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# COMPARISON OF REPEATED SPRINT TESTS IN YOUNG SOCCER PLAYERS: STRAIGHT VERSUS SHUTTLE

# PRIMERJAVA TESTOV PONAVLJAJOČIH SE ŠPRINTOV PRI MLADIH NOGOMETAŠIH: NARAVNOST PROTI CIKCAK

## ABSTRACT

The purpose of this study was to compare the differences between physiological and performance response to different repeated sprint tests (RSTs). Nine young soccer players (age 18.3 ± 1.0 years; height 176.8 ± 5.0 cm; body-mass 74.1 ± 6.9 kg) performed Yo-Yo Intermittent Recovery Test Level 1 (YIRT1), Wingate Anaerobic Test (WAnT) and four different RST's; including two straight tests (6 x 40 m, and 8 x 30 m) and shuttle tests (6 x 40 m and 8 x 30 m) maximal runs starting every 25s. Blood lactate (La-) was measured three minutes following each RST. Significantly higher average speed responses were determined from 6 x 40 m straight than other RSTs, Additionally, a strong correlation (r=0.80) was found between the best sprint times for 6 x 40 m and the 8 x 30 m straight RST protocols. Moderate correlations were found between YIRT1 performance and the 8 x 30 m straight test performance (range: r= 0.69 to 0.72) (p≤0.05). Moreover, there were significant correlations in the total sprint times of RSTs for all protocols except 8 x 30 m shuttle (range: r= 0.68 to 0.90). Therefore, if coaches want higher speed in their training, they can choose straight RSTs and if they want higher physiological response they may select shuttle RSTs.

*Key words:* Team sport, intermittent exercise, anaerobic capacity, aerobic capacity

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## IZVLEČEK

Namen te raziskave je bil primerjati razlike med fiziološkim odzivom in uspešnostjo pri različnih testih ponavljajočih se šprintov (RST). Devet mladih nogometašev (starost 18,3 ± 1,0 let; višina 176,8 ± 5,0 cm; telesna masa 74,1 ± 6,9 kg) je izvajalo test Yo-Yo Intermittent Recovery, 1. nivo (YIRT1), test Wingate Anaerobic (WAnT) in štiri različne teste RST, vključno z dvema testoma teka naravnost (6 x 40 m in 8 x 30 m) in cikcak (6 x 40 m in 8 x 30 m), pri čemer so se maksimalni teki začeli vsakih 25 s. Tri minute po vsakem testu RST je bila izmerjena vrednost laktata v krvi (La-). Pri teku naravnost 6 x 40 m je bila ugotovljena značilno višja povprečna hitrostna odzivnost kot pri drugih testih RST. Poleg tega je bila ugotovljena močna korelacija (r = 0,80) med najboljšimi časi šprinta pri protokolu RST s tekom naravnost na 6 x 40 in 8 x 30 metrov. Zmerne korelacije so bile ugotovljene med rezultati YIRT1 in rezultati testa šprinta naravnost na 8 x 30 m (razpon: r = 0,69 do 0,72) (p ≤ 0,05). Poleg tega so bile pomembne korelacije zabeležene tudi v skupnih časih šprinta pri RST za vse protokole, razen 8 x 30 m teka cikcak (razpon: r = 0,68 do 0,90). Iz tega sledi, da lahko trenerji, kadar želijo doseči višje hitrosti na treningih, izberejo RST s tekom naravnost, če pa želijo višjo fiziološko odzivnost, pa RST s tekom cikcak.

*Ključne besede:* ekipni šport, občasna vadba, anaerobna sposobnost, aerobna sposobnost

# INTRODUCTION

The physical demands of football (soccer) involve players covering 10-13 km during matches, most of which is at low-intensities (<14km.h-1) runs (Bangsbo et al., 2006). However, high intensity exercise, or repeated bouts of short duration (Little & Williams, 2007), is of critical importance for soccer performance (Bangsbo et al., 2006). It is known that International players complete around 2.43 km of high intensity running (≥18 km.h-1) including 650 m of sprinting (≥30 km.h-1) during matches (Mohr et al., 2003). Sprinting and striding last from 2.7 to 4.4 s and are repeated every 40-70 s in a soccer game (Spencer et al., 2005). Whilst acknowledged that many factors can affect player performance (technical, tactical and physical), given the importance of high-intensity efforts to match play outcomes, it has been suggested players require an anaerobic energy capacity (Castagna et al., 2006). Consequently the methods to determine both aerobic and anaerobic capacity and repeated high energy efforts may be relevant to soccer.

