of age groups, Figure 2 shows the variation in self-report scores of students. It is recognized that students in the residency (older) age group (23-25 years) exhibited lower mean scores compared to their younger counterparts. Mean difference of the senior (20-22) and residency (23-25) groups in Knowledge Acquisition at the greatest with 0.34. The youngest student-group (junior group) also possessed high agreement scores in all categories with the highest in the

**Table 2.** Age-group self-report analysis using One-way ANOVA

| | **Mean Square Between Groups** | **F** | **p** |
|---|---|---|---|
| Instruction | 4.61 | 11.03** | 0.000 |
| Learning Content | 5.96 | 13.98** | 0.000 |
| Course Design | 7.63 | 18.78** | 0.000 |
| Knowledge Acquisition | 4.75 | 11.40** | 0.000 |

*(continued on next page)*

*(continued from previous page)*

**Table 2.** Age-group self-report analysis using One-way ANOVA

| | Mean Square Between Groups | F | p |
|---|---|---|---|
| Ability to Transfer | 3.16 | 7.71** | 0.001 |
| Learning Support | 6.45 | 10.77** | 0.000 |
| Social Presence | 5.85 | 12.66** | 0.000 |
| Learning Platform | 3.68 | 9.06** | 0.000 |
| Instructor Interaction | 3.59 | 8.25** | 0.000 |
| Learner Interaction | 1.93 | 4.51* | 0.011 |
| Learner Satisfaction | 3.30 | 7.83** | 0.000 |
| **significant at 0.01<br>*significant at 0.05 | | | |

Social Presence variable with 3.35. Low scores in Learning Support are consistent across age groups. Statistical analysis using ANOVA in Table 2 shows mean differences across the 3 age groups are significant at $p<0.05$ in LI and at 0.01 for the rest of the categories.

Table 3 presents the interrelation between the 11 categories of quality indicators, with attention to learner satisfaction. Instruction-Course Design and Ability to Transfer-Knowledge Acquisition categories have the strongest correlation with r = 0.79. In relation to Learner Satisfaction, KA, LI, and ATT have the highest association with r values of 0.74, 0.73, and 0.72 respectively.

**Table 3.** Pearson correlation analysis of variables

| | Quality Indicator Categories (OLQ-TLP) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LC | CD | KA | ATT | LS | SP | LP | II | LI | L-Sat |
| I | 0.78 | 0.79 | 0.72 | 0.75 | 0.67 | 0.70 | 0.68 | 0.68 | 0.66 | 0.70 |
| LC | - | 0.78 | 0.73 | 0.76 | 0.67 | 0.71 | 0.67 | 0.68 | 0.66 | 0.70 |
| CD | - | - | 0.75 | 0.77 | 0.69 | 0.72 | 0.69 | 0.71 | 0.68 | 0.72 |
| KA | - | - | - | 0.79 | 0.65 | 0.69 | 0.71 | 0.69 | 0.67 | 0.74 |
| ATT | - | - | - | - | 0.68 | 0.73 | 0.70 | 0.71 | 0.71 | 0.72 |
| LS | - | - | - | - | - | 0.70 | 0.65 | 0.65 | 0.64 | 0.64 |
| SP | - | - | - | - | - | - | 0.68 | 0.71 | 0.71 | 0.71 |
| LP | - | - | - | - | - | - | - | 0.71 | 0.70 | 0.70 |
| II | - | - | - | - | - | - | - | - | 0.71 | 0.71 |
| LI | - | - | - | - | - | - | - | - | - | 0.73 |

Note: I - Instruction, LC - Learning Content, CD - Course Design, KA - Knowledge Acquisition, ATT - Ability To Transfer, LS - Learning Support, SP - Social Presence, LP - Learning Platform, II - Instructor Interaction, LI - Learner Interaction, & L-Sat - Learner Satisfaction

## Discussion

*Capital vs. The Peripheries*

The heterogeneous state of Physical Education quality in the Philippines posed variations on how the program is implemented, especially now that the country is facing remote methods of teaching and learning. Dominating issues on performance-based courses like Physical Education include the availability of facilities for physical activity is defined by the features of the locale. Another limiting concern is the availability of professional development in the peripheral regions, where access to continuing development and up-to-date training courses is distorted by the concentrated training institutes in the city capital. This significantly low satisfaction indicator scores among students in the peripheries are related to the findings of Mercier et al (2021) showed less effectiveness report during stay-at-home learning. This, of course, may go along with professional competency factors among PE instructors, specifically on the effective delivery by their sufficient knowledge in information technology.

The significant difference between genders, particularly in physical activity participation and perception has always been in the discussion due to physiological and anatomical distinctions. There was still an imbalance in opportunities for participation between genders, and expectations for male participants remain higher. Aside from the physical structure, gender influences motives for participation, affecting the dynamics how satisfaction differs across genders. For instance, in the study of Kopcakoya et al (2015), male participants focused on physical and health as motives while social motives are more dominant among females. In most categories in this study, females show greater learner satisfaction even physical activity participation is restricted. The mechanism behind gender and sexual distinction is attributed to psycho-physiological differences, affecting motives and exercise value propositions. This finding validated Kopcakova pertaining to the diminished physical engagement during online learning instruction.

On the side of the instructors, low satisfaction in the capital region showed how the remote methods highly contrasted on-site learning with how they perceive themselves as restricted in the delivery of their instruction potentials. The feeling of

disconnection and lack of technology management (Moralista & Oducado, 2020), and perceived generally to be low and difficult by frontline PE teachers. As described by Chan et al (2021), only 3.6% of participants did not report difficulty during online teaching, and mostly reported lack of practical skills on it.

*Age-group Cross-section*

With a long remote learning implementation, age group plays an important factor on how students perceive instructional activities and interventions. Particularly to students with on-site Physical Education experience, past outlooks are already in place as they go through the online Physical Education modality. Consistent with a previous study (Jamiai, 2021), older age-group learners prefer hybrid education, if not on-site, for their schooling, affecting their low reception of satisfaction and agreement. This contradicts Tankari's (2012) findings on purely online modality without the conditions brought by the pandemic. Surahman (2020) identified access to resources and lecturer-student attachment as a prime sources of dissatisfaction, and important aspects in addressing student-specific needs during online learning.

*Learner Satisfaction*

Quality indicators of the OLQ-TLP can be a tool in improving the delivery of online PE instruction. The intra-relation of the different categories helps in specifically address learner satisfaction, and how these indicators are perceived by students. The link between learner interaction, and student-instructor guidance to the satisfaction and dissatisfaction of students can be traced in previous studies (Surahman, 2020) and how social influence plays a big role in online physical activity participation (Puen et al., 2021). Beyond satisfaction, interactive courses even exhibited higher achievement in critical thinking learning (Lee & Rha, 2009). The uniformity of these current findings with discoveries in the past about remote learning during the COVID-19 pandemic suggests the increased integration of social and learner interaction, highlighting the humanistic rather than digital nature of learning, as educational satisfaction is strongly influenced by behavioral and emotional engagement (El-Sayad, Md Saad, & Thurasamy, 2021), and not cognitive engagement. This calls for the revision of learning programs, considering the integration of personal teacher-learner connections and interactions in the pedagogy of content, particular and limited to higher education students.

## Conclusion and Recommendations

In time of the COVID-19 pandemic, the Philippine government has put faith in quarantine policies to mitigate the increasing number of infections. This led to the suspension of on-site schooling and depended on remote modalities in training and teaching students, urging schools to expand and take advantage of the use of technology and resources in implementing online learning. Satisfaction self-report using OLQ-TLP showed significant discrepancy affecting students in the peripheral regions to be less satisfied. Male students also felt the impact of this instructional migration specifically in teachers' instruction, acquisition and application of knowledge, content, and the design of the college Physical Education courses. Older students who were used to the on-site methods were also dissatisfied more compared to the younger students. This dissatisfaction is associated with perceived low acquisition and application of knowledge in PE, and the demand for increased learner interaction. While the study was done with a substantial number of samples, data collection can be better done in a more controlled and standardized manner. The findings of this study are hoped to be used in developing online instruction of performance tasks in schools, and improve hybrid education systems for stability, as we face pandemics in the future.

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**Conflict of Interest**
The author declares that there is no conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

# Physical Fitness Improvement after 8 Weeks of High-intensity Interval Training with Air Bike

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**Abstract**

Physical fitness is an important part of overall health. High-intensity interval training (HIIT) is a popular form of exercise that has been repeatedly proven as a functional way of developing cardiorespiratory fitness. Air bike is a widespread cardio machine suitable for HIIT. The aim of this research was to verify the effect of HIIT using air bike on the development of selected physical fitness parameters and compare it to moderate-intensity continuous training (MICT). Twenty active young adults (age 22.1±2.5) were the subject of the research in the research. The participants underwent a complex strength and endurance test, a spiroergometric examination, and a body composition analysis. The experimental group (EG) did HIIT twice a week with work intervals (15–45 seconds), while the control group did MICT in a comparable time period. The results have shown significant improvement in back squat (8.25%), pulling strength (7.07%), aerobic endurance (18.74%), and VO2peak (10.62%). Comparison of the groups has shown a significant difference in bench press (ES=1.01), back squat (ES=0.68), anaerobic endurance (ES=0.97), aerobic endurance (ES=1.456), and VO2peak (ES=0.92). According to the results, we can conclude that HIIT using air bike is an effective way of developing multiple aspects of physical fitness and is thus suitable for training programs that aim to develop health and sports performance.

***Keywords:*** *cardiorespiratory fitness, $VO_{2peak}$, endurance, strength, body composition*

## Introduction

Physical fitness is an essential part of health and is directly connected to the quality of life, development of diseases of civilisation or mortality (da Silva Machado et al., 2019). The main aspects of physical fitness are cardiorespiratory fitness, strength, flexibility, and body composition. The secular trend clearly shows a negative trend, especially in cardiorespiratory parameters (by 2.4% per decade) and in an increase of body fat percentage (Blüher et al., 2019; Lamoureux et al., 2019). That is why it is important to look for effective training programs developing physical fitness.

High-intensity interval training (HIIT) is a popular form of exercise used to improve sports performance and health (Gibala & Jones, 2013). HIIT is an activity specific for its short intense intervals with prescribed rest periods. Although HIIT protocols used might be rather variable (number and length of the intervals, type and length of the rest periods, chosen intensity, chosen exercise, etc.), their effect on improving endurance, reducing the amount of body fat and developing cardiorespiratory fitness is shown in short-term interventions (Keating et al., 2017; Sultana et al., 2019).

Cardiorespiratory fitness, body composition, and strength parameters are most likely the most significant factors influencing overall health and quality of life. The effect of HIIT on developing VO2peak or reducing body fat percentage has been proven repeatedly (Batacan et al., 2016; Sultana et al. 2019). The activation of muscle fibres during HIIT and sprint-interval training (SIT) in particular are similar to the activation during resistance training, and analogic adaptation mechanisms can be expected (Callahan et al., 2021). Optimally designed HIIT or SIT could positively affect a wide spectrum of physical fitness aspects.

Frequent HIIT activities are running, cycling or rowing. It is shown that due to their different nature, they lead to unequal physiological reactions (maximal HR, blood lactate, VO2peak) (Menz et al., 2019). The chosen activity represents an important factor in the efficiency and effect of a HIIT protocol and it is

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crucial to have detailed information about this variable.

Air bike is already a widespread cardio machine used by general population, individuals with health problems, and professional athletes. It has gained great popularity as an option of strenuous exercise like HIIT. Air bike workout differs significantly from classic endurance disciplines. The riding has a low frequency, it is more strength-based and both upper and lower body are involved. The load during the ride is created by a big flywheel and its resistance grows exponentially with the increase of speed. Air bike is a comfortable cardio machine from the user's point of view (Looney & Rimmer, 2002), yet it also allows for high to maximal intensity (Schlegel & Křehký, 2020).

There is a lack of studies investigating the effect of HIIT with an air bike on the development of physical parameters. Hwang et al. (2016) found improvements in aerobic fitness and insulin resistance after an 8-week program. There were also positive changes in blood pressure and body composition. The effect on cardiac parameters (arterial stiffness) is not yet clear and requires further research (Kim et al., 2017). Both studies used a 4x4 minutes training protocol with a 3 minutes rest.

Most of the studies assessing the effect of air biking used ramp test and analysed maximal intensity in the context of spiroergometry. So far, there has been a small number of intervention studies. Moreover, the studies have focused only on specific groups, such as people with type 2 diabetes, seniors or patients who had suffered a myocardial infarction (Hwang et al., 2016; Kim et al., 2017). It is necessary to find out the exact effects of air biking on physical fitness which can thus improve overall health. The aim of the study was to verify the effect of a HIIT protocol with air bike on developing cardiorespiratory fitness, strength and endurance parameters, and change in body composition.

## Methods

*Participants*

The experimental group comprised 22 healthy, physically active individuals (average age 22.1±2.5, weight 70.6 kg, height 172.5 cm). Participants (14 women, 6 men) were introduced to the testing and research process. Participants were divided into experimental (EG) and control (CG) groups randomly (7 women and 3 men in both groups). They were supposed to not change their usual daily routines or sleeping and eating habits during the research. A rest day was prescribed one day before the testing. The anthropometric parameters were measured using bioimpedance scales (Tanita® RD-545), specifically weight, fat-free mass (FFM), body fat percentage, body mass index (BMI). People who have been already engaged in other intense sports activities were not allowed to take part in the research. The participants who missed more than one workout session (n=2) were excluded from the final analysis. The research was approved by the Faculty of Education of the University of Hradec Králové (RD 41/2020).

*Testing*

The testing was done using an air bike (Echo bike, Rogue®). It was preceded by a very light 3 minutes warm-up and 3 minutes passive rest. The testing protocol was a ramp test to failure, the load was increased every 3 minutes with no break (Lamont et al., 1992). The test was ended when the subject was not able to maintain the required speed. In spiroergometry (METAMAX® 3B, CORTEX Biophysik GmbH), the following parameters were measured: VO2peak, respiratory equivalent ratio (RER), heart rate (HR), minute ventilation (V'E), oxygen uptake to work rate (VO2/WR) and total test time that corresponds to absolute endurance performance (Total). So far, there have not been enough studies that would use ramp tests on air bike, so it was necessary to rely on own experience combined with researches by Lamont et al. (1992), Hoffman et al. (1996). The increasing intensity in the individual levels was organized by RPM (revolution per minute) and it differed for men and women, the base value was 40 RPM (85 watts) for men and 35 RPM (65 watts) for women.

All the participants had had previous experience with the selected strength tests. The following exercises were chosen to test strength: bench press (BP) and back squat (90°) (BS), the subjects had 20 minutes to find their 1 repetition maximum (1 RM) — the number of sets was not limited; pulling strength dynamometer (SH5007, Saehan Dynamometer) (Pull); standing broad jump (SBJ) (they had three attempts, and the best one was recorded, the same principle was used with the back dynamometer). The following tests were used to assess aerobic and anaerobic endurance: 30sec all-out test on an air bike (AN); 2 km on rowing machine test (Concept2®). Flexibility tests were not included in the research as it does not play such significant role in overall health (Nuzzo, 2020).

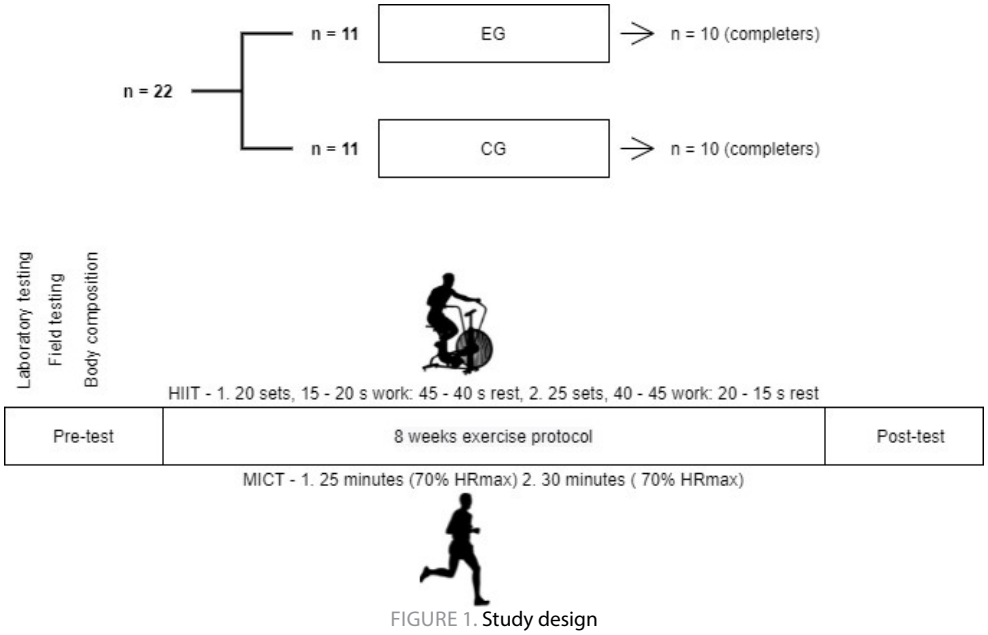


FIGURE 1. Study design

*Intervention*

8-Week training program comprised of three types of sessions. The experimental group did two workout sessions (HIIT and SIT) on air bike (1. 20 sets: 15 sec work, 45 sec rest; 2. 25 sets: 40 sec work, 20 sec rest). It was an original program inspired by studies with HIIT and SIT (Rosenblat et al., 2020). There was a requirement to maintain high intensity during all work sets—significant intensity drop was to be avoided. The rest was passive, the participants stayed seated on the air bike. The first workout session can be called sprint interval training (Gist et al., 2014), but an unconventional work-to-rest ratio of 1:3, or 1:2 respectively, was chosen and the number of intervals was increased as well. The control group did two MICT running sessions (1. 25 minutes run; 2. 30 minutes run). The intensity was kept by monitoring heart rate in combination

**Table 1.** Testing and body composition results

| | EG | | | | | | CG | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **PRE** | **POST** | **% change** | **Cohen´s d** | **p value** | **Descriptor** | **PRE** | **POST** | **% change** | **Cohen´s d** | **p value** | **Descriptor** |
| Weight (kg) | 74.49 ± 13.71 | 74.29 ± 13.10 | -0.27 | 0.01 | 0.740 | trivial | 66.6 ± 9.37 | 66.07 ± 8.80 | -0.80 | 0.05 | 0.264 | trivial |
| BMI | 24.49 ± 3.09 | 24.4 ± 2.91 | -0.37 | 0.02 | 0.611 | trivial | 22.68* ± 2.28 | 22.53* ± 2.25 | -0.66 | 0.06 | 0.476** | trivial |
| Body fat (%) | 18.44* ± 4.64 | 17.6 ± 4.53 | -4.56 | 0.18 | 0.169** | trivial | 17.41 ± 5.17 | 17.04 ± 5.02 | -2.13 | 0.07 | 0.540 | trivial |
| FFM (kg) | 57.64 ± 10.84 | 58.15 ± 10.83 | 0.88 | 0.04 | 0.316 | trivial | 52.3 ± 8.85 | 52.18 ± 8.68 | -0.23 | 0.01 | 0.737 | trivial |
| BS (kg) | 82.4 ± 28.75 | 89.2 ± 31.35 | 8.25 | 0.22 | 0.0117 | Small | 66.55 ± 19.95 | 69.9 ± 22.03 | 5.03 | 0.15 | 0.010 | trivial |
| BP (kg) | 57.25 ± 22.54 | 59.25 ± 23.95 | 3.49 | 0.08 | 0.120 | trivial | 52.05 ± 22.43 | 50.1 ± 20.30 | -3.75 | 0.09 | 0.207 | trivial |
| Pull (kg) | 183.9 ± 39.29 | 196.9 ± 36.54 | 7.07 | 0.34 | 0.009 | small | 148.1* ± 32.29 | 152.7* ± 34.38 | 3.11 | 0.11 | 0.173** | trivial |
| SBJ (cm) | 215 ± 32.53 | 223.5 ± 29.02 | 3.95 | 0.27 | 0.018 | small | 214 ± 33.40 | 219.5 ± 29.93 | 2.57 | 0.17 | 0.043 | trivial |
| AN (m) | 262 ± 29.26 | 272 ± 28.91 | 3.82 | 0.34 | 0.004 | small | 249 ± 23.43 | 251 ± 22.56 | 0.80 | 0.08 | 0.507 | trivial |
| 2 km row (s) | 530.8 ± 47.89 | 515.8 ± 50.22 | -2.83 | 0.30 | 0.025 | small | 555.7 ± 31.59 | 534.4 ± 35.05 | -3.83 | 0.64 | 0.019 | medium |
| Total (s) | 862.4 ± 223.56 | 1024 ± 217.78 | 18.74 | 0.73 | 0.0001 | medium | 823.9 ± 134.48 | 898.3 ± 134.98 | 9.03 | 0.56 | 0.0001 | medium |
| VO2peak (l/min/kg) | 43.3 ± 5.02 | 47.9 ± 6.47 | 10.62 | 0.79 | 0.007 | medium | 44.4 ± 4.88 | 46.3 ± 5.14 | 4.28 | 0.38 | 0.097 | small |
| RERmax | 1.11 ± 0.05 | 1.14 ± 0.03 | 2.25 | 0.72 | 0.177 | medium | 1.13 ± 0.03 | 1.13 ± 0.03 | 0.09 | 0.00 | 0.940 | trivial |
| V'Emax (l/min) | 115.21 ± 24.32 | 124.04 ± 24.83 | 7.66 | 0.35 | 0.045 | small | 116.72 ± 24.04 | 118.45 ± 25.47 | 1.48 | 0.06 | 0.590 | trivial |
| HRmax (bpm) | 187.5 ± 8.43 | 190.8* ± 5.93 | 1.76 | 0.45 | 0.110** | small | 191.8 ± 7.44 | 188.6 ± 9.95 | -1.67 | 0.36 | 0.124 | small |
| VO2/WR (ml/watt) | 12.3 ± 1.19 | 11.6* ± 1.28 | -5.69 | 0.05 | 0.17** | trivial | 12.5* ± 1.63 | 11.6* ± 0.66 | -7.20 | 0.19 | 0.11** | trivial |

EG – experimental group; CG – control group, FFM – fat-free mas; BS – Back squat; SBJ – standing broad jump; AN- 30 seconds all-out test; Total – Endurance ramp test on air bike; RER – respiratory exchange ratio; HRmax – maximal heart rate.

with the Borg rating of perceived exertion scale. The instruction was to keep heart rate about 70% HRmax and at the same time between 14 and 15 on the Borg scale (Keating et al., 2017). The third workout session was the same for both groups and comprised bodyweight exercises with low demands for space and equipment (squat, push up, lunge, plank, sit up, handstand hold) (similar to Menz et al., 2019). The workout session resembled high-intensity functional training and consisted of two 10-minute parts. The exercise was designed to engage the entire body in a complex way. All the workout sessions contained a general warm-up (5 minutes) and a specific preparation (5 minutes) according to the main part (run, air biking, resistance training).

*Statistical data processing*

The data is presented as an average ± SD (standard deviation). Before the statistical testing, to assess statistical significance, data normality was evaluated using two tools: histogram and Shapiro wilk test. When the normality was confirmed, parametric tests were used: two-sample t-tests for unpaired samples (testing between EG and CG) and two-sample t-test for paired samples (with the premise of an F-test of equality of variances; testing between pre- and posttest in the group). When the data were not distributed, non-parametric tests were used: Wilcoxon signed-rank test and Mann-Whitney U test for unmatched samples. Using non-parametric tests was necessary to ensure coherence of the whole research. To assess statistical significance, Cohen's d with the scale of <0.20 = trivial, 0.20–0.49 = small, 0.50–0.79 = medium, ≥ 0.80 = large was used (Cohen, 1992). The significance was tested at a significance level of p>0.05.

## Results

*Anthropometric parameters*

EG noticed only small changes in weight and body composition (fat -0.84 %, ES=0.18, p=0.169; FFM 0.51 kg, ES=0.04, p=0.316), CG noticed almost no changes. The difference between EG and CG was medium for FFM (ES=0.5, p=0.3), and small for body fat % (ES= 0.28, p=0.56). Although only small changes can be identified, it can be claimed that EG noticed an

**Table 2.** Comparison of HIIT and MICT group

| | EG* | CG* | Cohen´s d | p value | Descriptor |
|---|---|---|---|---|---|
| Weight (kg) | -0.20 ± 1.75 | -0.55 ± 1.33 | 0.21 | 0.66 | small |
| BMI | -0.089 ± 0.51 | -0.15 ± 0.53 | 0.11 | 0.81 | trivial |
| Body fat (%) | -0.84 ± 1.63 | -0.37 ± 1.74 | 0.28 | 0.56 | small |
| FFM (kg) | 0.51 ± 1.44 | -0.12 ± 1.04 | 0.50 | 0.30 | medium |
| BS (kg) | 6.8 ± 6.48 | 3.35 ± 3.09 | 0.68 | 0.17 | medium |
| BP (kg) | 2 ± 3.50 | -1.95* ± 4.30 | 1.010 | 0.06*** | large |
| Pull (kg) | 13 ± 11.82 | 4.56 ± 8.88 | 0.80 | 0.11 | large |
| SBJ (cm) | 8.5 ± 8.79 | 5.5* ± 7.02 | 0.38 | 0.53*** | small |
| AN (m) | 1.8 ± 1.83 | 0.30 ± 2.19 | 0.74 | 0.14 | medium |
| 2 km row (s) | -15 ± 16.75 | -15.3 ± 13.84 | 0.02 | 0.51 | trivial |
| Total (s) | 161.6 ± 76.97 | 74.4 ± 35.31 | 1.456 | 0.006 | large |
| VO2peak (l/min/kg) | 4.6 ± 2.76 | 1.9 ± 3.08 | 0.92 | 0.06 | large |
| RERmax | 0.03 ± 0.05 | 0.001 ± 0.04 | 0.53 | 0.28 | medium |
| V´Emax (l/min) | 8.83 ± 11.41 | 1.73 ± 9.31 | 0.68 | 0.17 | medium |
| HRmax (bpm) | 3.30 ± 5.73 | -3.20 ± 5.65 | 1.142 | 0.02 | large |
| VO2/WR (ml/watt) | -0.7 ± 1.42 | -0.9 ± 1.45 | 0.14 | 0.77 | trivial |

*average change between pre- and posttest; EG – experimental group; CG – control group, FFM –fat-free mas; BS – Back squat; SBJ – standing broad jump; AN- 30 seconds all-out test; Total – Endurance ramp test on air bike; RER – respiratory exchange ratio; HRmax – maximal heart rate

increase in muscle mass while decreasing the amount of fat. That is why the weight changed only slightly.

*Strength and endurance testing*

EG noticed a statistically more significant improvement in the basic strength test (ES=0.68-1.01, p=0.06-0.17). The greatest improvement was made in the back squat by 6.8 kg. The smallest improvement was made in SBJ, yet the EG still improved more than the CG (ES=0.38, p=0.53). 2 km row test was the only one where both groups made similar changes (ES=0.02). As for the anaerobic endurance test, the EG improved significantly (ES=0.97, p=0.08).

