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Does the length used in the 30-15 International Fitness Test (40- vs 28-m) influence the maximal running speed achieved by under-18 players from different sports?

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Abstract: The maximal running speed (MRS) achieved in the 30-15 International Fitness Test ($30\text{-}15_{IFT}$) is widely used to prescribe high-intensity interval training (HIIT). The $30\text{-}15_{IFT}$ can be performed in either 40- ($30\text{-}15_{IFT\text{-}40}$) or 28-meters ($30\text{-}15_{IFT\text{-}28}$) length. Objectives: The aim of this study was to evaluate the MRS achieved in the $30\text{-}15_{IFT\text{-}40}$ and the $30\text{-}15_{IFT\text{-}28}$. Methods: Fifty U-18 players from different sports (handball: n=19, soccer: n=19, tennis n=12) attended two testing sessions. Results: MRS did not differ between the $30\text{-}15_{IFT\text{-}40}$ and the $30\text{-}15_{IFT\text{-}28}$ in either handball or soccer players. However, tennis players showed significantly greater MRS values in the $30\text{-}15_{IFT\text{-}28}$ than in the $30\text{-}15_{IFT\text{-}40}$ (20.80±1.87 vs 20.05±2.09 km·h^{-1}; p = 0.030; ES = 0.38). In addition, tennis player showed significant greater MRS in the $30\text{-}15_{IFT\text{-}28}$ (20.80±1.87 km·h^{-1}) than both handball (18.58±1.13 km·h-1; p < 0.001; ES = 1.53) and soccer players (18.74±0.93 km·h^{-1}; p = 0.001; ES = 1.47). Conclusions: The different MRS values in the $30\text{-}15_{IFT\text{-}40}$ and the $30\text{-}15_{IFT\text{-}28}$, entail significant practical implications for HIIT prescription in tennis players.

Keywords: Testing, maximal running speed, team-sports, tennis.

1. Introduction

The nature of most team-sport and racket-sport activities is intermittent (Buchheit, 2008). Consequently, several studies have shown that the ability to perform high-intensity efforts interspersed by incomplete rest periods is a determinant factor in sports such as soccer (Krustrup Mohr, Ellingsgaard & Bangsbo, 2005; McMullan, Helgerud, Macdonald & Hoff, 2005), basketball (Ben Abdelkrim, Castagna, Jabri, Batthik, El Fazaa & El Ati, 2010), and tennis (Fernandez-Fernandez, Granacher, Sanz-Rivas, Sarabia Marín, Hernandez-Davo & Moya, 2018). This relationship between high-intensity intermittent efforts and sport success proves the necessity of including high-intensity interval training (HIIT) within athletes' training programs.

HIIT is commonly prescribed based on the individual athlete's maximal aerobic speed (MAS) (Billat, 2001), which has been described as the minimum speed that elicits maximal oxygen uptake (Lacour, Padilla-Magunacelaya, Chatard, Arsac & Barthélémy, 1991). This MAS is also important to quantify the training load during HIIT, as cardiopulmonary responses, energy systems contribution and neuromuscular load is highly dependent on the percentage of MAS used during the sessions (Buchheit & Laursen, 2013). The individual MAS value can be obtained through numerous tests, including both laboratory (e.g., treadmill) and field tests. Several classic tests using different procedures can be found in the literature, including continuous linear (Leger & Boucher, 1980) and shuttle (Leger, Mercier, Gadoury & Lambert, 1988) run tests. Further, in an attempt to increase the specificity found in most team- and racket-sport activities, newer tests such as the 30-15 International Fitness Test (30-15IFT) have emerged (Buchheit, 2008). The 30-15IFT test includes between-efforts rest periods as well as shuttle runs, and it is considered more specific to both the fitness evaluation and the HIIT prescription for athletes participating in intermittent sports (Buchheit, Al Haddad, Millet, Lepretre, Newton & Ahmaidi, 2009; Haydar, Haddad, Ahmaidi & Buchheit, 2011; Scott et al., 2015). Thus, research has shown significant correlations between the maximal running speed (MRS) achieved in the 30-15IFT and both aerobic (VO2max) and anaerobic (sprinting and jumping) performance (Buchheit, 2008). In addition, the 30-15IFT has been shown to present high reliability in a wide diversity of sport populations (Bruce & Moule, 2017; Jelicic et al., 2020; Scott et al., 2015; Thomas, Dos'Santos, Jones & Comfort, 2016).