The sprint and repeated sprint ability (RSA) of soccer players has been one of the most frequently discussed topics in recent years by coaches and sports scientists. For example, Paton et al. (2001) find that as little as a 0.8% decrease in sprint performance can affect performance negatively. In addition, Krustrup et al. (2006) examined muscle and blood metabolites during the game and relate it to possible changes in sprint performance of soccer players. They found that mean sprint time of players was unchanged after the first half, on the other hand, because of many factors which cause fatigue such as neural factors, muscular factors (Girard et al., 2011), it was longer after the match as well as after intense periods in the first and second halves. Thus, the development of RSA of players can help to make the sprint performed in the last stages of the competition the same quality.

The most popular test to determine anaerobic capacity of players is the Wingate Anaerobic Test (WAnT), performed on a cycle ergometer (Hoffman et al., 2000). However, the WAnT is thought to be inappropriate for soccer players because of limited transference and relevance of results to team sport performance (Aziz and Chuan, 2004; Meckel et al., 2009). Therefore, repeated sprint tests (RST) which measure the ability to perform subsequent sprints using minimal recovery (Spencer et al., 2005) have been used by sport scientists as a more relevant assessment of high-energy demands than WAnT. However, there are a variety of RST's, including straight line RST (Meckel et al., 2012; Spencer et al., 2011; Temfemo et al., 2011), change of direction RST (Abrantes et al., 2004; Da Silva et al., 2011; Meckel et al., 2009) and shuttle RST (Castagna et al., 2007; Impellizzeri et al., 2008; Krustrup et al., 2006). Consequently, as highlighted above, the diversity of RST's involve numerous variations that can affect repeated-sprint performance, and should be considered to ensure appropriate RST selection according to sport-specific needs (Spencer et al., 2005).

While many studies have investigated the relationships between various measures of aerobic, anaerobic and repeated sprint performance, few studies compare different types of RST to ensure they have similar construct validity. Meckel et al. (2009) examined the relationships between aerobic fitness, anaerobic capacity, and performance values for RSTs with two different test formats, including 6 x 40-m sprints with 30 s recovery, and 12 x 20-m sprints with 20 s recovery. The results of this study showed that there were significant moderate correlations between the fastest sprint time, total sprint time (respectively; $r = 0.61$; 0.70), and low correlations with performance decrement (PD; $r = 0.411$) of the 2 RSTs protocols. However, no difference was found between the blood lactate (La-) responses of the respective tests (Meckel et al., 2009). In another study, Wong et al. (Wong et al., 2012) stated that straight line RST and change of direction RST showed high correlations, concluding that these two tests have similar metabolic demands. Conversely, they found ≤ 50 % of the shared variance between the fastest time, average time, and total time– suggesting other factors were affecting performance responses. Buchheit et al. (2010) examined the relationships between two RSTs consisting of six repetitions of maximal 25 m sprints starting every 25 s, either in the format 6 x 2 x 12.5 m or 6 x 25 m. Buchheit et al. (2010) found large and very large correlation between best sprints (0.63) which proved that this variable had low shared variance (less than 50%), so this variable is considered different ability in those two tests. On the contrary, the correlation between mean sprints was higher (0.78) which proved that those two tests had more than 50% shared variance and that these to tests measure the same ability when the results are expressed in mean time. Finally, a moderate association has been found between Yo-Yo Intermittent Recovery Test Level 1 (YIRT1) performance and total time of repeated sprint and sprint decrement for 6 x 30 m sprints starting every 30 s (Spencer et al., 2011). However the results of studies which have examined the relations between YIRT1 performance and RST performance are not clear. The reason for these unclear results could be the large number of variations which can affect RST performance such as those mentioned above.

To date, studies have compared different RSTs focusing on the effects of the format of the tests (change of direction or shuttle) on performance (Buchheit et al., 2010; Wong et al., 2012), but no study has yet examined the effects of bout number, distance, and format on performance in RSTs, particularly with the same total distance, or the relationships between RSTs with aerobic and anaerobic performance. Therefore the purpose of this study was to compare the differences between physiological and performance response to different RSTs.