*Spiroergometry*

Both groups improved their VO2peak, EG by 4,6 ml/kg/min (10.62%) which was significantly more than CG (ES=0.92, p=0.06). A similar result was noticed also in the total duration of the ramp test where the groups improved by 9.03% (CG) and by 18.74% (EG). EG also reached higher RERmax in the posttest which meant medium effect in comparison with CG (ES=0.53, p=0.28). EG got a higher value of V'Emax (124 l/min) compared to CG (118.5 l/min) which was a significant difference (ES=0.68, p=0.17).

## Discussion

It was confirmed that HIIT using short intervals is an effective way to develop strength parameters. A positive (even though not significant) progress in isokinetic strength of the lower body (Sökmen et al., 2018) or squat jump (Soylu et al., 2021) was made as a result of running SIT. Although short rest periods were used in our research, there was still significant progress in the upper and lower body strength compared to CG. It seems that not only short intervals of high intensity but also the chosen means (air bike) have potential in strength development. Progress in strength was made also in the bench press (ES=1.01, p=0.06) which proves that air biking develops upper body strength too. Although both groups did one resistance training session a week, it did not lead to a significant improvement for CG. The combination with air bike was more effective.

In the studies (Hwang et al., 2016; Kim et al., 2008) that applied air bike in intervention, the work interval was 4 minutes which was also used in other researches focused on endurance athletes (Stepto et al., 1999; Sultana et al., 2019). In this study, a HIIT protocol with 15-45 sec intervals was used which allowed for higher power output, or higher speed. Air biking is more strength-based which is why it is logical to use SIT or HIIT with short intervals. During shorter and more intense intervals, fast-twitch fibres get more engaged and they consequently adapt more which results in strength parameters improvement (Chalmers, 2008). Especially in SIT, it is very important to maintain the correct form. On air bike, it is easier to maintain the correct form and it does not require any previous experience or a longer time to learn the proper technique.

The same modality in the intervention program and the testing program is a common practice (Rosenblat et al., 2020). The 2 km row test was a nonspecific endurance test—the participants were not introduced to the proper form before or during the research. In the posttest, there were similar positive changes in performance (ES=0.02). The nonspecific test might not show such positive transfer as the Total test, where EG improved significantly (ES=1.456; p=0.006). When designing HIIT programs, it is necessary to take into account coordination/technical or mental adaptation to the specific movement which might affect the test results (Franchini et al., 2016).

To develop cardiorespiratory fitness, differently designed HIIT and SIT sessions with modalities, such as running, cycling or rowing, were found effective (Batacan et al., 2016; Sultana et al., 2019; Rosenblat et al., 2020). Based on significant VO2peak (by 10.62%) and V'Emax (by 7.66%) improvement, air bike can also be labelled as an effective tool. In connection to this, Kim et al. (2017) also claim its positive effect on arterial stiffness as another possible result of training programs using air bike. Cervantes (2021) comes with different results when he notices a slight increase in VO2peak following a 4-week intervention, which however did not differ significantly from MICT. It is important to note that a low volume SIT was used (8 sets, 20 seconds work: 10 seconds rest).

Despite only small changes in body composition, a certain tendency was found—together with minor fat loss, FFM increased compared to the CG (ES=0.5, p=0.3). This trend can be observed in other authors too (Sultana et al., 2019). More significant changes can be expected in a sedentary population or obese individuals (Keating et al., 2017). In physically active population that undergoes a short HIIT program, only minor body composition changes can be expected. It seems that HIIT using air biking can expand the scale of effective ways to change body composition.

The results proved that different HIIT protocols can lead to a VO2peak improvement. This fact can be influenced by various variables: improvement in strength parameters, change in metabolic flexibility, muscle fibres conversion, improvement in respiration function, improvement in mental resilience towards physical discomfort during exercise, better movement efficiency (MacDougall et al., 1998; Callahan et al., 2021; Dolci et al., 2021). It is difficult to determine which specific factors were dominant in this research. There are, most likely, multiple factors at work in synergy.

This research has shown that the air bike is a low-tech machine that can develop cardiorespiratory fitness in general population. The air biking technique also allows to develop strength, which is another essential factor for longevity and quality of life. Based on the data and the studies mentioned, short and longer HIIT workout with a total duration of 20-30 minutes can be recommended. For additional benefits, it is suitable to combine air bike with resistance exercise based on high-intensity functional training.

A limitation of this research can be seen in the design of the whole intervention where simple bodyweight strength training sessions was also used. It is another variable affecting the adaptation of the organism and the final tests. However, the combination of resistance and endurance training is often included in programs aiming at the development of cardiometabolic health (Hunter et al., 2020).

It also has to be noted that even though spiroergometric testing using air bike is not a new method, it begins to gain significance only with this cardio machine's extended usage. It is a nonspecific tool that engages both the lower and upper body. Due to that, it has different demands for, e.g. cardiac output (Schlegel et al., 2020).

## Conclusion

HIIT has been used for a long time to develop endurance or cardiorespiratory fitness. Given the wide variability of individual programs and modalities, it is necessary to analyse new

tools. Air bike is a new tool whose functionality and efficiency has not yet been sufficiently confirmed. It has been shown that HIIT using air bike can positively influence cardiorespiratory, strength and endurance parameters in an 8-week intervention. A significant effect related to the characteristics of air bike is that it affects the strength performance of both the upper and lower body at the same time. Based on the findings of the research, air biking can be recommended as a suitable tool for developing physical fitness and performance. Because this it an original research, more related studies are required.

**Conflict of interest**

The authors declare no potential conflicts of interest with respect to research and/or publication of this article.

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SportMont

ORIGINAL SCIENTIFIC PAPER

# Effects of Foam Rolling on Strength and Flexibility of Hamstring Muscles

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**Abstract**

Purpose: Foam rolling is frequently implemented in warm-up prior to an exercise session. The purpose of this study was to evaluate the acute effects of a short bout of foam rolling on maximal knee flexion strength along with active and passive hamstring flexibility. Methods: Fourteen healthy young participants were included in this within-subject randomized controlled trial. After warm-up a short bout (two sets of 60 s) of foam rolling was performed on the intervention leg (counterbalanced leg dominance) while the contralateral leg was used as a control. Measurement of peak knee flexion torque and hamstring passive and active range of motion were performed on both sides in counterbalanced order. An analysis of variance was conducted to evaluate differences between the two groups. Results: Our results did not show significant differences between the intervention and control leg for any of the assessed parameters. Conclusion: The main findings are that a short bout of foam rolling does not affect maximal knee flexion strength and that the foam rolling intervention does not further affect flexibility although hamstring passive flexibility increases following a warm-up. Based on our results we conclude that short bouts of foam rolling can be used prior to exercise, as they have no deleterious effect on muscle performance. Foam rolling before exercise should be recommended solely based on individual preference.

***Keywords:*** *eccentric hamstring strength, isokinetic hamstring strength, hip range of motion, knee range of motion*

## Introduction

A well-designed warm-up is necessary to prepare the athlete for upcoming loads and to enable maximal performance. Most commonly, it consists of general low-intensity aerobic activities, dynamic stretching exercises and sport specific drills (Safran et al., 1989). In addition, static stretching has been frequently used as part of warm-up as it increases range of motion (ROM) (Behm & Chaouachi, 2011). However, intensive static stretching prior to activity leads to a reduction in strength and power generation, thus hindering performance (Chaabene et al., 2019). It has been suggested that foam rolling (FR) could be an adequate alternative to stretching for warm-up.

In the past years, FR has become a very popular supplementary tool in strength and conditioning. FR is a form of myofascial self-release technique, in which the individual uses his bodyweight to apply pressure to the targeted muscle and rolls it over the FR (Peacock et al., 2014). The effects of FR have been studied as an addition to a general warm-up or as a recovery strategy after strenuous exercise (Wiewelhove et al., 2019; Hendricks et al., 2020; Skinner et al., 2020). A recent meta-analysis by Wiewelhove et al. (2019) has shown that FR performed before activity may improve flexibility and sprint performance, while not affecting strength or jumping performance. Additionally, FR following intensive exercise seems to ameliorate declines in sprint and strength performance as well as decrease perception of post-exercise induced muscle pain. Based on their findings, the authors concluded that FR could be used in clinical practice as an addition to warm-up in order to improve performance, or after activity to augment the recovery.

Despite a vast amount of research on FR, most of the available studies did not evaluate the effects of adding FR to a general warm-up on hamstring flexibility. Morales-Artacho and colleagues (2017) found that adding FR to a cycling warm-up

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protocol does not result in additional improvements of passive knee extension ROM. Moreover, studies have not observed any additional benefits of FR in comparison to dynamic stretching exercises alone (Sagiroglu et al., 2017; Smith et al., 2018; Richman et al., 2019). On the other hand, Sagiroglu et al. (2017) reported significant short-term improvements after the addition of FR to aerobic running. All things considered, evidence regarding the additional benefits of adding FR to a general warm-up on knee extension or hip flexion ROM appears to be contradictory.

Current research findings indicate that adding FR to a warm-up does not affect maximal knee flexion strength. It is worth noting that the majority of studies have evaluated the effects of FR on isometric (Sullivan et al., 2013; Behara & Jacobson, 2017; Killen et al., 2019) and concentric strength (Su et al., 2017; Lee et al., 2018). Eccentric knee flexor strength seems to be an important factor in injury prevention, as it is often linked to increased risk of sustaining a hamstring strain injury (Green et al., 2020). Additionally, eccentric knee flexor strength has an impact on sports performance. High levels of hamstring strength are associated with superior horizontal force production and consequently enhanced sprint performance (Morin et al., 2015). Therefore, it is desired that the implementation of FR during a warm-up does not have a negative impact on eccentric knee flexor strength.

The available literature lacks studies investigating whether the addition of short bouts of FR to a general warm-up results in further improvements of hamstring flexibility and whether it affects eccentric knee flexion strength. Accordingly, the aim of our study was to evaluate the effect of adding a short bout of FR to an aerobic warm-up on knee flexion concentric and eccentric strength as well as active and passive flexibility of the hamstrings. To the best of our knowledge, no study to date has assessed the effects of FR as an addition to a warm-up on eccentric muscle strength.

## Methods

### *Participants*

Fourteen healthy volunteers (7 males, 7 females; age=25.5±4.7 years, height=171.6±9.5 cm, body mass=69.3±13.8 kg, BMI=23.3±2.8, body fat=19.7±4.1) were included in the study. The sample size was calculated using G-power to reach an effect size reported by previous studies (Madoni et al., 2018; Phillips et al., 2021), statistical power of 0.80 and statistical significance of 0.05. Inclusion criteria were age between 20 and 40 years and regular physical activity (>150 min per week) (Bull et al., 2020). Participants were excluded if they reported trunk or lower extremity injuries in the past 12 months, participated regularly in sports training or had any serious systemic disease. The study was conducted according to the Helsinki declaration and was approved by the Slovenian National Ethics Committee (0120-557/2017/4).

### *Study design*

This study was a within-subject randomized controlled trial in which one leg served as the control and the other as the intervention leg. The dominant (e.g. the leg participants kick the ball with) and non-dominant legs were randomized into the intervention and control groups, and order of measurement was also randomized, in a counterbalanced manner using the Latin square method. Prior to the beginning of measurement, the participants were informed about the study purpose and possible risks of participation. Baseline measurements included the passive straight leg raise test (PSLRT) and the active knee extension test (AKET). Afterwards, the participants engaged in an aerobic warm-up which consisted of 10 minutes of cycling at an individualized intensity (1.5 W per kg of body mass) at a standardized cadence of 90 bpm. Subsequently, the intervention leg was exposed to the FR protocol. The final measurements comprised PSLRT and AKET along with the isokinetic maximal knee flexion strength assessment. Strength assessment was performed only following the intervention, to eliminate the possible effects of maximal eccentric exertion during strength testing. The researcher that performed the measurements was blinded to the assignment of the legs to experimental and control groups.

### *Hamstring flexibility*

Passive and active hamstring flexibility were evaluated using the passive straight leg raise test (PSLRT) and the active knee extension test (AKET), respectively. The ROM was determined with a digital inclinometer (Baseline Digital Inclinometer, Fabrication Enterprises, White Plains, USA). For both measurements the inclinometer was placed on the middle of the tibia (half distance between the medial joint line of the knee and medial malleoli). For the PSLRT, the participants lay supine on a therapeutic table. They were instructed to fully relax. The first researcher stabilized the evaluated knee in full extension and performed passive hip flexion, while stabilizing the non-evaluated thigh. The second researcher palpated under the lumbosacral region to determine at which point the pelvis started to excessively tilt posteriorly (Clarkson & Gilewich, 1989). This point was defined as the end of ROM. For AKET, the participants lay supine on a training mat. The first researcher stabilized the evaluated hip in 90° of hip flexion. The opposite leg was fixated on the table. The participants were asked to actively extend their knee as much as possible. The second researcher measured the ROM with an inclinometer. Two repetitions were performed for each leg. The average value of the two repetitions was taken into further analysis.

### *Knee flexion strength*

Maximal knee flexion strength was measured using an isokinetic dynamometer (Humac Norm, Computer Sports Medicine Inc, Massachusetts, USA). The participants sat on the dynamometer with their hips flexed at 85° and positioned in neutral in the frontal and transverse plane. The dynamometer's axis was aligned with the lateral femoral condyle. Strap belts were used to fixate the measured thigh and trunk. The length of the lever bar was adjusted individually. The distal support was placed just proximal to the ankle joint, so that ankle motion was not compromised. After the participants were positioned, a familiarization trial was introduced (one set of five repetitions). Afterwards, two sets of five repetitions of eccentric-concentric cycles at 60 °/s were performed on each leg. The sets were interspersed with 2 min of rest. The participants were instructed to pull with their shin towards their buttock as hard as they could. Throughout the exertion, the researchers verbally encouraged the participants to assure their maximal engagement. Peak and average torque (Nm) values for both contraction modes were taken into analysis. Peak torque was defined as the highest value at constant speed. Average torque was defined as the average of three repetitions of the more successful set.

*Foam rolling*

The intervention leg was exposed to a short bout of FR. We used a rigid foam roller with a smooth surface. The FR consisted of two sets of one minute, with one minute of rest in between. A phone metronome application was used to control the tempo, which was set at 27 beats per minute. The participants were instructed to put as much weight as possible on the intervention leg during FR. To increase the pressure, the control leg was crossed and placed over the intervention leg (Figure 1). FR was applied from the ischial tuberosity to the popliteal fossa.

FIGURE 1. Foam rolling of the posterior thigh. To ensure a standardized range the participants were placed between a wall and a pad, which limited further motion of the foam roller.

*Statistical analysis*

The acquired data were statistically analysed in SPSS (version 25.0, SPSS Inc., Chicago, United States). The normality of distribution was verified using the Shapiro-Wilko test, coefficients of skewness and kurtosis. In case of non-normal distribution, the data were logarithmically transformed. For peak and average knee flexion torque, the two legs were compared using a paired samples t-test. For active and passive ROM, an analysis of variance for the two groups was performed to analyse the interaction effect between time and group. Statistical significance was set at $\alpha$=0.05. The effect sizes were expressed as partial eta squared ($\eta^2$) and interpreted as small (<0.13), medium (0.13–0.26), and large (>0.26; Bakeman, 2005). The effect sizes for t-tests were calculated as Cohen's d (0.0–0.2 – trivial; 0.2–0.6 – moderate; 0.6–1.2 – large; >1.2 – very large; Bernards et al., 2017).

## Results

We did not find a significant time × group interaction (p=0.82; $\eta^2$=0.002) or group effect (p=0.89, $\eta^2$=0.001) for passive ROM. The effect of time was large and statistically significant (p<0.001, $\eta^2$=0.51).

Likewise, we did not find a significant time × group interaction (p=0.94, $\eta^2$<0.001) or group effect (p=0.943; $\eta^2$<0.001) for active ROM. The effect of time was marginally significant (p=0.05, $\eta^2$=0.14). Figure 2 represents average changes of ROM.

No significant differences were observed between the control and intervention leg, neither for the peak knee flexor concentric (t=-1.57, p=0.14, d=0.42) and eccentric torque (t=-1.96, p=0.07, d=0.52), nor for the average knee flexor concentric (t=1.35, p=0.20, d=0.36) and eccentric torque (t=-0.58, p=0.58, d=0.15). Figure 3 represents the average values for peak and average knee flexion strength.

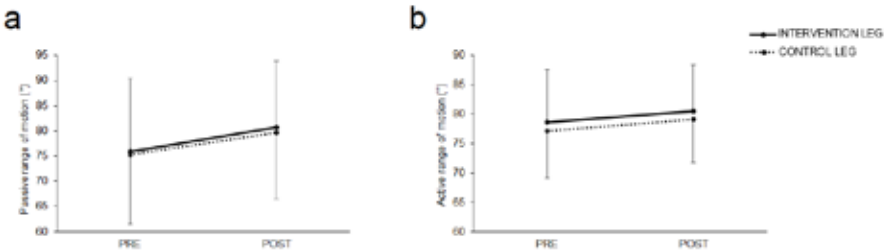


FIGURE 2. Passive (a) and active (b) hamstring flexibility measured on intervention and control leg before (PRE) and after (POST) intervention.

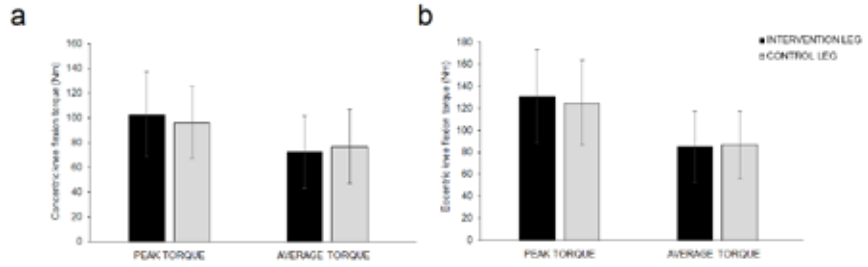


FIGURE 3. Comparison of knee flexion peak and average torque measured during concentric (a) and eccentric (b) exertion of the intervention and control leg.

## Discussion

The aim of the present study was to evaluate whether the addition of a short bout of FR to an aerobic warm-up has additional benefits on hamstring flexibility and whether it has an impact on strength. Our results indicate that 2 min FR of the hamstring muscles, as an addition to an aerobic warm-up, does not result in further improvements (compared to warm-up alone) of hamstring flexibility. Importantly, we found that adding FR does not have a negative effect on concentric or eccentric knee flexion strength. Additionally, the time effect was significant for the PSLRT and marginally significant for the AKET, which shows that the warm-up had a positive effect on hamstring flexibility.

Our results are comparable to the findings of Morales-Artacho et al. (2017), who performed the passive knee extension test. Although their aerobic warm-up protocol was of higher intensity and their FR protocol was of longer duration, they found no additional benefit of FR. Also, Couture and colleagues (2015) did not observe any difference regarding the passive knee extension test when adding FR to an aerobic warm-up, regardless of the duration of FR. In contrast, Behara and Jacobson (2017) found that the addition of FR to an aerobic warm-up resulted in improvement of the PSLRT, but not when compared to dynamic stretching. Furthermore, the studies that evaluated the influence of adding FR to dynamic stretching on the sit and reach test reported similar findings to ours (Peacock et al., 2014; Smith et al., 2018). On the other hand, Sagiroglu et al. (2017) found an immediate improvement in the sit and reach test after adding FR to an aerobic warm-up. However, their aerobic warm-up was rather short (5 minutes) and a substantial amount of time elapsed before the post-intervention measurements. Richman et al. (2019) observed that the addition of FR, but not walking, to an aerobic warm-up resulted in significant improvements in the sit and reach distance. After adding dynamic stretching exercises, there were no significant differences between groups. It is worth noting that in both studies that found improvements of flexibility after adding FR to an aerobic warm-up, the warm-up was performed preceding baseline measurements (Behara & Jacobson, 2017; Sagiroglu et al., 2017). Additionally, Behara and Jacobson (2017) did not report a comparison with a control group. Thus, one cannot safely assume that adding FR further improved ROM. Furthermore, the sit and reach test does not assess exclusively hip ROM and is thus not the most appropriate test for evaluating hamstring flexibility.

In the present study, hamstring flexibility increased following an aerobic warm-up regardless of whether FR was added, which is indicated by a significant time effect. An improvement of hamstring flexibility following an aerobic warm-up was reported previously by Morales-Artacho et al. (2017) and O'Sullivan et al. (2009). Increased ROM following aerobic activities is likely related to increased tissue temperature (Gleeson, 1998). Higher tissue temperature decreases its viscoelasticity and alters its mechanical properties, possibly leading to decreased tissue stiffness. Indeed, McNair (1996) found that plantar flexor stiffness decreased following 10 minutes of running. However, the authors did not observe a difference in dorsiflexion ROM. Also, decreased tissue stiffness is frequently mentioned as a possible effect of FR. This is in accordance with Morales-Artacho et al. (2017), who reported decreased passive stiffness of the hamstrings and decreased passive resistive knee flexion torque following cycling and FR. However, when only FR was implemented, the reduction in passive stiffness was not accompanied by improvements in passive ROM. More research is needed to establish the possible mechanisms underpinning the improvements of flexibility following warm-up.

Our results indicate that FR prior to activity does not lead to reductions in concentric and eccentric knee flexion strength. This is in agreement with the previous studies that measured isometric (Sullivan et al., 2013; Behara & Jacobson, 2017) and concentric knee flexion strength (Su et al., 2017; Lee et al., 2018), although the FR protocols implemented in the related studies differ in duration and tempo. To our knowledge, the present study is the first to evaluate the effects of FR on eccentric knee flexion torque. We hypothesized that adding FR to a warm-up will not affect eccentric knee flexion peak torque. Surprisingly, there was a trend of higher eccentric strength in our study that was marginally statistically insignificant. This could explain the improved sprint performance shown following FR (Wiewelhove et al., 2019), as eccentric knee flexor torque is related to sprint performance (Morin et al., 2015). Thus, short bouts of FR of the hamstrings might not have a negative impact on horizontal force production and hamstring injury risk, but this assumption would need to be tested directly. If this is indeed the case, a short bout of FR could be incorporated as part of a warm-up when performing with maximal velocities. Further studies are therefore needed to study the effect of FR on athletic performance and injury risk.

In summary, it appears that adding a short bout of FR to an aerobic warm-up does not have additional benefits on hamstring flexibility. Although the latest meta-analysis reported significant short-term effects of FR on flexibility (Wiewelhove et al., 2019), the majority of the included studies did not compare its effectiveness with a warm-up only control group. Additionally, FR does not have a negative impact on concentric and eccentric knee flexion strength. Furthermore, a potential positive effect on eccentric knee flexion peak torque was observed. Based on the findings of the present and previous studies, we suggest that a short bout of FR is included as part of a comprehensive warm-up solely based on individual preference. FR should not replace the general warm-up.

Finally, several limitations of our study should be considered. The study sample comprised physically active individuals, therefore caution should be taken when generalizing the results to an athletic population. Additionally, hamstring flexibility assessment was performed 5 minutes following the intervention, which could partially explain the absence of effects. Rest was introduced to mimic the practical application in clinical settings, since FR is rarely performed directly before activity. Strength assessments were not performed before the intervention to avoid the possible effects of maximal eccentric exertion during strength testing.

## Conclusions

The main findings of this within-subject randomized controlled study are that adding a short bout of FR to an aerobic warm-up does not have additional benefits on hamstring flexibility and does not affect maximal knee flexion strength. Moreover, it seems that adding FR could have a positive impact on eccentric knee flexion maximal strength. Based on our findings, we recommend that a short bout of FR should be included in a warm-up solely based on individual preference.

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**Conflict of Interest**
The author declares that there is no conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

# Differences in the Morphological Characteristics and Body Composition between Elite Montenegrin Kata and Kumite Karatekas

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**Abstract**

Elite karatekas should have specific morphological characteristics suitable for their specializations. This study aimed to determine the differences in morphological characteristics and body composition of elite Montenegrin karate athletes according to different specializations. This study consisted of a total of 16 male karate athletes divided according to specialization in kata (form or movement pattern) and kumite (fighting) disciplines. The subject sample included healthy, black belt karate senior athletes, with no prior injuries divided into kata (n-6, 19.83±4.71 years) and kumite (n-10, 20.4±5.21 years) athletes. Morphological characteristics and body composition were evaluated by a battery of 11 variables: body height (BH), body mass (BM), triceps skinfold (TS), biceps skinfold (BiS), back skinfold (BS), abdominal skinfold (AS), upper leg skinfold (UlS), lower leg skinfold (LlS), body mass index (BMI), fat percentage (FP), and muscle mass percentages (MP). The differences in morphological characteristics and the composition of the body between kata and kumite karatekas were determined by using a statistical procedure with a t-test for small independent samples. It was determined that the kumite had a higher body height, and body weight, as well as a higher percentage of muscle mass than kata karatekas. In other parameters concerning the distribution of subcutaneous adipose tissue, as well as the percentage of body fat, there was no difference between the groups. The results suggest that there is some difference in morphological characteristics between kata and kumite karatekas, but for more complete conclusions an analysis should be performed on a larger sample of high-level karate athletes.

***Keywords:*** *karate, anthropometrics characteristics, body composition, elite karatekas, Montenegro*

## Introduction

The morphological status of athletes is very important and nowadays it is known that morphological characteristics are directly related to success in sports (López-Plaza, Alacid, Muyor, & López-Miñarro, 2017; Slimani & Nikolaidis, 2019, Banjevic et al., 2022). It was established that according to the requirements of a certain sport, athletes must possess an optimal level of morphological characteristics (Popovic, Akpinar, Jaksic, Matic, & Bjelica, 2013; Masanovic, 2019; Slimani & Nikolaidis, 2019; Banjevic et al., 2022). The morphological status of top athletes is relatively homogeneous, depending on the sport, and can be defined as a pattern for athletes' achievements (Misigoj-Duraković, Matković, & Medved, 1995).

Karate is considered one of the most popular martial arts, which includes two competitive disciplines: forms (kata) and sports fighting (kumite) (Koropanovski et al., 2011; Tabben et al., 2013). To achieve top results in karate, in addition to other characteristics, the athlete must have suitable anthropometric characteristics (Lehmann & Jedliczka, 1998; Amusa & Onyewadume, 2001; Jukic, Katic, & Blazevic, 2012).

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Analyzing karate athletes, it is noticeable that they are characterized by a harmonious body constitution with a low percentage of fat tissue (Sterkowicz, 1992). In relation to the level of competition, there is no difference in body composition between intermediate and high-level competitors, although the percentage of fat tissue was lower in top competitors (Giampietro, Pujia, & Bertini, 2003). When considering some morphological characteristics, it was determined that the longitudinal dimensionality of the skeleton, with a smaller percentage of fat tissue, plays an important role in success in karate (Abdel-Baser, 2010; Chaabène, Hachana, Franchini, Mkaouer, & Chamari, 2012). However, the percentage of fat tissue in karate athletes varies in different studies with subjects of different nationalities (Chaabène et al., 2012).

