

ORIGINAL SCIENTIFIC PAPER

Performance Improvement in Yo-Yo Intermittent Recovery Test Level 2 and During Official Matches: The Role of Speed Endurance Training Production in Élite Football Players

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Abstract

This study aims to examine the performance improvement in yo-yo intermittent recovery test level 2 (IR2) and official matches, during a competitive season in professional football players (Italian 3rd Division Series C, 2019-2020). Twenty-eight (n=28) élite football players participated in this study (age 21.4±3.3; body weight 79.7±3.4; height 182.4±5.5; fat mass 9.2±1.9), without goalkeepers. In the pre-season (4 weeks, from July to August), the players performed yo-yo intermittent recovery test level 2 (IR2), to evaluate aerobic and anaerobic performance before the start of the season. Every player has been analysed with a K-GPS Live device 50Hz (K-Sport Universal STATS, Italy) and Polar Team System PRO 2 heart-rate sensor (Polar Electro, Finland) to recorder maximal heart rate. After 12 weeks of training (in season), the same players repeat an IR2 test to check performance improvements and verify whether the training programme is correct. The first element was to determine whether the improvement in distance covered during a test is better, the same, or worse with respect to the pre-season. After 12 weeks of training, the difference between the first trial (pre-season) and the second one (in-season) is statistically significant (ES: 0.48; p<0.05; 24%). At the same time, there has been a significant improvement in match physical performance. Regarding the importance of speed endurance training during a season, it is necessary to improve performance in IR2 test after 12 weeks and improve maximal oxygen uptake and glycolytic enzyme activity. Comparing match performance before (T1) the second trial IR2 with match performance after second (T2) trial of this test, there are statistically meaningful changes.

Keywords: speed endurance, IR2, training, performance, distance covered, high intensity

Introduction

Football is an intermittent sport characterized by about 1200 acyclic and unpredictable changes in activity (each lasting from 3 to 5 s) involving, among others, 30 to 40 sprints, more than 700 turns and 30 to 40 tackles and jumps (Izzo, Giovannelli, & D'Isanto, 2019). The rhythm of play has become faster in recent years, and players can run fast-

er, performing technical skills with higher speed (Altavilla, Riela, Di Tore, & Raiola, 2017). This team sport involves periods of high-intensity activity, interspersed with lower intensity actions (Strauss, Sparks, & Pienaar, 2019), as well as technical and tactical components (Raiola & D'Isanto, 2016). Recent studies have pointed out that football players cover between 8000 m and 14000 m during a match (Aguiar,



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Botelho, Lago, Maças, & Sampaio, 2012) showing that several physical skills such as running, kicking, dribbling, and tackling can affect a player's performance (Filetti, D'Ottavio, Ruscello, Manzi, & Moalla, 2016; Chang & Dong, 2016). These efforts increase the physical demands of the players and contribute to the characterization of football as a sport with high metabolic and physiological demands (Iaia, Rampinini, & Bangsbo, 2009; Arslan et al., 2017). Moreover, computerized time, motion, and video analyses have revealed that top-class football players perform 2 to 3 km of high-intensity running (>15 km/h) and about 0.6 km of sprinting (>20 km/h). In addition, the less successful teams exhibit more significant decreases in the total speed distance covered during the match, suggesting the importance of performing high-intensity activities (Izzo & Sopranzetti, 2016) through football-specific exercises (Iaia et al., 2009).

In recent years, different training methods, such as endurance training, high-intensity interval training (HIIT) and strength training, have been proposed to develop physical, technical, and tactical skills (Hammami, Negra, Shephard, & Chelly, 2017). Several studies have examined the effect of performing high-intensity training through football-specific

exercises, showing that it is possible to achieve an elevated exercise intensity using the ball, as demonstrated by elevated heart rates, marked blood lactate accumulations, and high rates of perceived exertions (Iaia et al., 2009; Izzo & Giovannelli, 2018). The ability to perform intense exercise is a key component of performance in a football game (Izzo & Lo Castro, 2015). Studies have demonstrated that both male and female top-class football players perform more considerable high intensity running and more sprinting in a game compared to elite players at a lower competitive standard. The difference is mainly due to the players at the higher level carrying out a higher number of intense runs, which is related to a better ability to recover from intense exercise. Fatigue development in a game can be evaluated by examining fluctuations in highly intense exercise throughout the game. In the most intense intervals during a game, a player can experience fatigue temporarily and needs to recover before another sequence of intense actions can be performed with high quality (Bangsbo, & Mohr, 2019). This is illustrated in Figure 1, which shows the high-intensity running of a male elite player during a game divided into five-minute periods.

