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Editor-in-Chief: **Zoran Milanović**, e-mail: *fupesed@junis.ni.ac.rs*
University of Niš, Faculty of Sport and Physical Education
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**Research article**

# RELATIVE AGE EFFECT CREATES A DISCRIMINATION AND DROPOUT PANDEMIC IN YOUTH FOOTBALL: SHOULD EVERYONE GET THE SAME CHANCE?

*UDC 316.662:796.322*

**Branislav Majkić, Nikola Stojanović, Aleksandra Aleksić-Veljković**

Faculty of Sport and Physical Education, University of Niš, Serbia

ORCID iDs: Branislav Majkić https://orcid.org/0000-0003-3360-097X
Nikola Stojanović https://orcid.org/0000-0002-9921-6391
Aleksandra Aleksić Veljković https://orcid.org/0000-0002-4333-2465

**Abstract.** *The goal of this study was to determine the dropout rate and the difference between football players born in different halves of the year. This study involved 101 sub-elite football players (14.4±2.9 yr, 168.2±9.4 cm, 60.1±5.3 kg, 21.7±2.2 BMI) divided into three age categories and two sub-groups for each of them (U-11a/b, U-14a/b and U-19a/b). The difference between the sub-groups was assessed using the T-test for independent groups and the Mann-Whitney U test with statistical significance set at the p < .05 level. The 10, 20 and 30 m running tests, SJ, CMJ, CMJmax, T-test, 9-3-6-3-9, and Slalom agility tests were used. Statistical difference for U-11 group was obtained for the SJ (p = .002), T-test (p = .012) and 9-3-6-3-9 test (p = .002). In U-14 group the statistical difference is shown in all speed and explosive strength tests (p < .05). Body fat did not show a statistically significant difference between groups while body height, body mass and muscle mass differ at a statistically significant level (p = .017, .041, .0.46, respectively). Compared to younger groups, U-19 group showed a significant difference on T-test and 10 m running (p = .017, .037, respectively). The main limitation is that this is not a longitudinal study with a single group followed throughout the process. In conclusion, it would be desirable for everyone to get an equal chance due to the different speed of development in order to be competent. Further recommendations are to divide youth categories into two separate leagues so that everyone gets the same playing time.*

**Key words:** *peak height velocity, adolescents, soccer, power performance*

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**Corresponding author:** Branislav Majkić
Faculty of Sport and Physical Education, University of Niš, Čarnojevićeva 10A, 18000 Niš, Serbia
E-mail: banesb@live.com

## 1. INTRODUCTION

In almost all sports, including football, when it comes to youth categories, the calendar year is taken as a range for making team selections, with the intention of giving everyone an equal chance (Musch & Grondin, 2001). This way of dividing the players is ignoring the potential differences that may occur between young athletes born in the same year such as power performance or morphological characteristics, thus discriminating against those born later in the year (Fragoso, Massuca, & Ferreira, 2015). It is also the case that in some competitions, athletes are classified into two age groups, which brings the difference between the youngest and the oldest to almost two years. It is, therefore, often seen that the imbalance in the number of players is in favour of those born earlier but the results do not necessarily show that they perform better on the tests (Peña-González et al., 2018). This type of discrimination is common due to the subjective assessment of coaches who tend to give more chances for success to the accelerants, those who entered puberty earlier, or who can currently provide better results regardless of the real potential that players have for the future (Figueiredo et al., 2019).

A problem with RAE is not a new phenomenon. Barnsley, Thompson, & Barnsley (1985) described it first and over the years it has been confirmed in many countries (Bezuglov et al., 2019; Rubajczyk & Rokita, 2018), and in many competitions (Brustio et al., 2018; González-Víllora, Pastor-Vicedo, & Cordente, 2015). In accordance with this is also one Brazilian study that examined data from 202.951 football players that played between 1921 and 1996 and concluded that with every decade RAE showed progressive growth (Costa, Albuquerque, & Garganta, 2012).

As many differences have been noted due to RAE, football players born earlier in the year are more likely to make a better impression on coaches and other sports experts and thus be considered as more talented. Portrayed as better, they can be given more opportunities to succeed by including them earlier in training centers and national teams, which allows them faster development, working with high-level coaches, training with better peers and playing against tougher opponents while using better facilities. During adolescence, younger players may feel inferior because of the lower functional capacities and can be portrayed as weaker and slower (Delorme, Boiché, & Raspaud, 2010b). Because of this, players born closer to a start of the year tend to have more playing time and, consequently, can improve their motivation, competitive skills, emotional stability and teamwork which can help them enhance their development (Baker & Logan, 2007). The consequences of the large number of dropouts in youth football are even visible at the top senior level where we also see an uneven distribution of players born at the beginning and at the end of the year, which can lead to unformed football players being rejected as untalented or not good enough, later resulting in not fulfilling their full potential and reducing the quality of clubs and national teams (Jiménez & Pain, 2008).

Previous research stated that there is a prevalence of football players born in the first quartile of the year in contrast to those born later (Skorski et al., 2016) and that older players often tend to be taller and heavier than their younger peers ($p < .05$) (Carling et al., 2009) and therefore achieve better test scores (Lovell et al., 2015). Much more research states that football players born early have a physical advantage over their peers but the results are not unified since they mostly depend of the participants' age. Peña-González et al. (2018) found moderate effect size body height, In contrast to this, Figueiredo et al. (2019) found almost no significant effect size between players born in different quartiles in 13-year-old male football players in body height and weight (η2 = .08, .05 respectively) and in the counter movement jump, running speed, and endurance (η2 = .01). Lovell et al. (2015) found a prevalence of players born in the first half of the year with most of them born in the first quartile in all the studied categories (U10, U12, U14, U16 & U18). The authors noted moderate effect size for body mass only in the U14 group (η2 = .62; p = .00), while for the rest of the groups the results were trivial or small for this variable. Motor skill tests showed a statistically significant difference in the U14 groups for the 10 m sprint, 20 m sprint, and agility (p – .000, .000, .021, respectively) while there was no difference in other groups between younger and older players.

Although RAE is widely examined, previous research mainly focused on birth quartiles and only one paper examined player differences by dividing them into those born in the first and second part of the year (Peña-González et al., 2021). This paper had 3 age categories but those categories followed one another without taking into account the potential differences of this phenomenon that may appear in ages that are not so close. Based on all of this, the main goal of this study was to determine the dropout rate in the top national youth club and to establish the difference between football players born in different halves of the year in three different age categories.

## 2. The Method

### 2.1. Participants

This study involved 101 sub-elite football players members of the same team playing in the top youth league (14.4±2.9yr, 168.2±9.4cm, 60.1±5.3kg, 21.7±2.2 BMI) divided into three age categories: group 1 (U-11) (n = 33, 11.5±0.2 yr, 145.2±3.1 cm, 41±2.9 kg, 23.3±1.4 BMI), group 2 (U-14) (n = 36, 14±0.4 yr, 168.8±4.2 cm, 59±3.6 kg, 21.4±2.6 BMI), and group 3 (U-19) (n = 32, 18.3±0.2 yr, 180.4±3.7 cm, 72±2.3 kg, 20.5±1.9 BMI) who, at the time of testing, had a training experience of 7.5±4.1 years. All groups were later divided into two sub-groups. The first sub-group included players born in the first half of the year (January 1 – June 30) and the second sub-group included players born in the second part of the year (July 1 – December 31). The youngest group (U-11) for this study was selected because of the fact that it is the first age group that plays 11v11 football on a full-size pitch. The second group (U-14) was selected based on the fact that this is the time period when the players reached adolescence and can show the biggest difference in RAE between accelerants and late bloomers (Vänttinen et al., 2011) because that is a period where peek height velocity (PHV) is near the end for players who started their PHV period earlier (Derman, 2013), and the third group (U-19) was selected because it is the last age category that plays youth football before the first team selection and all of them should exceed their PHV so the RAE should not be as noticeable in this group (Cobley et al., 2009). The consent of all participants (or their parents/guardians if they are underaged) regarding their voluntary participation in this research was obtained. The testing was carried out at the end of the competitive season in accordance with the Declaration of Helsinki and was approved by the Institutional Ethics Committee of the Faculty of Sport and Physical Education, University of Nis, Serbia (protocol code 04-831/1 and date of approval July 4, 2023). The participants were required to restrain from strenuous physical activity for 48h prior to testing.

### 2.2. Procedures

Testing of all groups of participants was done in one day. In the morning (08:00-11:00) body composition and anthropometric characteristics were measured, while in the afternoon (14:00-17:00) motor skills were measured. The participants were asked not to consume food and water for at least 12 hours before the beginning of the body composition measurement. During the first part of measurement, they were minimally clothed and barefoot. The motor skills tests were conducted on a football field with artificial grass, and the participants wore shorts, a t-shirt and football shoes. Before the beginning of the test, all of the participants performed a standard football warm-up lasting for 25 minutes, which consisted of: 10 minutes of aerobic running with dynamic stretching exercises, 5 minutes of warming up passing a ball , then 2x3 minutes of technical-tactical play on a reduced space and finally 1-2 minutes of potentiation exercises (jumps, maximum short sprints).

### 2.3. Anthropometry measurements

The first part of testing involved assessment of body composition using an OMRON® body composition monitor (BF-508). The participants were asked to step barefoot onto the measurement platform and to place feet on the foot electrodes. The participants held the grip electrodes firmly with hand and arms extended straight to their body. As the measurement completed, Body mass (BM), Muscle mass, BMI, body fat (BF) and visceral fat (VF) were subsequently recorded. For body height, the participants stood upright on a flat, firm surface without shoes and with their head in an upright position using a Martin anthropometer, GPM 101 (GPM GmbH Switzerland), accurate to 0.1 cm.

### 2.4. Running speed

Running speed performance was assessed by a linear 30-m sprint test with split times at 10 and 20 m. The participant is in a high start position with one foot just behind the starting line. At the meter's signal, the participant starts and runs the marked distance at maximum speed on a artificial grass surface. It is very important that the participant does not slow down before passing the last gate. Each participant had one attempt and in case of a bad start or interference during the run, a new attempt is allowed after a 2-minute break. The results are automatically stored on the computer. Sprint and split times were measured with four Witty photocell gates (Microgate, Italy), positioned at the starting line, 10 m, 20 m, and finish line (30 m), and all the results were recorded with an accuracy of 0.01 s.

### 2.5. Explosive strength

Explosive strength was assessed based on the squat jump (SJ), counter movement jump (CMJ) and counter movement jump with free arms (CMJmax) using the Optojump (Microgate, Italy) with an accuracy of 0.001 s. The participants performed a standardized warm-up before testing procedure. Jump height was recorded to the nearest 0.1 cm. Each participant had 3 attempts on each test. The pause between each attempt was 2 min.

### 2.6. Agility

Agility was assessed through the T-test, 9-3-6-3-9 and Slalom test. For the agility T-test, the participants began with both feet behind starting point A. At their own discretion, each participant sprinted forward 9.14 m (10 yd) to point B and touched a cone with their right hand. They then shuffled to the left 4.57 m (5 yd) and touched a cone (C) with their left hand. Participants then shuffled to the right 9.14 m and touched a cone (D) with their right hand. They then shuffled to the left 4.57 m back to point B and touched a cone once again, ran backward, passing the finish line at point A. Three test trials were performed, and times were recorded using Witty photocell gates (Microgate, Italy) mounted on a tripod with a height of 0.75 m at the starting line, with an accuracy of 0.01 sec. The second agility test used in this study is the 9-3-6-3-9 test where players run straight the whole time, run 9 m, touch the first cone (A) with one hand, make a 180° left or right turn, run 3 m to the second cone (B), again make a 180° turn, run 6 m (C), then they make another 180° turn, run another 3 m (A) before finally turn the last time and run 9 m to the finish line. The Slalom test is another commonly used agility test because of its simplicity. The task is to run around 6 cones, each one 2 m apart from the previous with the first cone 1 m away from the starting line. The goal is to run between cones, changing direction from right to left until each participant passes the last cone. Then he makes a 180° turn and runs to the starting line in the same pattern between the cones (Sporis et al., 2010).

### 2.7. Statistical analysis

Data analysis was performed with Statistical Package for Social Sciences (SPSS for Windows®, version 26.0.). Descriptive statistics were applied to evaluate the participants' basic characteristics and the Kolmogorov-Smirnov test was applied to confirm normality. The difference between the two sub-groups for every age group was assessed with the T-test for independent samples and when normality of distribution was violated, the Mann-Whitney U test was used. Effects Size (Cohens' *d*) will be determined based on the following <0.2 very small, 0.2-0.5 small, 0.5-0.8 medium and >0.8 large effect size (Cohen, 2013). Statistical significance was set at the $p < .05$ level.

## 3. RESULTS

The difference is noticeable between groups with a progressive increase in the results towards the older categories. The results of field tests clearly show that players in the older categories are better in all parameters than the players from younger categories. The biggest difference is seen on the explosive strength tests where technique and experience on how to produce maximal power is needed with movements not so common in football practice.

In all categories there are more players born in the first half of the year and that percentage is increasing with each category. In the U-11 groups, 54.5% of players are born in the first half while in the oldest category as much as 71.9%. The results given in this table represent the number of male children born in country in the same years as the participants in this study. In contrast to the results in this study, each year there is a prevalence of children born in the second half of the year which is the second sign that football players born in the first half of the year get more chances than their peers.