One study that investigated the difference in body composition between kata and kumite karatekas showed that there was no significant difference in body composition between the given athletes (Koropanovski et al., 2011). Even though karate is a very popular and massive individual sport, as well as fact that knowledge about the morphological characteristics and body composition of karate competitors is necessary, research in the field of karatekas morphology is not so numerous (Chaabène et al., 2012; Gloc, Plewa, & Nowak, 2012). There is an obvious lack of data on the differences between kumite and kata competitors in morphological characteristics (Koropanovski et al., 2011). Accordingly, the study aimed to identify differences in the morphological characteristics and body composition between kata and kumite karatekas.

## Methods

*Sample of respondents*

This cross-sectional study consisted of a total of 16 male karate athletes divided according to specialization in kata (form or movement pattern) and kumite (fighting) disciplines. The subject sample included healthy, black belt karate senior athletes, with no prior injuries divided into kata (n-6, 19.83±4.71 years) and kumite (n-10, 20.4±5.21 years) athletes. Athletes voluntarily participated in the research process, also this research was carried out following the Helsinki Declaration.

*Measurements*

The standard international biological procedure was used to determine morphological characteristics (Eston & Reilly, 2013). Morphological characteristics and body composition were evaluated by a battery of 11 variables: body height (BH), body mass (BM), triceps skinfold (TS), biceps skinfold (BiS), back skinfold (BS), abdominal skinfold (AS), upper leg skinfold (UlS), lower leg skinfold (LlS), body mass index (BMI), fat percentage (FP), and muscle mass percentages (MP). Anthropometer, caliper, and measuring tape were used for morphological measurements. To evaluate the body composition, Tanita body fat scale - model BC-418MA, was used.

*Statistics*

Basic parameters of descriptive statistics were calculated: arithmetic mean, standard deviation, minimum, maximum, and range. To determine differences in morphological characteristics, and body composition among groups of karatekas, a T-test for small independent samples was used. For all statistical analyses, significance was accepted at $p<0.05$. Data processing was performed using the statistical program SPSS 26 (Statistical Package for Social Sciences, v26.0, SPSS Inc., Chicago, IL, USA).

## Results

Table 1 indicates descriptive values of morphological parameters. Kata karatekas have an average height of 174.22±6.35 cm and a body weight of 67.75±4.67 kg, respectively, which are slightly lower than kumite karatekas (183.47±6.8 cm, and 77.34±10.15 kg). Body mass index values are similar for kata (22.42±2) and kumite (22.87±2.33), as well as fat percentage values (10.03±4.75% for kata and 9.70±4.46 for kumite karatekas). It is noticeable that kata has lower values for muscle mass (33.73±2.49%) compared to Kumite karatekas (39.28±4.58%). While the skinfold values

**Table 1.** Descriptive data of morphological parameters between the groups

| Groups | | Mean | Std. Dev. | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| Kata | Age | 19.83 | 4.71 | 16 | 28 | 12 |
| | Body height | 174.22 | 6.35 | 166.8 | 182.0 | 15.2 |
| | Body mass | 67.75 | 4.67 | 60.9 | 75.0 | 14.1 |
| | Triceps skinfold | 7.12 | 1.64 | 5.1 | 9.1 | 4.0 |
| | Biceps skinfold | 5.47 | 2 | 3.7 | 8.7 | 5.0 |
| | Back skinfold | 8.73 | 1.82 | 6.8 | 11.6 | 4.8 |
| | Abdominal skinfold | 9.42 | 2.92 | 6.0 | 13.2 | 7.2 |
| | Upper leg skinfold | 7.08 | 1.27 | 5.1 | 8.6 | 3.5 |
| | Lower leg skinfold | 12.33 | 1.87 | 9.6 | 14.0 | 4.4 |
| | Body mass index | 22.42 | 2 | 20.0 | 25.1 | 5.1 |
| | Fat percentage | 10.03 | 4.75 | 4.0 | 14.1 | 10.1 |
| | Muscle mass | 33.73 | 2.49 | 30.4 | 36.5 | 6.1 |
| Kumite | Age | 20.4 | 5.21 | 16 | 34 | 18 |
| | Body height | 183.47 | 6.8 | 166.6 | 192.0 | 25.4 |
| | Body mass | 77.34 | 10.15 | 63.6 | 96.3 | 32.7 |

*(continued on next page)*

*(continued from previous page)*

**Table 1.** Descriptive data of morphological parameters between the groups

| Groups | | Mean | Std. Dev. | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| | Triceps skinfold | 7.23 | 2.05 | 4.0 | 10.6 | 6.6 |
| | Biceps skinfold | 5.47 | 1.9 | 3.2 | 8.0 | 4.8 |
| | Back skinfold | 9.92 | 2.8 | 7.5 | 15.0 | 7.5 |
| | Abdominal skinfold | 9.57 | 4.75 | 6.0 | 22.0 | 16.0 |
| | Upper leg skinfold | 6.03 | 1.59 | 3.6 | 9.4 | 5.8 |
| | Lower leg skinfold | 11.44 | 4.87 | 6.0 | 21.0 | 15.0 |
| | Body mass index | 22.87 | 2.33 | 19.6 | 27.8 | 8.2 |
| | Fat percentage | 9.70 | 4.46 | 3.9 | 16.9 | 13.0 |
| | Muscle mass | 39.28 | 4.58 | 31.1 | 46.2 | 15.1 |

are approximately similar.

Based on the T-test (Table 2), it was determined that a significant difference was achieved in the aforementioned variables, in body height (0.17), body weight (0.49) and muscle mass (0.17). In other parameters, there was no significant difference between kumite and kata karatekas.

**Table 2.** Descriptive data and t-test of 16 karate athletes enrolled in the study

| | Grupe | Mean | Std. Deviation | t | p |
|---|---|---|---|---|---|
| Age | Kata | 19.83 | 4.71 | -.22 | .831 |
| | Kumite | 20.40 | 5.21 | | |
| Body height | Kata | 174.22 | 6.35 | -2.70 | .017* |
| | Kumite | 183.47 | 6.80 | | |
| Body mass | Kata | 67.75 | 4.67 | -2.16 | .049* |
| | Kumite | 77.34 | 10.15 | | |
| Triceps skinfold | Kata | 7.12 | 1.64 | -.12 | .910 |
| | Kumite | 7.23 | 2.05 | | |
| Biceps skinfold | Kata | 5.47 | 2.00 | -.00 | .997 |
| | Kumite | 5.47 | 1.90 | | |
| Back skinfold | Kata | 8.73 | 1.82 | -.92 | .373 |
| | Kumite | 9.92 | 2.80 | | |
| Abdominal skinfold | Kata | 9.42 | 2,.92 | -.07 | .944 |
| | Kumite | 9.57 | 4.75 | | |
| Upper leg skinfold | Kata | 7.08 | 1.27 | 1.37 | .192 |
| | Kumite | 6.03 | .59 | | |
| Lower leg skinfold | Kata | 12.33 | 1.87 | .43 | .676 |
| | Kumite | 11.44 | 4.87 | | |
| Body mass index | Kata | 22.42 | 2.00 | -.40 | .698 |
| | Kumite | 22.87 | 2.33 | | |
| Fat percentage | Kata | 10.03 | 4.75 | .14 | .890 |
| | Kumite | 9.70 | 4.46 | | |
| Muscle mass | Kata | 33.73 | 2.49 | -2.71 | .017* |
| | Kumite | 39.28 | 4.58 | | |

## Discussion

This study showed that there are differences between some morphological parameters between kata and kumite karatekas. When compared to kata karatekas, kumite karatekas have higher values for body height, body mass, and muscle mass percentage.

The average height of kata karatekas in this study is about the same as the height of the karatekas from North America and Central America (Huertas, De-los-Santos, Bersain, & Cabrera, 2006). Additionally, they are slightly larger than the Colombian (167.4 cm; Sánchez-Puccini, Argothy-Bucheli, Meneses-Echávez, López-Albán, & Ramírez-Vélez, 2014), and the Philippines karatekas (169.6 cm; Pieter and Barcades, 2015). On the other hand, kumite karatekas have higher average values, which are about the same height as Polish and Italian karatekas (Giampietro et al. 2003; Sterkowics-Przybycien, 2010 ).

Kata karatekas in our study, also had a lower body mass, which corresponds to Colombian (Sánchez-Puccini et al., 2014), Italian (Giampietro et al., 2003), and North-American (Huertas et al. 2006) karatekas, while kumite karatekas achieved higher values than that. In addition, the average body mass of Polish karate athletes was higher (91.1 kg; Sterkowicz-Przybycien, 2010) than any other sample of karatekas.

The morphological parameters, above all body height and mass, are quite variable because karatekas in these studies are not classified into kata and kumite disciplines. In this study, a significant difference was determined precisely in body height and mass, which is on the side of kumite karatekas, who are more robustly built. This corresponds to the data of Koropanovski et al. (2011) who showed in a sample of male karatekas of the Serbian national team that there is no significant difference in body mass index (as in our case) between kata and kumite karate fighters, but it was noted that kumite fighters were more "robust" (larger body dimensions) compared to katas.

The percentage of adipose tissue was similar between kata and kumite groups, and is consistent with claims that elite karate fighters have a lower percentage of adipose tissue (Giampietro et al., 2003) and roughly corresponds to Polish karatekas (Sterkowicz, 1992), and it is slightly higher than Japanese karate fighters who have 7.5% fat tissue (Imamura, Yoshimura, Uchida, Nishimura, & Nakazawa, 1998). In contrast to these data, the study found that Polish karatekas have 16.8% fat tissue (Sterkowicz-Przybycień, 2010). Although due to the weight categories in sports fighters, karatekas should have as little fat tissue as possible as ballast, we still see that the percentage of fat tissue in karate fighters varies in different studies with respondents of different nationalities, and Chaabène et al. (2012) came to a similar conclusion in their review study.

It should be noted that there was no difference in skinfolds between the karate fighters, which corresponds to the fact that there was no difference in the percentage of fat mass. Since skinfolds are known to be the main indicators of body fat percentage, because over 60% of body fat is located precisely in the subcutaneous region (Wang, Thornton, Kolesnik, & Pierson, 2000).

A significant difference was realized between the groups in the percentage of muscle mass, where it was determined that Kumite fighters have more muscle mass than Katas athletes. Greater muscle mass in athletes is considered an important factor for athletes who encounter heavy physical struggles during training and competition (Shariat, Shaw, Kargarfard, Shaw, & Lam, 2017), so it is clear why kumite karatekas have more muscle mass than kata karatekas who are not subject to struggles.

## Limitations

Additionally, this study has some limitations, most of which are related to the small sample size. However, it was not easy to find elite karate seniors who have a black belt in the territory of Montenegro.

The proposal for further research on the body composition of elite karatekas should be carried out on a larger sample and with the assistance of more cutting-edge equipment that would determine the body status for the entire body as well as for individual body segments. This will allow for the collection of more comprehensive data and the determination of whether kumite and kata karatekas have distinct body types.

## Conclusion

This study's findings showed that kata and kumite karatekas have some distinct morphological characteristics. Practical implications would be reflected in a new approach to working with karate athletes. Therefore, according to their discipline, karate athletes should have a special approach when creating a training and nutrition plan in relation to the needs of their discipline. This study is important because it shows the direction in which subsequent studies examining the morphological status of karate athletes should go.

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ORIGINAL SCIENTIFIC PAPER

# Correlation between Gaming, Motor Abilities, and Knowledge of English

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**Abstract**

In the last decade, gaming has become one of the activities that many school-aged children have been using daily. As such, gaming has been having a bad effect on children's physical activity but, at the same time, it has helped them in the process of learning English. The goal of the study was: 1) to establish a correlation between the frequency of gaming with motor abilities and grades in English; 2) to establish a correlation between motor abilities and English. Thirty-four 7th- graders (m=19, f=15; age 13.24±0.55) of a primary school in Split participated in the study. The subjects were tested in 3 motor and 1 functional ability test. Grades in English were collected. The participants also filled out the questionnaire on the frequency and manner of gaming. The questionnaire is reliable. There is no statistically significant correlation between the frequency of gaming and better grades in English. Girls game less than boys (MWU Test), have better grades in English, and achieve less in certain motor abilities (MWU Test trunk lifting; 6-min running). The findings suggest that by gaming we do not improve our knowledge of English but that gaming is statistically negatively correlated with motor abilities.

***Keywords:*** *digital gaming, English language, physical activity*

## Introduction

In recent years, we witness the rapid increase and the overall presence of various sophisticated technologies in our daily life. School-age children, in particular, have been growing up surrounded by electronic gadgets (laptops, cell phones, tablets) that form and create their daily interactions and routines (Šego, 2009). Even more, digital gaming, as a 'system in which players engage in artificial conflict, defined by rules, that results in a quantifiable outcome' (Salen & Zimmerman, 2004) has become one of the activities that many school-age children have been using daily (Dewit, 1993). Until very recently, research in gaming aimed at identifying only its negative effects, such as physical inactivity, increased aggression, social isolation, addiction, etc. (Anderson & Bushman, 2001; Gentile, Lynch, Linder, and Walsh, 2004). Recently, we read about the positive effects of gaming, such as overall wellness enhancement (Przybylski, Rigby, and Ryan, 2010), useful learning and assessment tools in education (Larsen McClarty et al., 2012), natural, spontaneous, and autonomous aid in learning (Thorne, 2008), etc. Saying this, there are also numerous benefits that contribute positive correlation between gaming and foreign language learning: through gaming, a foreign language is learned and transmitted autonomously, out of the classroom surrounding and in and by the community of gamers (Holec, 1981; Chik, 2014); reading game-related texts or manuals helps develop learner's reading proficiency (Consalvo, 2007; Apperley, & Walsh, 2012); gaming helps learners learn lexis easier and achieve higher scores in vocabulary tests because they connect new words with images in the game and not just as some abstract symbols (Gee, 2012; Sylvén & Sundqvist, 2012); gaming focuses primarily on developing communicative competence (Rama, Black, Van Es, & Warschauer, 2012).

In addition, scholarly studies have extensively documented numerous benefits of physical activity on the individual's health status. For instance, physical activity in adolescence contributes to the development of a healthy in adult lifestyle

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(Hallal, Victora, Azevedo, & Wells, 2006; Guthold, Stevens, Riley, & Bull, 2020); physical engagement greatly contributes to the development, not only of motor and functional abilities, but also to the development of brain synapses (Hillman, 2008; Erickson, Hillman, & Kramer, 2015); those who are more physically active will achieve better academic results or will have greater school success (Castelli, 2007; Donnelly, 2016); or simply said, 'benefits of regular physical activity on health, longevity, and wellbeing 'easily surpass the effectiveness of any drugs or other medical treatment' (Kumar, 2015). Therefore, we can agree that physical activity represents a tool to improve not only health status but also cognitive abilities that directly contribute to achieving better results in school. In addition, since we found no studies that have addressed the correlation between gaming, motor abilities, and the knowledge of English, we believe that this study and its results represent an important foreground for future studies on the issue, as well as for the future studies within all three fields of research separately (digital gaming, physical activity, and language learning).

Following these lines of thought, the goal of the study was: 1) to establish a correlation between the frequency of gaming with motor abilities and grades in English; 2) to establish a correlation between motor abilities and English. Based on our goals, we have defined the following hypotheses: H1-There is a correlation between gaming and English language performance (grades); H2-There is a correlation between gaming and physical engagement.

## Methods

*Participants*

A total of thirty-four 7th-graders (m=19, f=15; age 13.24±0.55) from a primary school 'Marjan', Split, Croatia participated in the study. Data were collected between April and June 2021.

*Variable Sample*

Variable sample consisted of 7 variables: 2 variables on English language usage in gaming, 1 variable on the grades in English at school, and 4 variables on functional motor abilities.

The newly constructed questionnaire was used in collecting data on English language usage in gaming as well as on the amount of gaming. The questionnaire, which was written in Croatian, consisted of four particles: 2 on using English in gaming and 2 on the amount of gaming. The participants completed the questionnaire at the beginning of their regular Physical Education (PE) class. The participants were informed that the questionnaire was anonymous, subject to their will, and with the written parents' consent. The study protocol followed the guidelines stated in the Declaration of Helsinki (2181-205-02-01-21-0011, 23/9/2021).

The participants were also tested in 3 motor abilities tests (chin-up hold, abdominal crunches, and long jump) and 1 functional ability test (6-minute run) during their regular Physical Education (PE) class.

*Statistical Analyses*

The data were analyzed using Statistics 13 (Statsoft, USA, 2013). The questionnaire is reliable (Cronbach's alpha=0.69 average inter-item correlation r=0.42). All variables were analyzed using descriptive statistics – mean, standard deviation, minimal and maximal result. The Spearman's rank correlation coefficient was used in testing variable correlation. The Mann-Whitney U Test was used in testing gender differences. The change in research data was statistically significant at $p<0.05$.

## Results

From Table 1 we see that this is a very homogeneous group and that there are no differences between boys and girls in variables describing the sample.

**Table 1.** Descriptive parameters: arithmetic mean and standard deviation (AS±SD), minimal and maximal results (min/max), difference between boys and girls (T-test)

| | All groups | | Girls | | Boys | |
|---|---|---|---|---|---|---|
| | AS±SD | Min/Max | AS±SD | Min/Max | AS±SD | Min/Max |
| Age | 13.24±0.55 | 12.00/14.00 | 13.20±0.56 | 12.00/14.00 | 13.26±0.56 | 12.00/14.00 |
| Hight (m) | 1.70±0.08 | 1.53/1.90 | 1.69±0.05 | 1.60/1.77 | 1.71±0.10 | 1.53/1.90 |
| Weight (kg) | 56.97±9.84 | 40.00/80.00 | 57.07±7.10 | 45.00/72.00 | 56.89±11.76 | 40.00/80.00 |
| BMI | 19.56±2.37 | 14.69/24.69 | 19.95±2.31 | 15.96/23.78 | 19.24±2.43 | 14.69/24.69 |
| Grade | 4.18±0.87 | 2.00/5.00 | 4.40±0.83 | 3.00/5.00 | 4.00±0.88 | 2.00/5.00 |

From Table 2 we see that the results of the correlation analysis did not show an association between the total amount of gaming and English language proficiency in the total sample. Further analysis of the correlation established a statistically significant correlation between the total amount of gaming and the test for assessing functional abilities, as well as a statistically significant correlation between language assessment

**Table 2.** Correlation between all the analysed variables (Spearman's rank correlation) for all groups together, and for boys and girls separately

| | | Amount of gaming | Chin-up hold | Abdominal crunches | Long jump | 6-min run | Grade |
|---|---|---|---|---|---|---|---|
| All groups | English in gaming | 0.61* | 0.01 | 0.27 | 0.03 | 0.29 | 0.34 |
| | Amount of gaming | | 0.24 | 0.12 | 0.21 | 0.14 | 0.41 |
| | Chin-up hold | | | 0.51* | 0.86* | 0.35 | 0.23 |
| | Abdominal crunches | | | | 0.41 | 0.65* | 0.21 |

*(continued on next page)*

*(continued from previous page)*

**Table 2.** Correlation between all the analysed variables (Spearman's rank correlation) for all groups together, and for boys and girls separately

| | | Amount of gaming | Chin-up hold | Abdominal crunches | Long jump | 6-min run | Grade |
|---|---|---|---|---|---|---|---|
| | Long jump | | | | | 0.23 | 0.27 |
| | 6-min run | | | | | | 0.01 |
| Girls | English in gaming | 0.78* | 0.17 | 0.44* | 0.24 | 0.49* | 0.17 |
| | Amount of gaming | | 0.27 | 0.33 | 0.27 | 0.45* | 0.02 |
| | Chin-up hold | | | 0.44* | 0.72* | 0.47* | 0.08 |
| | Abdominal crunches | | | | 0.41* | 0.64* | 0.09 |
| | Long jump | | | | | 0.43* | 0.17 |
| | 6-min run | | | | | | 0.08 |
| Boys | English in gaming | 0.82* | 0.02 | 0.21 | 0.10 | 0.41 | 0.30 |
| | Amount of gaming | | 0.01 | -0.10 | 0.12 | 0.23 | -0.07 |
| | Chin-up hold | | | 0.28 | 0.38 | 0.30 | 0.11 |
| | Abdominal crunches | | | | 0.20 | 0.14 | 0.14 |
| | Long jump | | | | | 0.38 | 0.16 |
| | 6-min run | | | | | | 0.53* |

*Statistically significant correlation on the level p<0.05

and functional abilities in girls.

Table 3 shows that there are statistically significant differences between boys and girls: in the amount of gaming in the last 3 months, in the amount of gaming/day, in gaming in total, in the abdominal crunches (repetitions), and in the 6-minute run test.

**Table 3.** Differences between boys and girls in the amount of gaming, physical abilities and grades in English

| Variables | U | Z | p |
|---|---|---|---|
| Grade | 105.00 | 1.28 | 0.20 |
| Amount of gaming in last 3 mths | 42.50 | -3.45 | <0.01* |
| Amount of gaming/day | 37.50 | -3.62 | <0.01* |
| Gaming in English? | 87.50 | -1.89 | 0.06 |
| Communication in English in gaming? | 88.50 | -1.86 | 0.06 |
| Gaming in total | 36.50 | -3.66 | <0.01* |
| Chin-up hold (sec) | 102.50 | -1.37 | 0.17 |
| Abdominal crunches (repetitions) | 62.50 | -2.76 | 0.01* |
| Long jump (cm) | 93.50 | -1.68 | 0.09 |
| 6-min run (m) | 54.00 | -3.05 | <0.01* |

*Statically significant difference between boys and girls

## Discussion

While there are studies concerning the correlation between motor abilities and learning among children (Milne et al., 2018) or the correlation between motor abilities and cognitive skills among children (Van der Fels et al., 2015), there are no studies that addressed or reviewed the correlation between motor abilities and the grade from English at school, which makes our explanation of the obtained results rather challenging. Namely, based on the results gained by this study, we read that motor abilities do not correlate with the grade from English at school in the total sample nor in girls, separately. In boys, only one test (functional ability) correlates with the grade from English. Saying this, we assume that the obtained results are due to their working habits. Or in other words, if it were a matter of working habits, then the other tests would also have correlated with the grade from English.

Furthermore, in our first hypothesis, we assumed that children who, in general, game more would, consequently, have better knowledge of English which, eventually, would result in them having better grades in English at school. Our results showed that boys who statistically gamed more than girls did not have better grades in English. Or in other words, the fact that boys spent more time gaming did not contribute to the assumption that they would have better grades in English at school. Even more, numerous studies emphasize that girls, in general, achieve higher (better) grades in English and learn a foreign language faster than boys (Özçalışkan & Goldin, Meadow, 2010; Payne & Lynn, 2011; Muñoz, 2020) no matter their exposure or non-exposure to gaming. Therefore, this study proved no significant correlation between gaming and better grades in English at school, which comes as a surprise when compared to the results obtained by other studies con-

ducted on the same topic. Namely, Yang and Hsu (2013) researched the correlation between the extent of the multiplayer online gaming experience and the achievement of English language tests in primary school children. Their results indicated that children who were exposed to excessive online gaming showed better knowledge on English language tests, i.e. obtained better grades. Smits (2019) compared the gaming behaviour of gamers and non-gamers to grades in English based on the results of English language skills tests (reading, writing, and speaking). Namely, it was found that children who gamed had better grades in all three tested language skills than those who did not game at all, i.e. that there is a significant correlation between gaming and better grades in English at school. Therefore, we concluded that the outcome of this study might is due to inadequately created English language tests children take at school. Namely, English language tests at school only test children's general knowledge of English language skills (general vocabulary, standard grammatical constructions, etc.) and, as such, test only broader knowledge of English used in various contexts and topics (e.g. English used in restaurants, vocabulary referred to clothing, etc.). We believe that if English school tests were created in a more targeted way towards the specific, for instance, the vocabulary used in gaming, the results between boys and girls in grades would be significantly different (in favour of boys who game more). Therefore, in some future studies, such tests should be created in a way to access and evaluate knowledge (whether lexical or communicational skills) of English that is learned and gained in and from gaming.

Based on the studies that point out primarily negative outcomes of gaming (Grüsser, Thalemann, and Griffiths, 2007), this study also hypothesized that the intensity of gaming would (negatively) affect the physical status of children (due to their physical inactivity during gaming). Interestingly, the results have not confirmed the hypothesis entirely. Namely, the results have shown that the amount of gaming is statistically significantly related only to functional abilities (6-minute run test) but only in girls. The results also pointed out that there is no such aforementioned correlation between the overall sample and the boys which might be due to the fact that boys still, at that age, tend to spend more time playing outside or that they are simply more involved in some sport or sports activity in contrast to girls. This fact has also been proven by other scholarly studies conducted on the same topic (Aarnio, 2002; Mota, 2002).

## Conclusion

Firstly, the study showed that grade in English at school and motor abilities are not in correlation. Secondly, the correlation between gaming and English language performance (grades) has also not been confirmed. Namely, due to general English language tests at school, we conclude that the obtained grade in school is not related to the amount of gaming in English. In addition, the research also aimed to investigate the impact of gaming on physical activity. In addition, it was assumed that this impact would be negative. Prolonged sitting at a computer or some gaming platform will not negatively affect motor abilities for the simple reason that boys who spend more time gaming, spend the rest of their free time doing sports or any other form of physical activity. The correlation between the amount of gaming and functional abilities in girls is surprising because, according to the study, they spend very little time gaming. In general, we cannot conclude that gaming will have a negative effect on motor abilities.

Lastly, there was also the restriction in conducting the study: an overall small sample of participants was due to Covid-19 restrictions according to which entrance to school and testing was rather limited and restricted. Therefore, future studies should include the following: a larger sample of participants, adjusted tests for testing specific English language skills that would examine the knowledge adopted by gaming, and a battery of physical fitness tests that would test more specifically possible negative consequences of prolonged sitting due to gaming.

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ORIGINAL SCIENTIFIC PAPER

# Sports Image, Attitudes, and Positive Psychological Capital of MZ-Generation Viewers in the 2020 Tokyo Olympic Games Depending on Medal-Winning Status

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**Abstract**

Each generation of modern society has lived in varying environments, and different reactions occur while viewing sports. This study compared and analyzed sports, sports attitudes, and positive psychological capital of two groups according to the presence or absence of medals in the event that most impressed them after watching the 2020 Tokyo Olympics. In total, 328 survey responses were collected, and the differences between the groups were statistically verified using multivariate analysis of variance. The results showed that Group 1, which was impressed by a medal-winning event, had a relatively higher average value of self-efficacy than Group 2, which was impressed by an event in which a medal was not won. In contrast, Group 2 had a higher positive image and more resilience than did Group 1. In addition, different psychological attitudes were found in the results of factors (behavioral image, evaluative image, cognitive attitude, affective attitude, behavioral attitude, and optimism) that were not statistically significant in the differences between the groups compared to those of the previous generation. The results of this study can be used as meaningful data in sports viewing-related studies.