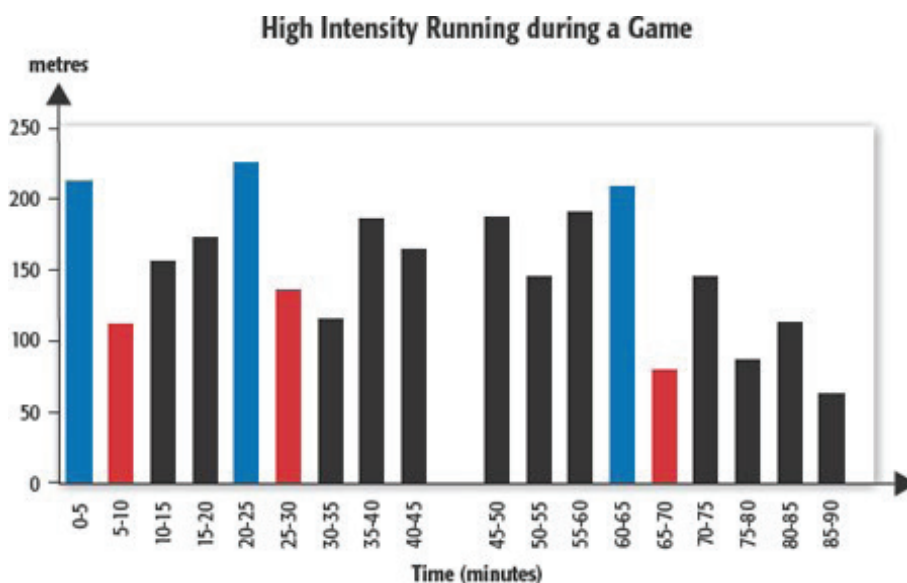


FIGURE 1. The figure shows the distance of high intensity running covered by an Italian Serie A midfield player (Bangsbo, & Mohr, 2019). Note that the player after the three most intense 5-minute intervals (blue bars) performed significant less work (red bars)

After the three most intense five-minute intervals (in blue), this player does less considerable high speed running in the following five-minutes (in red) because he has to recover from the intense exercise in the demanding game-periods. This type of temporary fatigue is different from the fatigue towards the end of a game and requires different testing modes. The faster a player recovers, the quicker the player can repeat another bout of intense exercise. Thus, the recovery capacity of a player should be evaluated (D'Isanto, D'Elia, Raiola, & Altavilla, 2019) to determine the ability to do football-specific intense exercise. In football games; the high-intensity bouts of running range from 5 to 70 metres, but the majority of these runs are less than 20 metres.

Furthermore, the player should be able to accelerate, decelerate and change direction, which are essential variables in intense football runs and need to be included in a foot-

ball-specific test. Most of the high-intensity running bouts in a game at an elite level are performed at speeds of 14–21 km/h, which means that running at these speeds must be challenged in an intense intermittent test for football players.

All these aspects are included in the Yo-Yo Intermittent Recovery (Yo-Yo IR) test, which measures the ability to recover and repeatedly perform intense exercise with similar characteristics as in a football game. For these reasons, it is obvious why the Yo-Yo IR test is the most commonly used test in both recreational and professional football; it has two levels (see below). In a recent study, all players in a Scandinavian National league were tested both with the Yo-Yo IR1 and Yo-Yo IR2 test, which demonstrated that the top three teams had significantly higher Yo-Yo IR2 scores than the bottom three, while no difference was observed in Yo-Yo IR1 performance (Figure 2).