**Table 1** Anthropological characteristics for the three age groups

| | U-11 (n – 33) | U-14 (n – 36) | U-19 (n – 32) | Mean ± SD |
|---|---|---|---|---|
| BH (cm) | 145.24 ± 3.1 | 168.86 ± 4.2 | 180.42 ± 3.7 | 163.86 ±10,24 |
| BM (kg) | 39.1 ± 2.9 | 53.9 ± 3.6 | 72.3 ± 2.3 | 55.12 ±11.35 |
| BMI | 23.3 ± 1.4 | 21.4 ± 1.6 | 20.9 ± 1.1 | 21.8 ± 1.8 |
| BF (%) | 15.5 ± 3.9 | 12.8 ± 4.3 | 12.9 ± 4.2 | 14.05 ± 4.54 |
| MM (%) | 39.7 ± 1.9 | 40.3 ± 2.1 | 42.5 ± 2.9 | 41.09 ± 2.65 |
| 10 m (s) | 2.03 ± .06 | 1.93 ± .06 | 1.84 ± .04 | 1.91 ± .08 |
| 20 m (s) | 3.67 ± .18 | 3.31 ± .16 | 3.11 ± .08 | 3.32 ± .24 |
| 30 m (s) | 4.99 ± .32 | 4.49 ± .29 | 4.16 ± .78 | 4.51 ± .67 |
| CMJ | 20.42 ± 1.71 | 26.57 ± 4.58 | 33.41 ± 2.71 | 27.74 ± 4.25 |
| CMJmax | 24.98 ± 3.12 | 31.42 ± 4.79 | 40.82 ± 6.62 | 33.64 ± 7.39 |
| SJ | 17.71 ± 2.26 | 24.12 ± 4.25 | 31.53 ± 3.01 | 25.50 ± 5.62 |
| T-test (s) | 12.35 ± .21 | 11.09 ± .58 | 9.41 ± .26 | 10.72 ± .87 |
| 9-3-6-3-9 (s) | 9.79 ± .35 | 8.25 ± .27 | 7.71 ± .34 | 8.84 ± .79 |
| Slalom (s) | 7.90 ± .39 | 7.11 ± .38 | 5.99 ± .31 | 6.85 ± .66 |

*Note*: BH (cm) = body height; BM (kg) – body mass; BMI = body mass index;
BF (%) = body fat percentage; MM (%) = muscle mass percentage; 10 m, 20 m, 30 m = split times for running speed; CMJ = countermovement jump; CMJmax = countermovement jump with arm swing;
SJ = squat jump; T-test, 9-3-6-3-9, Slalom = agility tests

**Table 2** The number of players and number of male children born in each half of the year

| | U-11 | | U-14 | | U-19 | |
|---|---|---|---|---|---|---|
| | U-11a | U-11b | U-14a | U-14b | U-19a | U-19b |
| n | 18 | 15 | 21 | 15 | 23 | 9 |
| pp% | 54,5 | 45,5 | 58,3 | 41,7 | 71,9 | 28,1 |
| nbc | 16993 | 18815 | 16894 | 18329 | 19243 | 21101 |
| bc% | 47,5 | 52,5 | 48 | 52 | 47,7 | 52,3 |

(*Source*: https://www.stat.gov.rs/)
Note: n = number of players born in each half of the year; p% = percentage of players born in each half;
nbc = number of male children born in country in each half of the year for the given groups;
c% = percentage of male children born in each half of the year in the country;
a = players born in first half of the year; b = players born in second part of the year

In Table 3, the results for two U-11 groups are presented. The only statistical difference is shown in the 9-3-6-3-9 agility test (p = .002) and SJ test (p = .002). The other tests did show discrimination between the sub-groups but without statistical significance. The ES showed a small effect in 20 m, 30 m, Slalom test, CMJmax, SJ, BH and BF (*d* - .09, .06, .09, .02, .01, .03, respectively) and a moderate effect in 10 m, T-test, 9-3-6-3-9, SJ, BM and MM (*d* - .53, .53, .38, .21, .29, .21, .72, respectively) with no large effect size in any test.

**Table 3** Differences in the U-11 groups between players born in different halves of the year

| | U-11a | U-11b | p | ES |
|---|---|---|---|---|
| BH (cm) | 145.18 ± 4.47 | 145.23 ± 5.19 | .862 | .01 |
| BM (kg) | 40.22 ± 4.73 | 39.15 ± 5.05 | .131 | .21 |
| BF (%) | 15.58 ± 4.31 | 15.41 ± 4.85 | .335 | .03 |
| MM (%) | 40.31 ± 1.27 | 39.22 ± 1.72 | .129 | .72 |
| 10 m (s) | 2.02 ± .08 | 2.04 ± .10 | .529 | .53 |
| 20 m (s) | 3.68 ± .11 | 3.67 ± .11 | .615 | .09 |
| 30 m (s) | 4.99 ± .12 | 4.98 ± .18 | .862 | .06 |
| CMJ (cm) | 20.31 ± 2.45 | 20.55 ± 1.59 | .088 | .21 |
| CMJmax (cm) | 24.94 ± 3.38 | 25.02 ± 3.12 | .102 | .02 |
| SJ (cm) | 17.42 ± 2.18 | 18.01 ± 1.91 | .002 | .29 |
| T-test (s) | 12.26 ± .33 | 12.45 ± .39 | .002 | .53 |
| 9-3-6-3-9 (s) | 9.72 ± .39 | 9.85 ± .28 | .012 | .38 |
| Slalom (s) | 7.89 ± .31 | 7.92 ± .29 | .148 | .09 |

*Note*: BH (cm) = body height; BM (kg) = body mass; BMI = body mass index; BF (%) = body fat percentage; MM (%) = muscle mass percentage; 10 m, 20 m, 30 m = split times for running speed; CMJ – countermovement jump; CMJmax = countermovement jump with arm swing; SJ = squat jump; T-test, 9-3-6-3-9, Slalom = agility tests

In Table 4, the results for the two U-14 groups are presented. Statistical difference is shown in all speed and vertical jump tests ($p<.05$). Agility tests did not show a statistical significant difference between football players born in the first and those born in the second part of the year for the U-14 groups. When anthropometric characteristics are taken into consideration, only BF does not show a statistically significant difference between groups while BH, BM and MM differ on a statistically significant level (p = .017, .041, .0.46, respectively). Small effect size was recorded on the T-test, 9-3-6-3-9 and Slalom tests (*d* - .18, .18 and .05, respectively), moderate effect size was recorded on 10 m, 20 m, 30 m, CMJ, CMJmax, SJ, BM, BF and MM (*d* - .53, .62, .26, .39, .48, .37, .74, .33 and .43, respectively) with a large effect size only for BH (*d* - 83).

**Table 4** Differences in the U-14 groups between players born in different halves of the year

| | U-14a | U-14b | p | ES |
|---|---|---|---|---|
| BH (cm) | 169.95 ± 6.32 | 163.21 ± 9.53 | .017 | .83 |
| BM (kg) | 56.71 ± 9.04 | 49.53 ±10.26 | .041 | .74 |
| BF (%) | 12.21 ± 3.26 | 13.74 ± 5.64 | .326 | .33 |
| MM (%) | 40.31 ± 1.27 | 39.22 ± 1.72 | .129 | .43 |
| 10 m (s) | 1.91 ± .08 | 1.95 ± .07 | .033 | .53 |
| 20 m (s) | 3.27 ± .16 | 3.35 ± .14 | .006 | .62 |
| 30 m (s) | 4.45 ± .33 | 4.54 ± .37 | .003 | .26 |
| CMJ (cm) | 28.23 ± 3.94 | 26.57 ± 4.58 | .007 | .39 |
| CMJmax (cm) | 33.92 ± 3.91 | 31.85 ± 4.64 | .001 | .48 |
| SJ (cm) | 25.65 ± 3.88 | 24.12 ± 4.25 | .007 | .37 |
| T-test (s) | 10.99 ± .55 | 11.09 ± .58 | .173 | .18 |
| 9-3-6-3-9 (s) | 8.22 ± .27 | 8.27 ± .27 | .117 | .18 |
| Slalom (s) | 7.10 ± .35 | 7.12 ± .38 | .633 | .05 |

*Note*: BH (cm) = body height; BM (kg) = body mass; BMI = body mass index; BF (%) = body fat percentage; MM (%) = muscle mass percentage; 10 m, 20 m, 30 m = split times for running speed; CMJ = countermovement jump; CMJmax = countermovement jump with arm swing; SJ = squat jump; T-test, 9-3-6-3-9, Slalom = agility tests

In Table 5, the results for the two U-19 groups are presented. In contrast to the previous group this group got statistical significance on just two tests. The only statistical difference was shown in the T-test agility test (p = .017) and the 10 m running test (p = .037). The other tests did show the discrimination between sub-groups but without statistical significance. In the U-19 groups, BH and BM shows a statistically significant difference (p = .002 and .008, respectively), while BH (p = .759) and BM (p = .309) and does show difference but not on a statistically significant level.

**Table 5** Differences in the U-19 groups between those born in different halves of the year

| | U-19a | U-19b | p | ES |
|---|---|---|---|---|
| BH (cm) | 179.14 ± 5.24 | 179.67 ± 6.32 | .759 | .09 |
| BM (kg) | 71.61 ± 6.34 | 73.73 ± 7.57 | .309 | .31 |
| BF (%) | 12.96 ± 3.44 | 16.31 ± 3.02 | .002 | 1.03 |
| MM (%) | 43.70 ± 2.19 | 41.87 ± 2.12 | .008 | .85 |
| 10 m (s) | 1.83 ± .06 | 1.87 ± .05 | .037 | .36 |
| 20 m (s) | 3.11 ± .08 | 3.13 ± .08 | .329 | .08 |
| 30 m (s) | 4.16 ± .32 | 4.17 ± .78 | .210 | .01 |
| CMJ (cm) | 33.57 ± 2.74 | 33.05 ± 2.67 | .538 | .19 |
| CMJmax (cm) | 40.42 ± 7.21 | 41.80 ± 5.06 | .502 | .22 |
| SJ (cm) | 31.61 ± 3.06 | 31.36 ± 2.96 | .801 | .08 |
| T-test (s) | 9.35 ± .21 | 9.54 ± .31 | .017 | .71 |
| 9-3-6-3-9 (s) | 7.65 ± .35 | 7.85 ± .29 | .026 | .62 |
| Slalom (s) | 5.95 ± .29 | 6.08 ± .32 | .148 | .43 |

Legend: BH (cm) – body height; BM (kg) – body mass; BMI – body mass index; BF (%) – body fat percentage; MM (%) – muscle mass percentage; 10 m, 20 m, 30 m – split times for running speed; CMJ – countermovement jump; CMJmax – countermovement jump with arm swing; SJ – squat jump; T-test, 9-3-6-3-9, Slalom – agility tests

## 4. DISCUSSION

The main goal of this study was to assess the difference between football players born in the first half of the year and their peers born in the second half of the year in anthropometric measurements and power performance. The second goal was to determine the dropout rate in male youth football and number of players that are playing in the starting eleven for each tested category. The results show a big difference in the U-14 groups and a little to no difference in the U-11 and U-19 groups and biased distribution in favour of players born in the first half of the year (approximately 63%) which is in accordance with previous research where distribution of the players born in the first half of the year goes up to almost 80% in some categories (Hirose, 2009).

Football is becoming an increasingly physically demanding sport and because of that coaches often force players to go beyond their limits. The problem is that more and more coaches have the same demands for younger football players and if they cannot fulfill the expectations right away they often tend to be discriminated against and removed from their teams. Because of that, players who mature faster and get physically bigger, get more playing chances and thus become more experienced. Anthropological characteristics and body composition parameters between the U-11 sub-groups are not statistically significant because they still did not reach adolescence so they do not differ much from each other (Vänttinen et al., 2011). Although some differences are noticed, and they are in favour of the group of players born in first half, there is no statistical difference. Most studies that had a U-11 group showed similar findings, where they found a prevalence in the number of players born toward the start of the year but due to a lack of physical characteristics and bigger hormonal activations they are still on the same level of performance (Towlson et al., 2021). In the U-14 group a statistically significant difference is recorded in all parameters except BF. That can easily be explained by the same training volume which players have during the week and thus not allowing body fat to accumulate. Other parameters are in favour of players born in the first half of the year because most of them are near the end of PHV and have an advantage in contrast to their peers that will, on average, reach that period a few months later (Del Campo et al., 2010). Altimari et al. (2021) also proved the difference between relatively older players and those born later during the year but Massa et al. (2014) showed a decreased RAE in the U-14 group in comparison to other age categories due to a different competition level and the club's ability to select players. Delorme, Boiché, & Raspaud (2010a) examined RAE in all French youth leagues and found that the greatest dropout of players occurs around the age of fourteen and the possible reason can be justified by the finding of Hirose (2009) who observed that anthropometrical variables were similar among U-10 football players, but in the U-14 group older players were statistically taller and heavier. In contrast to this, Malina et al. (2007) found no difference in BH, BM and the performance between players born later and earlier in the year. This difference might occur due to the level of competition. The youth club/academy might have that advantage to make a selection earlier and only keep players born later during the year that can fulfill every task at a same level as their older peers (Hirose, 2009). In the oldest group, the results are in favour of the relatively younger group, when we examine BH and BM, but with no statistical difference. Relatively older players have a statistically significant better BF and MM percentage which might be due to additional strength training some of them have that was not taken as a variable in this study.

Development of running speed is one of the most difficult tasks in football and coaches and sport scientists are always looking for better solutions. Since running speed consists of stride length and velocity, enhancing one of those two parameters directly influence running speed so it has been shown that an increase in running speed is associated with body height in youth football players mostly due to a bigger stride length (Wong et al., 2009). The results of this study show that when a group of football players (U-14) is statistically significantly taller than their peers they also get significantly better running speed results. On the other hand, no statistically significant difference was found between the U-11 and U-19 sub-groups, both in BH and speed performance. These results were confirmed by other studies where BH is found to be directly correlated with running speed in male youth football players (Mathisen & Pettersen, 2015).

Explosive strength, in the form of the achieved vertical jump height, is considered a good indicator of success in football, so functional testing of football players in which the vertical jump is not assessed is almost unthinkable (Stølen et al., 2005). The height of the jump on the tests showed a connection with success in youth categories (Mujika et al., 2009). Jump height is the most appropriate indicator due to its reliability, simplicity and the ability to track progress (Stølen et al., 2005). This study, in the U-11 group, showed a statistically significant difference only in the SJ test and not the CMJ and CMJmax tests, all three in favour of players born in second part of the year. This can be due to a better understanding of some players on how to prepare and use the body swing properly to gain maximal force. In accordance with these results are findings of a study which stated that there is no difference in the vertical jump performance between the U-10 and U-12 groups of players divided by quartiles (Lovell et al., 2015). In the U-14 group that difference is statistically significant in all three vertical jump tests ($p < .05$) and it can, as running speed, be explained by longer limbs and the overall physical dominance of players who entered their PHV first and gain more muscle mass which is important for the development of explosive strength (Perroni et al., 2014). These results are confirmed by almost all previous research that included this age group of football players (Currie, 2018). Lastly, the U-19 group showed no difference between players born in the first and those born in the second half of the year because, as explained earlier, by the time they are 19 they have to be ready for first team football and players born in the second part of the year do not show any maturational difference in relation to their peers. Previous research that examined U-19 and older players also concluded that there was no difference between birth quartiles, but all of them confirmed a larger number of players born in the first half of the year (Brustio et al., 2018).

Agility tests, in contrast to the above-mentioned tests, showed differences between the U-11 and U-19 groups and not in the U-14. More precisely there is a statistically significant difference in the T-test and 9-3-6-3-9 tests for the U-11 group (p - .002, .012, respectively) and for the U-19 group (p - .017, .026, respectively). The U-14 group did not show a difference mainly because being shorter can sometimes be an advantage due to shorter legs and the time needed to avoid obstacles (in this case cones) (Little & Williams, 2003). Peña-González et al. (2021) supported these results by showing no difference in the U-14 group in agility. Lovell et al. (2015) contrasted this by finding a difference for the U-14 and no difference for the U-10 and U-18 groups. The main difference between the studies is that Lovell et al. (2015) had a sample of players playing in lower leagues and therefore it could be that these players did not go through a full selection process.