***Keywords:*** *Olympic Games, sports image, attitudes, positive psychological capital, MZ-generation*

## Introduction

Large sporting events induce positive emotions and images in viewers (Smith, 2006) through the display of games, and fair sportsmanship, and a gamut of entertaining acts (Liao & Pitts, 2006). In addition to gaining information on various sporting events, viewers' psychological, affective, and emotional characteristics are largely influenced by the games played by athletes representing their countries, according to the media effects of the Olympic Games (Lu, Mihalik, Heere, Meng, & Fairchild, 2019). Viewers of the Olympics develop sports-related attitudes and intentions depending on the outcome of the games (Potwarka, Nunkoo, & McCarville, 2014) and learn about the culture and images of the host country (Essex & Chalkley, 1998).

Since the 1984 Los Angeles Olympic Games, South Korea has maintained a relatively high Olympic performance level, generally finishing around 10th place. However, compared to previous games, the country did not win as many medals or show as strong of a performance during the 2020 Tokyo Olympic Games. Instead of expressing disappointment over the game results, which had been the focus of viewers in the past, unlike the previous generation, the MZ generation tends to enjoy life, which is causing significant changes in various areas (Park, 2022). In this respect, these MZ generations displayed a trend of valuing the games themselves more than the medals that the athletes may win. With the newer generation, the primary viewers of the 2020 Tokyo Olympic Games are the

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MZ generation, that is, those born between 1980 and 2000, and who are known to emphasize their personal characteristics and importance (Baum, 2020). A generational shift in the viewers of mega-events, such as the Olympics, is changing how such events are perceived. Ultimately, the public reaction to the results of the Olympics is expected to vary according to the generation of viewers.

Among the preceding studies related to the Olympics with many issues and values around the world, there are studies comparing the emotional and psychological status of athletes according to medal status and grade (Medvec, Madey, & Gilovich, 1995; McGraw, Mellers, & Tetlock, 2005). In addition, from an economic point of view, there were studies that analyzed the national and corporate interests (Choi, Cho, & Im, 2011; Liu, Kim & Bea 2013) and losses (Chung, 2008) of hosting and broadcasting the Olympics. However, on the contrary, research related to the viewer's psychological perspective according to the presence or absence of an Olympic athlete's medal is very insufficient. Therefore, this study can help build data on sports images, sports attitudes, and the positive psychological capital of viewers depending on whether athletes won medals at the 2020 Tokyo Olympic Games. This may be used as basic data to improve the quality of life of people.

## Literature Review

### *Sports image*

Some images associated with sports include stadium and team images (Khatibzadeh, Kozechiyan, Honarva, & Saghdel, 2018), athlete image (Arai, Ko, & Ross, 2014), national image (Kim, Kang, & Kim, 2014), gender image (Hallmann, 2012), and sports image (Han, 2014). According to Ferrand and Pages (1999), there is an approximately 15% increase in ticket sales of a sports club after it is able to build a positive image. Kaplanidou and Vogt (2007) demonstrated that the image of a host country and city for a sporting event affects tourists' intentions to revisit the place as well as positive perceptions. This study examines sports images with a particular focus on the Olympic Games, which were chosen because viewers could watch numerous games and feel a wide spectrum of emotions. It analyzes changes in sports images perceived by viewers according to four sub-factors (behavioral, psychological, evaluative, and negative) based on whether athletes in both popular and unpopular sports in Korea won a medal.

### *Sports attitude*

Attitude is formed by an individual's phenomena of interest (Schwarz, 2007) and perceived thoughts (Kayai, Cicicoğlu, & Demir, 2018). It plays an effective role in individuals' value creation (Lee, Whitehead, Ntoumanis, & Hatzigeorgiadis, 2008). In particular, modern people have a positive attitude toward sports. Zaman, Mian, and Butt (2018) examined the sports attitudes of adolescents and college students and found that the majority responded positively to sports attitudes. Such an outcome can play a substantial role in individuals' overall quality of life, for it encourages participation in sports, raises psychological happiness and the value of an individual's life (Güngör & Çelik, 2020), and helps them stay future-oriented during physical activity (Graham, Sirard, & Neumark-Sztainer, 2011). Studies on sports attitudes are important because it is possible to predict participants' behaviors and psychology from multiple perspectives. This study classifies sports attitudes of the viewers of Olympic Games by cognitive, affective, and behavioral sub-factors and analyzes how attitudes affect individuals' sports participation and life value creation.

### *Positive psychological capital*

Self-efficacy, optimism, and resilience are sub-factors of positive psychological capital created in positive psychology. Self-efficacy refers to positive trust in oneself (Stajkovic & Luthans, 1998). Optimism indicates an individual having a positive outlook for the future and it decreases psychological uneasiness in the face of difficulties (Carver, Scheier, & Segerstrom, 2010). Resilience signifies an individual's ability to recover quickly from past stress or negative experiences. To this end, Bockorny and Youssef-Morgan (2019) argue that a high level of positive psychological capital helps to improve life satisfaction. Furthermore, Li et al. (2014) found that positive psychological capital plays an intermediary role in linking social support and subjective happiness. Finally, Afzal (2016) determined a significant correlation between individuals' positive and negative emotions and relative happiness by measuring positive psychological capital. The aforementioned studies support the notion that positive psychological capital is a key factor in improving quality of life. This study classifies the positive psychological capital that viewers gain from watching sports into self-efficacy, optimism, and resilience to offer viewers information on building a high quality of life.

## Methodology

### *Data collection procedure and participants*

Data were collected via online and offline (collecting data from respondents in person) survey forms from November 9 to December 15, 2021. Participants were male and female adults aged 20 years or older belonging to the MZ generation (which includes millennials, i.e., those born in the early 1980s to the mid-1990s, and Generation Z, i.e., those born in the mid-1990s to the early 2000s) with experience watching the 32nd 2020 Tokyo Olympics. This study is officially waived from Ethics Approval by the institutional review board (IRB) Committee at Kyung Hee University (reference number: KHGIRB-22-190) as a research in social science not collecting sensitive personal information. For online data collection, survey forms were distributed and collected via the Naver Office, an online survey platform. For offline data collection, the survey was conducted to collect data from respondents in person at two universities in Gyeonggi-do, Republic of Korea. Data were collected only from participants who voluntarily agreed to participate after the research purpose and the fact that there were no benefits or disadvantages to participating in the survey was explained.

A total of 400 questionnaires were distributed online and offline, and 354 responses were received (approximate response rate: 88.50%). However, 26 unfaithfully written, offline survey forms were excluded. Finally, 328 survey responses were collected for statistical analysis. Additionally, based on the question of what the most impressive game at the 2020 Tokyo Olympics was, the survey respondents were categorized into two groups depending on the presence or absence of medals, which was applied as the independent variable (Group 1: Viewers who indicated an event resulting in medals was impressive; Group 2: Viewers who indicated an event without a medal was impressive). Finally, all survey participants reported basic demographic information, such as gender, education, and preferred media device type. The study participants' demographic information is reported in Table 1.

**Table 1.** Study Participants' Social Demographic Information

| | | Group 1 (with medal) 191 (58.2%) | Group 2 (without medal) 137 (41.8%) |
|---|---|---|---|
| Gender | Male | 105 (55.0%) | 79 (57.7%) |
| | Female | 86 (45.0%) | 58 (42.3%) |
| Employment | Self-employed | 10 (5.2%) | 5 (3.6%) |
| | Public servant | 25 (13.1%) | 16 (11.7%) |
| | Employed | 50 (26.2%) | 28 (20.4%) |
| | Homemaker | 49 (25.7%) | 41 (29.9%) |
| | Student | 32 (16.8%) | 26 (19.0%) |
| | Professional | 16 (8.4%) | 12 (8.8%) |
| | Prefer not to say | 9 (4.7%) | 9 (6.6%) |
| Highest level of educational achievement | High school | 16 (8.4%) | 12 (8.8%) |
| | Bachelor's | 127 (66.5%) | 85 (62.0%) |
| | Master's or higher | 37 (19.4%) | 28 (20.4%) |
| | Prefer not to say | 11 (5.8%) | 12 (8.8%) |
| Media device type | Television | 72 (37.7%) | 68 (49.6%) |
| | Personal computer | 37 (19.4%) | 27 (19.7%) |
| | Smartphone | 69 (36.1%) | 36 (26.3%) |
| | Prefer not to say | 13 (6.8%) | 6 (4.4%) |

*Instruments*

The public perception of international sporting events, such as the Olympics, differs from that of the past. Regardless of the game outcome, the public displayed positive feelings, such as emotion, hope, and encouragement, and tended to value the game higher than the medals. First, in the case of sports images, the factors used in Han (2014) were modified to suit the participants and three sub-factors (behavioral, psychological, and evaluative) were evaluated in 12 questions. Next, in the case of sports attitudes, the factor applied to Park's (2010) study was modified and supplemented, and 13 questionnaires were used for three sub-factors (cognitive, affective, and behavioral). Finally, in the case of positive psychological capital, 12 items were included in the four sub-factors revised and supplemented to suit the participants of this study from the questionnaires used in Liu's study (2017). All scales were applied on a five-point Likert scale (1 = not at all, 5 = very much).

*Statistical Data analysis*

Statistical data analyses were implemented via SPSS version 23.0. First, the analysis reported the study participants' social demographic information (e.g., gender, employment, and education). Second, to secure the scale validity of the data collected, exploratory factor analysis (EFA) was conducted for three factors (i.e., sports image, sports attitude, and positive psychological capital). Third, Cronbach's alpha coefficients were calculated to verity the scale reliability of the data collected. Last, a multivariate analysis of variance (MANOVA) was performed to examine the differences in dependent variables between two groups. For all statistical analyses, significance was accepted at $p<0.05$.

## Results

*Scale validity and reliability*

The scales applied in the statistical analyses were tested for acceptable validity and reliability in previous research. However, as this study modified and supplemented the measurement tools to meet the research topic and study purpose, exploratory factor analysis (EFA) was implemented three times to ensure statistical clarity. Based on the results of the EFAs with Varimax rotation, eigenvalues greater than 1.0 were retained. Each factor was determined by a structure including three sub-factors: (a) sports image (behavioral, psychological, and evaluative), (b) sports attitude (cognitive, affective, and behavioral), and (c) positive psychological capital (self-efficacy, optimism, and resilience). The specific results of the EFAs and the survey questionnaires are reported in Tables 2, 3, and 4.

**Table 2.** Results of Exploratory Factor Analysis for Sports Image Factor

| Items | 1 | 2 | 3 |
|---|---|---|---|
| Fun | 0.822 | 0.016 | 0.158 |
| Interesting | 0.796 | -0.033 | 0.167 |
| Competitive | 0.771 | 0.160 | 0.050 |
| Dramatic | 0.750 | 0.140 | 0.099 |
| Healthy | -0.018 | 0.842 | -0.067 |
| Strong | -0.062 | 0.799 | 0.084 |
| Active | 0.241 | 0.764 | 0.256 |
| Dynamic | 0.268 | 0.613 | 0.256 |
| Popular | 0.168 | 0.082 | 0.836 |
| Successful | 0.128 | 0.115 | 0.826 |
| International | 0.100 | 0.136 | 0.789 |
| Eigenvalues | 3.786 | 1.966 | 1.505 |
| Variance (%) | 34.423 | 17.877 | 13.683 |

Note. 1 = Psychological image, 2 = Behavioral image, 3 = Evaluative image.

**Table 3.** Results of Exploratory Factor Analysis for Sports Attitude Factor

| Items | 1 | 2 | 3 |
|---|---|---|---|
| I need sports. | 0.864 | 0.119 | 0.068 |
| I have learned the rules and methods of the game. | 0.864 | 0.053 | 0.098 |
| I get information about my favorite team or player. | 0.834 | 0.150 | 0.007 |
| I gain expertise about games. | 0.822 | -0.040 | 0.024 |
| I praise the players for their games. | 0.098 | 0.810 | 0.094 |
| Sports are effective for refreshment. | 0.042 | 0.809 | 0.141 |
| I feel like I am a player. | 0.066 | 0.795 | 0.227 |
| I am touched by the world-class players' games. | 0.072 | 0.784 | 0.131 |
| I have a desire to work out. | 0.052 | -0.014 | 0.837 |
| I want to buy sports supplies or products. | 0.024 | 0.284 | 0.789 |
| I have the urge to become an athlete. | 0.142 | 0.101 | 0.753 |
| I look for a favorite player's game. | -0.038 | 0.294 | 0.671 |
| Eigenvalues | 3.937 | 2.575 | 1.626 |
| Variance (%) | 32.809 | 21.460 | 13.550 |

Note. 1 = Cognitive attitude, 2 = Affective attitude, 3 = Behavioral attitude.

**Table 4.** Results of Exploratory Factor Analysis for Positive Psychological Capital Factor

| Items | 1 | 2 | 3 |
|---|---|---|---|
| I can expect the best results even in uncertain situations. | 0.892 | 0.063 | 0.084 |
| When I start a new job, I think I can succeed. | 0.888 | 0.111 | 0.028 |
| I think that where there's a will, there's a way | 0.849 | 0.002 | 0.080 |
| I will be able to recover quickly even if I go through difficulties. | 0.021 | 0.861 | -0.025 |
| I do not think it will take long to recover even if I'm stressed out. | 0.118 | 0.820 | 0.009 |
| I will be able to endure hardships without any difficulties. | 0.025 | 0.817 | 0.053 |
| I think I can achieve most of the goals I planned. | 0.108 | -0.015 | 0.863 |
| I think I can do something perfectly even if I face difficulties. | -0.053 | -0.052 | 0.807 |
| I think I can solve difficulties well. | 0.138 | 0.110 | 0.781 |
| Eigenvalues | 2.707 | 2.007 | 1.774 |
| Variance (%) | 30.082 | 22.298 | 19.714 |

Note. 1 = Optimism, 2 = Resilience, 3 = Self-efficacy.

The reliability of the questionnaire was tested using Cronbach's alpha. The results were verified based on a cutoff value of 0.700 for satisfactory internal consistency for reliability (Nunnally & Bernstein, 1994): (a) behavioral image, α=0.782; (b) psychological image, α=0.813; (c) evaluative image, α=0.790; (d) cognitive attitude, α=0.872; (e) affective attitude, α=0.836; (f) behavioral attitude, α=0.790; (g) self-efficacy, α=0.755; (h) optimism, α=0.857; and (i) resilience, α=0.783. All the measurement tools used in this study showed satisfactory statistical reliability.

*Multivariate analysis of variance (MANOVA)*

A MANOVA was conducted to find the differences in sports image, sports attitude, and positive psychological capital of audiences in the 2020 Tokyo Olympic Games based on the type of event (acquisition of medals or not). Homogeneity of covariance was verified (Box's M=76.614, F=1.651, p>0.001), and statistically significant differences between the groups were found (Wilks' Lambda=0.779, F=10.044, p<0.05). Specifically, as reported in Table 5, statistically significant differences between the two groups were found for three factors: (a) psychological image, (b) self-efficacy, and (c) resilience. However, no statistically significant differences were observed for (a) behavioral images, (b) evaluative images, (c) cognitive attitudes, (d) affective attitudes, (e) behavioral attitudes, or (f) optimism. Table 6 reports the mean scores of all dependent variables between the groups drawn from the survey data.

**Table 5.** Results of Multivariate Analysis of Variance

| Dependent variables | | *df* | *F* | *p* | *η2* |
|---|---|---|---|---|---|
| Sports image | Behavioral image | 1 | 0.188 | 0.665 | 0.001 |
| | Psychological image | 1 | 10.343 | 0.001** | 0.031 |
| | Evaluative image | 1 | 1.144 | 0.286 | 0.003 |
| Sports attitude | Cognitive attitude | 1 | 3.269 | 0.072 | 0.010 |
| | Affective attitude | 1 | 1.024 | 0.312 | 0.003 |
| | Behavioral attitude | 1 | 0.041 | 0.840 | 0.000 |
| Positive psychological capital | Self-efficacy | 1 | 36.813 | 0.000*** | 0.101 |
| | Optimism | 1 | 0.134 | 0.715 | 0.000 |
| | Resilience | 1 | 19.124 | 0.000*** | 0.055 |

Note. *p<0.05, **p<0.01, ***p<0.001.

**Table 6.** Mean Scores of Dependent Variables between Groups

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Group 1 | 3.668 | 3.652 | 3.600 | 3.505 | 3.628 | 3.555 | 3.578 | 3.485 | 3.377 |
| Group 2 | 3.703 | 3.918 | 3.501 | 3.677 | 3.538 | 3.571 | 3.056 | 3.521 | 3.766 |

Note. Group 1 = Viewers who were impressed by watching events where medals were won, Group 2 = Viewers who were impressed by watching events without medals. 1 = behavioral image, 2 = psychological image, 3 = evaluative image, 4 = cognitive attitude, 5 = affective attitude, 6 = behavioral attitude, 7 = self-efficacy, 8 = optimism, 9 = resilience. Statistically significant higher mean scores between groups are indicated in bold.

## Discussion

This study examined individuals from the South Korean MZ generation who watched the 2020 Tokyo Olympic Games. Comparative analyses were conducted for sports image, sports attitudes, and positive psychological capital between the two groups, which were divided based on whether the research participants were emotionally moved by events in which the athletes won medals. This research also investigates shifts in psychological responses between the past and present generations. Among the nine comparative factors, psychological image, a sub-factor of sports image, and self-efficacy and resilience, sub-factors of positive psychological capital, exhibited statistically significant results. Furthermore, between the two research groups, psychological image and resilience were greater in Group 2 (no medal group) than in Group 1 (win medal group). However, Group 1 showed higher self-efficacy than did Group 2.

Group 2 (M=3.918) scored higher on psychological image than Group 1 (M=3.652). In the past, winning Olympic medals stimulated the development of a positive image for relevant countries (Essex & Chalkley, 1998), developing their economies (Berman, Brooks, & Davidson, 2000) and increasing their exports (Rose & Spiegel, 2011). Today's society, however, is led by the MZ generation, characterized by a strong sense of belief and independence rather than yielding to the social environment (Baum, 2020). Youths in their 20s and 30s watch sports to enjoy the game. People make dedicated efforts to improve the quality of their life (Costanza et al., 2007), however, past generations felt joy and triumph in good outcomes, such as winning medals, but the present generation is moved and inspired by how these games are played rather than the final outcome. Ultimately, this study's findings recognize the characteristics of the MZ generation that is rapidly changing how sports were viewed in the past, when Olympic medals were celebrated as a means of national prosperity.

Self-efficacy was higher in group 1 (M=3.578) than in group 2 (M=3.056). According to Fulton, Baranauskas, and Chapman (2021), self-efficacy in athletes increases through their participation in highly competitive games like the Olympics, having a positive effect on winning medals in the future. Self-efficacy in athletes' parents has been shown to increase simply because their children were competing in the Olympics (Arai et al., 2014). This suggests that individuals gain positive psychology in their ability to achieve something by watching others' successes even if they are not actually engaged in the performance. In line with the findings of this study, Dietz-Uhler and Lanter (2008) determined that interest in and passion for sports teams greatly influence viewers' emotions, and Wann and Branscombe (1993) found that viewers obtain an ego boost from the game results of teams they support. Moreover, Phua (2010) determined that watching sporting events, such as the Olympics, is an excellent measure of viewers' self-esteem. Therefore, the outcomes of the current study indicate that viewers' interest in various sports may be a response to a high level of success, as in winning Olympic medals, and such analysis or results may not be definitively limited to the MZ generation.

Finally, resilience was greater in Group 2 (M=3.766) than in Group 1 (M=3.377). Resilience in athletes is the ability to handle unfavorable issues that occur during a game, such as errors, point loss, and unexpected situations (Secades et al., 2016). It includes situations where athletes can return to their usual performance level even when they get lesser time to address these issues (Codonhato, Vissoci, Nascimento, Mizoguchi, & Fiorese, 2018). Additionally, slightly less talented athletes are more likely to experience such issues than are outstanding athletes who win medals. Unlike in the past, when results were strongly emphasized (Lee, 2016), viewers today express, in increasing frequency, their support and praise for athletes who gave their best during difficult games. According to Harker (2019), when individuals focus on another person or team, they feel as if they are in sync with their emotions (e.g., emotional identification). As study results show, the fact that viewers' self-efficacy increases regardless of the outcome of the game they watch could become important information for the current generation to relieve the stress they experience in their everyday lives (Togo, 2018). It also demonstrates the positive influence of watching sports, which has progressively changed over the years.

## Conclusion

The study results show that the positive psychological response of viewing sports has changed over time. The field was afflicted with economic and political instability in the past, and numerous efforts have been made to overcome a lack of elite athletes (Lee, 2016), which led to rapid growth in the sports industry (Gil & Mangan, 2002). However, the public's longing for excellent performances by athletes has persisted.

As evidenced by this, a Korean who won the Olympic medal in an unstable colonial environment in the early 1900s was considered a national hero (Podoler, 2021). It is true that the country has implicitly hoped for many gold medals and high rankings (Bridges, 2013). This has caused players to feel burdened; the public's excessive expectations can easily turn into strong criticism. The study results show that these expectations can be constructive for athletes and viewers to think of their own situations, a characteristic of the MZ generation, and help them develop positive emotions.

In addition, the lack of statistical differences between the two groups with regard to behavioral image, evaluative image, cognitive attitude, affective attitude, behavioral attitude, and optimism seen in the results of this study can be considered meaningful. Six out of nine factors did not have statistical significance biased to one side depending on the presence or absence of medals, and statistically significant statistical values (psychological image, self-efficacy, resilience) were also higher

in two out of three sub-factors (Group 2). Thus, the Olympic medal no longer has a substantial impact on the purpose of watching the games in modern society; our results indicate that the quality of the game itself, popular sports stars, and fandoms supported by individuals are becoming factors for enjoying the game.

## Limitations

This study compared and analyzed MZ generation viewers of the 2020 Tokyo Olympics by dividing them into two groups depending on whether a team in a sporting event winning medals impressed them. The sample population was limited to the MZ generation and it was possible to focus on recent trends. Nonetheless, other previous generations (e.g., baby boomers and the X generation) were excluded; hence, further research is needed for generalization. Additionally, owing to the COVID-19 outbreak, very few people watched the 2020 Tokyo Olympics. There were limitations in that the proportion of online survey responses was higher than that of offline responses. Furthermore, it is necessary to compare and analyze the public's sentiment, which may have changed since the 2020 Tokyo Olympics. Finally, this study explained the psychological reactions of comprehensive subjects by conducting quantitative research; however, future research that can compare and analyze more in-depth data by simultaneously conducting quantitative and qualitative research would be necessary.

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**Conflict of Interest**
The author declares that there is no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

# The Relationship between the Functional Movement Screen and the Star Excursion Balance Test in Non-Professional Soccer Players

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**Abstract**

Soccer is a very popular sport with a high incidence of injuries. Clinical screening tools are an important component of injury prevention. The aim of this study was to investigate the relationship between two screening tools, the Functional Movement Screen (FMS) and Star Excursion Balance Test (SEBT), and whether there are differences regarding SEBT scores, injuries, and painful symptoms in participants below and above the FMS cutoff score of ≤14. The research was performed as a secondary analysis of a longitudinal cohort study and included 42 non-professional soccer players from Eastern Croatia (age 25.5±6 years, training experience 15.8±6.6 years). Participants were surveyed regarding their sociodemographic data, soccer playing, and FMS and SEBT tests were performed. They were followed for 3.5 months when an additional set of data regarding injuries and painful symptoms was obtained. Moderate to good correlation was found between FMS total score and posterolateral reach of dominant and non-dominant legs (r=0.503, p=0.001; r=0.525, p<0.001). Significant correlations were found between FMS total score and SEBT composite scores for dominant and non-dominant legs (r=0.486, p=0.001; r=0.453, p=0.003). Numerous significant correlations were found between individual items of FMS and SEBT. Participants with FMS score ≤14 had a higher occurrence of injuries and painful symptoms (p=0.018; p=0.034) and lower results of SEBT composite scores for dominant and non-dominant legs (p=0.010; p=0.001). There is a significant relationship between FMS and SEBT scores. Players with FMS scores ≤14 are more prone to injuries and painful symptoms and they have lower SEBT scores.

***Keywords:*** *football, amateur athletes, injury prevention, clinical screening, postural stability*

## Introduction

Soccer is a worldwide popular sport with a high risk of injuries. The incidence of injuries in non-professional soccer ranges from 2.7 to 4.5 per 1000 h of practice, and it is even higher during the game where it ranges from 12.3 to 24.7 per 1000 h (van Beijsterveldt et al., 2014; Hammes et al., 2015; Hägglund, Waldén, & Ekstrand, 2016). Furthermore, participation in soccer can play part in the development of strength asymmetries which could have a significant role in injury occurrence (Fousekis, Tsepis, & Vagenas, 2010). Sports-related injuries have significant short- and long-term consequences. Short-term consequences include pain, functional limitations, as well as absence from the practice and the game. Long-term consequences may include residual pain, degenerative conditions of the musculoskeletal system, disability, lost income, healthcare costs, and decreased quality of life.

Injury prevention plays an important factor in reducing injury risk in amateur soccer (Thorborg et al., 2017; Faude, Rommers, & Rössler, 2018). An important component of injury prevention is the use of clinical screening tools. Their purpose

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is to identify individuals with a higher risk of injuries. These tools test movement quality, improper movement patterns and asymmetries, joint range of motion, sensorimotor dysfunction, balance, and postural stability. The results of these tools can be used in the planning of preventive strategies with the goal of injuries risk reduction. Two very common screening tools are the Functional Movement Screen (FMS) (Cook, Burton, & Hoogenboom, 2006a; Cook, Burton, & Hoogenboom, 2006b) and the Star Excursion Balance Test (SEBT) (Hertel, Miller, & Denegar, 2000; Plisky, Rauh, Kaminski, & Underwood, 2006). FMS measures movement capacity with elements of postural control, stability, mobility, and neuromuscular control while SEBT evaluates dynamic postural stability (Harshbarger, Anderson, & Lam, 2018). Previous studies suggest that the FMS score ≤14 is frequently used as a cutoff for determining increased injury risk (Moore, Chalmers, Milanese, & Fuller, 2019). Furthermore, anterior and posteromedial reach asymmetry of ≥4 cm and normalized composite SEBT score <89.6% were associated with future injury risk in the literature (Plisky, Schwartkopf-Phifer, Huebner, Garner, & Bullock, 2021).

Both screening tools have acceptable reliability (Munro & Herrington, 2010; Shultz, Anderson, Matheson, Marcello, & Besier, 2013; Gribble, Kelly, Refshauge, & Hiller, 2013). They also share some similar components. Both of them assess balance, core stability, and sensorimotor control (Harshbarger et al., 2018). While FMS provides more insight into functional movement patterns, SEBT assesses dynamic reaching motion which can also offer relevant information. There are limited data regarding a potential relationship between these two screening tools. Only two previous studies investigated the relationship between the FMS and SEBT (Armstrong, 2020; Harshbarger et al., 2018), however, none of them included senior soccer players. Exploring the potential relationship between these two screening tools could provide valuable information regarding the contributions of each tool to the screening process, save time and positively affect athletes' health. The purpose of this study was to examine the relationship between the FMS and SEBT. The secondary purpose was to explore whether there are differences in SEBT score and occurrence of injury and painful symptoms in participants below and above FMS cutoff score of ≤14. We hypothesized that there will be significant correlations between FMS and SEBT scores and that those below FMS cutoff score of ≤14 will have significantly lower SEBT scores.