The 30-15IFT was originally conceived for a 40-m shuttle distance (30-15IFT-40), although Haydar et al. (2011) developed an adaptation using a 28-m shuttle distance (30-15IFT-28). The use of a shorter distance not only facilitates the implementation of the test in most sport facilities, but also uses a more specific distance for athletes participating in "short" field sports, such as handball, tennis, or basketball. Using a sample of 24 team-sports athletes (handball, futsal, basketball, and soccer), Haydar et al. (2011) showed that the MRS achieved in the 30-15IFT-28 was nearly perfectly correlated (r = 0.95) with the MRS in the original 30-15IFT-40. In addition, physiological responses such as peak heart rate and lactate concentration did not differ between the two tests. In consequence, it could be interpreted that both distances can be used interchangeably to perform the athletes' testing. In fact, testing is commonly performed using the specific mobile app for the test, which includes the beep sounds for both 40- and 28-m tests. Nevertheless, to date, there is no research assessing the influence of the test length in different sport populations.

Therefore, the main objective of the present study was to evaluate the influence of the length used during the 30-15IFT (40-m vs 28-m) on the performance of under-18 (U18) players of different sports (handball, soccer, and tennis). The second aim of the study was to analyze the relationships between MRS achieved in the two different 30-15IFT lengths and sprinting, jumping, and change of direction performance.

2. Materials and Methods

Subjects

A total of 50 male U18 players took part in the study. Participants were from three different sports: handball (n = 19), tennis (n = 12), and soccer (n =19). All participants were involved in four or five training sessions per week (8.2 ± 1.3 hours) and competed at a regional level. Descriptive data of all the participants are shown in the Table 1. Before participation, all participants underwent a medical screening, with none reporting any contraindications to perform vigorous exercise. All participants were required to maintain their normal nutritional and hydration habits and refrained from caffeine intake in the three hours before each testing session. Prior to the investigation, all participants and their guardians were fully informed about the testing procedures and provided written informed consent. The study methods were approved by the ethics committee of the university.

Table 1. Descriptive data of the participants.

Sport	Age (years)	Height (m)	Body mass (kg)
Handball (*n* = 19)	16.9 ± 0.4	1.81 ± 0.07*	78.9 ± 12.2*#
Soccer (*n* = 19)	17.1 ± 0.7	1.72 ± 0.05	63.7 ± 6.7
Tennis (*n* = 12)	16.8 ± 0.8	1.77 ± 0.04*	68.3 ± 3.8

** = significant difference with soccer players; # = significant difference with tennis players*

Design

The study followed a within-subject design that examined the influence of the length used in the 30-15$_{IFT}$ in the MRS achieved in three different sport populations: U18 handball, tennis, and soccer players. In addition, the potential associations between the MRS in both tests and sprinting (20-m linear sprint), jumping (countermovement jump [CMJ]), and change of direction (5-0-5 agility test) performance were evaluated. To do this, all participants attended two testing sessions separated by one week. Participants were familiarized with all the testing procedures as a part of their usual fitness evaluation. To avoid experimental variability, all participants were scheduled at the same time for both testing sessions. In addition, both testing sessions were performed in their habitual practicing facilities and the temperature was similar between both testing days (18–20º C). All participants were required to refrain from any strenuous exercise 24 h before each testing session.

Methodology

Testing sessions were conducted following the same order (Figure 1). After a standardized warm-up, participants performed two submaximal attempts of each of the explosive tasks (i.e., 5-0-5 agility test, CMJ, and 20-m linear sprint). Ten minutes apart, all participants performed the 30-15$_{IFT}$. The unique difference between both testing sessions was the length used for the 30-15$_{IFT}$ test (40 or 28 m), with this variable randomly balanced between participants.

Standardized Warm-up - After 4 minutes of self-selected low-intensity running, participants performed a single set of 20 seconds of dynamic stretching exercises (straight leg march, forward lunge with opposite arm reach, forward lunge with an elbow instep, lateral lunge, trunk rotations, multi-directional skipping). Afterwards, participants performed two submaximal (incremental) attempts of each explosive task.

CMJ - CMJ performance was assessed using a contact platform (Tapeswitch Signal Mat, Tapeswitch Corporation America, New York, USA). Jumps were performed with a self-selected depth, with the hands on the hips and with the instruction to jump as high as possible. Each participant performed two attempts separated by 1 minute of passive recovery, using the best trial for statistical analysis. Aiming to reduce methodological bias (landing with a notable knee flexion), the same experienced researcher validated each attempt visually.