Relative age effect and dropout rate can generally be explained by the maturational theory outlined by Malina, Bouchard, & Bar-Or (2004). This theory indicates that there is a bias towards selecting boys who are accelerants (most often born in the first months of the year) and are maturational advanced (better anthropometric, cognitive and physical characteristics) in contrast to their peers born towards the end of the year. Also, it is well-known that players (kids) tend to stay more involved in sport where they are succesful and recognized (Deaner, Lowen, & Cobley, 2013). Regardless of the results of existing research, it shows a lower number of players born in the second part of the year without exception and that must be a clear sign that football experts are missing something.

The main limitation of this study is that it is not a longitudinal study with a single group of players followed throughout the process which would provide much more precise data on the dropout rate. Due to the very nature of football, such a study would be difficult to do due to the constant departures of football players and the arrival of new ones, unless it is a top elite club that can oblige their players with contracts and scholarships to stay at the club for years, and if the research starts when they are eleven years old and finish when they are nineteen it could be a completely different team and those data would not be relative. Also, future research should implement some variables for measuring biological and chronological maturation.

## 5. Conclusion

This study showed that the RAE exists among sub-elite young footballers. This difference, according to the number of represented players, is visible in all categories with a progressive increase as age increases. The difference in pre-pubescent players does not exist in the tested parameters as well as in players who are near the end of their physical development, while in players who are in puberty, more precisely in those who are near the end of PHV, there is a drastic difference between players born in the first and players born in the second half of the year in almost all the tested parameters. As the results showed, the biggest dropout happens after the age of 14, because until then, players who later reach football maturity had fewer playing chances and thus less progress, so their motivation decreases and they stop playing sports or change clubs. In addition, clubs bring in new players during the transition periods, who again make a difference in favor of players born in the first half of the year. The main conclusion of this paper is that all youth football players must be given the same chance because not everyone reaches full maturity at the same time in order to be competent until the PHV period is over for everyone. It is also further recommended that the leagues in the junior categories be divided into two parts (the league for footballers born in the first half of the year and the league for those born in the second half) so that everyone gets approximately the same playing chance.

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# EFEKAT RELATIVNE STAROSTI STVARA DISKRIMINACIJU I PANDEMIJU OSIPANJA U OMLADINSKOM FUDBALU: DA LI SVI TREBA DA DOBIJU ISTU ŠANSU?

*Cilj ove studije bio je da se utvrdi stopa osipanja i razlika između fudbalera rođenih u različitim polovinama godine. U ovoj studiji učestvovao je 101 subelitni fudbaler (14,4±2,9 god, 168,2±9,4 cm, 60,1±5,3 kg, 21,7±2,2 BMI) podeljenih u tri starosne kategorije i dve podgrupe za svaku kategoriju (U-11a/b, U-14a/b i U-19a/b). Razlika između podgrupa je procenjena korišćenjem T-testa za nezavisne grupe i Mann-Vhitney U testa sa statističkom značajnošću postavljenom na nivo p < .05. Testovi korišćeni u ovom istraživanju su: 10, 20 i 30 m, SJ, CMJ, CMJmax, T-test, 9-3-6-3-9 i Slalom. Statistička razlika za grupu U-11 dobijena je kod SJ (p = .002), T-testu (p = .012) i 9-3-6-3-9 testu (p = .002). U grupi U-14 statistička razlika je prikazana u svim testovima brzine i eksplozivne snage (p < .05). Parametar telesnih masti nije pokazao statistički značajnu razliku između grupa, dok se telesna visina, telesna masa i mišićna masa razlikuju na statistički značajnom nivou (p = .017, .041, .0.46 respektivno). U poređenju sa mlađim grupama, grupa U-19 pokazuje značajnu razliku na T-testu i trčanju na 10 m (p = .017, .037, respektivno). Glavni nedostatak ovog istraživanja je to što nije longitudinalnog karaktera sa jednom grupom koja bi se pratila tokom celog procesa. Zaključno, bilo bi poželjno da svi dobiju jednaku šansu zbog različite brzine razvoja kako bi bili kompetentni. Dalje preporuke su da se omladinske kategorije podele u dve odvojene lige kako bi svi imali isto vreme za igru.*

Ključne reči: *period najvećeg rasta, adolescenti, performanse*

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**Research article**

# THE INFLUENCE OF LIFTING STRAPS ON ISOMETRIC BACK EXTENSOR MUSCLE STRENGTH MECHANICAL CARACTHERISTICS: A STUDY OF POWERLIFTERS

*UDC 796.894*

**Aleksandar Rajković, David Nikolić, Marko Smrkić, Nevena Vukadinović, Milivoj Dopsaj**

Faculty of Sport and Physical Education, University of Belgrade, Belgrade, Serbia

ORCID iDs: Aleksandar Rajković https://orcid.org/0009-0008-9132-2211
David Nikolić https://orcid.org/0000-0001-5638-3408
Marko Smrkić https://orcid.org/0009-0000-2084-3783
Nevena Vukadinović https://orcid.org/0009-0005-2623-4678
Milivoj Dopsaj https://orcid.org/0000-0001-7153-2993

**Abstract**. *The aim of this study was to investigate how lifting straps affect isometric back extensors muscle strength. The participants were divided according to gender and training level: trained – powerlifters (n = 17) and control – a specifically non-trained group (n = 24). For the purposes of this study, the maximum voluntary contraction of the back extensors was measured in isometric conditions in the isometric back extension exercise. After a 5-minute standard and specific warm-up, the participants had three trials each with lifting straps and without lifting straps, with a break of 2 minutes between trials. They were given the verbal instruction "pull as hard and fast as possible" and hold for 2 to 3 seconds. Repeated measures ANOVA showed a general statistically significant difference ($p<0.05$) between testing procedures (classical and straps). A paired samples t-test was used to determine differences between maximal and explosive strength variables. Then, the percentage difference (Δ) of all variables ($F_{max}$ - maximal force, $RFD_{max}$ - maximal rate of force development, $tF_{max}$ - time needed to reach maximal force, $tRFD_{max}$ - time for maximal rate of force development) was calculated using the formula: $F_{max\_\Delta} = ((F_{max\_straps} - F_{max\_class}) / F_{max\_class}) * 100$. Differences in the maximum isometric back extension force ($F_{max}$) were found in both groups (powerlifter males - $p = 0.004$, females - $p = 0.019$ and control group males - $p = 0.018$, females – $p = 0.001$), while differences in $tF_{max}$ were observed only in the control group (males – $p = 0.001$ and females - $p = 0.000$). The results showed that lifting straps have a positive effect in measuring supra-maximal isometric strength (averaged enhancement was 15.93±4.58% regardless of gender and training status), and can potentially be used in a methodological sense to determine the objective values*

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**Corresponding author:** Aleksandar Rajković
Faculty of Sport and Physical Education, University of Belgrade, Belgrade, Serbia
Phone: • E-mail aleksandarrajkovic96@gmail.com

*of the biological contractile potential in terms of maximum strength, in pulling type of exercises that include a hand grip (the deadlift, lat pull down, mid-thigh pull test).*

**Key words**: *resistance training, rate of force development, testing*

## INTRODUCTION

The deadlift, along with the bench press and squat, is a primary component of powerlifting competitions (Fleck and Kraemer, 2004). It is a multi-joint exercise, where the lifter lifts the barbell from the floor performing a hip, knee, and ankle extension until the torso is fully erect and subsequently eccentrically lowered to the floor, and it is used in many modalities of training (Swinton et al., 2011; Haff and Triplett, 2015), as such, it is critical for strength development (Bird and Barrington-Higgs, 2010). Although high loads can be used in the deadlift, the lifter's ability to handle the bar, through grip strength, is often a limiting factor for the amount of weight that can be lifted (Garhammer, 1993).

The study of muscle force as a motor ability in sports has grown dramatically over the years (Stankovic et al., 2021). Muscle force, or muscle strength is an ability that can directly affect the sport result (powerlifting, weightlifting), or indirectly (athletics, sports game) using strength training, which has been shown to lead to an increase in the force per unit CSA of the muscle. This effect has been attributed either to an increase in the neural drive (Moritani & de Vries, 1979; Hakkinen & Komi, 1983; Narici et al., 1989) or to an actual increase in muscle-specific tension due to a denser packing of muscle filaments, which might account for the observed increase in muscle radiological density (Jones and Rutherford, 1987).

Muscle strength testing has been the most often applied approach in testing muscle function in general, as well as functional movement abilities (Abernethy et al., 1995; Jaric, 2002). Muscle strength can be tested by isotonic or isometric tests. The phenomenon of isometric muscle force (IMF) can be estimated in different ways (Marković et al., 2018). Recently, researchers and practitioners have begun using maximal isometric testing to examine the performance and adaptation to training stimuli (Comfort et al., 2019; Haff et al., 1997). The same authors said that, when compared to traditional maximal strength assessments (i.e., RM protocols), isometric testing is considered potentially safer due to biomechanical simplicity, reduced fatigue, and improved time-efficiency. Comfort et al. (2019) are using the isometric mid-thigh pull (IMTP), which is a multi-joint isometric test that has been previously used extensively in research. The IMTP consists of participants pulling against an immovable bar located at a position that mimics the second pull position of the clean exercise, and it allows the assessment of peak force (PF), time-specific force values, and rate of force development (RFD) (Comfort et al., 2015; Dos Santos et al., 2017; Haff et al., 2005; 2015).

When the deadlift is used, the strength of the forearm muscles is a very important factor. Therefore, to reduce fatigue of the forearm muscles during the deadlift exercise, many strategies have been suggested, such as the use of an inverted grip, alteration of bar thickness, magnesium powder, and use of lifting straps (Ratames et al., 2007; Beggs, 2011). With lifting straps, the limitations due to grip strength become less pronounced and, theoretically, an associated load increase would promote greater activation of the targeted muscles (Rimmer, 2001). Coswing et al. (2015) showed greater force using the straps during the deadlift, while Trahey et al. (2023) showed that participants that were using straps could perform more repetitions.

While this was done in a standard deadlift with a barbell, there is no research that shows how lifting straps affects classical isometric deadlift (IDL) testing and how influence in mechanical muscle strength characteristics, as a one of the standard tests used in sports science practice in laboratory and field testing (Dopsaj et al., 2000; Backham et a., 2012; Marković et al., 2018) which is the purpose of this research.

## METHODS

The research was conducted in laboratory conditions at the Faculty of Sports and Physical Education in Belgrade. Data collection was performed by the test-retest method, trial after trial. Testing was done in two different conditions: without and with lifting straps. Body composition was measured using bioelectrical impedance. The contractile characteristics of the muscle strength of the back extensors were measured with a tensiometric dynamometer under conditions of maximal isometric contractions. The study was conducted in accordance with the principles of the Helsinki Declaration, as well as with the approval of the Ethics Committee of the Faculty of Sports and Physical Education of the University of Belgrade (484/2).

### Subject sample

The research was conducted on a total sample of 41 healthy adults. The participants were divided according to gender and training level: trained - powerlifters (n=17) and control – a specifically non-trained group (n=24). Basic descriptive characteristics of the group of powerlifters (male, n=9 and female, n=8), as well as the control group, consisted of the students of Faculty of Sports and Physical Education (male, n=12 and female, n=12) are shown in Table 1.

### Testing procedure

Body height was measured with an anthropometer using a standardized procedure (Dopsaj et al., 2020). Electrical bioimpedance analysis (BIA, InBody 720) described in earlier measurements was used to assess body composition (Bankovic et al., 2018). For the purposes of this study, the maximum voluntary contraction of the back extensors was measured in isometric conditions during the isometric back extension exercise. After the 5 minutes of a standard and specific warm-up exercises, the participants had three trials each with lifting straps and without lifting straps, with a break of 2 minutes between trails. The participants were given the verbal instruction “pull as hard and fast as possible” and hold for 2 to 3 seconds. Figures 1 and 2 show the lifting straps and body position during isometric back extension testing. The test was conducted under laboratory conditions in the methodological research laboratory at the Faculty of Sports and Physical Education. The testing was conducted according to the previously established procedure and equipment (All4gym d.o.o., Serbia) under conditions of maximal isometric contractions (Dopsaj et al., 2019; Dopsaj et al., 2022).

**Fig. 1** Lifting straps

**Fig. 2** Body position during IDL testing

**Variables**

The following variables (12) was used in study as well:

Isometric back extension measure in classical test conditions:

1. $F_{max\_class}$ – maximal isometric back extension force measured in classic test conditions, expressed in Newtons (N);
2. $RFD_{max\_class}$ – maximal rate force of development measured in classic test conditions, expressed in Newtons per second (N/s);
3. $tF_{max\_class}$ – time needed to reach maximal isometric back extension force measured in classic test conditions, expressed in seconds (s);
4. $tRFD_{max\_class}$ – time needed to reach maximal rate force of development measured in classic test conditions, expressed in seconds (s);

Isometric back extension was measured with lifting straps in test conditions:

1. $F_{max\_straps}$ – maximal isometric back extension force measured in classic test conditions, expressed in Newtons (N);
2. $RFD_{max\_straps}$ – maximal rate force of development measured in classic test conditions, expressed in Newtons per second (N/s);
3. $tF_{max\_straps}$ – time needed to reach maximal isometric back extension force measured in classic test conditions, expressed in seconds (s);
4. $tRFD_{max\_straps}$ the time needed to reach maximal rate force of development measured in straps test conditions, expressed in seconds (s);

To determine the percentage difference between two measurements (with and without lifting straps) the following variables were used:

1. $F_{max\_\Delta}$ – the difference between $F_{max\_straps}$ and $F_{max\_class}$ expressed in percentages (%);
2. $RFD_{max\_\Delta}$ – the difference between $RFD_{max\_straps}$ and $RFD_{max\_class}$ expressed in percentages (%);
3. $tF_{max\_\Delta}$ – the difference between $tF_{max\_straps}$ and $tF_{max\_class}$ expressed in percentages (%);
4. $tRFD_{max\_\Delta}$ – the difference between $RFD_{max\_straps}$ and $RFD_{max\_class}$ expressed in percentages (%);

### Statistical analysis

For the basic characteristics of the participants, the measure of central tendency was used – average (mean) and measure of dispersion – standard deviation (SD). The t-test for paired samples was used to determine the differences between the maximum and explosive strength variables ($F_{max}$ and $RFD_{max}$), as well as for the time variables ($tF_{max}$ and $tRFD_{max}$). Repeated measures ANOVA was used to determine if there was an overall statistically significant difference. Then, the percentage difference (Δ) of all variables ($F_{max\_\Delta}$, $RFD_{max\_\Delta}$, $tF_{max\_\Delta}$, $tRFD_{max\_\Delta}$) was calculated using the formula (Dopsaj et al., 2022):

$$F_{max\_delta} = \frac{(F_{max\_straps} - F_{max\_delta})}{F_{max\ class}} \times 100$$

## RESULTS

The results of the ANOVA showed a general statistically significant difference between testing procedures (classical and straps) regardless of the participant group and gender (powerlifters and control, male and female – powerlifter males classic vs straps $F_{ANOVA}$= 49.78, p=0.000; powerlifter females classic vs straps $F_{ANOVA}$=93.12, p=0.000; control group males classic vs straps $F_{ANOVA}$=58.20, p=0.000; control group females classic vs straps $F_{ANOVA}$=165.09, p=0.000). Table 1 shows the basic descriptive indicators of the studied variables.