## METHODS

### Subjects

Nine soccer players (age 18.3± 1.0 years; height 176.8 ± 5.0 cm; body-mass 74.1 ±6.9 kg, training experiences = 6.3 ± 1.3 years) from amateur league voluntarily participated in this study. All the players were members of the same team and trained for one and half hours five days per week in addition to weekly official match. Players were uninjured and had no medical concerns. While all of the players were notified about the research procedures, requirements, benefits, and risks before giving informed consent, no information was given about the aim of the study. Written informed consent was obtained from all the subjects. The local University Ethics Committee approved the study protocol design, which respected the principles of the Declaration of Helsinki.

### Procedures

All data collection was conducted over a 5 week during the season period. In the first two weeks the participants were familiarized with the RSA test which used in the study all test were performed two times by all players. On the first day of third week, YIRT1 and anthropometric measurements (height and body mass) were recorded from each player. After 48 hours from YIRT1, the subjects performed the WAnT. Fourth and fifth week of the study of first, second, third and fourth day, the four RSTs were performed in random order by all players with at least 48 hours between each testing day (Only one test was carried out on any given day) (Gharbi et al., 2014). Blood lactate concentration (La-) was determined three minutes after the end of the

RSTs (Padulo et al., 2015). While the YIRT1 and RSTs were performed on a synthetic grass pitch, the WAnT was performed in a laboratory at a similar time of the day (between six and eight p.m) to attempt to control for chronobiological characteristics (Drust et al., 2005). Players are not allowed to eat in the 2 h before testing, but drink water. The players asked to give their maximal effort during each of the fitness tests and verbally encouraged were used for all players during all tests. Players asked to wear the same football boots in outdoor test and running shoes during WAnT test (Spencer et al., 2011).

**The Yo-Yo intermittent recovery test (Level 1)(YIRT1)**

The YIRT1 was carried out using the standard protocol. This involves repeated 20-m runs back and forth between the starting, turning and finishing lines at a progressively increasing speed, which is controlled by audio bleeps. When the subject failed to reach the finishing line in time twice, the distance covered was recorded as the test result (Krustrup et al., 2003).

**The Wingate Anaerobic Test (WAnT)**

The Wingate Anaerobic Test (WAnT) was performed using a mechanically braked cycle ergometer (834 E, Monark, Vansbro, Sweden). The duration of the test was 30 s. The subjects warmed up for 5 minutes against no load, which included 10 practice sprints. These involved pedalling against no resistance to 120 rpm, at which stage a resistance of 7.5 % of body weight was applied and subjects were encouraged to pedal as fast as possible until end of the test. Peak power and mean power was calculated automatically by the Wingate Anaerobic Test computer program (Kin-Isler et al., 2008). The Fatigue index (FI) was calculated using Equation 1 below.

**Equation 1**

FI = [(Peak Power Output - Min Power Output) /Peak Power Output] x 100

**Repeated Sprint Tests (RSTs)**

Four different RST protocols were performed by the subjects. The 4 protocols consisted of the following parameters: 1) 6 x 40 m shuttle; 2) 6 x 40 m straight; 3) 8 x 30 m shuttle; 4) 8 x 30 m straight (Figure 1). For each RST protocol, the sprints involved maximal runs starting every 25s and the total distance covered was 240 m. Each subject performed standard warm-up (Castagna et al., 2007), and no static stretching (Nelson et al., 2005). Times were measured using an electronic timing system (Newtest Powertimer 300-series®, Oy, Finland). Players asked to positon the front foot before a marker 30 cm from photocell beam in order to avoid starting time (Padulo et al., 2015). The percentage of performance decrement (PD) for each test was calculated using Equation 2 below (Oliver, 2009). Meckel et al.'s procedure was followed in the current study (Meckel et al., 2009).