## Methods

*Study design and participants*

This was a secondary analysis of a longitudinal cohort study that analyzed possible prediction of injuries based on FMS and SEBT scores in 42 non-professional male soccer players (age 25.5±6 years, body height 181±6.3 cm, body mass 78.8±8.1 kg, training experience 15.8±6.6 years) from three amateur soccer clubs from Eastern Slavonia region of Croatia. Sixty non-professional soccer players were invited to participate in the trial, however, 42 accepted the invitation and fulfilled the inclusion criteria. The study was carried out in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee for Biomedical Research, Faculty of Health Studies, University of Rijeka, Croatia (21/02/2019). Participants gave their written consent. To be recruited, participants had to meet the following criteria: being non-professional soccer player, being involved in regular practice and games in the soccer club at least six months before the beginning of the study, being active soccer player for at least 5 years, and non-existence of injury or painful symptoms in the period of performing screening tests. Exclusion criteria were serious medical conditions including surgery or concussion 6 months prior to testing.

*Procedures*

All participants were asked to complete an intake form that collected baseline information. It included demographic data, medical history, height and body mass, duration of soccer playing, training load in the past 6 months, tactical position, injuries, and painful symptoms in the past 6 months, and leg dominance. Leg length was measured in centimeters on each lower limb three times for each leg, from greater trochanter to lateral malleolus. Body mass index (BMI) was calculated according to the standard equation. After the initial interview, leg length measurements, and 10 minute warm-up, participants had their first assessment – FMS. On the next day, after 10 min warm-up, participants had their second assessment – SEBT. After 3.5 months follow-up interview was conducted. It included information on training load, injuries, and painful symptoms in the period after screening.

*Functional Movement Screen*

Seven subtests (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability) and 3 control tests (impingement test, spinal extension test, and spinal flexion) were used according to the protocol described in the literature (Cook et al., 2006a; Cook et al., 2006b). Each movement was scored from 0 to 3 based on the following criteria: 0 – participant experiences pain during movement, 1 – participant fails to complete functional movement, 2 – participant performs the compensatory movement, and 3 – participant performs the movement without compensatory movement and as demonstrated. Individual task scores were summed to produce a composite score that ranges from 0 to 21, with a higher score suggesting better movement capacity (Cook et al., 2006a; Cook et al., 2006b). For each test, the correct procedure was demonstrated to the participants. Three trials were performed for each subtest, and the best score was recorded and used for the analysis. In the bilateral tests, the lower score was recorded as the final score.

*Star Excursion Balance Test*

The SEBT comprises a single-leg balance with an oppositional reaching movement. It was performed according to the previous report (Plisky et al., 2006) measuring anterior, posterolateral, and posteromedial reach of both legs. Test and testing procedures were demonstrated to the participants and they practiced 6 trials in each direction prior to formal testing. Athletes were positioned with their foot centered in the middle of the testing grid which was created by aligning a series of three tape measures secured on the floor. Participants were told to keep their hands on their hips, head facing forward, keep their stance foot flat on the floor, and to reach as far as possible in the three directions with the toe of the other foot and make single, light toe touch on the tape measure. Reach distance was measured by marking the tape with a pen and then measured using a tape measure. The greatest of 3 trials for each reach direction was used for analysis. The trial was repeated if the participant failed to maintain a unilateral stance, lifted or moved the stance foot from the center of the grid, touched down with

the reach foot, or failed to return the reach foot to the starting position. The distance reach was normalized to leg length using the following calculation: excursion distance divided by leg length and then multiplied by 100. Composite scores were calculated by using the sum of the three reach directions divided by 3 times leg length and then multiplied by 100.

*Statistical analysis*

Statistical analyses were performed using SPSS 25.0 (IBM, Armonk, NY, USA). Descriptive statistics were performed for all variables of interest and presented as mean±standard deviation or frequency and percentages. FMS and SEBT composite scores, as well as FMS subtest and individual reach scores in three directions, were analyzed using a Pearson's correlation coefficient (r). Correlation coefficients were interpreted as little or no correlation (0.00-0.25), fair correlation (0.25-0.50), moderate to good correlation (0.50-0.75), and good to excellent correlation (>0.75) (Portney & Watkins, 2007). As a secondary analysis, for between-group analyses regarding FMS cutoff score, we used independent samples T-test for continuous variables and Fisher's exact test for nominal variables. Results were considered significant for $p<0.05$.

## Results

Participants' baseline variables and sociodemographic data are presented in Table 1. Majority of participants, 19 of the total sample (45.2%), had the tactical position of midfielder. There were 10 (23.8%) strikers, 7 (16.7%) defenders, and 6 (14.3%) goalkeepers. Results of the Functional Movement Screen and the Star Excursion Balance Test are shown in Table 2. FMS score ≤14 was recorded in 29 participants (69%). None of the participants had anterior asymmetry ≥4 cm, however 5 (11.9%) participants had posteromedial asymmetry ≥4 cm. All but one participant had their SEBT score <89.6%.

We recorded several significant positive correlations (Table 3). Moderate to good correlation was found between FMS to-

**Table 1.** General Characteristics of the Participants (N=42)

| Variable | mean±SD |
|---|---|
| Age (years) | 25.5±6 |
| Body height (cm) | 181±6.3 |
| Body mass (kg) | 78.8±8.1 |
| Body mass index (kg/m2) | 24±2.1 |
| Training experience (years) | 15.8±6.6 |
| Weekly training load six months before screening tests (min) | 334.5±134.6 |
| Weekly training load three months after screening tests (min) | 310.5±131.7 |

Note. N: sample; SD: standard deviation.

**Table 2.** Results of the Functional Movement Screen and the Star Excursion Balance Test (N=42)

| Variable | mean±SD |
|---|---|
| Functional Movement Screen | |
| Deep squat | 1.8±0.7 |
| Hurdle step | 1.7±0.6 |
| In-line lunge | 1.7±0.8 |
| Shoulder mobility | 1.5±0.8 |
| Active straight leg raise | 2.2±0.5 |
| Trunk stability push-up | 2.6±0.6 |
| Rotary stability | 1.4±0.6 |
| Total score | 12.9±2.5 |
| Star Excursion Balance Test (normalised (%)) | |
| Dominant leg | |
| Anterior reach | 58.5±2.5 |
| Posteromedial reach | 99.2±4.5 |
| Posterolateral reach | 96.2±3.8 |
| Composite score | 84.7±3.1 |
| Non-dominant leg | |
| Anterior reach | 59.4±2.5 |
| Posteromedial reach | 100.4±4.1 |
| Posterolateral reach | 97.2±3.6 |
| Composite score | 85.7±2.9 |

Note. SD: standard deviation.

tal score and posterolateral reach of dominant leg (r=0.503, p=0.001), as well as non-dominant leg (r=0.525, p<0.001). Fair correlations were recorded between FMS total score and anterior reach of dominant leg (r=0.323, p=0.037), posteromedial reach of dominant (r=0.407, p=0.007) and non-dominant leg (r=0.390, p=0.011) and composite SEBT score of the dominant (r=0.486, p=0.001) and non-dominant leg (r=0.453, p=0.003). Deep squat and hurdle step were fairly positively correlated with posterolateral reach of dominant (r=0.313, p=0.044; r=0.406, p=0.008) and non-dominant leg (r=0.425, p=0.005; r=0.401, p=0.009), as well as composite scores of dominant (r=0.305, p=0.049; r=0.342, p=0.027) and non-dominant leg (r=0.378, p=0.14; r=0.344, p=0.026). Active straight leg raise was fairly correlated with posterolateral reach of dominant (r=0.317, p=0.041) and non-dominant leg (r=0.368, p=0.017). Rotary stability was fairly correlated with anterior reach (r=0.347, p=0.024) and a composite score of the dominant leg (r=0.330, p=0.033).

Differences between participants with FMS score ≤14 and those with FMS score ≥15 regarding their weekly training load, the occurrence of injury and painful symptoms, and SEBT results are presented in Table 4. While there were no differences in weekly training load before and after screening between groups, we found that those with FMS score ≥15 had a lower occurrence of painful symptoms lasting longer than 24h (p=0.034), and injury or pain which caused temporary absence from practice sessions (p=0.018). Furthermore, those with FMS score ≤14 had also lower results of posteromedial reach of dominant (p=0.010) and non-dominant leg (p<0.001), posterolateral reach of dominant (p=0.011) and non-dominant leg (p=0.004), and a composite score of dominant (p=0.010) and non-dominant leg (p=0.001).

**Table 3.** Correlations Between the Functional Movement Screen and Star Excursion Balance Test

| | Dominant leg SEBT | | | | Non-dominant leg SEBT | | | |
|---|---|---|---|---|---|---|---|---|
| **FMS** | **Anterior reach** | **PM reach** | **PL reach** | **Composite score** | **Anterior reach** | **PM reach** | **PL reach** | **Composite score** |
| Deep squat | 0.198 | 0.262 | 0.313* | 0.305* | 0.258 | 0.259 | 0.425* | 0.378* |
| Hurdle step | 0.182 | 0.267 | 0.406* | 0.342* | 0.110 | 0.299 | 0.401* | 0.344* |
| In-line lunge | 0.007 | 0.180 | 0.291 | 0.207 | -0.033 | 0.205 | 0.292 | 0.212 |
| Shoulder mobility | 0.146 | 0.296 | 0.169 | 0.250 | 0.081 | 0.277 | 0.228 | 0.251 |
| Active straight leg raise | 0.213 | 0.228 | 0.317* | 0.294 | 0.146 | 0.218 | 0.368* | 0.299 |
| Trunk stability push-up | 0.274 | 0.000 | 0.183 | 0.121 | -0.103 | -0.030 | 0.092 | -0.005 |
| Rotary stability | 0.347* | 0.278 | 0.254 | 0.330* | 0.162 | 0.216 | 0.193 | 0.233 |
| Total score | 0.323* | 0.407* | 0.503* | 0.486* | 0.158 | 0.390* | 0.525* | 0.453* |

Note. FMS: Functional Movement Screen; SEBT: Star Excursion Balance test; PM: posteromedial; PL: posterolateral; *significant correlation p<0.05.

**Table 4.** Differences Between Participants with FMS Score ≤14 and FMS Score ≥15 (N=42)

| **Variable** | **FMS ≤14 (N=29) (N(%) or mean±SD)** | **FMS ≥15 (N=13) (N(%) or mean±SD)** | **p** |
|---|---|---|---|
| Weekly training load six months before screening tests (min) | 320±136.5 | 366.9±129.6 | 0.302 |
| Weekly training load three months after screening tests (min) | 310.9±134.2 | 309.2±131.2 | 0.971 |
| Painful symptoms lasting longer than 24h | | | |
| Yes | 17 (58.6) | 3 (23.1) | 0.035a* |
| No | 12 (41.4) | 10 (76.9) | |
| Injury or pain which caused temporary absence from practice sessions | | | |
| Yes | 13 (44.8) | 1 (7.7) | 0.018a* |
| No | 16 (55.2) | 12 (92.3) | |
| Star Excursion Balance Test (normalised (%)) | | | |
| Dominant leg | | | |
| Anterior reach | 58.2±2.7 | 59.2±1.8 | 0.194 |
| Posteromedial reach | 98±4.5 | 101.8±3.6 | 0.010b* |
| Posterolateral reach | 95.3±3.7 | 98.4±3.1 | 0.011b* |
| Composite score | 83.8±3.2 | 86.5±2.1 | 0.010b* |
| Non-dominant leg | | | |
| Anterior reach | 59.2±2.8 | 60±2 | 0.325 |
| Posteromedial reach | 99.2±4.3 | 103±1.9 | <0.001b* |
| Posterolateral reach | 96.2±3.6 | 99.5±2.5 | 0.004b* |
| Composite score | 84.8±3 | 87.6±1.6 | 0.001b* |

Note. FMS: Functional Movement Screen; N: sample; SD: standard deviation; *statistically significant; aFisher's exact test; bIndependent samples T-test.

## Discussion

This study aimed to examine if there is a relationship between FMS and SEBT scores in non-professional soccer players. Furthermore, the secondary purpose was to explore if significant differences in the occurrence of injury, painful symptoms, and SEBT scores exist between participants with FMS score ≤14 and ≥15. The results confirmed our both hypotheses. We reported numerous significant correlations between FMS and SEBT scores. Players who scored ≤14 on the FMS had a higher occurrence of injuries and painful symptoms, and all their SEBT scores, except anterior reach, were significantly lower than in those with FMS score ≥15. To the best of our knowledge, only two previous studies have examined the relationship between FMS and SEBT scores, and none in non-professional soccer players, which makes a comparison of our study with other studies difficult.

One of the previous studies examining the relationship between FMS and SEBT scores was performed by Harshbarger et al. (2018). They investigated the relationship between FMS and SEBT scores in 52 intercollegiate athletes of both genders from 8 team sports. Majority of their sample consisted of males playing American football (38.5%), and they only had 2 male soccer players (3.8%) in their sample. Contrary to our results, they reported little-to-no correlations between the composite scores of the FMS and SEBT. Furthermore, they reported no-to-fair correlations between FMS item scores and SEBT composite scores. The only significant correlations were reported between FMS rotary stability score and the anterior and posteromedial reach direction of the SEBT which were also reported in our study.

Another previous study, conducted by Armstrong (2019) also examined the relationship between FMS and SEBT scores in 47 female university dancers. Author reported 11 significant correlations between FMS and SEBT. In that study, FMS composite score positively correlated only with anterior reach of the dominant leg which was also present in our study, but we also recorded significant correlations between FMS composite score and other SEBT components. SEBT composite score in Armstrong's study only correlated with rotary stability while we also recorded correlations between SEBT composite score and deep squat, hurdle step, and total FMS score. Furthermore, in that study, posterolateral reach of non-dominant leg only correlated with rotary stability. On the contrary, in our study, posterolateral reach of non-dominant leg correlated with deep squat, hurdle step, active straight leg raise and total FMS score, but not with rotary stability. Furthermore, Armstrong (2019) found several correlations between anterior reach and FMS items (hurdle step, shoulder mobility, active straight leg raise) which we did not confirm in our study except the correlation between total FMS score and the anterior reach of the dominant leg.

Our results showed correlations between FMS total score and SEBT composite score as well as all but one component of the SEBT test. Although the previous two studies did not find such distinctive and strong correlations, our sample was quite different, especially in their FMS total score which was on average only 12.9. We had players with relatively low FMS score and almost all of them had SEBT score <89.6% which is a predictor of non-contact lower extremity injury (Plisky et al., 2021). These scores imply that we had a high-risk population of athletes with possibly significant deficits in their functional capacity of movement and significant potential for improvements in neuromuscular control. It seems that in this population FMS scores capture some of the same constructs for postural stability as SEBT, and that the FMS could be a good indicator of whole-body dynamic stability. The observed relationship between FMS items and SEBT components could also provide some ideas regarding performance interventions and preventive strategies using training of these specific movements for the purpose of reduction of musculoskeletal problems. Preventive exercise programs for soccer players, based on FMS screening, have proven not only to improve FMS results, but also decrease non-contact injury rates (Dinc, Kilinc, Bulat, Erten, & Bayraktar, 2017).

FMS is a very popular clinical screening tool (Cook et al., 2006a; Cook et al., 2006b), however, its predictive role is controversial. In our study, we compared players with FMS scores ≤14 and ≥15 and found that those with scores ≤14 are more affected by injuries and painful symptoms. A systematic review conducted by Bonazza, Smuin, Onks, Silvis, & Dhawan (2017) supported the injury predictive value of the FMS and reported that scoring ≤14 is associated with a small threefold increase in all-cause injury odds in athletes, firefighting and military population. However, Dorrel, Long, Shaffer, & Mayer (2015), and Moran, Schneiders, Mason, & Sullivan (2015) in their systematic reviews did not support its use as an injury prediction tool. A recent systematic review performed by Moore et al. (2019) reported that the FMS composite score ≤14 can be associated with small harmful effects in male and senior athletes, however, effect sizes are small.

The current study has some limitations. First, our sample was small and consisted of only male non-professional soccer players from three soccer clubs which makes it difficult to generalize our results. Also, our follow-up period was quite short and we did not analyze players' injuries regarding their type, mechanism, and region of the body. Future studies should consider a larger population which will include both male and female athletes, different sports, detailed analysis regarding injuries and painful symptoms, and a longer period of follow-up.

In conclusion, our data suggest a significant relationship between FMS and SEBT scores. Furthermore, it seems that non-professional soccer players with FMS score ≤14 are more prone to injuries and painful symptoms, and they have lower SEBT scores. Further studies are needed to confirm these findings.

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**Conflict of Interest**

The author declares that there is no conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

# External Load Seasonal Variations and Positional Differences in Elite Soccer Players

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**Abstract**

The present study explored the external load in professional soccer players throughout the extent of a full competitive season using GPS tracking technology. Twenty-seven male players were categorized based on their playing position: (1) central defenders (n=5), (2) full-backs (n=4), (3) midfielders (n=9), (4) wingers (n=3), and (5) forwards (n=6). Their physical performance was analyzed and interpreted as the overall external load over the extent of 36 competition recordings and 169 recordings of training sessions from up to 5 days prior to match day (i.e., MD-5, MD-4, MD-3, MD-2 and MD-1). The data were collected only from outfield players (excluding goalkeepers) who participated in >90min of total duration in official games and were analyzed with the use of a 10-Hz GPS tracking device (WIMUPRO, RealTrack Systems Almeria, Spain). The results indicated match days minus three and four as the sessions with the highest intensities and physical demands, with no significant differences between the two days. Significant differences in high-speed running and sprint distance were observed between central defenders and full-backs during matches and training sessions. These results would benefit practitioners in designing the annual plan of professional soccer teams and allow for proper monitoring of the external load based on the players' playing position.

***Keywords:*** *Soccer, GPS, positional differences, high-speed running, sprint distance, high metabolic load distance*

## Introduction

Soccer requires great levels of physical conditioning, and practitioners have a complex objective of quantifying the activities to meet these demands (Bradley et al., 2010). In addition, the nature of the sport has evolved tremendously throughout the last decade in terms of physicality, tactical perspectives, and variations in training load (Bradley et al., 2013). Soccer players are required to frequently transition between brief bouts of high-intensity actions and periods of extended low or very low activity. Thus, each weekly microcycle consists of different training designs, triggering endurance, strength/power, speed, the ability to change direction, and reactive agility.

Recently, the global positioning system (GPS) has been implemented in elite-level soccer, and practitioners can quantify the exercise dosage accurately (Randers et al., 2010). The various systems used by professional clubs worldwide have been presented as valid and reliable in quantifying the speed and total distance (TD) covered (Portas et al., 2010). Although disparity may exist, researchers have established categories for important external load variables. For instance, high-speed running (HSR) is heralded as an essential variable and is delineated as the distance covered from 19.8km/h to 25.2km/h. Furthermore, recorded distances above the 25.2km/h threshold are presented as 'sprint distance' (Gregson et al., 2010). The GPS technology can further assess accelerations and decelerations, change of direction, and vertical power (Vickery et al., 2014). Accelerations at maximum intensity have been established and categorized with three different thresholds, 2.78m/s-2,9 3m/s-2,10 and 4m/s-2, respectively (Buchheit et al., 2014). The high volume of accelerations and decelerations during competitive matches was associated with an increased mechanical load which, if altered, could decrease muscular performance and intensify risks of muscular damage (Gastin et al., 2014). The authors discuss that the high-intensity intermittent activity that characterizes both the training sessions and official matches can potentially increase the mechanical, locomotor, and metabolic external

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and internal load of players. Mallo & Dellal (2012) suggest that practitioners must have an annual plan (periodization) to adjust the external load appropriately. Emphasis is given to the microcycle, which is the weekly training plan designed to prepare the players for the official game. Microcycle variability is challenging to encapsulate and is a subject of debate among practitioners (Carling et al., 2016). The authors argue that a major reason for the difficulties in microcycle planning is the significant variability in physicality among player positions. Typically, defenders cover less distance with low metabolic power, whereas midfielders perform more accelerations and decelerations. Wingers and strikers cover more distance with high speed-running and perform more high-velocity actions (Delaney et al., 2018). Thus, an ideal microcycle should include the appropriate training load variations considering the positional playing needs of the athletes. Despite the successful physical performance being influenced by a myriad of factors, the design of the preceding to the official game microcycle is one of them. Although the literature is limited, recent reports demonstrated that the microcycle running performance might affect the official game running performance (Harriss, Macsween & Atkinson, 2019). Therefore, this study aims to quantitatively analyze the physical performance of elite soccer players throughout a complete competitive season, assess the weekly microcycles and how they relate to game day's physical performance, and evaluate the variations in physical performance between playing positions.

## Methods and materials

*Participants*

Twenty-seven male division-1 elite soccer players (age: 28.12±5.5 years, height: 179.3±6.25 cm, body mass: 75.8±6.6 kg) participated in this study. The players were categorized based on their playing position. The study examined their physical performance during the weekly microcycles and official matches throughout an entire season. Furthermore, data were collected only from outfield players (excluding goalkeepers) who participated in >90min of the total duration of official games. The study was approved by the University of Central Lancashire Science, Technology, Engineering, Medicine and Health (reference number STEMH 541) ethics committee board and the Cyprus National Committee on Bioethics (CNCB, 7 July 2021). Furthermore, this study was conducted ethically based on the international standards (Harriss, Macsween & Atkinson, 2019).

*Sample*

The sample consisted of 36 competition recordings and 169 recordings of training sessions from up to 5 days before matchday 5 (MD-5) (i.e., MD-5, MD-4, MD-3, MD-2, and MD-1). Similarly to previous studies by Di Salvo et al. (2013), players were categorized into five different playing positions: central defenders (n=5), full-backs (n=4), midfielders (n=5), wingers (n=3), and forwards (n=6) (Table 1).

**Table 1.** Descriptive characteristics (Mean ± SD) of the professional soccer players per playing position.

| Positions | n | Age (years) | Height (cm) | Weight (kg) | Body fat (%) | VO2max (ml/kg/m) |
|---|---|---|---|---|---|---|
| | | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD |
| Defenders | 3 | 33 ± 2 | 181.67 ± 4 | 82.60 ± 2.5 | 9.71 ± 1.3 | 52.69 ± 3.8 |
| Full backs | 6 | 26.7 ± 4.6 | 176.83 ± 6.2 | 71.13 ± 3.5 | 9.73 ± 1 | 54.79 ± 2.7 |
| Midfielders | 6 | 28.2 ± 5.7 | 178.33 ± 2.3 | 76.85 ± 5.6 | 10.43 ± 1.5 | 56.83 ± 3.6 |
| Wingers | 3 | 30 ± 7 | 175 ± 7 | 71.67 ± 2.9 | 9.25 ± 1 | 54.44 ± 3.9 |
| Forwards | 4 | 29 ± 6.3 | 178 ± 2 | 77.63 ± 3.8 | 8.01 ± 0.7 | 55.01 ± 2.2 |
| All positions | 22 | 29.4 ± 2 | 178.0 ± 1.8 | 76.0 ± 1.2 | 9.4 ± 0.3 | 54.8 ± 0.8 |

*Equipment and data collection*

Recordings of external load parameters were analyzed with the use of a 10-Hz GPS tracking technology (WIMUPRO, RealTrack Systems Almeria, Spain). The efficiency and reliability of these devices have been successfully evaluated in recent studies (Gomez et al., 2019; Pino et al., 2019). Detailed intercession of separating drills and acquiring recordings of active time was executed in real-time (SVIVO software, version 2021.211.2.0, RealTrack Systems Almeria, Spain). Following the conclusion of each session, all data and activity markings were transferred to a computer and examined by SPROTM (RealTrack Systems Almeria, Spain).

*Analyzed parameters*

The external load parameters were recorded as the following: The total distance (TD) covered in meters. The high metabolic load distance (HMLD) is the distance covered in meters when the metabolic power is over 25.5 W/kg. Furthermore, this value corresponds to the moments when running is intense >5.5 m/s2, including high acceleration activities (Tierney et al., 2016). Absolute high-speed running (HSR) represents the distance covered at >21km/h. The sprint distance was recorded when the running speeds were greater than 24km/h (Di Salvo et al., 2013). Finally, the number of accelerations and decelerations and the respective distances covered during these actions.

*Statistical analyses*

Statistical analyses were performed using the statistical package of social science SPSS (Version 26.0 for Windows; SPSS inc., Chicago, IL, USA). Descriptive statistics are presented as means and standard deviations for the anthropometric measurements and the physical parameters during training sessions and match days. Data were analyzed using the (ANOVA) repeated measures within-between interactions to assess possible differences between player positions and their physical performance between training sessions and match days. Furthermore, the weekly external load and its effect on match performance were analyzed using (ANOVA) repeated measures over time. Finally, a G*power analysis for the (ANOVA) repeated measures within-between interactions with a medium effect size (d=.50) was conducted to determine the appropriate sample size (Faul et al., 2017). The required sample size of minimum eight participants per group was needed to obtain 95% statistical power.

## Results

The results were normally distributed, and equal variances were assumed based on the results of Levene's test ($F(4,17)=1.02$, $p=.421$). No significant differences were observed in the remaining parameters between player positions. The mean scores for all parameters and sessions depending on playing position are presented in Table 2.

Significant differences were observed between all sessions concerning the player's performance (Table 3).