**Table 1** Basic descriptive results regarding the sample of participants characteristic titles

| Variables | Powerlifters Male | Powerlifters Female | Control group Male | Control group Female |
|---|---|---|---|---|
| Age | 22.7 ± 3.1 | 25.5 ± 5.3 | 24.2 ± 2.5 | 22.6 ± 1.7 |
| BH (cm) | 182.1 ± 4.8 | 170.5 ± 6.8 | 184.2 ± 6.8 | 169.1 ± 4.7 |
| BM (kg) | 86.6 ±10.7 | 66.2 ± 9.7 | 82.5 ± 13.3 | 61.8 ± 6.3 |
| BMI (kg/m²) | 26.1 ± 2.4 | 22.7 ± 2.9 | 24.2 ± 2.8 | 21.6 ± 1.4 |
| PBF (%) | 11.7 ± 4.3 | 15.7 ± 6.2 | 11 ± 3.3 | 20.7 ± 8.7 |
| PSMM (%) | 51.04 ± 2.7 | 47.7 ± 4.2 | 50.96 ± 2 | 45.6 ± 2.1 |
| Tr/week (n) | 6.9 ± 2.1 | 5.9 ± 0.8 | 3.3 ± 1 | 3.8 ± 1.1 |
| TDP_session (min) | 93.3 ±23.5 | 82.5 ±21.2 | 85 ± 17.3 | 68.2 ±14 |

Tr/week (n) – number of training sessions per week; TDP_session (min) – average training duration per session; BH (cm) – body height; BM (kg) – body mass; BMI (kg/m²) – Body Mass Index; PBF(%) – percentage of body fat index; PSMM (%) – percentage of skeletal muscle mass

Table 2 presents the differences between classic contractions and the use of lifting straps. The results show differences between male (p=0.00) and female (p=0.02) powerlifters only in the $F_{max}$ variable. Differences also exist in the control group for both females in the Fmax (p=0.00) and $tF_{max}$ (p=0.00) variables and males in the $F_{max}$ (p=0.02) and $tF_{max}$ (p=0.00) variables.

**Table 2** Differences between classic contractions and lifting straps in the following variables

| Group | Powerlifters | | | | Control group | | | |
|---|---|---|---|---|---|---|---|---|
| Gender | Males | | Females | | Males | | Females | |
| | t | p | t | p | t | p | t | p |
| $F_{max\_class}$ vs $F_{max\_straps}$ | -3.93 | 0.004* | -3.04 | 0.019* | -2.77 | 0.018* | -4.85 | 0.001* |
| $RFD_{max_class}$vs $RFD_{max\_straps}$ | -0.56 | 0.588 | -1.48 | 0.182 | 1.40 | 0.189 | -1.33 | 0.209 |
| $tF_{max\_class}$ vs $tF_{max\_straps}$ | -1.11 | 0.300 | -0.72 | 0.497 | -4.20 | 0.001* | -5.48 | 0.000* |
| $tRFD_{max\_clas}$ vs $tRFD_{max\_stras}$ | -0.58 | 0.152 | -0.42 | 0.690 | 0.60 | 0.561 | -0.07 | 0.944 |

Significant difference * p<0.05

Figure 1 shows that the highest percentage difference is present in the female controls, while the smallest percentage differences are present in female powerlifters.

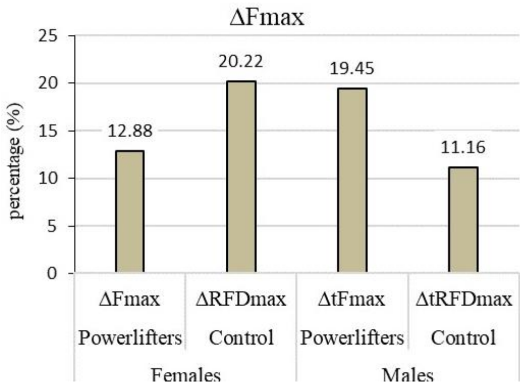


**Fig. 1** Percentage differences in the variable ($\Delta F_{max}$) relative to gender and group

Figure 2 shows that the highest percentage difference is present in female powerlifters, while the smallest percentage differences are present in the male control group.

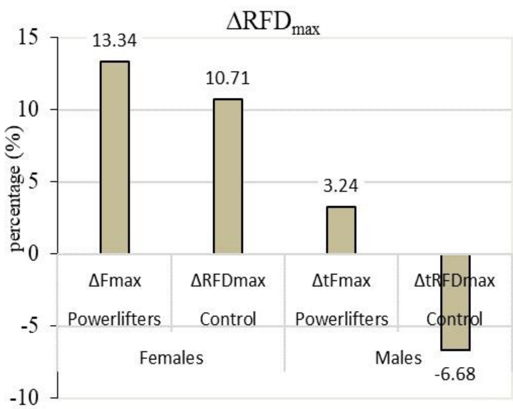


**Fig. 2** Percentage differences in the variable ($\Delta RFD_{max}$) relative to gender and group

Figure 3 shows that the highest percentage difference is present in the female control group, while the smallest percentage differences are present in male powerlifters.

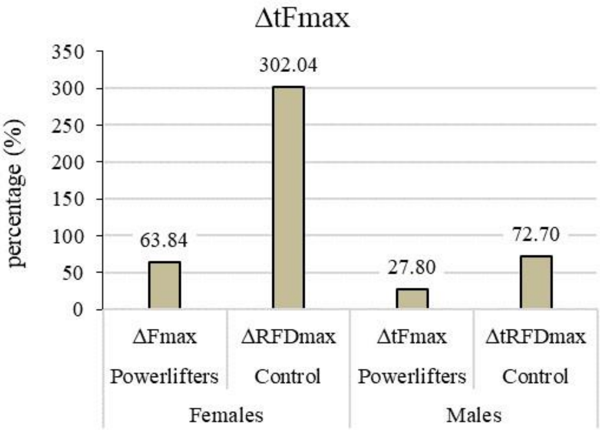


**Fig. 3** Percentage differences in the variable ($\Delta tF_{max}$) relative to gender and group

Figure 4 shows that the highest percentage difference is present in male powerlifters, while the smallest percentage differences are present in the female control group.

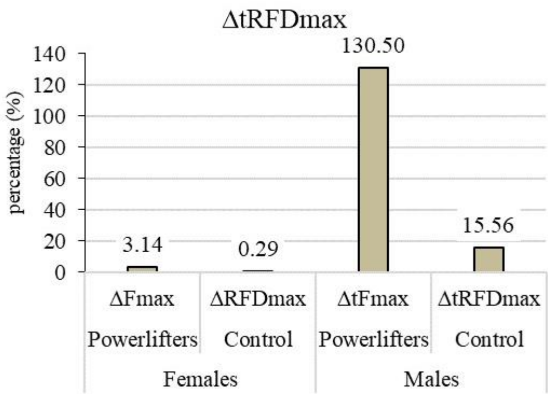


**Fig. 4** Percentage differences in the variable ($\Delta tRFD_{max}$) relative to gender and group

## DISSCUSION

This study aimed to evaluate the effects of lifting straps on isometric strength muscle testing realized on the isometric back extension test. Differences in $F_{max}$ were found in both groups, while differences in the tFmax were observed only in the control group (Table 2).

The variable $F_{max\_straps}$ was significantly greater than $F_{max\_class}$ in the powerlifters group: males ($F_{max\_\Delta}$=19.45%; p=0.004) and females ($F_{max\_\Delta}$=12.87%; p=0.019) and the control group: males ($F_{max\_\ \Delta}$=11.16%; p=0.018) and females ($F_{max\_\Delta}$=20.21%; p=0.001, Table 2,

Figure 1, respectively). Coswig et al. (2015) reported similar results in their study in which participants lifted more weight in the deadlift exercise when they were using straps (180±14.8 kg) in comparison to when they were not (151±23 kg). Straps increased the amount of weight lifted by 19.20%. In the study of Elkins (2020) male participants with lifting straps produced more force (2102.3±506.2N) than without straps (1468.6±286N) in the mid-thigh pull test, which is 43.1% greater force output. Also, the female participants, when strapped (1105±294.7N), produced a 17.5% greater force in comparison to when they do not use straps (940.6±155.7N). The findings of both mentioned studies are in line with results of our study. The most possible reason for the presented results may be explained by the mechanical and neural component of muscle force production (Gollhofer, 2008). Lifting straps additionally increase friction between hand skin and the bar, just as they decrease the pain of the skin also created as a product of friction, during the maximum isometric pull (Pratt et al., 2020).

Nominally higher values of $F_{max\_\Delta}$ in males from the powerlifter group compared to males from the control group of participants were found (19.45% vs. 11.16%, Figure 1). Trivedi et al. (2022) measured the average powerlifter grip strength of 618.03N and Dopsaj et al. (2019) measured 517.1N as the average hand grip strength of male students, which is only 16.4% less than powerlifters, so we can conclude that the difference is not as close as a difference in the isometric back extension test. So our results can be explained by a greater difference in force production between the back extension test and hand grip strength in powerlifters compared to the control group. Therefore, grip strength is a bigger limiting factor for powerlifters, so using lifting straps can be more beneficial for them.

Nominally higher values of $F_{max\_\Delta}$ in females from the control group compared to females from the powerlifters group were found (20.21% vs. 12.87%). These results can be explained by the low level of grip strength of the female population that is not specifically trained. Massy-Westropp et al. (2011) reported mean values of 294.3N for the right and 274.68N for the left hand, which is 37% lower compared to the male participants. Dopsaj et al. (2019) measured 279.1N for the dominant hand and 258.5 for the non-dominant hand in female students, which is 46.3% lower than for the male participants. Therefore, females that are not specifically trained have a much greater ability to produce force in the isometric back extension test than they can hold with their hands, so they can benefit more from using lifting straps, than specifically trained females who have practiced lifting without straps.

Therefore, the results showed that the influence of lifting straps, as a coaching methodological tool, is much greater in control group of females than in specifically trained group of females. Most likely, this phenomenon can be explained by the lower training level of the control group in the form of maximal contractile potentials in isometric back extension testing (less experience in lifting technique, less experience of using lifting straps, less experience in maximal voluntary contractions, motivation, etc.). So by adding lifting straps, the contractile potential increases to a much greater extent than in powerlifters. In other words, due to experience and training level, during the basic performance of the test, the female powerlifters were able to increase the level of contractile potential during the maximum isometric effort, and therefore the addition of the lifting straps had relatively smaller additional effect on improving the results.

The effects of lifting straps on $RFD_{max}$ were not significant for either group ($p>0.05$, Table 2). These results are in agreement with the results of Hori et al. (2010), who found that peak vertical RFD was not significantly different between the lifting straps conditions (16011.7±8301.5 N/sec) and no lifting straps conditions (16012.3±7341.5

N/sec) ($p>0.05$). The explanation can be found in the fact that neither the powerlifters nor the control group were trained with a focus on explosiveness. The goal of powerlifters training is to produce as much force as possible, i.e. to lift as much weight as possible, so they have a pattern of force development that does not focus on reaching the maximum force in the shortest amount of time (IPF, 2023).

Time variables ($tF_{max}$ and tRFD) show differences only in the control group for $tF_{max}$. Participants from the control group needed less time to reach $F_{max}$ when using straps (male $p=0.001$; female $p<0.001$, Table 2). The most possible reason for these results is that the control group participants do not have an established pattern of force production, so as soon as the conditions change, their pattern changes, concerning reducing time needed for $F_{max}$, more significantly compared to powerlifters.

The results of this study suggest that the use of lifting straps improves performance in terms of achieving greater maximal strength and explosiveness. Therefore, lifting straps could be used in the training of athletes and recreational lifters, considering that grip strength is a limiting factor, and it could be beneficial in adding more reps to a performance (Trahey et al., 2023). A limitation of this study could be familiarity with isometric strength testing. In this regard, an additional day of familiarization would give the participants the opportunity to practice the test procedure.

## CONCLUSION

The use of lifting straps allows the participants to realize a statistically significantly higher level of maximum force compared to the classic testing situation, i.e. testing without them, in an isometric back extension test, regardless of the training level or sex (averaged enhancement was: 15.93±4.58%, or from 11.16% for the control male to 20.22% for the control female, and for 12.88% for the female to 19.45% for the male powerlifters). It was also found that lifting straps have no influence on $RFD_{max}$ in the same test. The results of the study showed that for specifically trained participants (powerlifters), straps do not affect the time parameters of the realization of the isometric contraction, while for non-specifically trained participants (the control group) it leads to a reduction of the time to reach $F_{max}$. The results showed that lifting straps have a positive effect in achievement supra-maximal isometric strength, considering that strength of the forearm muscles is a very important factor, and can potentially be used in a methodological sense to determine the so-called objective values of the biological contractile potential in terms of additional maximum strength level, in pulling type of exercises that include a hand grip (the deadlift, lat pull down, mid-thigh pull test).