**Equation 2**

PD% = (TT - IT)/IT× 100
(Ideal time (IT) = SBT × 6 or 8
Total time (TT) = S1 + S2 + S3 + S4 + S5+ S6+ (S7 +S8)
(SBT = Best sprint time)

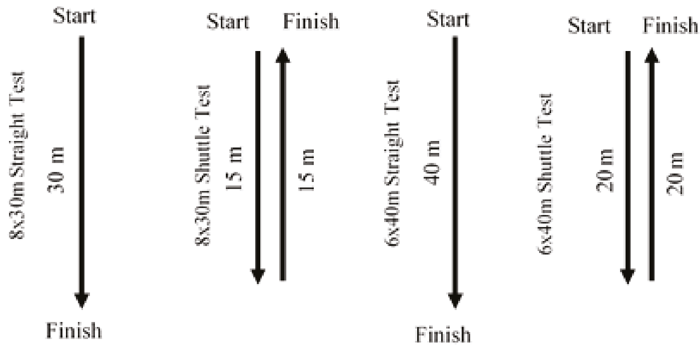


Figure 1: Repeated sprint tests

**Blood Sampling**

A portable lactate analyser (The Lactate Plus, Nova Biomedical, USA) which had previously been validated (Tanner, Fuller, & Ross, 2010), was used in order to measure La- concentration. Capillary blood samples were taken from the ear lobe 3 minutes after the completion of each RST (Taoutaou, 1996).

**Statistical analysis**

The data are reported as means and standard deviations. Before using parametric tests, the assumption of normality was verified using the Shapiro-Wilk test. A repeated-measures analysis of variance was performed on each dependent variable, including level of La-, Best sprint (s), Total sprint time (s), Performance decrement (%), speed values of 240 m of all RSTs to compare differences between RSTs. A Bonferroni Post Hoc test was applied to make a pairwise comparison between the different levels of within players' factors (grouping methods). Effect sizes (η2) were also calculated and values of 0.01, 0.05 and above 0.15 were considered small, medium and large, respectively (Cohen, 1988). Pearson correlations were calculated between the YIRT1 distance, the performance indices from the WAnT, and the performance values of the four different RSTs. The level of statistical significance was set at $p < 0.05$.

## RESULTS

The anaerobic performance and YIRT performance of the soccer players in the study are shown in Table 1, while the RSTs test results are presented in Table 2. Players reached highest average speed in the 6 x 40 m straight RST and results show that the best sprint times, total times and average speed for all RSTs were significantly different from each other ( respectively, Large effect= 0. 994; p<0.05; Large effect= 0. 991; p<0.05; Large effect= 0. 998; p<0.05), with the exception of the 6 x 40 m straight and 8 x 30 m Shuttle RST protocols best times 6 x 40 m shuttle and 8 x 30 m shuttle total times and average speed (Figure 2). While the highest La- and %PD responses were determined from 6x40m shuttle, La- and %PD responses of 6 x 40 m straight was the lowest. However, no significant differences were evident between RST formats for La- or %PD responses (p>0.05).

Table 1: Soccer players' physical characteristics and test performances

| Parameters | Mean± SD |
|---|---|
| Age (year) | 18.33±1.00 |
| Body height (cm) | 176.0±5.03 |
| Body weight (kg) | 74.11±6.97 |
| YIRT1 Distance (m) | 1862.22±386.32 |
| WAnT peak power (W/kg) | 12.38±1.60 |
| WAnT minimum power (W/kg) | 7.91±0.65 |
| WAnT average power (W/kg) | 4.00±0.84 |
| WAnT Fatigue Index (%) | 67.00±5.63 |

YIRT1: The Yo-Yo intermittent recovery test Level 1; WAnT : Wingate Anaerobic Test

Table 2: Total sprint time, performance decrement and blood lactate for the 4 different RSTs

| | 6 x 40 m Shuttle | 6 x 40 m Straight | 8 x 30 m Shuttle | 8 x 30 m Straight | F | η2 |
|---|---|---|---|---|---|---|
| Best sprint (s) | 7.35±0.17 | 5.68±0.20 | 5.64±0.16 | 4.50±0.15 | 1.250* | 0.994 |
| Total sprint time (s) | 45.93±0.84 | 34.90±1.21 | 46.41±1.32 | 37.21±1.23 | 891.638* | 0.991 |
| Performance decrement (%) | 4.13±1.81 | 2.42±1.43 | 2.85±1.51 | 3.29±0.91 | 2.425 | 0.233 |
| Blood lactate (mmol.L-1) | 9.27±2.46 | 7.58±1.36 | 7.87±2.06 | 8.05±1.43 | 1.852 | 0.188 |

* Repeated sprint tests significantly different from each other, p<0.05; RST: Repeated sprint test