20-m linear sprint - The time during a 20-m sprint in a straight line was measured by means of photocells (Witty System, Microgate, Bolzano, Italy). The players performed two maximal sprints interspersed with 2 minutes of passive recovery. Each sprint was initiated from an individually chosen standing position 50 cm behind the photocell. The fastest attempt was used for analysis.

5-0-5 agility test - The ability of the players to perform a single, rapid 180° change of direction over a 5-m distance was measured (photocells) using a modified version (stationary start) of the 5-0-5 agility test (Gallo-Salazar et al., 2017). Players started in a standing position with their preferred foot behind the starting line, followed by accelerating forward at maximal effort. Each player performed two trials pivoting on both the right and left feet, separated by 2 minutes of passive recovery. The fastest trial was used for analysis.

30-15 IFT - The 30-15$_{IFT}$ was performed using the procedures described elsewhere (Buchheit 2008; Haydar et al., 2011; Scott et al., 2017). Briefly, the test consists of 30-second shuttle runs interspersed by 15

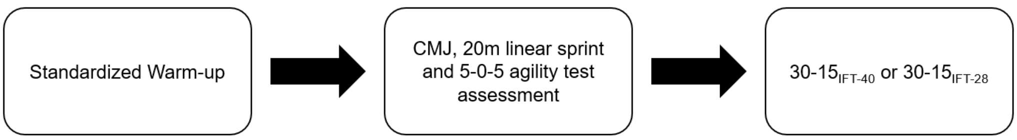

Figure 1. Testing sessions schedule.

seconds of recovery. The starting running speed was 8.0 km·h^{-1} and increased 0.5 km·h^{-1} after each stage. Participants were required to run back and forth between the two lines separated by 40 (30-15$_{IFT-40}$) or 28 m (30-15$_{IFT-28}$) following the pacing established by a recorded beep sound. This beep helps the participants to adjust their running speeds by entering in the 3-m zone located in each extreme and in the middle (20 or 14 m, depending on the length of the 30-15$_{IFT}$ used) of the field when the beep sounds. The test is considered finished when the athlete is unable to maintain the running speed imposed by the beep sound or did not reach the 3-m zone in three consecutive times (Buchheit, 2008). The last stage completed by each participant was considered its MRS in the test.

Statistical Analysis

All statistical analyses were performed using the statistical package SPSS 25 (IBM, Chicago, IL, USA). After checking data normality using the Kolmogorov–Smirnov test, a two-ways ANOVA with sport (handball, tennis, soccer) and 30-15$_{IFT}$ distance (40 vs 28 m) as main factors was performed, with a Bonferroni *post hoc* test for pairwise comparisons. The magnitude of the differences were calculated using the *Cohen's d* effect size (ES), and interpreted as trivial (< 0.2), small (0.2-0.5), moderate (0.5-0.8) and large (> 0.8). To analyze the relationship between MRS and CMJ, 20-m linear sprint, and the 5-0-5 agility test, Pearson's coefficient correlation (*r*) was calculated and interpreted as trivial (*r* <0.1), small (*r* = 0.1–0.3), moderate (*r* = 0.3–0.5), large (*r* = 0.5–0.7), very large (*r* = 0.7–0.9), and almost perfect (*r* > 0.9). Statistical significance was set at $p < 0.05$.