**Table 2.** Players' performance parameters (mean and standard deviation) on each session independent of their playing position.

| Match Days | | Distance (m) | Duration (min) | HMLD (m) | Explosive Distance (m) | Accelerations (count) | Decelerations (count) | Distance Acceleration (m) | Distance Deceleration (m) |
|---|---|---|---|---|---|---|---|---|---|
| -1 MD | Mean | 3546.94 | 58.75 | 460.04 | 426.36 | 2215.96 | 2215.64 | 163.82 | 77.69 |
| | Std. Deviation | 320.75 | 9.80 | 61.09 | 50.12 | 404.75 | 404.73 | 34.36 | 17.36 |
| -2 MD | Mean | 3687.98 | 61.36 | 478.67 | 436.51 | 2244.32 | 2243.38 | 160.78 | 75.26 |
| | Std. Deviation | 269.51 | 9.19 | 94.42 | 70.83 | 363.80 | 363.08 | 36.56 | 20.26 |
| -3 MD | Mean | 4917.47 | 65.74 | 814.39 | 657.55 | 2340.94 | 2340.62 | 265.66 | 136.62 |
| | Std. Deviation | 447.19 | 7.10 | 106.72 | 90.54 | 308.22 | 308.37 | 54.96 | 28.58 |
| -4 MD | Mean | 4574.86 | 65.33 | 744.53 | 622.80 | 2366.03 | 2365.83 | 262.95 | 123.34 |
| | Std. Deviation | 522.40 | 8.87 | 103.73 | 97.95 | 371.36 | 371.59 | 44.05 | 27.15 |
| -5 MD | Mean | 4525.48 | 61.70 | 656.13 | 616.40 | 2217.64 | 2217.14 | 209.17 | 110.02 |
| | Std. Deviation | 445.00 | 8.48 | 153.98 | 118.26 | 395.10 | 395.53 | 55.85 | 34.29 |
| MD | Mean | 10023.30 | 93.04 | 1962.92 | 1343.54 | 2929.61 | 2929.43 | 417.89 | 307.62 |
| | Std. Deviation | 796.71 | 2.01 | 354.06 | 222.81 | 313.94 | 314.45 | 91.34 | 64.86 |
| Total | Mean | 5212.67 | 67.65 | 852.78 | 683.86 | 2385.75 | 2385.34 | 246.71 | 138.42 |
| | Std. Deviation | 2266.58 | 14.06 | 542.59 | 332.01 | 435.32 | 435.46 | 103.46 | 86.59 |

Note. HMLD: high metabolic load distance

**Table 3.** Significant differences between sessions in all parameters.

| Parameters | Wilks' (Λ) | F |
|---|---|---|
| Total Distance | 0.007 | 364.850* |
| High Metabolic Load Distance | 0.026 | 96.479* |
| High-Speed Running | 0.42 | 59.545* |
| Sprint Distance | 0.064 | 38.188* |
| Acceleration Count | 0.027 | 93.855* |
| Deceleration Count | 0.025 | 101.593* |
| Acceleration Distance | 0.087 | 27.141* |
| Deceleration Distance | 0.063 | 38.770* |

Note. *p<0.05

The TD and HMLD covered by the players independent of their playing position had no significant difference among training sessions during MD-5, MD-4, and MD-3 and between MD-2 and MD-1. However, training sessions during MD-5, MD-4, and MD-3 demonstrated a significant difference com-

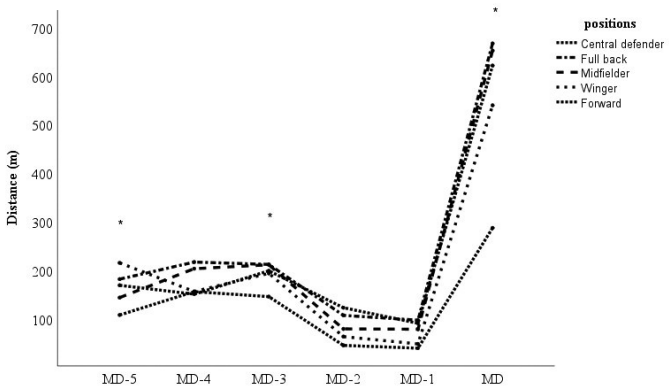


FIGURE 1. Estimated sessions based on player position. Estimations were performed for HSR (distance covered >21km/h). Significant differences were observed between central defenders and full-backs when indicated by * (p<0.05).

pared to MD-2 and MD-1. Similar results were observed for HSR and sprint distance between the sessions with a single exception, as MD-1 and MD-2 differed significantly. The accelerations and decelerations count significantly differed between MD-1, MD-5, and MD-1, MD-4. Further assessment of the distance covered in acceleration and deceleration indicated significant differences between MD-2 and MD-1 and MD-5, MD-4, and MD-3. A significant difference in the distance covered in acceleration and deceleration was also observed between MD-5 and MD-4. Furthermore, the MD-3 was significantly different from both MD-5 and MD-4. The MD was significantly different from all sessions in all parameters, and the MD-2 and MD-1 were significantly different from MD-5, MD-4, and MD-3. The player position had significant effects on HSR and sprint distance. Specifically, the significant differences were between central defenders and full-backs (Figures 1 & 2).

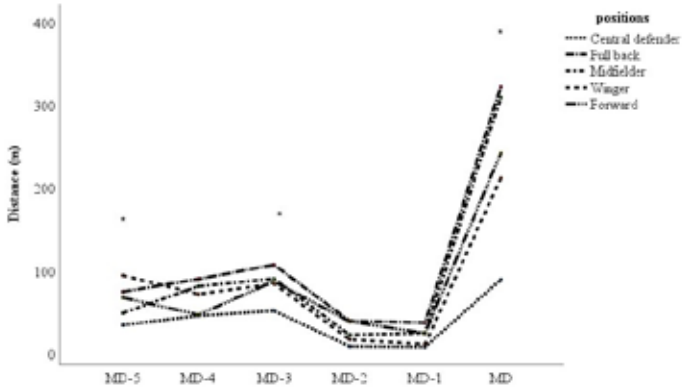


FIGURE 2. Estimated sessions based on player position. Estimations were performed for Sprint distance (distance covered >24km/h). Significant differences were observed between central defenders and full-backs when indicated by * ($p<0.05$).

## Discussion

The present study aimed to demonstrate the professional soccer players' seasonal variations in measures of external load during training sessions and official matches using GPS technology. The study further quantified the work-rate outcome of each player depending on their playing position and the effects of the weekly microcycles on their physical performance during the official games. The results demonstrated that the mean TD of an elite Cypriot division-1 soccer player independent of playing position throughout a 90-min match amounted to 10148m. Our findings rank fairly below the average recordings for TD covered by elite international soccer players. Based on the literature, players participating in the UEFA Champions League cover an average of 10723m, top-level Europa league players cover an average of 11320m, while TD covered by elite Premier league players is reported to be around 10500m (Andrzejewski et al., 2015; Bradley et al., 2016). Although TD can deviate between leagues, the results of our study could have been significantly affected by external elements such as player formation, team strategy, different climates, and match outcomes (Pons et al., 2021).

The external load parameters analysis indicated a significant difference in training load between the MD-5, MD-4, and MD-3 as well as between the MD-2 and MD-1. The highest values of external load were recorded during the MD-4 and MD-3 days, representing the loading phase of the weekly microcycles (Delaney et al., 2018). In contrast, the lowest values were documented during the MD-2 and MD-1. Additionally, locomotor values of external load, such as HSR and sprint distance, decreased gradually throughout each microcycle, therefore characterizing the tapering and pre-game phases (Vanrenterghem et al., 2017). There was a significant difference demonstrating greater values of locomotor performance in MD-2 than in MD-1. Premier League teams have reported similar training periodization (Malone et al., 2015). Nonetheless, few studies diverge from applying HSR within the last three days before competition due to the limited recovery time, typically on the hamstring muscles. The total load deriving from HSR on the hamstring muscles should be followed by a seventy-two-hour rest period for the full recovery of the muscle group (Ekstrand, Hagglund, & Walden, 2011). Therefore, operating with HSR-related exercises on MD-3, MD -2, and MD-1 could prevent a complete hamstring muscle recovery. The current study recorded a mean score of 199m of HSR in MD-3, which is 33% of the HSR usually recorded during MD, and it is considered a low-risk value (Rampinini et al., 2007). Nevertheless, high-velocity sessions are necessary to maintain and improve performance and aid injury prevention (Sweeting et al., 2017). Locomotor parameters are significantly different from soccer players' total metabolic demands (Buchheit et al., 2015). The highest accelerations count, decelerations count, and distance covered, indicating the metabolic power and external mechanical load, were recorded during MD-4 and MD-3. The results show the additional locomotor external load recorded from HSR and sprint distance, thus, categorizing the two sessions as the peak performance from within the microcycle. Research indicated that distances covered with high metabolic power are relatively different from high-velocity distances (Guadino et al., 2014). The high metabolic load distance covered in training sessions and matches is approximately twice as high as the distance covered at high velocities (Osgnach et al., 2010). The load applied from these explosive parameters is often underestimated and neglected in basic analytics, even though 85% of maximum accelerations fail to extend into high-speed movements (Varley & Aughey, 2013). Inadequate monitoring of high metabolic load during training sessions can be crucial as increases in accelerations and decelerations during competitive matches are associated with decreased neuromuscular performance and risks of skeletal muscle damage (Gastin et al., 2019). Therefore, obtaining precise data from each training is essential to appropriately analyze the total external load (Cummins et al., 2013). The current study presented no significant difference in mechanical and locomotor external load between MD-4 and MD-3. Although greater emphasis is typically applied to monitoring HSR, it is indicated that the quantity of medium and high ac-

celerations and decelerations are very similar between training sessions and matches (Tom et al., 2017). Therefore, differentiating the appropriate required stimulus from accelerations and decelerations in conjunction with HSR/sprint distance between training sessions can aid in developing superior training models.

The current study assessed the positional differences in player performance during competitive matches and demonstrated significant differences between central defenders and full-backs on HSR and sprint distance. Similar results were observed during training sessions as full-backs recorded the highest values in HSR and sprint distance. Our findings agree with the theory that central defenders typically cover significantly less distance at high velocities, and midfielders and full-backs are accountable for the superior metrics in those parameters (Delaney et al., 2018). Obtaining knowledge of the physical requirements depending on the player's position can be highly beneficial in designing a training regime that could support each position's physical necessities with the appropriate training load. Accordingly, training sessions should include regiments based on the player's physical profile considering the high-velocity activities and external locomotor load significantly different from the total metabolic demands (Guadino et al., 2014).

To our knowledge, this is one of the few studies that analyzed the GPS data of professional adult male players of the first division in the region. Despite the significant findings, this study comes with limitations. The main limitation is the small sample per playing position. Future studies with a greater number of players in each position are encouraged using video analysis with GPS.

## Conclusion

In sum, the current observational study presented data from a complete season of a professional soccer team that competes at the highest level of the Cyprus Soccer League. The outcome of the current study demonstrated the applied external load during training sessions and official matches amongst different playing positions in elite soccer players. The results on external load from weekly microcycles categorized MD-4 and MD-3 as the sessions with the highest intensities and physical demands, with no significant differences between the two days. Whereas the sessions with the lowest physical values were those of MD-1. Significant differences in HSR and sprint distance were observed between central defenders and full-backs during matches and training sessions. The study demonstrated how the training load varies during the microcycles and official match days, as well as playing position differences. Finally, this study presented the annual data on accelerations and decelerations. The results revealed significant differences between training sessions in both the distance covered in accelerations and decelerations and the extent of their quantity. These results would benefit practitioners in designing the annual plan of professional soccer teams and allow for proper monitoring of the external load based on the players' playing position.

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**Conflict of Interest**
The author declares that there is no conflict of interest.

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ORIGINAL SCIENTIFIC PAPER

# Identification of the Main Factors of Physical Development and Sports Preparedness in 12, 14 and 16-Year-Old Bulgarian Girls Basketball Players

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**Abstract**

The regularities in the dynamics of the physical development of the female organism and the changes that occur in it led to problems in the manifestation of motor qualities at different ages. The study aims to optimize the training process of U12, U14, and U16 basketball players by revealing the factor structure and identifying the main factors of physical development and sports fitness in different age groups. Specialized literature was analyzed to carry out the research, and a test battery for sports-pedagogical testing was used, according to Borukova (2021). 173 female basketball players were studied. The results showed a change in the factor models of physical development and the specific performance with age increasing. The factor components with the most significant weight for the U12 are the anthropometric characteristics, for the U14 are the technical basketball skills, while for the U16, the height is a prerequisite for more outstanding achievements in the maximum vertical jump. The rearrangement of the features in the integral factor structure of the sports preparedness enables the coaches to optimize the training process for the U12, U14, and U16 female basketball players.

***Keywords:*** *physical development, training, basketball, girls*

## Introduction

Modern basketball is an extremely spectacular and attractive sport, and the selection of young female basketball players requires not only opting for a large stature but also observing the proper development of physical qualities and an excellent level of technical skills.

Factors structure shows that physical qualities were derived as the first component for U12, for U14 that was the anthropometric data, and technical skills for U16. The trend is to have lower results with each past year. This necessitates the design of a new test battery and an up-to-date normative system to it (Tsarova & Borukova, 2012).

While body height is genetically predetermined, power, speed, and change of direction speed are subject to training adaptation and could be used for the assessment of players' physical potential to overcome the challenges of a basketball game (Stojanovic et al., 2018; Zaric, Dopsaj, & Markovic, 2018; Mancha-Triguero, García-Rubio, Calleja-González, & Ibáñez, 2019).

For monitoring the functional state of athletes and determining the level of sports training it is necessary to constantly conduct tests with young female players. Timely adjustments in the sports coaching and training process can be done after proper processing and analysis of the results for the achievement of short-term and long-term goals. Depending on the importance of the individual indicators for the sporting achievement, their factor weights are more or less important for the optimization of the training process in a strategic aspect. Evaluation of results with the help of normative tables provides the opportunity for optimization of the training process depending on the momentary level of development of each of the signs of competitive efficiency (Tsarova, 2012;

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Borukova, 2021).

To the greatest extent, the contribution of each of the studied indicators to the sporting achievement of a given individual or group depends on 3-4 main factors (Tsarova & Borukova, 2012).

The contribution of each of the researched indicators to the sports achievement of a particular person or a group of people depends to a great extent on 3-4 major factors (Tsarova & Borukova, 2012).

This is important in selection as well as training evaluation processes. Identification of younger players who have the good physical potential for basketball games reduces the probability of false selection, while early detection of deficits in the main physical abilities indicates that the training could be adjusted and may reduce the risk of unwanted injuries (Greco, Koropanovski, Jakovljevic, & Dopsaj, 2022).

Managing the selection and training process depends on the adequacy of the assessment system in collecting information on an athlete's or a team's training level in order to provide a precise evaluation of the training level (Zatsiorsky & Kraemer, 2008; Ivanovic, Dopsaj, Jakovljevic, & Karalejic, 2019; Belyakova & Gorskaya, 2022). Furthermore, the usability of results obtained by the assessment depends on the specificity and sensitivity of the applied tests. The more specific the test is with regard to sport, the more representation of competitive readiness is valid (Drinkwater, Pyne, & McKenna, 2008; Zaric et al., 2018; Ivanovic et al., 2019).

The available literary sources reveal a lack of specific tests and normative systems for assessment of the physical qualities and specific preparation in the different age categories - U12, U14, and U16 female basketball players.

Tests of a generic nature have more frequently been used for assessing physical fitness in basketball players, e.g., aerobic and anaerobic capacity or jump performance (Drinkwater, Pyne, & McKenna, 2008; Zaric et al., 2018; Mancha-Triguero et al., 2018; Ivanovic et al., 2019; Brini et al., 2020).

Scientific and practical experience of the basketball experts is exceptionally important for achieving high-effective control (Borukova, 2021). With our rich experience in setting up sport-pedagogical tests in basketball for coming up generations, after a questionary with basketball coaches in Bulgaria, we have established that the test batteries applied till now make it difficult for the coaches as the tests are numerous and require more than one training session. Analyzing various test batteries from leading basketball schools such as Spanish, Russian, American, Serbian, and Australian, we have established that in additionally to the tests for physical development and physical preparedness, there should exist such, which are most close to the 4 tests presented by AAHPERD (American Alliance for Health, Physical Education, Recreation and Dance), so we apply tests submitted in Bulgaria (Tsarova & Borukova, 2012), tests from a test battery applied in the USA (Popovic, 2007) and those from Serbia (Karalejič & Jakovljevič, 1998) with a total duration of 120 minutes. that is why we have combined tests (Popovic, 2007).

Up to now, all coaches of the teams which took part in the sport-pedagogical study with Borukova's (2021) new test battery think that it covers exhaustive information in relation to the physical development, physical preparation, and competitors' level of technical skills. They like the fact that the tests are conducted within one training session only, which makes it easier for them; they wish to go on with current and phase tests during the present season. The use of the Sigma method allows the development of normative tables by which the status of each sign (indicator) under study can be easily evaluated. That would help the work with coaches to optimize the school-training process (Borukova, 2021).

In view of the listed facts, our personal experience, and observations during tests conducted with young female basketball players, this study aims to determine the hierarchical structure of the anthropometric characteristics, physical preparedness, and technical skills in basketball for each individual age group of girls: up to U12, up to U14 and up to U16 years of age. The highest ranked variables of physical development and specific preparedness for each age group show that these indicators are of best usefulness in predicting the future sports development of female players.

## Methods

This research was conducted in the period March 2021 – June 2021.

*Participants*

The research was done among 173 girls in three age groups: (U12, n-71; U14, n-49; U16, n-53). The sport-pedagogical tests are applied by one and the same researcher or coach of the respective team at terrain conditions within the frame of one training session (120 min). The testing session was carried out during morning hours between 10:00 and 12:00 a.m. The anonymity of the children was guaranteed; each one was listed under a different number, known to the team coach only. Everybody participated voluntary in the research and has not received money or financial compensation for his/her contribution. Nobody from the participants refused to take part in the study except those injured or not feeling well. Team coaches had the consent of the children's parents to carry out the tests. Physical development data were taken in the medical offices of the sports halls and all female players were barefooted and had their sportswear on. Before tests, players had performed a standardized warm-up, consisting of 5 min jogging, 5 min dynamic stretching, and 5 min of short acceleration-decelerations, gradual building of running velocity, submaximal jumping, and agility exercises Short instructions, video, and demonstration of the test battery were provided prior the tests. The research was effected within standard conditions – a basketball hall with the necessary equipment: chronometer, measuring apparatuses, cones, and basketball balls. The participants performed the tests twice. Better achievements were taken into mind for the analysis of the results.

*Measurments*

Table 1 presents Borukova's test battery (2021). The test battery covers 20 indicators containing information about the physical development basic signs, physical preparedness, and basketball technical skills. The indicators are divided into three groups: those for physical development from the 1st to the 7th; for physical preparedness from the 8th to the 14th and for technical skills – from the 15th to the 20th indicator. The tests for physical development and physical preparedness are the standard ones used in sports practice for many years already; indicator No.13 "Shuttle run – 140 m" will be the one described as it is somewhat different from the ones in use so far.

**Table1.** Description of Borukova's Test Battery (2021)

| № | Indexes | Measurements | Exact. of measurem | Direction of increase |
|---|---|---|---|---|
| 1. | Height – H(cm) | cm | 1.0 | + |
| 2. | Weight - W(kg) | kg | 0.50 | |
| 3. | Body Mass Index – BMI (kg/m$^2$) | kg/m$^2$ | 0.01 | |
| 4. | Horizontal extension – HE(cm) | cm | 1.00 | + |
| 5. | Vertical extension – VE (cm) | cm | 1.00 | + |
| 6. | Chest measurement – Pause – ChMP (cm) | cm | 1.00 | + |
| 7. | Chest measurement - respiratory difference – ChMD (cm) | cm | 1.00 | + |
| 8. | Sprint 20 m - S 20m (s) | s | 0.01 | - |
| 9. | Squat jump - SJ(cm) | m | 0.01 | + |
| 10. | Vertical jump - VJ(cm) | cm | 1.00 | + |
| 11. | Maximum Vertical jump - MVJ (cm) | cm | 1.00 | + |
| 12. | Flexibility - F(cm) | cm | 1.00 | + |
| 13. | "Shuttle" run - 140 m, Sr (s) | s | 0,01 | - |
| 14. | Test for swift-moving - Agility - A(s) | s | 0.01 | - |
| 15. | Dribble and shooting at high speed – DS(s) | s | 0.01 | - |
| 16. | Catching and passing, shooting the basket-CPS (s) | s | 0.01 | - |
| 17. | Shooting – time – Sh(s) | s | 0.01 | - |
| 18. | Shooting – score - Sh 2(n) for 2points | number | 0.01 | + |
| 19. | Shooting – score Sh 3(n) for 3 points | number | 0.01 | + |
| 20. | Free throw- FT(%) | % | 0.01 | + |

The technical skills tests are new for the Bulgarian coaches and competitors and for better clearness and perception of the information, they should be described. The lengths done on the court for indicators: №15 Dribble and shooting at high speed – DS(s) (Figure 1) and № 16 Catching and passing, shooting the basket-CPS (s) (Figure 2) depend on the age of the girls. Girls aged U12 do two lengths, U14 - four lengths, and U16 - six lengths.

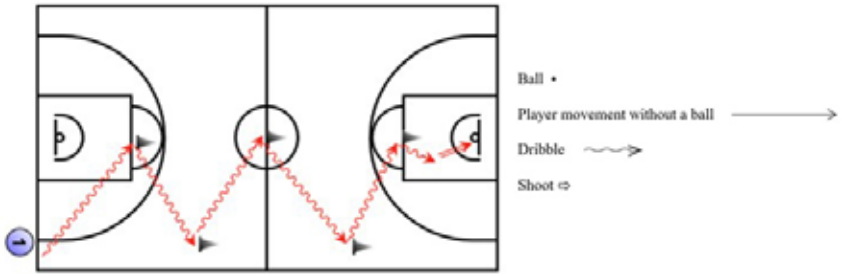


FIGURE 1. Dribble, change of direction at high speed, and shooting while moving


FIGURE 2. Catching, passing on while moving, and shooting while moving

When executing indicator №17 Shooting – time – Sh(s); №18 Shooting – score - Sh 2(n) for two points and №19 Shooting – score Sh 3(n) for three points, the player shoots for one minute without a passer Sh(s), U12 make ten 2-pointers, while U14 and U16 make five 2-pointers and five 3-pointers (Figure 3).

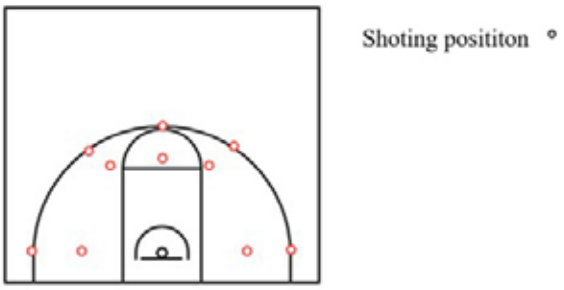


FIGURE 3. Shooting into the basket for one minute from five positions for three points and five positions for two points

For the realization of the purpose and tasks set for the study, the following methods of research were applied: a survey study of the specific literature and sport-pedagogical testing.

*Statistics*

All statistical operations were carried out by applying the Microsoft® Office Excel 2010 and mathematical-statistical processing with SPSS for Windows, Release 23. depending on the tasks of the research the following statistical method was applied: variation analysis, ANOVA test (Fcritical=3.34), and Factor analysis and Index method. To achieve more effective control, 50 rate normative system will be developed for the test battery while the normative tables shall be presented respectively by sex and age; for girls up to U12, U14, and up to U16, and for boys up to U12, U14 and U16 (Borukova, 2021).

## Results

Results for the descriptive statistics (Mean and Standard deviation) of the observed characteristics with regard to different ages are shown in Table 2.

**Table 2.** Descriptive Statistics of The Observed Characteristics with Regard to Different Age Groups

| № | Indicators | U12 | U14 | U16 |
|---|---|---|---|---|
| | | Mean ± SD | Mean ± SD | Mean ± SD |
| 1. | Height | 1.56 ±0.079 | 1.66±0.062 | 1.68±0.068 |
| 2. | Weight | 45.88±9.245 | 59.62±11.340 | 62.82±9.129 |
| 3. | Body Mass Index | 18.02±4.507 | 21.46±3.123 | 22.26±3.143 |
| 4. | Horizontal extension | 1.55±0.083 | 1.66±0.064 | 1.69±0.072 |
| 5. | Vertical extension | 2.02±0.103 | 2.14±0.082 | 2.16±0.093 |
| 6. | Chest measurement – Pause | 78.23±7.690 | 86.18±6.369 | 87.86±5.396 |
| 7. | Chest measurement - respiratory difference | 6.46±1.468 | 7.38±1.184 | 7.52±1.259 |
| 8. | Sprint 20 m | 3.40±0.332 | 3.82±0.633 | 3.78±0.189 |
| 9. | Squat jump | 1.65±0.202 | 1.76±0.164 | 1.80±0.221 |
| 10. | Vertical jump | 29.41±6.303 | 32.41±5.377 | 36.78±6.034 |
| 11. | Maximal Vertical jump | 33.00±10.00 | 38.00±6.600 | 44.97±7.108 |
| 12. | Flexibility | 100.64±6.703 | 105.89±7.128 | 109.23±5.714 |
| 13. | "Shuttle" run - 140 m, | 34.43±3.113 | 33.76±1.231 | 32.68±1.938 |
| 14. | Test for swift-moving - Agility | 19.65±1.865 | 18.06±1.154 | 17.06±0.960 |
| 15. | Dribble and shooting at high speed | 28.47±4.391 | 63.94±8.642 | 83.24±6.457 |
| 16. | Catching and passing, shooting the basket | 17.87±3.155 | 30.53±3.116 | 43.06±2.798 |
| 17. | Shooting – time | 53.02±5.146 | 62.96±4.344 | 63.99±8.881 |
| 18. | Shooting – score for 2 points | 2.92±2.003 | 1.10±1.122 | 1.81±1.302 |
| 19. | Shooting – score for 3 points | - | 0.76±0.879 | 1.23±1.103 |
| 20. | Free throw (%) | 44.79±17.309 | 39.18±29.780 | 50.57±24.762 |

Anthropometry established dynamics in the age development of girls of U12, U14, and U16. For all indicators, the greatest increase is observed in the age between 12 and 14. At H (cm) difference is the biggest of almost 10 cm, respectively at HE (cm) and VE (cm) we also have +12 cm and this also affects the change of W(kg) U12 - 45.88±9.24 and U14 - 59.62±11.340 and of BMI (kg/m$^2$) where values of the areas of the normal level of obesity for this age (WHO, 2022) are increased. Higher values are also observed with ChMP (cm), where for U12 - 78.23±7.690 cm and for U14 - 86.18±6.369 cm, the difference in chest measurement ChMD (cm) is increased by nearly 1 cm. In the analysis of Table 2, we see that the dynamics of anthropometry values between U14 and U16 are small. ANOVA test was applied for the comparison of dis-

persion between groups only. With Ftabl=3.34, the high values of F indicate the strong effect of the age factor on the development of basic anthropometric signs in girls.

Physical indicators of preparedness also show a dynamic development within the age of 12 to 14 where average values register the biggest differences. Smooth development for all three age groups was registered in the high jump VJ (cm), the maximum bounce MVJ (cm), and the flexibility F (cm). Indicators also change positively for agility A(s), where for U12 - 19.65±1.865s, for U14 - 18.06±1.154s, and for U16 - 17.06±0.960s, the difference is 1-1.5s and SD decreases with an increase of age. Speed endurance Sr (s) -140 m registers the best improvement between U14 - 33.76±1.231s and U16 - 32.68±1.938s.