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# UTICAJ GURTNI NA MEHANIČKE KARAKTERISTIKE IZOMETRIJSKE SNAGE MIŠIĆA TOKOM MRTVOG DIZANJA: STUDIJA NA POWERLIFTERIMA

*Cilj ovog istraživanja bio je da se ispita kako gurtne utiču na izometrijsku snagu mišića tokom mrtvog dizanja. Ispitanici su podeljeni prema polu i nivou treninga: trenirani – powerlifteri (n = 17) i kontrolna grupa – specifično netrenirani pojedinci (n = 24). Maksimalna voljna kontrakcija mišića opružača leđa merena je u izometrijskim uslovima u vežbi mrtvog dizanja. Nakon standardnih i specifičnih vežbi zagrevanja u trajanju od 5 minuta, ispitanici su izveli po tri pokušaja sa gurtnama i bez gurtni, uz pauzu od 2 minuta između pokušaja. Verbalne instrukcije su bile: „Povuci maksimalno jako i maksimalno brzo" i zadrži 2 - 3 sekunde. ANOVA za ponovljena merenja pokazala je statistički značajnu razliku (p<0,05) između testiranja (klasično i sa gurtnama). T-test za zavisne uzorke korišćen je za utvrđivanje razlika između maksimalnih i eksplozivnih varijabli sile. Procentualna razlika (Δ) svih varijabli ($F_{max}$ – maksimalna sila, $BRS_{max}$ – maksimalna brzina razvoja sile, $tF_{max}$ – vreme potrebno za dostizanje maksimalne sile, $tBRS_{max}$ – vreme postizanja maksimalne brzine razvoja sile), izračunata je pomoću formule: $F_{max\Delta}=((F_{maxgurtne}-F_{maxklasično})/F_{maxklasično})*100$. Razlike u maksimalnoj izometrijskoj sili mrtvog dizanja ($F_{max}$) pronađene su u obe grupe (powerlifteri muškarci – p = 0,004, žene – p = 0,019 i kontrolna grupa muškarci – p = 0,018, žene – p = 0,001), dok su razlike u $tF_{max}$ uočene samo u kontrolnoj grupi (muškarci – p = 0,001 i žene – p = 0,000). Rezultati su pokazali da gurtne imaju pozitivan efekat na merenje supramaksimalne izometrijske snage (prosečno povećanje iznosilo je 15,93±4,58%, bez obzira na pol i nivo treninga) i mogu se potencijalno koristiti u metodološkom smislu za određivanje objektivnih vrednosti biološkog kontraktilnog potencijala u smislu maksimalne snage, kod vežbi vučenja koje zahtevaju jačinu hvata (mrtvo dizanje, vučenje na lat mašini, "mid-thigh pull test").*

Ključne reči: *trening snage, brzina razvoja sile, testiranje*

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**Research article**

# TEST-RETEST AND INTER-RATER RELIABILITY OF VOLLEYBALL ACCURACY TESTS IN SCHOOL CHILDREN

*UDC 796.325-053.5*

**Nebojša Trajković[1], Elzan Bibić[2], Dejan Ćeremidžić[2], Marjan Mladenović[3]**

[1]Faculty of Sport and Physical Education, University of Niš, Niš, Serbia
[2]Faculty of Physical Education and Sports, University of East Sarajevo, Bosnia and Herzegovina
[3]Elementary School "Đura Jakšić", Turekovac, Serbia

ORCID iDs: Nebojša Trajković https://orcid.org/0000-0001-6276-3052
Elzan Bibić N/A
Dejan Ćeremidžić https://orcid.org/0009-0000-1806-3497
Marjan Mladenović N/A

**Abstract.** *The aim of this study was to examine the test-retest and inter-rater reliability of volleyball accuracy tests in a sample of school children. The study involved a sample of 46 school children aged 12-13 years (Height: 158.97 ± 5.39 cm; Mass: 52.20 ± 5.58 kg; Age = 12.4 ± 0.7 years) who had been participating in their school volleyball programs for at least one year. The sessions were organized over two separate occasions to assess test-retest reliability, with the same procedures followed each time. To evaluate inter-rater reliability, two raters independently recorded the performance of the participants, ensuring that the scoring was consistent and unbiased. Players were tested for the overhead and underhand passing, setting and serving. Perfect test-retest reliability (Interclass correlation coefficient (ICC) > 0.90; coefficient of variation (CV)% < 10%) was observed for setting and serving. Additionally, we found nearly perfect reliability for overhead (ICC = 0.84) and underhand passing (ICC = 0.72) with high CV% (> 10%). The results of the inter-rater reliability showed very high ICC's (>0.89) for all the variables. The study demonstrated that the volleyball skill testing protocol provides consistent and reliable assessments for players, with no significant differences between test and retest sessions across all the evaluated skills.*

**Key words**: *testing, volleyball, school children, reliability*

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**Corresponding author:** Nebojša Trajković
Faculty of Sport and Physical Education, University of Niš, Čarnojevićeva 10A, 18000 Niš, Serbia
Phone: • E-mail nele_trajce@yahoo.com

## INTRODUCTION

Volleyball is an interval sport characterized by short bursts of high-intensity activity followed by periods of rest, necessitating training programs that reflect this dynamic. Such activities rely on both anaerobic and aerobic energy systems; therefore, exercises should be designed to engage the ATP-CP and aerobic pathways while accurately simulating the kinematic patterns of competitive play (Shepard, Gabbet, & Stanganelli, 2009). The ability to accurately execute volleyball skills is a crucial aspect of the game, particularly for school-aged children who are developing their athletic abilities (Zetou, Tzetzis, Vernadakis, & Kioumourtzoglou, 2002).

The development of volleyball skills is crucial for effective performance in both competitive and educational settings. According to Zetou, Michalopoulou, Giazitzi, and Kioumourtzoglou (2007), the application of contextual interference can significantly impact the learning and retention of volleyball skills, suggesting that varied practice conditions enhance skill acquisition. Additionally, Harrison et al. (1999) highlighted the importance of instructional models, such as skill teaching and mastery learning in improving skill development, knowledge, self-efficacy, and game play among students. These studies highlight the need for well-structured physical education programs that focus on skill refinement to foster both physical and cognitive growth in volleyball players.

Reliable and valid assessment tools are necessary to accurately evaluate the skill level of young volleyball players and children in physical education and monitor their progress over time (Bartlett, Smith, Davis, & Peel, 1991; Lidor, Hershko, Bilkevitz, Arnon, & Falk, 2007; Gabbet and Georgief, 2006). Previous research has highlighted the importance of establishing the measurement properties of motor competence assessments in children and adolescents (Hulteen, et al., 2020). Specifically, studies (Gabbet and Georgief, 2006; Milić et al., 2016) have found strong support for the validity and reliability of assessments that measure skills such as overhead and underhand passing, setting, serving.

Establishing the reliability of volleyball accuracy tests is crucial, as these assessments can provide valuable information to coaches, physical education teachers, and researchers regarding the skill level and progress of young athletes. This study will contribute to the existing literature by providing evidence on the test-retest and inter-rater reliability of volleyball accuracy tests, which can inform the use of these assessments in school-based settings. The aim of this study was to examine the test-retest and inter-rater reliability of volleyball accuracy tests in a sample of school children.

## METHODS

### Participants

The study involved a sample of 46 school children aged 12-13 years (body height: 158.97 ± 5.39 cm; body mass: 52.20 ± 5.58 kg; Age = 12.4 ± 0.7 years) who had been participating in their school volleyball programs for at least one year. Participants were recruited from a local school, ensuring a diverse representation of both male and female students. The inclusion criteria for the study required the participants to be within the specified age range and to be currently enrolled in their school's volleyball program. Additionally, the participants had to have parental consent and be willing to commit to both the test and retest sessions. Exclusion criteria included any children who had sustained injuries or had medical conditions that could affect their ability to perform the volleyball accuracy tests safely. Students who were involved in external volleyball training that could interfere with their school volleyball participation or introduce confounding variables into the study were also excluded. The study protocol was carried out in accordance with the Declaration of Helsinki and was approved by the ethics committee of the Faculty of Sport and Physical Education, University of Nis.

### Procedure

The testing procedures were conducted in a sports hall to ensure a controlled environment with standardized conditions for all the participants. Each participant was given a thorough explanation of the testing protocols and a brief demonstration of the volleyball accuracy tests. The tests involved targeting specific areas on the volleyball court, with each participant completing a series of trials. The sessions were organized over two separate occasions to assess test-retest reliability, with the same procedures followed each time. To evaluate inter-rater reliability, two raters independently recorded the performance of the participants, ensuring that the scoring was consistent and unbiased. Raters were physical education teachers who are engaged with volleyball courses in schools. All of the equipment that was used, including volleyballs and target markers, was standardized to maintain uniformity across tests.

### Overhead and underhand passing

Target hitting with the overhead and underhand pass from zone VI to position III, with ball tossing from the assistant from zone VI from the other side of the court (Fig. 1). The test the participants' service reception will be evaluated by determining their ability to pass the ball with their fingers to a target positioned on the net, 3 meters from the right sideline. The target dimensions are 1.5 meters in length and 2 meters in width. The coach is positioned at the serving position, about 1 meter above the ground and 10 meters from the receiving player, tosses the ball overhead and passes it with their fingers to the receiving player. The participants were required to pass the ball to another player who stands with their hands above their head in the target zone. Players who successfully pass the ball to the player in the target area receive 2 points. The second target area is for balls that did not reach the main target area but would likely reach the player in a match situation. The second target area extends from the right sideline and measures 3 meters in length and 4 meters in width. Players who successfully pass the ball to the second target area receive 1 point. Finally, passes that do not reach the target areas receive 0 points. The final score was the sum of points from 6 attempts. This test showed good reliability in this age group (Gabbett, et al., 2007).

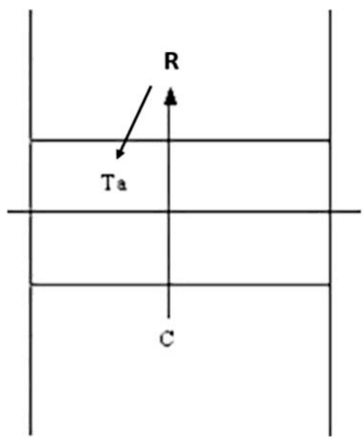


**Fig. 1** Overhead and underhand passing; R - passer; C - coach; Ta - target

### Setting

The testing procedures for assessing the accuracy of volleyball setting were conducted in a sports hall to ensure a controlled environment. The test involved participants aiming to hit a horizontal target with their fingers positioned in front of their heads. The objective was to measure the accuracy of setting the ball to a specific target area in position IV from zone III, with ball feeds from zone VI on the same side of the court. The equipment included an 80 cm diameter hoop placed vertically at a height of 2.70 meters in position IV, a cart with 10 balls, and a scoring sheet. The participants' setting ability was evaluated based on their skill in hitting the target positioned near the net at a height of 2.7 meters and a distance of 5.5 meters from the player performing the set. This target was chosen to mimic the position of a hitter preparing to spike the ball during a match. The coach, positioned 5 meters from the player, tossed the ball overhead to the center player, who then attempted to set the ball through the 80 cm hoop. Successful sets through the target earned 3 points, balls hitting the outer part of the hoop and not passing through earned 2 points, and sets landing 2.3 meters from the net (1.5 meters from the target) earned 1 point, marked by adhesive tape. Balls not landing in any target zone earned 0 points. The final score was the sum of points from 6 attempts. The participants were allowed one practice attempt, and the next ball feed began after the previous set was completed and either hit or missed the target. This test was a modification of a previously conducted test by Milić et al. (2016).

### Serving

The test aimed to measure the precision of serves using a volleyball court, ten volleyballs, a measuring tape, and boundary tape. During the procedure, each player performed ten consecutive serves underhand using their dominant hand, aiming to direct the ball towards target zones of higher value. They stood in the serving zone, positioned 9 meters from the volleyball net (which is 2.24 meters high). The participants were instructed to aim for designated areas marked on the floor of the opposite court. Instructions included assigning points for each serve based on the hit target areas, with zero points awarded if the ball landed outside the court. They were instructed to serve with maximum force to ensure the ball crossed the net, while also aiming to accurately hit the far corners of the opposite court. The opposite court was divided into four areas. Serving the ball to the far corners earned 5 points, landing in the middle zone earned 3 points, and hitting the area nearest the net earned 1 point. Missing the court resulted in a score of 0. Higher points were given if the ball landed between two zones. Players were allowed to choose their desired position behind the service line and had 8 seconds for each serve, matching the preparation time permitted in actual matches. This test was developed and explained and its reliability was determined for the mentioned age groups (Lidor, & Mayan, 2005; Lidor, et al., 2007).

### Statistical analysis

The statistical analysis for inter-rater reliability and test-retest reliability was conducted using the IBM SPSS Version 25 software (IBM SPSS Inc., Armonk, MY). To assess inter-rater reliability, Intraclass Correlation Coefficients (ICCs) were calculated, considering a two-way random effects model to account for the consistency and absolute agreement among raters. The ICC values were interpreted based on established guidelines, with values interpreted as: low = < 0.10, moderate = 0.11 – 0.30, high = 0.31 – 0.50, very high = 0.51 – 0.70, nearly perfect = 0.71 – 0.90 and perfect = 0.91 – 1.0 (Hopkins, 2000). Test-retest reliability was determined using the Intraclass Correlation Coefficient (ICC). The within-subject variation for each of the tests was determined by calculating the coefficient of variation (CV). Additionally, a paired sample t-test was conducted to compare the mean scores from the two testing occasions, ensuring that there were no significant differences that could indicate variability in the test conditions or participants' performance over time. The level of significance was set at $p < 0.05$ for all statistical tests.

## RESULTS

### Test – retest reliability

Similar overhead passing (test = 6.6 ± 2.2; retest = 7.2 ± 1.8), underhand passing (test = 5.3 ± 1.3; retest = 5.7 ± 1.2) setting (test = 7.4 ± 2.9; retest = 8.3 ± 2.9), and serving (test = 29.2 ± 8.2; retest = 30.4 ± 8.4) values were observed between two volleyball skill testing (Table 1). Non-significant differences ($p > 0.05$) were observed between testing sessions for all volleyball skills. High test-retest reliability (ICC > 0.90; CV% < 10%) was observed for setting and serving. However, we found good reliability for overhead passing (ICC = 0.84) and underhand passing (ICC = 0.72) with a high CV% (> 10%).

**Table 1** Test-retest reliability of volleyball accuracy tests; data are mean ± SD

| | Test | Retest | ICC | CV% |
|---|---|---|---|---|
| Overhead passing | 6.6 ± 2.2 | 7.2 ± 1.8 | 0.84 (0.68-0.92) | 15.4 (12 – 21.6) |
| Underhand passing | 5.3 ± 1.3 | 5.7 ± 1.2 | 0.72 (0.48-0.86) | 14.3 (11.2 – 20.1) |
| Setting | 7.4 ± 2.9 | 8.3 ± 2.9 | 0.99 (0.98-1.00) | 6.0 (4.7 – 8.3) |
| Serving | 29.2 ± 8.2 | 30.4 ± 8.4 | 0.98 (0.96-0.99) | 4.7 (3.7 – 6.5) |

### Inter-rater reliability

Very high ICC's were found > 0.89 for all variables. The results of the inter-rater reliability of the two raters are shown in Table 2.

**Table 2** Inter-rater reliability; data are mean ± SD

| | Rater 1 | Rater 2 | ICC |
|---|---|---|---|
| Overhead pass | 6.6 ± 2.2 | 7.2 ± 2.1 | 0.93 (0.85 – 0.97) |
| Underhand pass | 5.3 ± 1.5 | 5.8 ± 1.6 | 0.89 (0.76 – 0.95) |
| Setting | 7.4 ± 2.9 | 8.2 ± 2.8 | 0.97 (0.95 – 0.99) |
| Serving | 29.2 ± 8.2 | 29.7 ± 8.2 | 0.99 (0.99 – 1.00) |

## DISCUSSION

This study aimed to determine the test-retest and inter-rater reliability of volleyball accuracy tests in a sample of school children. The results of the volleyball skill testing reveal consistent performance between the initial test and the retest sessions across all evaluated skills, with no significant differences observed. This indicates that the participants' performance was stable over time. Perfect test-retest reliability was particularly evident for setting and serving, suggesting that these skills are more consistently executed by players, possibly due to the repetitive and practiced nature of these actions. Overhead passing and underhand passing, while also showing nearly perfect reliability, exhibited more variability. This could be due to the inherent complexity and variability in these skills, which may be influenced by factors such as ball trajectory, player positioning, and coordination. The greater variability in these skills suggests that they may be more susceptible to fluctuations in player performance or external conditions, highlighting potential areas for targeted training and assessment refinement to improve consistency. Additionally, the results of the inter-rater reliability demonstrated very high intraclass correlation coefficients (ICCs) above 0.89 for all items, indicating that the two raters were highly consistent in their evaluations. Overall, the findings highlight the robustness of the testing protocol for evaluating volleyball skills, while also pointing to specific areas where variability may need to be addressed.