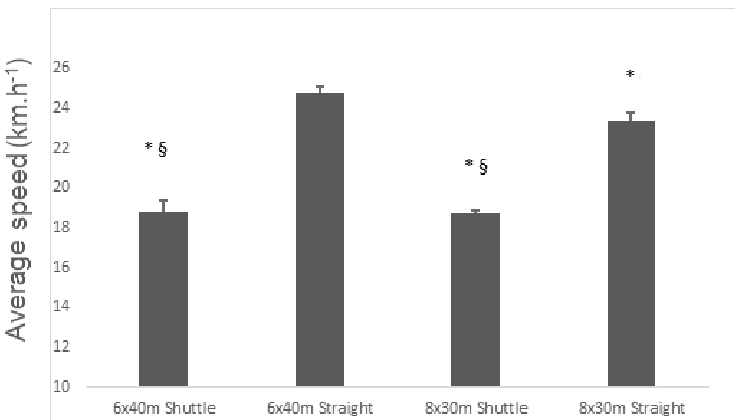


Figure 2: Average speed of all repetition of repeated sprint tests

*Significantly difference from 6 x 40 m straight;§ Significantly difference from 8 x 30 m straight

Table 3 shows the correlations among the best sprint times for the four RST protocols. Those for the 6 x 40 m shuttle protocol were moderately correlated with those for the 8 x 30 m Shuttle and 8 x 30 m straight formats (r= 0.74 and r= 0.73, respectively). Additionally, a high correlation (r=0.80) was found between the best sprint times for 6 x 40 m Straight and the 8 x 30 m straight RST protocols. However, there were no significant correlations between the results of the other RST protocols. The correlations between total sprint times of the 4 RST protocols are summarized in Table 4. There were significant correlations in the total sprint times of RSTs for all protocols except 8 x 30 m shuttle (in range; r= 0.68 - 0.90).

Table 3: Correlations among best sprint values of different RSTs

| Best sprint (s) | 6 x 40 m Shuttle | 6 x 40 m Straight | 8 x 30 m Shuttle | 8 x 30 m Straight |
|---|---|---|---|---|
| 6 x 40 m Shuttle | | 0.64 (0.06) | 0.74* (0.02) | 0.73* (0.02) |
| 6 x 40 m Straight | | | 0.51 (0.15) | 0.80*(0.00) |
| 8 x 30 m Shuttle | | | | 0.67(0.40) |
| 8 x 30 m Straight | | | | |

*p< 0.05; RST: Repeated sprint test

Table 4: Correlations among total time values of different RSTs

| Total sprint time (s) | 6 x 40 m Shuttle | 6 x 40 m Straight | 8 x 30 m Shuttle | 8 x 30 m Straight |
|---|---|---|---|---|
| 6 x40 m Shuttle | | 0.77* (0.01) | 0.68* (0.04) | 0.83** (0.00) |
| 6 x 40 m Shuttle | | | 0.90**(0.00) | 0.78*(0.01) |
| 6 x 40 m Straight | | | | 0.61(0.07) |
| 8 x 30 m Shuttle | | | | |
| 8 x 30 m Straight | | | | |

*p< 0.05; RST: Repeated sprint test

Table 5 shows the correlations between WAnT performance, YIRT performance and results (total time, best time, % PD) for the RST protocols. YIRT1 was moderately correlated with % PD for the 8 x 30 m straight RST protocol, with PD and best sprint time for the 6 x 40 m shuttle RST protocol (r= -0.72; r= -0.72; r=0.69, respectively). Additionally, a high correlation was found between WAnT average power and % PD for the 8 x 30 m shuttle RST protocol (r=0.76). However, there were no correlations between neither WAnT performance, nor YIRT performance and results for the other RST protocols.