Regarding dribble and field shooting technical skills, DS(s) indicators as well as field passing and catching CPS (s) cannot be compared as field lengths performed during the test are different for each age group. In the case of shooting without assistance for 1 minute Sh(s) (Table 2), it is obvious that U12 registers the best results for shooting time Sh(s), (53.02±5.146 s) as well as number of registered baskets (2.92±2.003 n), but

**Table 3.** Factor Analysis Structure Matrix for Each Age Group

| Factor | U12 | | U14 | | U16 | |
|---|---|---|---|---|---|---|
| | Variables | Value | Variables | Value | Variables | Value |
| 1st Factor | Vertical extension | 0.911 | Dribble and shooting at high speed | 0.951 | Vertical extension | 0.979 |
| | Horizontal extension | 0.903 | Horizontal extension | 0.941 | Height | 0.954 |
| | Height | 0.883 | Shooting – time | 0.925 | Horizontal extension | 0.937 |
| | Weight | 0.775 | Free throw | 0.922 | Maximal Vertical jump | 0.826 |
| | Chest measurement – Pause | 0.690 | Vertical jump | 0.778 | | |
| | Maximal Vertical jump | 0.631 | Shooting – score for 2points | 0.743 | | |
| | | | Shooting – score for 3 points | 0.716 | | |
| 2nd Factor | Sprint 20 m | 0.76 | BMI | 0.955 | Shooting – score for 3 points | 0.810 |
| | Squat jump | -0.755 | Weight | 0.879 | Shooting – score for 2points | 0.777 |
| | "Shuttle" run - 140 m | 0.723 | Chest measurement – Pause | 0.821 | | |
| | Vertical jump | -0.614 | | | | |
| | Agility | 0.590 | | | | |
| | BMI | 0.561 | | | | |
| 3rd Factor | Dribble and shooting at high speed | 0.873 | Vertical extension | 0.913 | Weight | 0.923 |
| | Catching and passing, shooting the basket | 0.797 | Height | 0.899 | BMI | 0.905 |
| | | | | | Chest measurement – Pause | 0.876 |
| 4th Factor | Shooting – score for 2points | 0.955 | Agility | -0.884 | Shooting – time | 0.726 |
| | Free throw | 0.504 | Squat jump | 0.691 | Free throw | 0.703 |
| | | | Chest measurement - respiratory | 0.648 | "Shuttle" run - 140 m | 0.689 |
| 5th Factor | Shooting – time | -0.657 | Catching and passing, shooting the basket | 0.774 | Dribble and shooting at high speed | 0.958 |
| 6th Factor | Flexibility | -0.635 | Maximal Vertical jump | 0.842 | Catching and passing, shooting the basket | 0.956 |
| | Chest measurement - respiratory | 0.541 | "Shuttle" run - 140 m | -0.838 | | |
| 7th Factor | | | Sprint 20 m | -0.777 | Squat jump | -0.713 |
| | | | Flexibility | 0.626 | Vertical jump | -0.689 |
| 8th Factor | | | | | Agility | 0.670 |
| | | | | | Sprint 20 m | 0.590 |
| | | | | | Flexibility | 0.852 |
| | | | | | Chest measurement - respiratory | -0.544 |

they shoot for 2 points only. U16 registered most of the total shootings for 2 and for 3 points and they have the highest percentage of registered free throws (50.57±24.762%). In order to have a high percentage of registered free throws proper technique and many shootings are needed.

With the help of the ANOVA test, it was established that the age factor has a moderate influence on the execution and realization of the free throws (F=5.01).

Perhaps distinguish between proficient and non-proficient free throw shooters in 94% of the cases, small changes in their magnitudes may lead to unsuccessful free throw shooting outcomes (Dimitrije, Fry, John, & Michael, 2021).

For all age groups, the factor analysis extracted different numbers of significant factors (Table 3), which cumulatively explained 73.02%, 79.48%, and 82.40% of the variance in U12, U14, and u16. Extracted factor components increase progressively with age, as well as the explained dispersion, which was highest with U16 of 82.40%.

Table 3 shows the structure matrix with the variable saturation for each age group. Measured physical characteristics provide a similar factor structure for each age group. Anthropometric indicators register the greatest availability in the first factor of U12. With U14 in the first factor are the indicators of technical skills in basketball and the vertical jump. With U16 anthropometric indicators that define a bigger maximal vertical jump are included in the first factor. For girls of U12, factor components are 6, the second factor of highest importance contains indicators of physical preparedness, and the third one - technical skills. In the case of U14 number of factors is already 7 the second one being morphological, the third one – anthropometric, and the fourth one defines the place of the physical preparedness for this age group. Eight-factor components are already observed in the case of U16. In the first one, the anthropometric indicators related to body length are a prerequisite for better achievement in the maximal vertical jump. Shooting for 2 and three points is the second component and the third one is related to body weight and measurements. The last eighth component is entirely composed of indicators of physical preparedness.

## Discussion

Research results show that in the case of U12, U14, and U16 the physical development is dynamic, and laws of biological development characteristic for each age are observed. The most dynamic development of all indicators is observed within 12 to 14 years of age and that is also in connection with their age of puberty which is already the age of 14 and 16, in which case unsubstantial changes in the indicators are registered. For a basketball game, it is necessary for female players to be of bigger body height, have longer arms, and be physically stronger because when shooting or mastering the rebound under the basket and when playing defense, they will occupy a larger space and will be more stable in contact play with a defender. Taller players have higher blocking reach, cover wider space by arm span, and possess higher body mass, and absolute strength, which all contribute to successful one-on-one play under the 3.05-m basket (Zaric et al., 2018; Ranisavljev, Mandic, Cosic, Blagojevic, & Dopsaj, 2020).

Dynamic development is also observed in the group of indicators of physical preparedness, assuming that this is also due to the specificity of the training process in basketball. Over 70% of the movements in basketball are of speed-force nature - the lower limbs are most actively involved and to a lesser extent are the upper limbs (Borukova, 2018). Characteristic of the process of basketball training is the increase of lower limbs strength after the age of 14 thus increasing agility and the work for speed endurance.

Regarding indicators of technical skills, it is normal to have the best results with U16. Measured characteristics of the technical skills by age have different structures in the function of the specified factors which, in our opinion is due to the age adaptation to the basketball training process and the sports experience of the people subject of the research. Sports technical qualities have to be perfected in relation to the development of their motive qualities as well (Sergiev, 2019).

The results obtained in this research show that the measured characteristics with regard to different ages have different structures in the function of the specified factors under the influence of different mechanisms with regard to the training process. In the case of U12 girls most important is anthropometric data and that provides an opportunity for a selection to be made of this age. With U14 skills in basketball technique are determined in the first place that is better if HE (cm) and VJ (cm) are of higher values. This will give them the opportunity to dominate in the 1v1 game with both physique and technique.

For U16 body lengths and MVJ (cm) are of decisive importance. The age of 16 sets the beginning of the transition to women's basketball which requires of players to have bigger body heights, be physically stronger, and be excellently trained in the technical aspect. This is a prerequisite for developing their basketball talent in the future. Body height significantly predicts success at FIBA-WWC, suggesting that talent identification and selection could be improved in female basketball (Zaric et al., 2020)

This study examines the hierarchical structure of physical development characteristics, physical preparedness, and technical skills of young female basketball players of U12, U14, and U16, and aims to derive the leading factor components for each age group which enables coaches to predict the development of basketball female players and work purposefully in the process of training. The main findings showed a specific change in the order of the factor components for girls by single age groups.

The research done shows that development of good female basketball players should start with a selection from U12 and up to U14 they should be trained in basketball skills and technique of the game and when the correctly selected girls are already U16 they should have the wanted profile of a basketball player - bigger body height, physically strong body and high level of technical skills. As a main limitation of the study, we can point out the impossibility to conduct the tests with all players taking part in the state championship for the respective age.

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**Conflict of Interest**

The author declares that there is no conflict of interest.

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SportMont

ORIGINAL SCIENTIFIC PAPER

# Motivational Structure for Sports Practice during COVID-19 Pandemic in Professional Football Players

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**Abstract**

Investigating of the athletes' motivation for sports practice is necessary to encourage them to participate in sport, and continue exercising. During the Covid-19 pandemic period due to changes in athletes' routines, the role of motivation to play sports could be even more important. The research aimed to determine the motivation structure for sports practice in football players with the help of factor analysis. The sample of respondents consisted of 360 professional football players (21.71±4.42 years) from the Premier League of Bosnia and Herzegovina. A questionnaire on motivation for sports during the Covid-19 pandemic period was used, consisting of 18 items related to motivation to play sports and modified according to the Participation Motivation Questionnaire (PMQ). A five-point Likert scale was used in the questionnaire. The questionnaire was in electronic form and was sent to the football players via Google form. Factor analysis identified six dimensions: 'Sport success', 'Support', 'Social status', 'Friendship', 'Physical health', and 'Sports activities'. These six dimensions explain the total manifest motivation participation space with 62.26% of the total variance. In conclusion, this study contributed to the understanding of the motivational structure of professional football players for playing sports. That is, the main motivational dimensions for engaging and committing to sports during the Covid-19 pandemic were singled out. This all points to the importance of this research and may serve future studies that will examine the motivational structure of professional athletes.

***Keywords:*** *soccer, senior players, sports motivation, Covid-19 lockdown, factorial analysis, PMQ*

## Introduction

The Covid 19 pandemic has tremendously affected sports around the world. Pandemic has changed the lives of athletes and brought uncertainty regarding the maintenance of training, and postponing sports events (Mon-López, de la Rubia, Hontoria, & Refoyo, 2020; Parm, Aluoja, Tomingas, & Tamm, 2021). The outbreak of the Covid-19 caused significant changes also in football, such as the suspension of leagues, isolation of players, individual training, etc. (Brooks et al., 2020).

During the Covid-19 lockdown, many teams have designed home training programs for their players, which included physical, technical, and tactical preparation (Peña et al., 2021). Although coaches struggled to make training plans and programs, athletes trained mostly at home alone without supervision (Sarto et al., 2020) which made it difficult to conduct training. It is noticeable that home-based training faces more challenges such as inappropriate training conditions, poorly organized training, movement restriction, and lack of communication with coaches (Jukic et al., 2020) which can negatively affect the motivation of football players to carry out sports activities.

Motivation is a fundamental factor that encourages the participation of athletes in sports activities (Roychovdhury, 2018), and affects success in sports (Bollok, Takacs, Kalmar, & Dobay, 2011). Motivation can be either intrinsic or extrinsic, and in sports intrinsic factors (excitement of the sport, personal ac-

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complishment, improving skills) are considered more important, and athletes who show inner (intrinsic) motivation enjoy the sports activity and performance itself, and this is what gives them pleasure. For extrinsic or external motivation, participation in sports is determined by the acquisition of some benefits that can be of a material (e.g. monetary reward) or social nature (e.g. status) (Đurović, Veljković, & Petrović, 2020). Although early theories in the field of motivation assumed that total motivation represents the sum of internal and external motivation, today it is recognized that this relationship is much more complex than originally thought (Mladenović & Trunić, 2011). Athletes with high intrinsic motivation have better self-appreciation and are more successful in their activities compared with their intrinsically less motivated mates. On the whole, task-oriented, environment-motivates athletes, in addition to being able to afford higher performance levels, are not adversely affected by a long preparation. On the other hand, ego-oriented individuals compare their abilities with those of others or, if they have to perform well, they become overwhelmed by worries and tension (Bollók, Takács, Kalmár, & Dobay, 2011; Vlachopoulos, Karageorghis, & Terry, 2000). Therefore, the motivational structure should be analyzed to determine which factors are dominant in playing professional sports.

Although many authors have assessed motivation for sport in a variety of sports in both young and older athletes (Trembath et al., 2002; Jones, Mackay, & Peters, 2006; Moradi, Bahrami, & Dana, 2020), a small number of authors tried to determine the motivational structure, and they were mostly based on younger athletes and recreational athletes. In these studies, the number of factors identified through factor analysis has varied depending on the sample under investigation (Gill et al., 1983; Buonamano, Cei, & Mussino, 1995; Koivula, 1999; Jones, Mackay, & Peters, 2006). Therefore, the authors recommend identification of motivation dimensions for different samples (Jones et al., 2006). Also, it should be added that no studies have been found that have established a motivational structure for playing sports in adult professional football players, hence the need for this study.

In the Covid-19 pandemic period due to changes in athletes' routines such as reduced training and increased uncertainty in setting goals, the role of motivation to play sports could be more significant (Tingaz, 2021). It is not surprising that the authors deal with the topic of sports motivation during a specific Covid-19 period (Ruffault, Bernier, Fournier, & Hauw, 2020; Leyton-Román, de la Vega, & Jiménez-Castuera, 2021; Rozmiarek, et al., 2022). In this regard, the research aimed to determine the motivation structure for sports practice during the Covid-19 Pandemic in football players with the help of factor analysis. This will contribute to the understanding of the factorial structure for motivation and commitment to sports practice with professional athletes, and highlight which motivational dimensions are important for playing sports.

## Method

*Subjects*

The sample of respondents consisted of 360 professional football players from the Premier League of Bosnia and Herzegovina (21.71±4.42 yrs) who stated that they trained an average of 113.60±42.43 min/day during 5.38±.95 day/weeks in Covid-19 lockdown. All the football players involved were healthy, without serious injuries and they have been training for over 5 years. Ethical review and approval required for the study on human participants in accordance with the local legislation and institutional requirements. Before participation, experimental procedures were explained to all the participants. The research was conducted in accordance with the Declaration of Helsinki.

*Measurements*

A questionnaire on motivation for participation in sport, and keeping up exercise during the Covid-19 pandemic was used, consisting of 18 items related to motivation to play sports and modified according to PMQ (Gill, Gross, & Huddleston, 1983; Zahariadis & Biddle, 2000). A five-point Likert scale was used in the questionnaire, and responses were identified as 'very important', 'important', 'somewhat important', 'unimportant', and 'not at all important' (Joshi, Kale, Chandel, & Pal, 2015). The questionnaire was in electronic form and was sent to the football players via Google form.

*Statistics*

Factor analysis was used to examine the internal structure of the questionnaire for motivation in sports participation. The Kaiser-Meyer-Olkin Measure and Bartlett's Test of Sphericity were computed to determine whether the data were suitable for factor analysis. The Guttman-Kaiser criterion was used to determine the number of significant main components, according to the criteria of factor loadings above 0.30, and eigenvalues above 1.0 are isolated (Ntoumanis, 2001). The magnitude of the relative contribution of each isolated factor in explaining the variance of the whole system of manifest variables is shown as a percentage. Pearson Correlation Coefficients between motivation participant factors will be used. The data were analyzed using the statistical package SPSS version 26.0 (SPSS Inc., Armonk, NY, USA).

## Results

Table 1 shows the results of the Bartlett test ($\chi 2$=1522.015; df=153; p<.000) and the Kaiser-Meyer-Olkin index (KMO=.788), which exceeds the recommended value of 0.6 (Kaiser, 1974) showing that the correlation matrix is suitable for conducting factor analysis.

According to Kaiser-Guttman's criterion, six factors were retained (Table 2), whose eigenvalues are greater than 1.00, which

**Table 1.** KMO and Bartlett's Test

| Variables | | Value |
|---|---|---|
| Kaiser-Meyer-Olkin Measure | | .788 |
| Bartlett's Test of Sphericity | | |
| | Approx. Chi-Square | 1522.015 |
| | df | 153 |
| | Sig. | .000 |

explains the total manifest motivational space with 62.26% of the total variance. The individual contribution for the first main component is 24.64%, for the second 10.23%, for the third 7.93%, for the fourth 7.33, for the fifth 6.51, and the sixth 5.63%. Rotation was performed with hair direct oblimin transformation. It is evident that the first main component carries most of the variance (24.64%), so it can be considered the most significant measure of all applied manifest motivational variables.

**Table 2.** Total Variance Explained

| Factor | Eigenvalue | % of variance | Cumulative % |
|---|---|---|---|
| 1 | 4.44 | 24.64 | 24.64 |
| 2 | 1.84 | 10.23 | 34.86 |
| 3 | 1.43 | 7.93 | 42.79 |
| 4 | 1.32 | 7.33 | 50.12 |
| 5 | 1.17 | 6.51 | 56.63 |
| 6 | 1.01 | 5.63 | 62.26 |

In Table 3, the variables were grouped into six factors based on their calculated factor weights. The first main component can be defined as a factor of success (Sport success) because the largest projections have the same variables: 'like to compete', 'want to play at a higher level', 'like the rewards', and 'like the sport challenge'. The second main component (Support), which is isolated from the residual variability of all applied motivational variables, has significant projections of the variable: 'need support from colleges', 'need support from coach', and 'wished for socializing with colleagues'. On the third main component (Social status), significant projections have variables: 'want to be popular', and 'want to gain status'. On the fourth (Friendship) significant projection the variables are: 'like to meet new friends', 'like the teamwork', 'like being on a team', and 'like the excitement'. On the fifth (Physical health) significant projections have variables: 'want to be healthy', and 'want to stay in shape'. On the sixth (Sports activities) significant projections we have variables: 'wished of group training', 'wished of friendly games', and 'wished of officially games'.

In table 4, based on Pearson Correlation Coefficients, it is noticeable that motivation participant constructs correlate weakly with each other (.01-.28).

**Table 3.** Factorial Structure for the Variable Solution (18 items) of the Participant Motivation Questionnaire (n = 360)

| | Factor Pattern Matrix | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Sport success | | | | | | |
| like to compete | .77 | | | | | |
| want to play at a higher level | .68 | | | | | |
| like the rewards | .64 | | | | | |
| like the sport challenge | .58 | | | | | |
| Support | | | | | | |
| need support from colleges | | .90 | | | | |
| need support from a coach | | .88 | | | | |
| wished for socializing with colleagues | | .34 | | | | |
| Social status | | | | | | |
| want to be popular | | | .90 | | | |
| want to gain status | | | .75 | | | |
| Friendship | | | | | | |
| like to meet new friends | | | | -.73 | | |
| like the teamwork | | | | -.72 | | |
| like being on a team | | | | -.60 | | |
| like the excitement | | | | -.39 | | |
| Physical health | | | | | | |
| want to be healthy | | | | | .84 | |
| want to stay in shape | | | | | .57 | |
| Sport activity | | | | | | |
| wished of group training | | | | | | .71 |
| wished of friendly games | | | | | | .68 |
| wished of official games | | | | | | .66 |

**Table 4.** Pearson Correlation Coefficients between Motivation Participant Questionnaire Constructs

| Component | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 2 | .06 | | | | |
| 3 | .18 | -.09 | | | |
| 4 | -.22 | -.18 | -.11 | | |
| 5 | .16 | .01 | .08 | -.07 | |
| 6 | .28 | .13 | .01 | -.24 | .16 |

## Discussion

This study aims to make a specific contribution in an attempt to determine the internal structure of motivation and commitment to sports practice during the Covid-19 pandemic in professional football players and to highlight which motivational dimensions are important for playing sports. Factor analysis identified six dimensions: 'Sport success', 'Support', 'Social status', 'Friendship', 'Physical health', and 'Sports activities'. This corresponds to previous studies where mostly basic 6 to 8 factor structures have been found (Fabrigar, Wegener, MacCallum, & Strahan, 1999; Jones et al., 2006).

When analyzing the isolated dimensions, it is noticeable that they correspond to the factors that have been isolated in previous studies. Thus 'Success', corresponds to 'Achievement status' (Bačanac et al., 1994); 'Social status' corresponds to 'Reward/status' (Jones et al., 2006); 'Friendship' is also found in the study (Jones et al., 2006); and suits as a 'Team' (Bačanac et al., 1994); while 'Physical health' corresponds to 'Physical fitness' (Gill, 1983; Bačanac et al., 1994; Jones et al., 2006). Although the factors mostly correspond to previous studies, it should be noted that some items in one paper may belong to one category (factor), and the same statement in another study belongs to another factor.

It should be added that in our study, two other factors were singled out, such as 'Support', which refers to support during the Covid-19 pandemic, and 'Sports Activities', which refers to items related to the fact that athletes wanted to return to training and competition activities. As this is a modified version of the PMQ questionnaire, several different claims are consistent with the Covid-19 pandemic situation, and in this regard, it is clear why these two separate factors do not meet in previous studies.

It is evident that the first factor 'Sport success' carries most of the variance (24.64%), so it can be considered the most significant measure of all applied manifest motivational variables. This factor is defined by motives such as 'like to compete', 'want to play at a higher level', 'like the rewards', and 'like the sport challenge', which are the main motivation for participation in adult professional footballers. This is not in line with the studies of the authors (Gould et al., 1985; Frederick and Rian, 1993) which state that competitors in sports rated 'Skills development' as their primary motivator. It can be seen here that although they are adult professional athletes, there are different motivational structures, which is in line with (Jones et al., 2006) which indicate different motivational dimensions in different athletes. The second factor was 'Support', which corresponds to the given situation in which the athletes found themselves, so their need for support is understandable to easily overcome the given situation. The other 4 factors explain a smaller part of the variance, but they are not negligible.

The limitations of this study can be reflected in a smaller number of items in the questionnaire, so the recommendations for further research would be to take into account more claims that will more fully examine the motivational structure for playing sports.

## Conclusion

In conclusion, this study contributed to the understanding of the motivational structure of professional football players for playing sports. That is, the main motivational dimensions for engaging and committing to sports during the Covid-19 pandemic were singled out. Factor analysis identified six dimensions: 'Sport success', 'Support', 'Social status', 'Friendship', 'Physical health', and 'Sports activities'. Previous researches have determined the motivational structure of various athletes, but they have not dealt with professional senior football players. It should also be noted that the motivational structure was examined during the Covid-19 lockdown, in a period when the routine of athletes was changed, which could have affected their motivation. This all points to the importance of this research and may serve future studies that will examine the motivational structure of professional athletes.

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**Conflict of Interest**
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Revised September 2019

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Number (Arabic numerals) the pages consecutively (centering at the bottom of each page), beginning with the title page as page 1 and ending with the Figure legend page.

Include line numbers (continuous) for the convenience of the reviewers.

Apart from chapter headings and sub-headings avoid any kind of formatting in the main text of the manuscripts.

### 1.2. Type & Length

SM publishes following types of papers:

Original scientific papers are the results of empirically- or theoretically-based scientific research, which employ scientific methods, and which report experimental or observational aspects of sports science and medicine, such as all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side. Descriptive analyses or data inferences should include rigorous methodological structure as well as sound theory. Your manuscript should include the following sections: Introduction, Methods, Results, and Discussion.

☑Open Submissions ☑Indexed ☑Peer Reviewed

Original scientific papers should be:

- Up to 3000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 30;
- Maximum combined total of 6 Tables/Figures.

Review papers should provide concise in-depth reviews of both established and new areas, based on a critical examination

of the literature, analyzing the various approaches to a specific topic in all aspects of sports science and medicine, such as all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

☑Open Submissions ☑Indexed ☑Peer Reviewed

Review papers should be:

- Up to 6000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 100.

Editorials are written or commissioned by the editors, but suggestions for possible topics and authors are welcome. It could be peer reviewed by two reviewers who may be external or by the Editorial Board.

☐Open Submissions ☑Indexed ☑Peer Reviewed

Editorials should be:

- Up to 1000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 10.

Short reports of experimental work, new methods, or a preliminary report can be accepted as two page papers. Your manuscript should include the following sections: Introduction, Methods, Results, and Discussion.

☑Open Submissions ☑Indexed ☑Peer Reviewed

Short reports should be:

- Up to 1500 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 15.

Peer review - fair review provides authors who feel their paper has been unfairly rejected (at any journal) the opportunity to share reviewer comments, explain their concerns, and have their paper reviewed for possible publication in SM.

☑Open Submissions ☑Indexed ☐Peer Reviewed

Peer review - fair review should be:

- Up to 1500 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 15.

Invited papers and award papers include invited papers from authors with outstanding scientific credentials. Nomination of invited authors is at the discretion of the SM editorial board. SM also publishes award papers selected by the scientific committee of the International Scientific Conference on Transformation Processes in Sport.

☐Open Submissions ☑Indexed ☐Peer Reviewed

Invited papers and award papers should be:

- Up to 3000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 30;
- Maximum combined total of 6 Tables/Figures.

## 1.3. Submission

SM only accepts electronic submission to the e-mail of the Journal Office: **sportmont@ucg.ac.me**.

Submitted material includes:

- A manuscript prepared according to the Guidelines for the Authors;
- A signed form that states the study was not previously published, nor has been submitted simultaneously for consideration of publication elsewhere, that states that all of the authors are in agreement with submission of the manuscript to SM, and that, for studies that use animal or human individuals, authors must include information regarding their institution's ethics committee, and which identifies the official approval number;
- A signed form that there is no conflict of interest.

Name the files according to the family name of the first author. Authors submitting revised versions of the manuscript can use the identification number of their manuscript as provided by the Journal Office. *See* example:

- ✓ FAMILY NAME-manuscript.doc – (main manuscript file)
- ✓ FAMILY NAME-statement.PDF – (authorship statement)
- ✓ FAMILY NAME-declaration.PDF – (declaration of potential conflict of interest)
- ✓ FAMILY NAME-fig1.tiff – (Figure 1)

## 1.4. Peer Review Process

A manuscript submitted for publication will be submitted to the review process as long as it fits the following criteria:

- The study was not previously published, nor has been submitted simultaneously for consideration of publication elsewhere;
- All persons listed as authors approved its submission to SM;
- Any person cited as a source of personal communication has approved the quote;
- The opinions expressed by the authors are their exclusive responsibility;
- The author signs a formal statement that the submitted manuscript complies with the directions and guidelines of SM.

The editors-in-chief and associate editors will make a preliminary analysis regarding the appropriateness, quality, originality and written style/grammar of the submitted manuscript. The editors reserve the right to request additional information, corrections, and guideline compliance before they submit the manuscript to the ad-hoc review process.

SM uses ad-hoc reviewers, who volunteer to analyze the merit of the study. Typically, one or two expert reviewers are consulted in a double-blind process. Authors are notified by e-mail when their submission has been accepted (or rejected). Minor changes in the text may be made at the discretion of the editors-in-chief and/or associate editors. Changes can include spelling and grammar in the chosen language, written style, journal citations, and reference guidelines. The author is notified of changes via email. The final version is available to the author for his or her approval before it is published.

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SM only publishes studies that have been approved by an institutional ethics committee (when a study involves humans or animals). Fail to provide such information prevent its publication. To ensure these requirements, it is essential that submission documentation is complete. If you have not completed this step yet, go to SM website and fill out the two required documents: Declaration of Potential Conflict of Interest and Authorship Statement. Whether or not your study uses humans or animals, these documents must be completed and signed by all authors and attached as supplementary files in the originally submitted manuscript.

## 1.6. After Acceptance

After the manuscript has been accepted, authors will receive a PDF version of the manuscripts for authorization, as it should look in printed version of SM. Authors should carefully check for omissions. Reporting errors after this point will not be possible and the Editorial Board will not be eligible for them.

Should there be any errors, authors should report them to the Office e-mail address **sportmont@ucg.ac.me**. If there are not any errors authors should also write a short e-mail stating that they agree with the received version.

## 1.7. Code of Conduct Ethics Committee of Publications


SM is hosting the Code of Conduct Ethics Committee of Publications of the **COPE** (the Committee on Publication Ethics), which provides a forum for publishers and Editors of scientific journals to discuss issues relating to the integrity of the work submitted to or published in their journals.