Reliability and inter-rater reliability are critical factors in assessing volleyball skills, ensuring that the evaluations are consistent and objective. Gabbett, Georgieff, and Domrow (2007) highlight the importance of using a combination of physiological, anthropometric, and skill data to predict player selection in junior volleyball squads. This multi-faceted approach can enhance the reliability of the assessment by considering various aspects of an athlete's performance. Gabbett and Georgieff (2006) further emphasize the development of a standardized skill assessment for junior players, which can significantly improve the reliability of skill evaluations by providing a consistent framework for assessment. Lidor et al. (2007) demonstrate that the measurement of talent in volleyball requires longitudinal tracking to ensure that the assessment tools remain reliable over time. Their study on elite adolescent players over a 15-month period underscores the need for continuous validation of skill tests to maintain their reliability. Bartlett et al. (1991) contribute to this discussion by developing a valid volleyball skills test battery, which serves as a benchmark for other skill assessments and reinforces the importance of standardized testing procedures.

Inter-rater reliability, which ensures that different evaluators provide consistent ratings, is another crucial aspect. Standardized protocols, as discussed by Gabbett and Georgieff (2006), help mitigate subjective biases and improve inter-rater reliability. The comprehensive approach taken by Gabbett, Georgieff, and Domrow (2007) also supports this by incorporating objective measures alongside skill assessments, thereby enhancing the overall reliability of the evaluations. Thus, the integration of standardized assessments, objective measures, and longitudinal tracking collectively contribute to the reliability and inter-rater reliability of volleyball skill evaluations.

The findings of this study align with previous research on volleyball skill assessment instruments, highlighting their effectiveness and reliability. Zonifa (2020) emphasized the importance of developing robust skill test instruments for advanced-level students, which is corroborated by our results showing high test-retest reliability, particularly for setting and serving. This suggests that well-designed assessments can effectively gauge advanced players' abilities and track their development over time. Yudiana, Hidayat, Hambali, & Slamat (2017) discussed the significance of content validity in assessment instruments, particularly through volleyball information systems, ensuring that the tests measure the intended skills accurately. Our study’s high inter-rater reliability further supports the validity of the testing protocol, as consistent evaluations across different raters reinforce the accuracy of skill measurement. Additionally, Sopa and Pomohaci (2018) highlight the evaluation of motor development and skills in younger volleyball players, emphasizing the need for reliable assessments to monitor growth. While our study focused on a broader age range, the observed consistency and reliability of skill assessments can similarly be applied to younger athletes, aiding in their early development and long-term improvement. The current results along with the above mentioned references highlight the critical role of reliable and valid skill assessment tools in enhancing volleyball training and player development across different skill levels and age groups.

Studies on volleyball skill assessment have several limitations and strengths. One limitation is that they often have limited sample sizes or focus on specific groups, such as junior players, which may affect the generalizability of the findings to broader populations. Additionally, many studies provide short-term assessments, potentially missing long-term skill development and changes in reliability over time. Even with standardized protocols, subjectivity can persist in evaluating complex skills and gameplay situations, impacting inter-rater reliability. Variability in testing conditions, such as differences in environments, equipment, and procedures, can also introduce inconsistencies, affecting the validity of the assessments. Furthermore, some assessments focus on specific skills, potentially overlooking other important aspects of a player's performance. The reliance on specific technologies or testing equipment can limit the applicability of assessments in different settings or regions lacking such resources.

Despite these limitations, there are notable strengths in these studies. The development of standardized testing protocols enhances the reliability and comparability of skill evaluations across different contexts. Combining physiological, anthropometric, and skill data provides a comprehensive evaluation of players, offering a holistic understanding of their abilities and potential. Longitudinal studies allow for the assessment of skill development over time, providing valuable insights into the progression and consistency of skill acquisition. Including objective metrics alongside subjective evaluations helps mitigate biases and improve the overall reliability of the assessments. Creating validated skill test batteries sets benchmarks for other studies, ensuring assessments are grounded in reliable and valid measurement principles. Lastly, focusing on talent identification contributes to optimizing selection processes in competitive sports, leading to better development pathways for young athletes.

## CONCLUSION

The study demonstrated that the volleyball skill testing protocol provides consistent and reliable assessments for players, with no significant differences between test and retest sessions across all evaluated skills. Perfect test-retest reliability was observed for setting and serving, indicating that these skills are more consistently executed by players. Overhead passing and underhand passing also showed nearly perfect reliability, though with greater variability, suggesting these skills are more susceptible to fluctuations in performance. The very high inter-rater reliability, with ICCs above 0.89 for all items, confirms that the evaluation method is also consistent across different raters. This reliability indicates that the testing protocol can be effectively used by various coaches and evaluators, ensuring uniformity in skill assessment. Coaches can use this reliable testing protocol to identify specific areas where players need improvement, particularly focusing on the more variable overhead and underhand passing. This targeted approach can help in developing more consistent skill execution. Moreover, the consistent and reliable nature of the testing protocol makes it a valuable tool for talent identification, helping coaches and scouts make informed decisions about player selection. Overall, the reliable assessment of volleyball skills through this protocol can enhance training effectiveness, player development, and talent identification, contributing to the overall improvement of volleyball performance.

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# TEST-RETEST I INTER-RATER POUZDANOST TESTOVA PRECIZNOSTI U ODBOJCI KOD ŠKOLSKE DECE

*Cilj ovog istraživanja bio je ispitati test-retest i inter-rater pouzadnost testova preciznosti u odbojci na uzorku dece školskog uzrasta. Studija je obuhvatila uzorak od 46 ispitanika uzrasta 12-13 godina (telesna vsina: 158.97 ± 5.39 cm; telesna masa: 52.20 ± 5.58 kg; godine starosti: 12.4 ± 0.7 godina) koja su najmanje godinu dana učestvovala u školskim programima odbojke. Testiranje je sprovedeno u dva odvojena navrata radi procene test-retest pouzdanosti, pri čemu je svaki put praćena ista procedura. Za procenu inter-rater pouzdanosti, dva merioca su nezavisno beležila učinak ispitanika, osiguravajući konzistentno i nepristrasno bodovanje. Testirane varijable podrazumevale su gornji i donji prijem, dizanje lopte i servis. Perfektna test-retest pouzdanost (Intraklasni koeficijent korelacije (ICC) > 0.90; koeficijent varijacije (CV)% < 10%) uočena je za dizanje i servis. Pored toga, pronađena je skoro perfektna pouzdanost za gornji prijem (ICC = 0.84) i donji prijem (ICC = 0.72) sa visokim CV% (> 10%). Rezultati inter-rater pouzdanosti pokazali su veoma visoke ICC vrednosti (> 0.89) za sve varijable. Studija je pokazala da protokol testiranja veština u odbojci pruža konzistentne i pouzdane procene za igrače, bez značajnih razlika između test i retest sesija u svim procenjivanim veštinama.*

Ključne reči: *testiranje, odbojka, školska deca, pouzdanost*

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**Research article**

# ADOPTION OF AI IN RACE AND MARATHON EVENT MANAGEMENT: A CASE STUDY IN SERBIA

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**Ivana Manevska[1], Tatjana Pivac[1], Vanja Pavluković[1], Igor Stamenković[1], Marija Bratić[2]**

[1]Department of Geography, Tourism and Hotel Management, Faculty of Sciences, University of Novi Sad,
[2]Department of Geography, Faculty of Sciences, University of Niš

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|---|---|---|
| ORCID iDs: | Ivana Manevska | https://orcid.org/0009-0000-6927-1827 |
| | Tatjana Pivac | https://orcid.org/0000-0002-1660-1295 |
| | Vanja Pavluković | https://orcid.org/0000-0001-7093-3656 |
| | Igor Stamenković | https://orcid.org/0000-0001-6901-5946 |
| | Marija Bratić | https://orcid.org/0000-0001-7122-8668 |

**Abstract**. *This study investigates the adoption of artificial intelligence (AI) among marathon and race organizers, evaluating their familiarity with this technology and its potential benefits in event management. A survey was conducted among 25 marathon and race organizations across Serbia, with responses received from 14 organizations. The results showed varying levels of familiarity with AI, alongside diverse perspectives on its effectiveness in event management. While some organizers believe AI improves efficiency in organizing and managing events, others remain skeptical due to limited exposure. The findings suggest that AI integration into marathons and races in Serbia is in its early stages, though there is a growing interest and recognition of AI's potential. Key metrics, such as the competency and readiness levels for AI adoption, averaged 3.4 and 5.6 (on a scale of 1-10), respectively. The study concludes that AI's full potential remains largely unexplored by most organizers.*

**Key words**: *artificial intelligence, AI, marathons, races, event industry*

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**Corresponding author:** Manevska Ivana
Department of Geography, Tourism and Hotel Management, Faculty of Sciences, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia
E-mail ivanam1998.im@gmail.com

## 1. INTRODUCTION

The event industry officially began in the mid-1970's, with the exact date and event varying widely depending on the source (Schmader et al., 1997; Fletcher et al., 2009). The numbers and types of events increase daily, ranging from sports and recreation events to professional meetings, conventions, fairs, festivals, expositions, fundraising, corporate, community, marketing, and entertainment events. As the industry has diversified, so too have the professionals who organize these events, often learning and adapting through hands-on experience (Fletcher et al., 2009).

Sports events, particularly marathons and races, have gained prominence as one of the most popular event types globally. Additionally, those events contribute to the prestige and positive image of a location, providing an opportunity to present positive changes in a place (Lubowiecki & Basińska, 2011; Piekarz et al., 2015; Łuczak, 2021). Running, as a form of physical activity, has seen increasing participation rates, making it one of the most practiced exercise activities worldwide (Scheerder et al., 2015; Running USA, 2014; Janssen et al., 2020). Marathons and races attract a diverse group of participants, ranging from casual runners to professional athletes, which introduces multiple risks associated with this diversity; therefore, careful planning is essential to ensure safety, comfort, and satisfaction for all participants (Janssen et al., 2006; Lubowieck & Basińska, 2011; Piekarz et al., 2015; Scheerder et al., 2015; Cook et al., 2016; Janssen et al., 2017; Łuczak, 2021; Janssen et al., 2020). Marathon organization involves collaboration among organizers, healthcare officers, safety officers, support teams, and marathoners (Hall et al., 2019; Phua et al., 2024). The industry is currently experiencing social and technological transformations, driven by the fourth industrial revolution and AI advancements, offering new management capabilities and emphasizing the importance of understanding human behavior and preferences for successful event planning (Ekici & Toksoz, 2021).

The COVID-19 pandemic acted as a catalyst, revolutionizing marathon events and improving runner engagement (Phua et al., 2024). Users became familiar with tools on Internet of Things, leading businesses to explore AI and big data to improve customer experience (Almeida et al. 2020; Yuksel et al. 2021; González-Serrano et al. 2023; Phua et al., 2024). For instance, AI influences different aspects of sports event management, including marketing automation and optimizing operational processes. Additionally, virtual assistants and facial recognition technology streamline event logistics, enhancing participant experiences and security. (Neuhofer et al., 2021; Ogle & Lamb, 2019; https://time.ly/blog/clever-ways-to-use-artificial-intelligence-ai-in-events/; https://www.glueup.com/blog/ai-events/;https://www.eventible.com/learning/ai-in-events/)

Findings from previous research highlight the importance of further investigating the adoption of AI among marathon and race organizations, assessing their familiarity with AI and the ways it can facilitate marathon or race organization. Since the correlation between AI and the organization of marathons and races remains unclear, this study aimed to examine the impact of AI on the process of organizing marathons and races in Serbia.

## 2. METHOD

In order to understand the extent of AI familiarity among marathon and race organizations in Serbia, a quantitative approach was chosen as the most suitable methodology.

### 2.1. Sample of participants in the research

Marathons and races in Serbia were identified on the website (https://www.trcanje.rs /kalendar/?_rstr_nocache=rstr452660fb3349409a), where all the details about upcoming races and marathons in Serbia were found, including basic information about the location, date, distance, and organizer of each event. After identifying marathon and race organizations in Serbia, to gather more details about the organizations, their website, email, phone number, and social media profiles such as Facebook and Instagram, a Google search was conducted. This data led us to discover that 25 organizations in Serbia host sport events like marathons, half marathons, and races.

**Table 1** Characteristics of the organizations

| N | M | HM | OR | P |
|---|---|---|---|---|
| 14 | 5 | 1 | 26 | 30-13000 |

Descriptive statistics found in Table 1 include the number of organizations that responded to the survey (N); the total number of marathons organized by these organizations in one year (M), which may vary depending on the existence of their organization; the total number of half marathons organized by these organizations in one year (HM), which may vary depending on the existence of their organization; the total number of other races organized by these organizations in one year (OR), which may vary depending on the existence of their organization; the range of participants in the marathons, half marathons, and other races (P), varying depending on the organization and event.

### 2.2. Measures

The questionnaire was based on a scholarly investigation delving into the roles and practical uses of robotic technology, AI, and service automation in event management, emphasizing their potential to enhance safety protocols, marketing strategies, operational efficiency, and overall participant experience (Ogle & Lamb, 2019). Additionally, examples from blogs describing clever ways to use AI in event planning, promotion, execution, and analytics to enhance processes and maximize the potential of events were utilized and adapted in the context of marathons and races in the questionnaire (https://time.ly/blog/clever-ways-to-use-artificial-intelligence-ai-in-events/; https://www.glueup.com/blog/ai-events). The first part of the questionnaire is focused on basic demographic data and other information about the organization of marathons and races, using open-ended questions. The second part addresses technology and AI, combining open-ended questions with yes/no/unsure responses, and a scale from 1 to 10 to evaluate their readiness to use AI technologies, development among employees, as well as the effectiveness and efficiency of AI; with 0 indicating no use. This section also includes questions where respondents expressed their views on AI through statements rated on a Likert scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Unsure, 4 = Mostly Agree, 5 = Agree, and 6 = Strongly Agree.

### 2.3. Procedures

The survey questionnaires were prepared in digital format using Google Forms and depending on the contact information found, the questionnaires were disseminated in February 2024. For data processing, methods of descriptive statistics were used. Google Forms was used as a tool to disseminate the questionnaires, and textual responses were coded and analyzed in Excel (Pivot). The survey was sent to 25 organizations of marathons and races, and responses were received from 14 organizations. Thanks to the response section in Google Forms, it was possible to quickly and clearly see the results, as the sample size was not large.