Table 5: Correlations between results of WAnT, YIRT1 and RSTs

| | | YIRT1 (m) | WAnT Peak Power (W/kg) | WAnT Average Power (W/kg) | WAnT FI (%) |
|---|---|---|---|---|---|
| 6 x 40 m Shuttle | Total Time | 0.20 (0.58) | -0.23(0.53) | -0.31(0.40) | 0.35(0.34) |
| | Best Time | 0.69* (0.03) | -0.20(0.60) | -0.29(0.44) | 0.56(0.11) |
| | %PD | -0.72*(0.02) | 0.17(0.65) | 0.07(0.85) | -0.39(.29) |
| 6 x 40 m Straight | Total Time | 0.30(0.42) | -0.10(0.78) | -0.16(0.67) | 0.45(0.22) |
| | Best Time | 0.34 (0.30) | -0.22(0.56) | -0.27(0.47) | 0.29(0.43) |
| | %PD | -0.07(0.84) | 0.35(0.34) | 0.28(0.46) | 0.38(0.30) |
| 8 x 30 m Shuttle | Total Time | 0.39(0.29) | -0.07(0.84) | 0.02(0.95) | 0.46(0.20) |
| | Best Time | 0.38(0.30) | -0.43(0.24) | -0.36(0.33) | 0.41(0.26) |
| | %PD | -0.08(0.83) | -0.20(0.60) | 0.76*(0.01) | 0.07(0.85) |
| 8 x 30 m Straight | Total Time | 0.21(0.57) | -0.15(0.70) | -0.15(0.68) | 0.26(0.49) |
| | Best Time | 0.42 (0.26) | -0.29(0.43) | -0.26(0.49) | 0.14(0.70) |
| | %PD | -0.72*(0.02) | -0.59(0.08) | 0.47(0.20) | 0.41(0.27) |

*p< 0.05; YIRT1:The Yo-Yo intermittent recovery test level 1; PD: Performance decrement; FI: Fatigue Index; RST: Repeated sprint test; WAnT : Wingate Anaerobic Test

# DISCUSSION

The purpose of this study was to compare the differences between physiological and performance response to different RSTs. The main finding of the current study was that there were differences between four different RSTs.

Present study showed that average speed value of 6 x 40 m straight RST was significantly higher than other RSTs. In addition, although, the 6 x 40 m shuttle RST protocol elicited the highest La- values, no significant differences was found in terms of La- response of the four RST protocols. Furthermore moderate to strong correlations were found between 4 RST protocols for the total sprint times, with the exception of 8 x 30 m straight and 8 x 30 m shuttle. Strong relations were found between 8 x 30 m shuttle and 6 x 40 m shuttle RSTs, 6 x 40 m shuttle and 6 x 40 m straight, 8 x 30 m straight for best sprint time values. In our study, in the same as each other distance tests, the longer sprint distance caused higher La- response than a shorter sprint distance with a higher number repetitions independently of RSTs format (shuttle or straight). While shuttle protocols increase muscle activity over a 40m shuttle distance they decrease muscle activity for 30 m shuttle protocols. The reason of low La- responses of 30 m shuttle may be explained by those short distances which do not let players reach sufficient speed. There are some similar studies in literature. Such as, Padulo et al. (2015) compared one change of direction and two changes of direction repeated tests (RCOD) and reported that there are no differences between La- values of these two RSTs. Furthermore, they stated that there were high correlation between the best time and total time values for the two RSTs. Meckel et al. (2009) found that there were no significant differences in La- values for 12 x 20 m and 6 x 40 m RSTs. Wong et al. (2012) found that straight line RST and RCOD showed high correlations in terms of total time, fastest time and average time. On the other hand, they found ≤ 50 % of the shared variance between the fastest time, the average time, and the total time values for the RSTs in their study. In the light of these results, they reported that players need different motor abilities for RSA and RCOD tests. Buchheit et al. (2010) found that best and mean times for shuttle and straight RST were highly correlated and, additionally, that shuttle RST has a higher La- response than straight line RSTs. They concluded that shuttle RST might lead to greater systemic physiological load than straight-line RSTs. Padulo et al. (2015) reported that RSTs involving change of direction increase muscle activity. Additionally, the angles of the change of direction in the test affect physiological and perceptual response to RSTs (Buchheit et al., 2012).