# *2. MANUSCRIPT STRUCTURE*

## 2.1. Title Page

The first page of the manuscripts should be the title page, containing: title, type of publication, running head, authors, affiliations, corresponding author, and manuscript information. *See* example:

Body Composition of Elite Soccer Players from Montenegro

Original Scientific Paper

Elite Soccer Players from Montenegro

Dusko Bjelica[1]

[1]Univeristy of Montenegro, Faculty for Sport an Physical Education, Niksic, Montenegro

Corresponding author:

*Dusko Bjelica*

*University of Montenegro*

*Faculty for Sport and Physical Education*

*Narodne omladine bb, 81400 Niksic, Montenegro*

*E-mail: sportmont@t-com.me*

Word count: 2,946

Abstract word count: 236

Number of Tables: 3

Number of Figures: 0

### 2.1.1. Title

Title should be short and informative and the recommended length is no more than 20 words. The title should be in Title Case, written in uppercase and lowercase letters (initial uppercase for all words except articles, conjunctions, short prepositions no longer than four letters etc.) so that first letters of the words in the title are capitalized. Exceptions are words like: "and", "or", "between" etc. The word following a colon (:) or a hyphen (-) in the title is always capitalized.

### 2.1.2. Type of publication

Authors should suggest the type of their submission.

### 2.1.3. Running head

Short running title should not exceed 50 characters including spaces.

### 2.1.4. Authors

The form of an author's name is first name, middle initial(s), and last name. In one line list all authors with full names separated by a comma (and space). Avoid any abbreviations of academic or professional titles. If authors belong to different institutions, following a family name of the author there should be a number in superscript designating affiliation.

#### 2.1.5. Affiliations

Affiliation consists of the name of an institution, department, city, country/territory (in this order) to which the author(s) belong and to which the presented / submitted work should be attributed. List all affiliations (each in a separate line) in the order corresponding to the list of authors. Affiliations must be written in English, so carefully check the official English translation of the names of institutions and departments.

Only if there is more than one affiliation, should a number be given to each affiliation in order of appearance. This number should be written in superscript at the beginning of the line, separated from corresponding affiliation with a space. This number should also be put after corresponding name of the author, in superscript with no space in between.

If an author belongs to more than one institution, all corresponding superscript digits, separated with a comma with no space in between, should be present behind the family name of this author.

In case all authors belong to the same institution affiliation numbering is not needed.

Whenever possible expand your authors' affiliations with departments, or some other, specific and lower levels of organization.

#### 2.1.6. Corresponding author

Corresponding author's name with full postal address in English and e-mail address should appear, after the affiliations. It is preferred that submitted address is institutional and not private. Corresponding author's name should include only initials of the first and middle names separated by a full stop (and a space) and the last name. Postal address should be written in the following line in sentence case. Parts of the address should be separated by a comma instead of a line break. E-mail (if possible) should be placed in the line following the postal address. Author should clearly state whether or not the e-mail should be published.

#### 2.1.7. Manuscript information

All authors are required to provide word count (excluding title page, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References), the Abstract word count, the number of Tables, and the number of Figures.

## 2.2. Abstract

The second page of the manuscripts should be the abstract and key words. It should be placed on second page of the manuscripts after the standard title written in upper and lower case letters, bold.

Since abstract is independent part of your paper, all abbreviations used in the abstract should also be explained in it. If an abbreviation is used, the term should always be first written in full with the abbreviation in parentheses immediately after it. Abstract should not have any special headings (e.g., Aim, Results…).

Authors should provide up to six key words that capture the main topics of the article. Terms from the Medical Subject Headings (MeSH) list of Index Medicus are recommended to be used.

Key words should be placed on the second page of the manuscript right below the abstract, written in italic. Separate each key word by a comma (and a space). Do not put a full stop after the last key word. *See* example:

**Abstract**

Results of the analysis of

***Key words:*** *spatial memory, blind, transfer of learning, feedback*

## 2.3. Main Chapters

Starting from the third page of the manuscripts, it should be the main chapters. Depending on the type of publication main manuscript chapters may vary. The general outline is: Introduction, Methods, Results, Discussion, Acknowledgements

(optional), Conflict of Interest (optional). However, this scheme may not be suitable for reviews or publications from some areas and authors should then adjust their chapters accordingly but use the general outline as much as possible.

#### 2.3.1. Headings

Main chapter headings: written in bold and in Title Case. *See* example:

- ✓ **Methods**

Sub-headings: written in italic and in normal sentence case. Do not put a full stop or any other sign at the end of the title. Do not create more than one level of sub-heading. *See* example:

- ✓ *Table position of the research football team*

#### 2.3.2 Ethics

When reporting experiments on human subjects, there must be a declaration of Ethics compliance. Inclusion of a statement such as follow in Methods section will be understood by the Editor as authors' affirmation of compliance: "This study was approved in advance by [name of committee and/or its institutional sponsor]. Each participant voluntarily provided written informed consent before participating." Authors that fail to submit an Ethics statement will be asked to resubmit the manuscripts, which may delay publication.

#### 2.3.3 Statistics reporting

SM encourages authors to report precise p-values. When possible, quantify findings and present them with appropriate indicators of measurement error or uncertainty (such as confidence intervals). Use normal text (i.e., non-capitalized, non-italic) for statistical term "p".

#### 2.3.4. 'Acknowledgements' and 'Conflict of Interest' (optional)

All contributors who do not meet the criteria for authorship should be listed in the 'Acknowledgements' section. If applicable, in 'Conflict of Interest' section, authors must clearly disclose any grants, financial or material supports, or any sort of technical assistances from an institution, organization, group or an individual that might be perceived as leading to a conflict of interest.

## 2.4. References

References should be placed on a new page after the standard title written in upper and lower case letters, bold.

All information needed for each type of must be present as specified in guidelines. Authors are solely responsible for accuracy of each reference. Use authoritative source for information such as Web of Science, Medline, or PubMed to check the validity of citations.

#### 2.4.1. References style

SM adheres to the American Psychological Association 6th Edition reference style. Check "American Psychological Association. (2009). Concise rules of APA style. American Psychological Association." to ensure the manuscripts conform to this reference style. Authors using EndNote® to organize the references must convert the citations and bibliography to plain text before submission.

#### 2.4.2. Examples for Reference citations

One work by one author

- ✓ In one study (Reilly, 1997), soccer players
- ✓ In the study by Reilly (1997), soccer players
- ✓ In 1997, Reilly's study of soccer players

Works by two authors

- ✓ Duffield and Marino (2007) studied
- ✓ In one study (Duffield & Marino, 2007), soccer players
- ✓ In 2007, Duffield and Marino's study of soccer players

Works by three to five authors: cite all the author names the first time the reference occurs and then subsequently include only the first author followed by et al.

- ✓ First citation: Bangsbo, Iaia, and Krustrup (2008) stated that
- ✓ Subséquent citation: Bangsbo et al. (2008) stated that

Works by six or more authors: cite only the name of the first author followed by et al. and the year

- ✓ Krustrup et al. (2003) studied
- ✓ In one study (Krustrup et al., 2003), soccer players

Two or more works in the same parenthetical citation: Citation of two or more works in the same parentheses should be listed in the order they appear in the reference list (i.e., alphabetically, then chronologically)

- ✓ Several studies (Bangsbo et al., 2008; Duffield & Marino, 2007; Reilly, 1997) suggest that

**2.4.3. Examples for Reference list**

Journal article (print):

Nepocatych, S., Balilionis, G., & O'Neal, E. K. (2017). Analysis of dietary intake and body composition of female athletes over a competitive season. *Montenegrin Journal of Sports Science and Medicine, 6*(2), 57-65. doi: 10.26773/mjssm.2017.09.008

Duffield, R., & Marino, F. E. (2007). Effects of pre-cooling procedures on intermittent-sprint exercise performance in warm conditions. *European Journal of Applied Physiology, 100*(6), 727-735. doi: 10.1007/s00421-007-0468-x

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Bangsbo, J. (2003). The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Medicine and Science in Sports and Exercise, 35*(4), 697-705. doi: 10.1249/01.MSS.0000058441.94520.32

Journal article (online; electronic version of print source):

Williams, R. (2016). Krishna's Neglected Responsibilities: Religious devotion and social critique in eighteenth-century North India [Electronic version]. *Modern Asian Studies, 50*(5), 1403-1440. doi:10.1017/S0026749X14000444

Journal article (online; electronic only):

Chantavanich, S. (2003, October). Recent research on human trafficking. *Kyoto Review of Southeast Asia, 4*. Retrieved November 15, 2005, from http://kyotoreview.cseas.kyoto-u.ac.jp/issue/issue3/index.html

Conference paper:

Pasadilla, G. O., & Milo, M. (2005, June 27). *Effect of liberalization on banking competition*. Paper presented at the conference on Policies to Strengthen Productivity in the Philippines, Manila, Philippines. Retrieved August 23, 2006, from http://siteresources.worldbank.org/INTPHILIPPINES/Resources/Pasadilla.pdf

Encyclopedia entry (print, with author):

Pittau, J. (1983). Meiji constitution. In *Kodansha encyclopedia of Japan* (Vol. 2, pp. 1-3). Tokyo: Kodansha.

Encyclopedia entry (online, no author):

Ethnology. (2005, July). In *The Columbia encyclopedia* (6th ed.). New York: Columbia University Press. Retrieved November 21, 2005, from http://www.bartleby.com/65/et/ethnolog.html

Thesis and dissertation:

Pyun, D. Y. (2006). *The proposed model of attitude toward advertising through sport.* Unpublished Doctoral Dissertation. Tallahassee, FL: The Florida State University.

Book:

Borg, G. (1998). *Borg's perceived exertion and pain scales*: Human kinetics.

Chapter of a book:

Kellmann, M. (2012). Chapter 31-Overtraining and recovery: Chapter taken from Routledge Handbook of Applied Sport Psychology ISBN: 978-0-203-85104-3 *Routledge Online Studies on the Olympic and Paralympic Games* (Vol. 1, pp. 292-302).

Reference to an internet source:

Agency. (2007). Water for Health: Hydration Best Practice Toolkit for Hospitals and Healthcare. Retrieved 10/29, 2013, from www.rcn.org.uk/newsevents/hydration

## 2.5. Tables

All tables should be included in the main manuscript file, each on a separate page right after the Reference section.

Tables should be presented as standard MS Word tables.

Number (Arabic) tables consecutively in the order of their first citation in the text.

Tables and table headings should be completely intelligible without reference to the text. Give each column a short or abbreviated heading. Authors should place explanatory matter in footnotes, not in the heading. All abbreviations appearing in a table and not considered standard must be explained in a footnote of that table. Avoid any shading or coloring in your tables and be sure that each table is cited in the text.

If you use data from another published or unpublished source, it is the authors' responsibility to obtain permission and acknowledge them fully.

### 2.5.1. Table heading

Table heading should be written above the table, in Title Case, and without a full stop at the end of the heading. Do not use suffix letters (e.g., Table 1a, 1b, 1c); instead, combine the related tables. *See* example:

- ✓ **Table 1.** Repeated Sprint Time Following Ingestion of Carbohydrate-Electrolyte Beverage

### 2.5.2. Table sub-heading

All text appearing in tables should be written beginning only with first letter of the first word in all capitals, i.e., all words for variable names, column headings etc. in tables should start with the first letter in all capitals. Avoid any formatting (e.g., bold, italic, underline) in tables.

### 2.5.3. Table footnotes

Table footnotes should be written below the table.

General notes explain, qualify or provide information about the table as a whole. Put explanations of abbreviations, symbols, etc. here. General notes are designated by the word *Note* (italicized) followed by a period.

- ✓ *Note.* CI: confidence interval; Con: control group; CE: carbohydrate-electrolyte group.

Specific notes explain, qualify or provide information about a particular column, row, or individual entry. To indicate specific notes, use superscript lowercase letters (e.g. [a, b, c]), and order the superscripts from left to right, top to bottom. Each table's first footnote must be the superscript [a].

- ✓ [a]One participant was diagnosed with heat illness and n = 19.[b]n =20.

Probability notes provide the reader with the results of the texts for statistical significance. Probability notes must be indicated with consecutive use of the following symbols: * † ‡ § ¶ || etc.

- ✓ *P<0.05,†p<0.01.

### 2.5.4. Table citation

In the text, tables should be cited as full words. *See* example:

- ✓ Table 1 (first letter in all capitals and no full stop)
- ✓ ...as shown in Tables 1 and 3. (citing more tables at once)
- ✓ ...result has shown (Tables 1-3) that... (citing more tables at once)
- ✓ ....in our results (Tables 1, 2 and 5)... (citing more tables at once)

## 2.6. Figures

On the last separate page of the main manuscript file, authors should place the legends of all the figures submitted separately.

All graphic materials should be of sufficient quality for print with a minimum resolution of 600 dpi. SM prefers TIFF, EPS and PNG formats.

If a figure has been published previously, acknowledge the original source and submit a written permission from the copyright holder to reproduce the material. Permission is required irrespective of authorship or publisher except for documents in the public domain. If photographs of people are used, either the subjects must not be identifiable or their pictures must be accompanied by written permission to use the photograph whenever possible permission for publication should be obtained.

Figures and figure legends should be completely intelligible without reference to the text.

The price of printing in color is 50 EUR per page as printed in an issue of SM.

#### 2.6.1. Figure legends

Figures should not contain footnotes. All information, including explanations of abbreviations must be present in figure legends. Figure legends should be written bellow the figure, in sentence case. *See* example:

- ✓ **Figure 1.** Changes in accuracy of instep football kick measured before and after fatigued. SR – resting state, SF – state of fatigue, *p>0.01, †p>0.05.

#### 2.6.2. Figure citation

All graphic materials should be referred to as Figures in the text. Figures are cited in the text as full words. *See* example:

- ✓ Figure 1
  - × figure 1
  - × Figure 1.
  - ✓ ….exhibit greater variance than the year before (Figure 2). Therefore…
  - ✓ ….as shown in Figures 1 and 3. (citing more figures at once)
  - ✓ ….result has shown (Figures 1-3) that... (citing more figures at once)
  - ✓ ….in our results (Figures 1, 2 and 5)... (citing more figures at once)

#### 2.6.3. Sub-figures

If there is a figure divided in several sub-figures, each sub-figure should be marked with a small letter, starting with a, b, c etc. The letter should be marked for each subfigure in a logical and consistent way. *See* example:

- ✓ Figure 1a
- ✓ …in Figures 1a and b we can…
- ✓ …data represent (Figures 1a-d)…

## 2.7. Scientific Terminology

All units of measures should conform to the International System of Units (SI).

Measurements of length, height, weight, and volume should be reported in metric units (meter, kilogram, or liter) or their decimal multiples.

Decimal places in English language are separated with a full stop and not with a comma. Thousands are separated with a comma.

| Percentage | Degrees | All other units of measure | Ratios | Decimal numbers |
|---|---|---|---|---|
| ✓ 10% | ✓ 10º | ✓ 10 kg | ✓ 12:2 | ✓ 0.056 |
| × 10 % | × 10 º | × 10kg | × 12 : 2 | × .056 |

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

## 2.8. Latin Names

Latin names of species, families etc. should be written in italics (even in titles). If you mention Latin names in your abstract they should be written in non-italic since the rest of the text in abstract is in italic. The first time the name of a species appears in the text both genus and species must be present; later on in the text it is possible to use genus abbreviations. *See* example:

- ✓ First time appearing: *musculus biceps brachii*

Abbreviated: *m. biceps brachii*

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ISSN 1451-7485

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- Community-based dialogue on articles;
- Worldwide media coverage.

SMJ is published three times a year, in February, June and October of each year. SMJ publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Sports Science and Medicine, as well as it can function as an open discussion forum on significant issues of current interest.

SMJ covers all aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

Prospective authors should submit manuscripts for consideration in Microsoft Word-compatible format. For more complete descriptions and submission instructions, please access the Guidelines for Authors pages at the SMJ website: http://www.sportmont.ucg.ac.me/?sekcija=page&p=51. Contributors are urged to read SMJ's guidelines for the authors carefully before submitting manuscripts. Manuscripts submissions should be sent in electronic format to sportmont@ucg.ac.me or contact following Editors:

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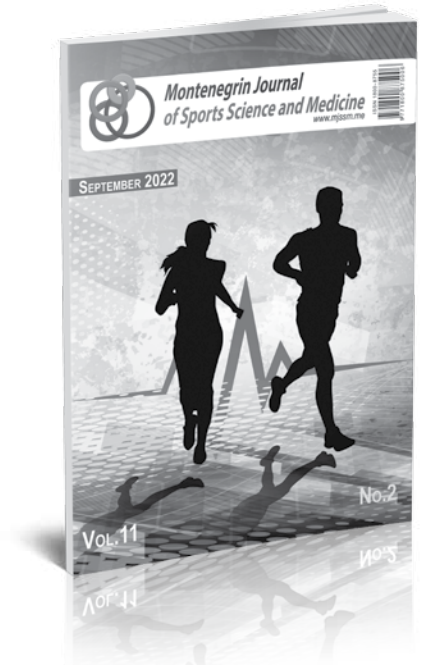
Montenegrin Journal of Sports Science and Medicine

**M**ONTENEGRIN **J**OURNAL
OF **S**PORTS **S**CIENCE
AND **M**EDICINE

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

MJSSM is published biannually, in September and March of each year. MJSSM publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Sports Science and Medicine, as well as it can function as an open discussion forum on significant issues of current interest.

MJSSM covers all aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

Prospective authors should submit manuscripts for consideration in Microsoft Word-compatible format. For more complete descriptions and submission instructions, please access the Guidelines for Authors pages at the MJSSM website: http://www.mjssm.me/?sekcija=page&p=51. Contributors are urged to read MJSSM's guidelines for the authors carefully before submitting manuscripts. Manuscripts submissions should be sent in electronic format to office@mjssm.me or contact following Editors:

Dusko BJELICA, Editor-in Chief – sportmont@t-com.me
Damir SEKULIC, Editor-in Chief – damirsekulic.mjssm@gmail.com

Publication date: Spring issue – March 2023
Autumn issue – September 2023

# Montenegrin Sports Academy welcomes you to *Dubrovnik, Croatia*


www.csakademija.me/conference

## KEY DATES

- **1st of July 2022, 24:00 CET**
  Abstract submission opening and opening of registration
- **1st of December 2022, 24:00 CET**
  Abstract submission deadline
- **15th of January 2023, 24:00 CET**
  Notification to authors about acceptance
- **1st of February 2023, 24:00 CET**
  Deadline for early-bird registration for presenting authors
- **15th of February 2023, 24:00 CET**
  Deadline for late registration for presenting authors

* CET = Central European Time

## CONTACT

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# MSA Dubrovnik 2023

## 20th Annual Scientific Conference of Montenegrin Sports Academy "Sport, Physical Activity and Health: Contemporary Perspectives"

MSA Dubrovnik 2023

## 20th - 23th April 2023

## CONFERENCE VENUE

**Hotel Croatia Cavtat**, situated across the bay from the historic walls of Dubrovnik, Hotel Croatia Cavtat is a leading five-star resort and conference hotel on the southern part of Adriatic. Hotel Croatia's architecture blends seamlessly with its natural surroundings. Shaded by a pine tree forest, while offering spectacular sea views, all 487 accommodation units feature balconies which overlook the Adriatic Sea or Cavtat Bay. State-of-the-art facilities include numerous gourmet restaurants, a spa centre, and private beaches. Hotel Croatia is ideal for a broader experience of the Dubrovnik Riviera. Suited for business and relaxation alike, Hotel Croatia serves as an excellent base for exploring the city of Dubrovnik and the Dubrovnik Riviera.

## WELCOME TO DUBROVNIK

Regardless of whether you are visiting Dubrovnik for the first time or the hundredth, the sense of awe never fails to descend when you set eyes on the beauty of the old town. Indeed it's hard to imagine anyone becoming jaded by the city's white limestone streets, baroque buildings and the endless shimmer of the Adriatic, or failing to be inspired by a walk along the ancient city walls that protected a civilised, sophisticated republic for centuries.

## LANGUAGE

The official Conference language is English.

## FIRST ANNOUNCEMENT

Dear Friends and Colleagues,

Montenegrin Sports Academy will mark its 20th Anniversary by organising the 20th Annual Scientific Conference during 20.-23. April 2023 in Dubrovnik Croatia. The 20th Anniversary Conference will be held in Hotel Croatia, Cavtat.

Reserve your calendars, let us gather in person after these turbulent times and make our conference even more prestigious. Guarantee for our further prosperity is our international partners and Montenegrin Sports Academy. See you in Dubrovnik next spring!

We look forward to seeing you in spring 2023,

Prof. Duško Bjelica, Conference President

## Conference sub-themes include:

Adapted Physical Activity; Anthropology; Architecture and Urbanism; Biochemistry; Biomechanics; Coaching; Economics; Health and Fitness; History; Molecular Biology; Motor Learning; Neuromuscular Physiology; Nutrition; Olympism; Philosophy and Ethics; Physical Education and Pedagogics; Physiology; Physiotherapy; Psychology; Rehabilitation; Sociology; Sport Management and Law; Sport Statistics and Analyses; Sport Technology; Sport Tourism; Sports Medicine and Orthopaedics; Training and Testing; Traumatology; and other Multi- & Interdisciplinary Themes.

## Look inside!

### Montenegrin Journal of Sports Science and Medicine

*Volume 11, 2022, 2 issues per year;*
*Print ISSN: 1800-8755, Online ISSN: 1800-8763*

**www.mjssm.me**


### Sport Mont

*Volume 20, 2019, 3 issues per year;*
*Print ISSN: 1451-7485, Online ISSN: 2337-0351*

**www.sportmont.ucg.ac.me**


### Journal of Anthropology of Sport and Physical Education

*Volume 6, 2022, 4 issues per year;*
*Print ISSN: 2636-569X, Online ISSN: 2536-5703*

**www.jaspe.ac.me**

## CALL FOR ABSTRACTS

Research scholars and students are invited to present their original work in any of the conference sub-themes. The list of the conference sub-themes is not exhaustive and, therefore, authors should not feel limited by them. Authors can submit their original work in the form of an ABSTRACT, free of charge. An author may submit only one abstract as the first author and two abstracts as the co-author. After undergoing the reviewing process, all authors will be notified about the condition of their submission (accepted or rejected). Presenters (= the first authors) must be registered and have paid registration fees for the conference to secure their oral or poster (not debated) presentation during the conference and the publication in Montenegrin Journal of Sports Science and Medicine that is abstracted/indexed in Emerging Sources Citation Index, SCOPUS and other database, under the condition that the first author has paid registration fee.

## CALL FOR PAPERS

Full-length manuscripts may be submitted for publishing in the Sport Mont journal (see at HYPERLINK "http://www.sportmont.ucg.ac.me" www.sportmont.ucg.ac.me), an international peer-reviewed scientific journal, indexed in Scopus, DOAJ, SPORTDiscus, Index Copernicus, ERIH PLUS, et cetera. Full-length paper submission is free of charge but author(s) has to pay additional 50 euros per accepted full-length paper to cover publication costs. Full manuscripts should be submitted for consideration of publication by the 15th of March, 2023 and prepared according to the guidelines for authors.

## REGISTRATION FEES

For participants 260 EUR (220 EUR early-bird)
For students 190 EUR (160 EUR early-bird)
For accompanying persons 140 EUR (110 EUR early-bird)

# MONTENEGRIN SPORTS ACADEMY

Founded in 2003 in Podgorica (Montenegro), the Montenegrin Sports Academy (MSA) is a sports scientific society dedicated to the collection, generation and dissemination of scientific knowledge at the Montenegrin level and beyond.

The Montenegrin Sports Academy (MSA) is the leading association of sports scientists at the Montenegrin level, which maintains extensive co-operation with the corresponding associations from abroad. The purpose of the MSA is the promotion of science and research, with special attention to sports science across Montenegro and beyond. Its topics include motivation, attitudes, values and responses, adaptation, performance and health aspects of people engaged in physical activity and the relation of physical activity and lifestyle to health, prevention and aging. These topics are investigated on an interdisciplinary basis and they bring together scientists from all areas of sports science, such as adapted physical activity, biochemistry, biomechanics, chronic disease and exercise, coaching and performance, doping, education, engineering and technology, environmental physiology, ethics, exercise and health, exercise, lifestyle and fitness, gender in sports, growth and development, human performance and aging, management and sports law, molecular biology and genetics, motor control and learning, muscle mechanics and neuromuscular control, muscle metabolism and hemodynamics, nutrition and exercise, overtraining, physiology, physiotherapy, rehabilitation, sports history, sports medicine, sports pedagogy, sports philosophy, sports psychology, sports sociology, training and testing.

The MSA is a non-profit organization. It supports Montenegrin institutions, such as the Ministry of Education and Sports, the Ministry of Science and the Montenegrin Olympic Committee, by offering scientific advice and assistance for carrying out coordinated national and European research projects defined by these bodies. In addition, the MSA serves as the most important Montenegrin and regional network of sports scientists from all relevant subdisciplines.

The main scientific event organized by the Montenegrin Sports Academy (MSA) is the annual conference held in the first week of April.

Annual conferences have been organized since the inauguration of the MSA in 2003. Today the MSA conference ranks among the leading sports scientific congresses in the Western Balkans. The conference comprises a range of invited lecturers, oral and poster presentations from multi- and mono-disciplinary areas, as well as various types of workshops. The MSA conference is attended by national, regional and international sports scientists with academic careers. The MSA conference now welcomes up to 200 participants from all over the world.

It is our great pleasure to announce the upcoming 19th Annual Scientific Conference of Montenegrin Sports Academy "Sport, Physical Activity and Health: Contemporary Perspectives" to be held in Dubrovnik, Croatia, from 7 to 10 April, 2022. It is planned to be once again organized by the Montenegrin Sports Academy, in cooperation with the Faculty of Sport and Physical Education, University of Montenegro and other international partner institutions (specified in the partner section).


The conference is focused on very current topics from all areas of sports science and sports medicine including physiology and sports medicine, social sciences and humanities, biomechanics and neuromuscular (see Abstract Submission page for more information).

We do believe that the topics offered to our conference participants will serve as a useful forum for the presentation of the latest research, as well as both for the theoretical and applied insight into the field of sports science and sports medicine disciplines.

**USEFUL CONTACTS**

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# Sports Science and Medicine Journals

## from Montenegrin Sports Academy

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

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

# Look Inside!


## Sport Mont Journal

Editors-in-Chief: **Dusko Bjelica**, Montenegro; **Zoran Milosevic**, Serbia
Managing Editor: **Borko Katanic**, Montenegro; **Nedim Covic**, Bosnia and Herzegovina

*Volume 20, 2022, 3 issues per year; Print ISSN: 1451-7485, Online ISSN: 2337-0351*

Sport Mont Journal is a scientific journal that provides: Open-access and freely accessible online; Fast publication time; Peer review by expert, practicing researchers; Post-publication tools to indicate quality and impact; Community-based dialogue on articles; Worldwide media coverage. SMJ is published three times a year, in February, June and October of each year. SMJ publishes original scientific papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers in the fields of Sports Science and Medicine, as well as it can function as an open discussion forum on significant issues of current interest.

**www.sportmont.ucg.ac.me**


## Montenegrin Journal of Sports Science and Medicine

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

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**www.mjssm.me**


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MSA Conference 2023

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# "Sport, Physical Activity and Health: Contemporary perspectives"

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CRNOGORSKA SPORTSKA AKADEMIJA • MONTENEGRIN SPORTS ACADEMY •

20th - 23th April 2023,
Dubrovnik - Croatia