3. Results

The two-way ANOVA revealed a significant main effect for sport ($p < 0.001$), with tennis players showing greater MRS than handball ($p < 0.001$) and soccer players ($p < 0.001$). There was no main effect for distance (30-15$_{IFT-40}$ = 18.83 ± 1.66 km·h^{-1}; 30-15$_{IFT-28}$ = 19.10 ± 1.51 km·h^{-1}; $p = 0.290$), nor sport x distance interaction ($p = 0.536$). Specifically, the MRS achieved in the 30-15$_{IFT-40}$ was significantly lower in the handball players compared with the tennis players (18.34 ± 1.22 vs 20.05 ± 2.09 km·h^{-1}; $p = 0.009$; ES = 1.07, large), and in the soccer players compared with the tennis players (18.68 ± 1.54 km·h^{-1} vs 20.05 ± 2.09 km·h^{-1}; $p = 0.048$; ES = 0.78, moderate) with no differences between handball and soccer players ($p = 0.980$). When performing the 30-15$_{IFT-28}$, the MRS achieved by the tennis players was significantly higher than both handball (18.58 ± 1.13 vs 20.80 ± 1.87 km·h^{-1}; $p < 0.001$; ES = 1.53, large) and soccer players (18.74 ± 0.93 vs 20.80 ± 1.87 km·h^{-1}; $p = 0.001$; ES = 1.47, large). When analyzing the influence of 30-15IFT distance in each sport, results showed non-significant differences between the MRS achieved in both handball ($p = 0.610$) and soccer ($p = 0.987$) players. Nevertheless, tennis players achieved significantly higher MRS values in the 30-15$_{IFT-28}$ (20.80 ± 1.87 km·h^{-1}) than in the 30-15$_{IFT-40}$ (20.05 ± 2.09 km·h^{-1}; $p = 0.030$; ES = 0.38, small).

The relationships between the MRS achieved in both tests, and CMJ, 20-m linear sprint, and the 5-0-5 agility test performance are shown in Table 2. The MRSs achieved in the 30-15$_{IFT-40}$ and the 30-15$_{IFT-28}$ were largely correlated. MRSs in both 30-15$_{IFT-40}$ and 30-15$_{IFT-28}$ showed significantly moderate negative correlations with 20-m linear sprint.

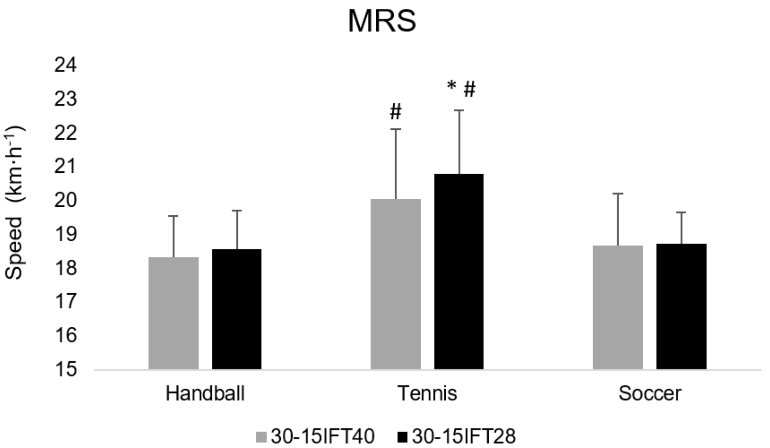

Figure 2. MRS achieved by each group in the 30-15IFT-40 and the 30-15IFT-28. ** = significant within-sport difference; # = significantly greater than handball and soccer players in the same distance.*

The relationships between MRS and 5-0-5 agility test showed a moderate, although non-significant, negative correlation (p = 0.078-0.110).

Table 2. Relationships between the MRS achieved with jumping, sprinting and change of direction performance.

	30-15$_{IFT28}$	CMJ	20m sprint	5-0-5
30-15$_{IFT-40}$	.806**	.051	-.489*	-.417
30-15$_{IFT28}$	-	.017	-.496*	-.389

*** = significant correlation (p < .001); * = significant correlation (p < .05).*

4. Discussion

The present study aimed to assess the influence of the length used during the 30-15$_{IFT}$ (40 m vs 28 m) on the MRS achieved by U18 players from three different sports (handball, tennis, and soccer). In addition, the relationships between the MRS and jumping, sprinting, and change of direction performance were evaluated. The main finding of the present study was that in tennis players, the MRS differed significantly between the 30-15$_{IFT-40}$ and the 30-15$_{IFT-28}$. Regarding correlation analysis, both tests showed significant correlations with linear sprint performance.