We found correlations between aerobic performance and PD values for the 6 x 40 m shuttle and 8 x 30 m straight RST protocols but not between aerobic performance and PD values for the 8 x 30 m shuttle and 6 x 40 m straight protocols. In a similar study, Chaouachi et al. (2010) found a moderate relationship between YIRT1 distance and percentage sprint decrement. In another study, which examined the relationship between YIRT1 performance and 6 x 30 m RST with 30 s rest, moderate correlations were found between YIRT1 performance and repeat sprint total time for U16-18 age groups and small correlations for the U17 age group (Spencer et al., 2011). In a review study, Turner and Steward (2013) state that no relationship has been established between VO2max and RSTs which involve less than 40 m or 6 s or where the work rest ratio ≥ 1:5 for sufficient recovery to resynthesize ATP and PCr using the aerobic system, according to results of study of Da Silva et al. (2011). These findings support our results, because one bout of the 6 x 40 m shuttle test duration lasted more than 6 s and the work : rest ratio is large enough in the 8 x 30 m RST protocol. Another important factor which may lead to different results could be PD or fatigue index (FI) (Oliver et al., 2006), which have been used in order to determine the relationship between performance in RSTs and aerobic performance. Therefore, it may be more useful for a coach to focus on average sprint or total sprint performance instead of PD or FI (Bishop et al., 2011; Turner and Stewart, 2013). If they want to use one of these measures, it would be advisable for coaches to use a PD measurement that includes all sprint values instead of FI, which has equation, consists of best and worst values (Girard et al., 2011; Glaister et al., 2008). The lack of correlations indicates that there are other factors which effect the RSA performance apart from aerobic performance; players need high amount of creatine phosphate (PCr) store and high recovery ability of these stores instead of aerobic performance (Alizadeh and Hovanloo, 2010). The other important energy system that is dominant during RSTs is the lactate system, which is why the buffering capacity of the muscles is also important for performance in RSTs (Spencer et al., 2011).

According to our results, there was no relation between WAnT performance and four RSTs performance. In a similar study, Aziz and Chuan (2004) found only moderate correlations between WAnT relative mean power and total sprinting time for an 8 x 40 m straight RST protocol (30 s rest) and between the two tests' fatigue indicators. Similarly, Meckel et al. (2009) found that the fastest and total sprint times for a 6 x 40 m RST and the total sprint times for a 12 x 20 m RST were correlated with the mean power of the WAnT; no correlations were found with the other results of the RSTs. The results of previous studies reveal an uncertain picture, the reason of that could be used many different RSTs in the studies. Additionally, researchers have found no or only moderate correlations between WAnT performance and RSTs performance perhaps because these two tests could have different energy demands, contrary to common belief. The energy demands of WAnT are met from the aerobic, anaerobic alactic and lactic acid metabolism (18.6% ± 2.5; 31.1% ± 4.6 and 50.3% ± 5.1, respectively) (Beneke et al., 2002). In contrast, it has been shown that the energy demands of RSTs differ. Girard et al. (2011) summarized that the energy demands of the first sprint were met by aerobic, anaerobic alactic, lactic acid metabolism and ATP (8% ; 40%; 46% and 6%, respectively), while for the last sprint, the level of aerobic energy and PCr reaches 40% and 49% and the level of lactic acid metabolism and ATP decreases to 9% and 2%. Gaitanos et al. (1993) stated that, in the first bout of a ten bout RST lasting 6 s with 20 s recovery time, 50% of the energy demand was contributed by PCr and this value reached 80% by the tenth bout. At the end of the study they concluded that the energy demand in RSTs is mainly met by PCr and oxidative metabolism. In light of these results, it seems clear that WAnT and RSTs do not have similar physiological properties. Meckel et al.( 2009) concluded that both these test have similar duration, however the format of the tests differ; RSTs follow an intermittent format which consists of consecutive short sprint exercises interspersed with brief low intensity running or passive recovery, while WAnT is an all-out continuous test. Based on this observation, while WAnT seems suitable for assessing athletes engaging in track and field and swimming (cyclic sports), it is not recommended for team sports like soccer (acyclic sports) (Aziz and Chuan, 2004; Meckel et al., 2009).

According to current study results, the format of RSTs should be taken into account by coaches, practitioners and sport scientists in the selection of RSTs. If coaches want higher speed in their training, they can choose straight RST instead of shuttle RSTs and if they want higher physiological response they may select 40 m shuttle instead of the other formats. In addition, studies have found low or no correlation between the results of a range of RST protocols and those of aerobic tests. This indicates that RSTs are affected by factors other than aerobic performance.

It seems likely that PCr storage, the rate of PCr degradation and buffering capacity may be more important factors than the aerobic performance of players in RSTs (Spencer et al., 2011). Therefore, although RSTs elicit a highly anaerobic physiological response, they are not related to the gold standard anaerobic test WAnT and thus RSTs are likely more appropriate for team sports involving intermittent activity, such as soccer (Aziz and Chuan, 2004; Meckel et al., 2009). We think that further research on RST should be done in the future.

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