## 3. RESULTS

After disseminating the questionnaires to 25 organizers of marathons and races, responses were received from 14 organizers, while 11 organizers did not respond.

Table 2 shows that technologies are widely used in managing events, with 79% of the respondents confirming their use. However, the adoption of AI in planning is significantly lower, with only 14% using it. Additionally, 50% of the respondents are unsure about their intention to adopt AI in the future, indicating uncertainty about its future application.

**Table 2** Use of technologies, AI and intention of using AI

| Response Type | Use of technologies in managing | Use of AI in planning | Intention to implement AI |
|---|---|---|---|
| Affirmative | 79% | 14% | 21% |
| Negative | 21% | 86% | 29% |
| Unsure | / | / | 50% |

Table 3 demonstrates that social media (44%) and registration systems (25%) are the most commonly used technologies, while other tools like interactive maps, marketing tools, and specific software are used by a smaller percentage of the respondents.

**Table 3** Specific technologies used in marathons and races

| Technology | % of usage |
|---|---|
| Social media | 44% |
| Application with interactive maps and notifications | 6% |
| Marketing tools (unspecified) | 6% |
| Notion, Witisi Software, Photography App, etc. | 6% |
| Registration systems | 25% |
| Website for promotion | 6% |
| Runtrace portal | 6% |

The data in table 4 show a low level of competency in using AI, while their readiness to adopt AI (5.6) shows moderate potential for future integration.

**Table 4** Evaluation of the competencies and readiness of the organizations to use AI

| Evaluation competencies and readiness to use AI | Mean result (scale 1-10) |
|---|---|
| Competency level of the organisation in using AI | 3.4 |
| Readiness level of the organisation to use AI | 5.6 |

Table 5 shows general agreement on AI's potential to improve aspects like marathon safety and logistics. However, the respondents are unsure about AI's effectiveness in areas like crisis management and predictive analytics for crowd dynamics.

**Table 5** Views on AI enhancing in marathons and races

| Statement | Agreement Level |
|---|---|
| AI enhances marathon safety with facial recognition. | Mostly agree |
| AI predictive analytics manage crowd dynamics effectively. | Unsure |
| AI provides real-time updates on race details. | Mostly agree |
| AI personalizes engagement based on participant data. | Mostly agree |
| AI handles large data for better event logistics. | Mostly agree |
| AI and AR offer immersive marathon experiences. | Mostly agree |
| AI enables virtual participation for remote users. | Mostly agree |
| AI aids logistics with trend insights and resource forecasting. | Mostly agree |
| AI gives tailored training recommendations based on performance. | Unsure |
| AI supports crisis management with real-time insights. | Unsure |

Table 6 reveals that there is resistance to using AI for generating emails and marketing materials, while there is a relatively higher acceptance (36%) for using AI in preparing programs.

**Table 6** Usage of chatbots

| Response Type | Preparing programs | Generating emails | Creating marketing materials | Generating planning templates |
|---|---|---|---|---|
| Affirmative | 36% | 14% | 29% | 7% |
| Negative | 64% | 86% | 71% | 86% |
| Unsure | 0% | 0% | 0% | 7% |

The evaluation of chatbots in table 7 reveals that chatbots are efficient in creating programs and marketing content, with higher effectiveness in email generation.

**Table 7** Evaluation of used chatbots

| Evaluation of used chatbots | Mean result (scale 1-10) |
|---|---|
| Efficiency of chatbots in creating programs | 5.7 |
| Chatbots' contribution to marketing content | 5.4 |
| Time-effectiveness of chatbots for generating emails | 6.5 |

## 4. Discussion

The findings address the research questions regarding AI familiarity and application among marathon and race organizers. Based on the feedback, it is recommended that sports event organizers in Serbia could start exploring AI technologies by implementing tools such as chatbots for customer support or personalized marketing, gradually expanding towards predictive analytics and automated logistics to improve efficiency. The study showed that even though there is interest in AI, the marathon and race organizations do not use it often or at all, since they are uncertain or unprepared to adopt AI technologies. This supports Neuhofer et al.'s (2021) claims that AI is beneficial for some areas such as. targeted marketing and dynamic pricing, but requires qualified staff and careful data handling to avoid bias and misuse. Similarly, the results align with previous studies (Ogle & Lamb, 2019; Fletcher et al., 2009) that identified the potential of AI to improve safety protocols, marketing strategies, and operational efficiency, but noted that implementation is still limited.

Furthermore, policy makers could support the adoption of AI by providing subsidies and education initiatives aimed at training event organizers. For instance, there is a growing interest in AI within the travel and tourism industry, but the existing research is mostly conceptual (Buhalis et al., 2019; Ivanov and Webster, 2019; Murphy et al., 2017; Samara et al., 2020; Tung and Au, 2018; Tung and Law, 2017; Tussyadiah, 2020; Filieri et al., 2021). Marathon and race organizations in Serbia recognize AI's benefits but face challenges in its implementation. A practical recommendation for marathon organizers is to adopt simple AI tools to streamline participant registration, optimize schedules, predict attendance, and improve sponsor communication.

The low use of AI might be because of a lack of resources, technical knowledge, or skepticism about new technologies. This underscores the need for further education about AI potential in events like marathons and races. Lommatzsch (2018) and Bhaskar and Sharma (2022) also indicate that, although chatbots and robots can replace human workers, clients still rely on the human factor for complex tasks, which aligns with our findings. Additionally, the findings support the theory that adopting new technologies like AI requires not only technical resources and education but also a change in mindset and approach among organizations. Consequently, this study shows how important it is to learn and change business models to make AI work well.

Previous studies (Schmader et al., 1997; Fletcher et al., 2009) also emphasize the events industry's evolution and the need for continuous learning and adaptation. Based on the findings of this study, marathon and race organizations should invest in training and developing skills related to AI. They should also create networks to share knowledge and resources to help each other with AI use.

The main limitation of the study is that only 14 organizations participated in the survey, and most lacked experience with artificial intelligence, limiting their ability to assess its effectiveness or contribute insights. It is also necessary to draw attention to the fact that the findings of this study are tied to the Serbian context and may not be relevant to countries. For future studies, it is important to consider the perspectives of marathon and race participants, as their satisfaction is a priority. Future research should additionally explore AI adoption across different sports and examine how it can improve the experience for athletes and audiences. Therefore, exploring their attitudes toward the integration of AI in events like marathons and races would be valuable.

## 5. CONCLUSION

Our findings indicate that AI is still in its early stages of adoption within the events industry, particularly in sports events such as marathons and races in Serbia. However, this study has shown that organizations in Serbia possess certain perceptions and awareness regarding its potential. Authors believe that completing the questionnaire sparked curiosity among those with limited AI experience and encouraged them to explore how their organizations could use AI to simplify various event organization processes.

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# USVAJANJE VEŠTAČKE INTELIGENCIJE U UPRAVLJANJU DOGAĐAJA POPUT TRKA I MARATONA: STUDIJA SLUČAJA U SRBIJI

*Ova studija istražuje usvajanje veštačke inteligencije (VI) među organizatorima maratona i trka, ocenjujući njihovu upoznatost s ovom tehnologijom i njenim potencijalnim prednostima u upravljanju događajima. Istraživanje je sprovedeno među 25 organizacija za maratone i trke širom Srbije, a odgovore je dalo 14 organizacija. Rezultati su pokazali različite nivoe upoznatosti sa VI, kao i različite perspektive o njenoj efikasnosti u upravljanju događajima. Dok neki organizatori veruju da VI poboljšava efikasnost u organizaciji i upravljanju događajima, drugi ostaju skeptični zbog ograničenog poznavanja. Rezultati istraživanja ukazuju da je integracija VI u maratone i trke u Srbiji još uvek u ranim fazama, iako raste interesovanje i prepoznavanje potencijala VI. Ključne metrike, poput nivoa kompetencije i spremnosti za usvajanje VI, u proseku su iznosile 3,4 i 5,6 (na skali od 1 do 10). Studija zaključuje da je pun potencijal VI većine organizatora još uvek u velikoj meri neistražen.*

Ključne reči: *veštačka inteligencija, VI, maratoni, trke, industrija događaja*

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**Raview paper**

# THE EFFECTS OF AN ADDITIONAL RECREATIONAL FOOTBALL PROGRAM ON PHYSICAL FITNESS IN CHILDREN – A REVIEW

*UDC 796.325-053.2*

**Stevan Stamenković[1], Ana Lilić[1], Dušan Nikolić[2]**

[1]Faculty of Sport and Physical Education, University of Nis, Niš, Serbia
[2]Academy of Vocational Studies South Serbia, Department of High School for Teachers Bujanovac, Bujanovac, Serbia

| ORCID iDs: | | |
|---|---|---|
| | Stevan Stamenković | https://orcid.org/0000-0002-3835-4838 |
| | Ana Lilić | https://orcid.org/0000-0002-7970-4689 |
| | Dušan Nikolić | N/A |

**Abstract**. *Football is the most popular sport in the world, so it is hardly unexpected that numerous organizations have employed football-related activities to address and raise awareness of health issues globally. Recreational football has shown to be a useful weapon in the fight against childhood obesity prevention and improve physical fitness. The aim of the present study was to provide a review of evidence about muscular fitness demands and cardiorespiratory fitness during recreational football according to the duration and frequency of training interventions in schoolchildren. The literature review adhered to the PRISMA guidelines. A manual database search was also performed using the following key terms, either singly or in combination: 11 for health, physical activity, motor ability, physical fitness. After the study selection, two sets of research studies were chosen according to their content: muscular fitness and cardiorespiratory fitness. The present study's findings supported the theory that the football training and recreation football program would enhance children's physical health in schoolchildren. The study showed that additional recreational football programs influence better results on muscular fitness demands on sprint 20m ($p \leq 0.05$) and Flamingo test ($p \leq 0.05$). Also, there is a statistically significant difference between the experimental group that participated in an additional recreational football program and the control group at the initial and final measurement in Resting HR and Maximal HR parameters. The recreation football is recommended to be included in the syllabus of the schools in all groups to enhance physical well-being and lower the likelihood of acquiring non-communicable diseases.*

**Key words**: *soccer, school, Yo-Yo: intermittent recovery children's running, blood pressure, heart rate*

Received September 03, 2024 / Accepted 11 October, 2024
Corresponding author: Ana Lilić
Faculty of Sport and Physical Education, University of Niš, Čarnojevićeva 10A, 18000 Niš, Serbia
E-mail analilic93@gmail.com

## INTRODUCTION

In the world, there is a substantial correlation between physical inactivity and health issues (Andersen, Mota, & Di Pietro, 2016; World Health Organization, 2018), and many people do not adhere to national physical activity (PA) recommendations (World Health Organization, 2018). According to Skinner, Perrin, Moss, & Skelton (2015) and McMurray & Andersen (2010), obesity and physical inactivity (PI) are linked to all the risks of cardiovascular illnesses, which raises the possibility of premature mortality (Freedman, Mei, Srinivasan, Berenson, 2007). Globally, PI is becoming a bigger danger to public health. As a result, throughout the course of the 42-year examination, the global prevalence of obesity rose by 4.9% for girls and 6.9% for boys, with no sign that most countries will soon reach a plateau (Cvetković, Stojanović, Stojiljković, Nikolić, Scanlan et al., 2018a). It is often recognized that if overweight and obese children do not make the necessary lifestyle changes, such as increasing physical activity and cutting calories, then over half of them will grow up to be obese adults (Freedman, Khan, Serdula, Dietz, Srinivasan et al., 2005). The World Health Organization (WHO) advises kids and teenagers to participate in moderate-to-intense PA, primarily aerobic, for at least 60 minutes a day on average throughout the week (Burtscher, Millet, & Burtscher, 2023).

Based on the available data, school programs offer a significant chance to boost physical activity levels, as kids spend over 50% of their waking hours in school (Cvetković et al., 2018a). Consequently, it is debatable whether regular PE sessions may prevent childhood obesity without adding more physical exercise. The children's major problem with PE courses is the total amount of active time and low average intensity (Kirkham-King, Brusseau, Hannon, Castelli, Hilton et al., 2017). In order to achieve physical activity recommendations, only a tiny percentage of youngsters (boys = 2.9%, girls = 1.8%) are sufficiently active throughout the entire class (Nettlefold, McKay, Warburton, McGuire, Bredin et al., 2011). Considering that time constraints and low motivation are two frequently mentioned obstacles to physical activity, it is evident that children benefit from extra physical activity that addresses these problems, is quick, and engages them. Frequent PA offers major benefits for both physical and mental health, especially in childhood and adolescence (Bangsbo et al., 2016). Few studies find that kids, who are physically active as children, have a higher likelihood of remaining active as adults (Telama, Yang, Laakso, & Viikari, 1997; Malina, 2001a; Malina, 2001b).

Football is the most popular sport in the world, it is hardly unexpected that numerous organizations have employed football-related activities to address and raise awareness of health issues globally (Fuller, Junge, DeCelles, Donald, Jankelowitz et al., 2010). Small-sided games, regardless of the body mass index, degree of fitness, or previous football experience causes high heart rates, a lot of intense actions coupled with high engagement, technical success rates, and training effects in both boys and girls (Bendiksen, et al., 2014; Krustrup, et al., 2014). According to Krustrup et al. (2014), recreational football has shown to be a useful weapon in the fight against childhood obesity prevention. Furthermore, for obese children, this kind of physical activity is a suitable substitute for continuous-practice exercises like jogging, cycling, swimming, or other activities that enhance the cardiorespiratory system over a brief training period (Castagna et al., 2007). Recreational football has positive effects on the development of the cardiorespiratory system as well as body fat reduction and oxidation (Nybo et al., 2010; Krustrup et al., 2010). Recreational football is typified by a lot of twists, hops, and quick sprints that help players build their bone density and muscle mass (Krustrup, Rollo, Nielsen, & Krustrup, 2007; Andersson, Ekblom, & Krustrup, 2008). Additionally, because recreational football is so widely utilized, has a lot of incentive features, and is simple to use, it should be used to promote health. Hansen, et al. (2021) showed short-term recreational football training is suitable for positive structural and functional cardiovascular adaptations in overweight children. However, the short-term effects of recreational football on physical fitness in overweight and obese children are still unclear. Also, we do not have more information on additional classes on recreational football and its benefits regarding muscular fitness demands and cardiorespiratory fitness in schoolchildren.

In this context, the purpose of the present study was to provide a review of the evidence about muscular fitness demands and cardiorespiratory fitness during recreational football according to the duration and frequency of training interventions in schoolchildren.