Before implementing a test for athletes' performance assessment, it is important to use a test as specific as possible for a given sport. In a previous study, Haydar et al. (2011), aiming to facilitate the implementation of the 30-15$_{IFT}$, developed an adaptation of the original length of the 40-m test into a shorter 28-m length. In that study, using a sample of regional-to-national level team-sports athletes (soccer and handball among them), the authors reported a non-significant difference between the MRSs achieved in the 30-15$_{IFT-40}$ (18.8 ± 2.1 km·h^{-1}) and in the 30-15$_{IFT-28}$ (18.7 ± 1.8 km·h^{-1}). The results of the present study agree with those reported by Haydar et al. (2011), as both handball and soccer players reported similar MRSs (ranging from 18.34 to 18.74 km·h^{-1}) independently of the length used for the 30-15$_{IFT}$. However, tennis players showed significantly higher MRS values (+ 0.75 km·h^{-1}) when performing the 30-15$_{IFT-28}$ in comparison to the 30-15$_{IFT-40}$. This higher MRS can be considered important, as previous research has suggested that changes of 0.5 km·h^{-1} in the 30-15$_{IFT}$ can be interpreted as a real change in performance (Scott et al., 2015). It can be hypothesized that, due to the nature of tennis requirements, with short (3 m) between-strokes displacements and a high number of changes of direction per point (Fernandez-Fernandez Ulbricht & Ferrauti, 2014), the players are better adapted to the slightly different characteristics (i.e., greater number of changes of direction) of the 30-15$_{IFT-28}$. Future studies are needed to assess if the greater MRS achieved in the 30-15$_{IFT-28}$ leads to greater physiological requirements (i.e., heart rate peak, lactate concentration) than the 30-15$_{IFT-28}$ in the tennis players.

The greater performance of tennis players during the 30-15$_{IFT-28}$ led to significant between-sports differences (see Figure 2). Apart from other potential fitness differences among tennis, soccer, and handball players, sport-specific requirements could have influenced the differences between sport populations. As explained before, tennis requires the performance of several high-intensity changes of direction during each point, interspersed by short between-point recovery periods. In comparison with tennis players, handball players perform a significantly lower number of high-intensity displacements (approximately 300 vs 100) (Chelly et al., 2011; Povoas, Seabra, Ascensão, Magalhães, Soares & Rebelo, 2012). The potential explanation of differences between soccer and tennis players' performance may be attributed to differences in the between-efforts recovery, as soccer players rest 60 seconds between high-intensity efforts (Carling, Le Gall & Dupont, 2012), while tennis players are allowed to rest a maximum of 20–25 seconds between points.

All the participants evaluated in the present study were practitioners from intermittent sports (handball, tennis, and soccer). Therefore, the appropriateness of the

30-15$_{IFT}$ is guaranteed, as this test has been shown to be linked to maximal oxygen uptake as well as sprinting, jumping, and change of direction performance (Buchheit, 2008; Covic et al., 2016; Scott et al., 2016). In the present study, significant negative correlations were found only between MRS and 20-m linear sprint time (see Table 2). This relationship is in line with other studies showing moderate-to-large correlations between MRS in the 30-15$_{IFT}$ and 10-m (Buchheit, 2008) and flying 20-m sprint (Scott et al., 2016). In the latter study, Scott et al. (2016) also reported significant correlations between MRS and the 5-0-5 agility test. In the present study, this relationship did not reach statistical significance, although a trend for relationships (with moderate correlations) was found. Contrary to Buchheit (2008), in the current study, CMJ performance was not related to MRS. This discrepancy can be linked to differences in the sample used, as Buchheit (2008) used a mixed sample of male and female athletes, while the sample of the present study was composed of male athletes with a similar competitive level. In fact, with a more homogenous sample of rugby players, Scott Hodson, Govus and Dascombe (2017) also reported no correlations between CMJ and MRS in the 30-15$_{IFT}$. Altogether, these results suggest that, in the sample used in the present study both linear sprint and change of direction ability are factors that positively contribute to better 30-15$_{IFT}$ performance, while jumping ability seems to be unimportant.

In conclusion, the results of the present study support the interchangeable use of both the 30-15$_{IFT-40}$ and the 30-15$_{IFT-28}$ in team-sport (handball and soccer) players. However, tennis players showed significantly greater MRS during the 30-15$_{IFT-28}$. As HIIT prescription is usually based on the MRS achieved in the test, coaches should be aware of the different MRSs achieved when using the different test lengths to precisely prescribe running-based HIIT sessions for tennis players. Based on the results of the present study, HIIT programming for tennis players using the MRS achieved in the30-15$_{IFT-40}$ could lead to a suboptimal training stimulus prescription. It is therefore recommended to evaluate tennis players using the short version (28 m) of the 30-15$_{IFT}$. Future studies are required using larger samples and athletes from different sports using small fields (e.g., badminton) to elucidate the potential differences in MRS as well as in physiological responses between the 30-15$_{IFT-40}$ and the 30-15$_{IFT-28}$ in racket-sport players.

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