## METHODS

### Study Design

The literature review adhered to the PRISMA guidelines for systematic reviews and meta-analyses (Moher et al., 2009). A literature search was conducted using the following bases: MEDLINE, Google Scholar, PubMed, Scopus, DOAJ. For the collection and review of previous research, the descriptive method was used parallel with the theoretical analysis. The study included “11 for health”, “physical activity”, “motor ability”, “physical fitness” studies closely associated with the physical fitness of schoolchildren who were carefully analyzed and also met all the criteria for selection. The initial literature search identified 67 references which fulfilled some of the criteria of the study. However, 55 were disqualified based on the selection and additional standards (Figure 1). Only studies in which the participants were schoolchildren 9 to 13 years old. The study was limited to research papers published in the period from 2010 to 2023. In addition, to identify further studies with the same or comparable research challenges, the references of every study were examined.

#### *Study selection and data collection*

Using the Population, Intervention, Comparator, and Outcome (PICO) criteria (see Table 1), the participants' ages were the most crucial factor in the selection process, and at the same time represented the primary aim. The second requirement for accepting a study was that it was related to football activity and physical fitness. After the study selection, two sets of studies were chosen according to their content: muscular fitness and cardiorespiratory fitness. The frequency was two times per week with a minimum of 45 minutes per session. Also, this research included a study with an experimental design with a minimum of one experimental and control group. Every category is shown in the table separately because it is better visibility.

**Table 1** PICO Criteria

| | |
|---|---|
| Population | Recreational football (schoolchildren) |
| Intervention | Measuring muscular fitness and cardiorespiratory fitness before and after the recreational football |
| Comparator | Observational group |
| Outcome | CMJ: countermovement jump; HJ: Horizontal jump; PB: Postural balance; SLJ: Standing Long Jump; Yo-Yo: intermittent recovery children's running test; AAT: arrowhead agility test; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate |

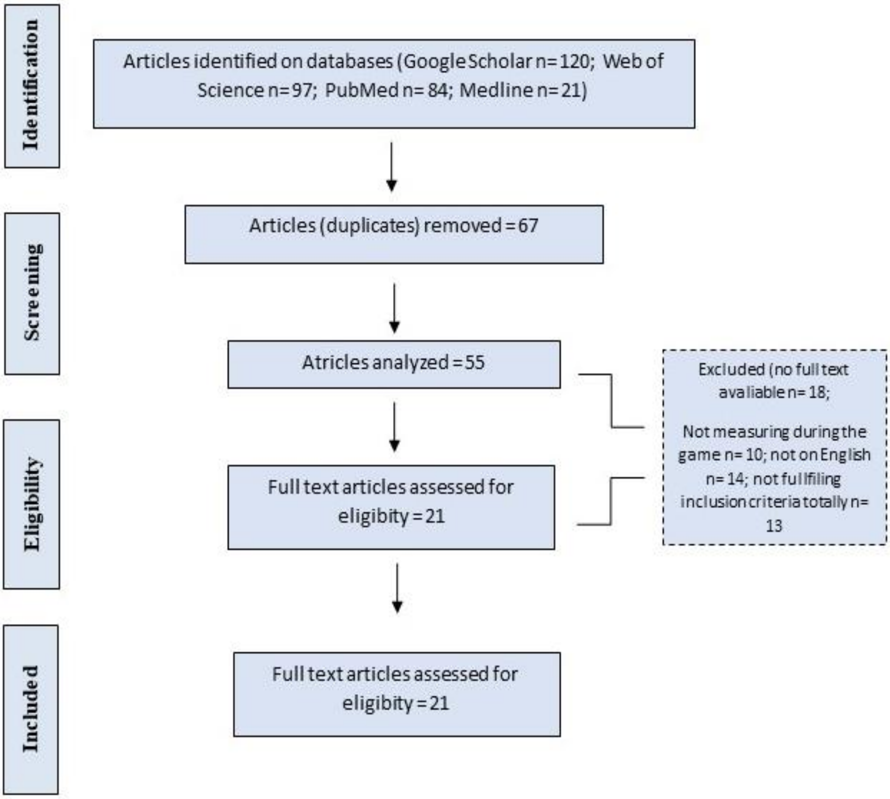


**Fig. 1** PRISMA flow chart of article selection process

The collected and analyzed studies are shown in Table 2. Each study is shown with the following parameters: years of research, gender, sample size, muscular fitness (countermovement jump; CMJ with arm swing; standing long jump, Agility, sprint) and cardiorespiratory fitness parameters (intermittent recovery children's running test, systolic blood pressure, diastolic blood pressure, heart rate).

The number of participants varied from study to study so that the minimum number of participants (14) was found in study conducted by (Cvetković et al., 2018a; Cvetković, Stojanović, Stojiljković, Nikolić & Milanović, 2018b) and the largest number of participants (944) in the study conducted by Ørntoft et al. (2016). As for the sample, it could not be strictly separated into categories of men or women because it mainly included studies involving both sexes.

## RESULTS

**Table 2** Research findings

| Study | Age | Number and sex | Programs | Weeks/ Time per weeks X Minutes | Muscular fitness | Cardio-respiratory fitness | Results |
|---|---|---|---|---|---|---|---|
| Krustrup et al., 2014 | 9 to 10 | M and F<br>CG = 51<br>IFG = 46 | CG<br>IFG = Play football | 10/2x45 | | Resting HR, SBP, DBP | SBP = ↔, DBP = ↔, Resting HR = ↔ |
| Ørntoft et al., 2016 | 11 | M and F<br>CG = 140<br>IFG = 386 | CG<br>IFG = Play football (11 for Health) | 11/2x60 | Sprint 20m, Flamingo, HJ | YoYo, Resting HR, SBP, DBP | Sprint 20m[a] = ↓, Flamingo[a] = ↑, YoYo[a] = ↑, SBP[b] = ↓, DBP[b] = ↓ |
| Skoradal et al., 2018 | 10 to 12 | M and F<br>CG = 100<br>IFG = 292 | CG<br>IFG = Play football | 11/ 2x45 | HJ; PB | YoYo; Resting HR, SBP, DBP | HJ[a] = IFG↑ vs CG↓<br>PB[a] = IFG↑ vs CG↓<br>YoYo ↔<br>Resting HR ↔<br>SBP[a] = IFG↓ vs CG↑<br>DBP ↔ |
| Cvetković et al., 2018a | 11 to 13 | M<br>CG = 14<br>IFG = 14<br>HIIT = 14 | CG<br>IFG = Play football<br>HIIT = Work/rest = 100:0% MAS | 12/3x60 | CMJ; T-test; Sit and reach | YoYo; Resting HR, Maximal HR, SBP, DBP | Resting HR[a] = IFG, HIIT↓vs CG ↑, Maximal HR[a] = IFG, HIIT↓vs CG ↓; YoYo [b] = IFG, HIIT↑vs CG ↔; T-test[b] = IFG, HIIT↑vs CG ↔ |
| Cvetković et al., 2018b | 11 to 13 | M<br>CG = 14<br>IFG = 14<br>HIIT = 14 | CG<br>IFG = Play football<br>HIIT = Work/rest = 100:0% MAS | 12/3x60 | CMJ; Sprint 10m and 30m | | CMJ = IFG, HIIT↔vs CG ↔, Sprint 10m and 30m = IFG, HIIT↔vs CG ↔ |
| Ryom et al., 2021 | 10 to 12 | M and F<br>CG = 178<br>IFG = 944 | CG<br>IFG = Play football (11 for Health) | 11/2x45 | SLJ; Balance | YoYo, Resting HR, SBP, DBP | SLJ = ↔, Balance = ↔, YoYo[a] = ↑, Resting HR = ↔, SBP = ↔, DBP = ↔ |
| Larsen et al., 2023 | 10 to 12 | M and F<br>CG = 47<br>IFG = 61 | CG<br>IFG = Play football (11 for Health) | 11/2x45 | SLJ; PB | | PB[a] = IFG↑ vs CG↓<br>SLJ = ↔ |
| Lilic et al., 2023 | 9 to 11 | M and F<br>IFG = 39 | IFG = Play football (11 for Health) | 11/2x45 | Sprint 20m, AAT, SLJ, Balance | YoYo | Sprint 20m[b] = ↓, AAT[b] = ↓, SLJ[b] = ↑, Balance = ↔, YoYo = ↔ |

*Legend*: CG: Control group; IFG: Intervention football group; MAS: Maximal aerobic speed; CMJ: countermovement jump; HJ: Horizontal jump; PB: Postural balance; SLJ: Standing Long Jump; Yo-Yo: intermittent recovery children's running test; AAT: arrowhead agility test; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; [a] = Significant between-group difference; [b] = Significant between initial and final; ↔ = there are no significant differences; ↑ = values are higher; ↓ = values are smaller;

## DISCUSSION

This study aimed to provide a review of evidence about muscular fitness demands and cardiorespiratory fitness during recreational football according to the duration and frequency of training interventions in schoolchildren. In their study, Ørntoft et al. (2016) showed that additional recreational football programs influence better results on muscular fitness demands on the 20m sprint ($p \leq 0.05$) and the Flamingo test ($p \leq 0.05$). Similar results indicated (Cvetković et al., 2018a) that children were better on only the T-test between the initial and final results, but there were no differences between groups. Meanwhile, Cvetković et al. (2018b) showed that additional recreational football or additional HIIT training did not show significant effects on muscular fitness demands. From the presented studies (Ørntoft et al., 2016; Cvetković et al., 2018a; Cvetković et al., 2018b) it can be seen that there are discrepancies in the results. Although the programs had a greater volume (60 minutes per session) and frequency (3 times per week) of programs, there were still no significant changes in muscular fitness demands.

On the other hand, when we talk about cardiorespiratory fitness during recreational football, Ørntoft et al. (2016) showed that an additional program of recreational football has a positive effect on cardiorespiratory fitness. In the endurance test (yo-yo) there are significant differences between the groups at the final test ($p \leq 0.05$), while the SBP and DBP values were lower in the experimental group at the initial measurement. Similar results were also obtained by Cvetković et al. (2018a), where there is a statistically significant difference between the experimental group that participated in an additional recreational football program and the control group at the initial and final measurement in Resting HR and Maximal HR parameters. Krustrup et al. (2017) explained recreational football is superior to other forms of exercise in lowering DBP through improved muscle capillarization, decreased arterial stiffness, and increased cardiac relaxation time. In addition, short-term recreational football intervention was related to increased left ventricular posterior wall diameter, isovolumetric relaxation time, and tricuspid annular plane systolic excursion in overweight and obese children (Hansen et al., 2013). Based on the works that had a greater volume and frequency of programs in their content, we can see that this type of program has an easier effect on cardiorespiratory fitness.

Studies with a standard additional protocol 2 times per week and 45 minutes per session also had different results on muscular and cardiorespiratory fitness. Skoradal et al. (2018) results showed that muscular fitness demands indicated statistically significant differences between groups in the initial and final results on the horizontal jump ($p \leq 0.05$) and postural balance ($p \leq 0.05$). However, cardiorespiratory fitness parameters did not have statistical differences except in systolic blood pressure. Improved postural balance could have resulted from adaptive changes in the somatosensory system and stronger bone and muscle in the lower limbs (Jakobsen, Sundstrup, Krustrup, & Aagaard, 2011; Helge et al., 2010). Similar results (Ryom et al., 2021) showed no statistical differences between groups for muscular fitness. In cardiorespiratory fitness parameters, they displayed differences only in the intermittent recovery children's running test ($p \leq 0.05$) in favor of improving the results of the experimental group. Studies have shown that high-intensity football training is associated with aerobic intermittent high-intensity exercise capacity, and that high-intensity training can be efficient at improving aerobic exercise in adolescents and adults (Póvoas et al., 2016; Hansen et al., 2013; Krustrup, Dvorak, & Bangsbo, 2016). Larsen et al. (2023) studied only muscular fitness demands and they showed that postural balance indicated differences between groups ($p \leq 0.05$) but not in the standing long jump. Muscular fitness demands in the study of Lilic et al. (2023) indicated statistical differences only between initial and final testing, but not in groups. They showed that children improved and the results were better at the final testing than initial. Krustrup et al. (2014), who only studied cardiorespiratory fitness parameters, showed that there were no differences between the groups. There are several limitations that needs to be acknowledged. Firstly, the small number of studies should be noted, since including large number of studies could enable the generalisation of the results. Furthermore, the vast heterogeneity of the outcome variables prevented us from performing a meta-analysis.

## CONCLUSION

In summary, the present study's findings supported the theory that the recreation football program would enhance children's physical health in schoolchildren. Although we studied the differences according to the duration and frequency of training interventions in schoolchildren, researchers showed significant differences and improved muscular fitness demands and cardiorespiratory fitness in children with additional recreation programs, regardless of the duration and frequency of the program. Therefore, this kind of training with recreational football is recommended to be included in the syllabus of the schools in all groups to enhance physical well-being and lower the likelihood of acquiring non-communicable diseases. Future studies should include more tests and more participation because some studies showed discrepancies in the results.

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# EFEKTI DODATNOG REKREATIVNOG FUDBALSKOG PROGRAMA NA FIZIČKU SPREMNOST DECE – PREGLED

*Fudbal je najpopularniji sport na svetu, stoga su brojne organizacije angažovale aktivnosti vezane za fudbal kako bi se bavile i podigle svest o zdravstvenim problemima na globalnom nivou. Rekreativni fudbal se pokazao kao korisno oružje u borbi protiv prevencije gojaznosti kod dece poboljšanje fizičkog fitnesa. Cilj ove studije bio je da pruži pregled dokaza o zahtevima za mišićnu kondiciju i kardiorespiratornoj kondiciji tokom rekreativnog fudbala prema trajanju i učestalosti trenažnih intervencija kod školske dece. Pregled literature je bio u skladu sa smernicama PRISMA. Ručna pretraga baze podataka je takođe izvršena korišćenjem sledećih ključnih pojmova, pojedinačno ili u kombinaciji: 11 za zdravlje, fizičku aktivnost, motoričku sposobnost, fizičku spremnost. Nakon izbora studija, izabrana su dva skupa istraživačkih studija prema njihovom sadržaju: mišićni fitnes i kardiorespiratorni fitnes. Nalazi ove studije podržavaju teoriju da bi fudbalski trening i rekreativni fudbalski program poboljšao fizičko zdravlje dece kod školaraca. Studija je pokazala da dodatni rekreativni fudbalski programi utiču na bolje rezultate na zahteve za mišićnu kondiciju na sprintu 20m (p ≤ 0,05) i flamingo testu (p ≤ 0,05). Takođe, postoji statistički značajna razlika između eksperimentalne grupe koja je radila dodatni rekreativni fudbalski program i kontrolne grupe na inicijalnom i finalnom merenju u parametrima srčane frekvence u mirovanju i maksimalne srčane frekvence. Rekreativni fudbal se preporučuje da se uključi u nastavni plan i program škola u svim grupama kako bi se poboljšalo fizičko blagostanje i smanjila verovatnoća dobijanja nezaraznih bolesti.*

Ključne reči: *fudbal, škola, Yo Yo: interminentno trčanje za decu, krvni pritisak, puls*

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