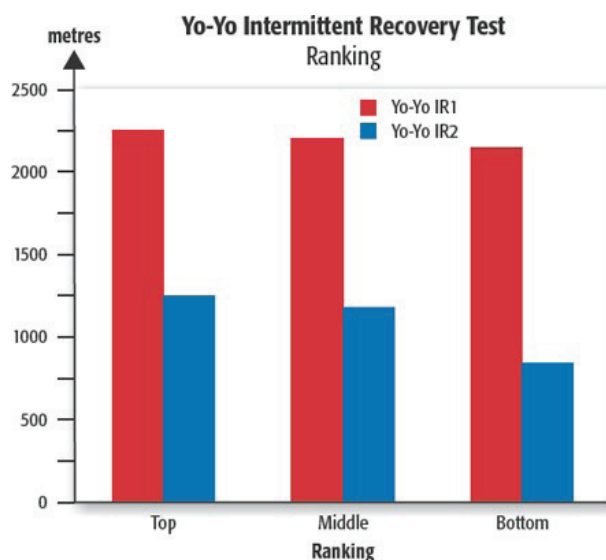


FIGURE 2. The figures shows performance in the Yo-Yo IR1 (red) and Yo-Yo IR2 (blue) test for the three teams positioned in the top of the league (op), teams in the middle (Middle) and the three teams in the bottom (Bottom). Note that the players in the top teams performed significantly better in the Yo-Yo IR2 test than the players in the bottom teams, indicating that the test result reflects the quality of play even within the same league.

Thus, for elite players, the Yo-Yo IR2 test provides a precise measure of performance in football and can distinguish between teams of different performance levels within the same

league, which is further supported by observations of male players in a top-league being superior to players in the second and third divisions in the same country (Figure 3).

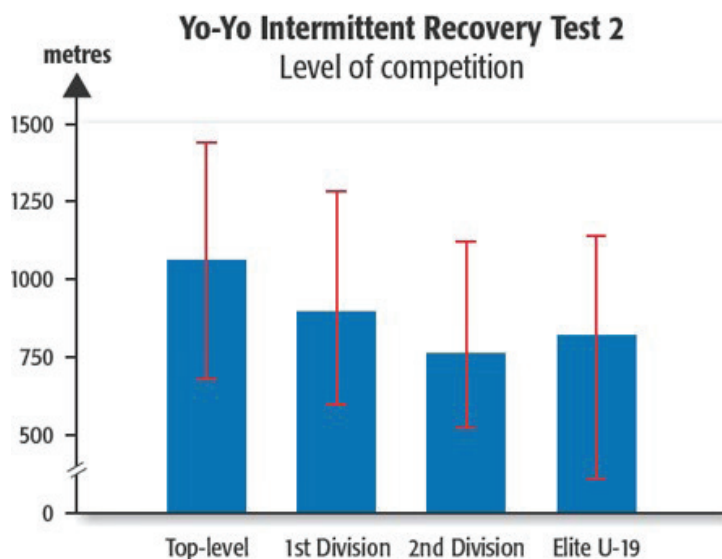


FIGURE 3. Yo-Yo IR2 performance of players from a European top-league, second and third division as well as elite U19 players from the same country. The range is also shown as vertical lines. Note that the senior players from the top-league are superior to the other three groups and that the U19 players had the same performance level as the senior players from the second and third division.

Moreover, in the same study, it was demonstrated that elite U19 players had a Yo-Yo IR2 performance level similar to that of senior players in the second and third divisions, but were inferior to the senior players in the top-league (Figure 3). Newer GPS devices may provide an acceptable tool for the measurement of constant velocity, acceleration, and deceleration during straight-line running, showing sufficient sensitivity for detecting changes in performance in team sports.

Methods

Twenty-eight (n=28) elite football players participated

in this study (age 21.4 ± 3.3 ; body weight 79.7 ± 3.4 ; height 182.4 ± 5.5 ; fat mass 9.2 ± 1.9), without goalkeepers. All athletes are elite players by Italian football championship. To be included in the study, subjects had to 1) ensure regular participation in all the training sessions, 2) have competed regularly during the previous competitive season, and 3) possess medical clearance. Before entering the study, participants were fully informed about the study aims and procedures, and they provided written informed consent before the testing procedure. The study protocol was conformed to the code of Ethics of the World Medical Association

(Declaration of Helsinki). The professional football team trained for approximately 1h five times per week (always on Monday, Tuesday, Wednesday, Thursday, and Friday) plus the official match played on Saturday or Sunday. The study was conducted during the 2019–2020 competitive season (i.e., from July to October) and we examined and recorded 13 official matches during this period. The team was systematically playing in a 4-3-3 module. All participants during the week were followed by video analysis, GPS Live (50Hz, K-Sport Universal STATS Italy) and heart rate monitoring during training; at the end of each session, RPE (rating perceived of exertion) was recorded. During a test, there was an MP3 sound system for IR2 audio track. The same protocol is followed during matches on Saturday or Sunday to analyse the external and internal loads. Before and after 12 weeks, each player completed an IR2 test on the same grass surface.

Equipment

The players' physical activity during the matches and each training session was monitored using a portable live 50 Hz global positioning system (GPS) technology (GPS, K-Sport, Universal STATS Montelabbate, PU, Italy) positioned on the upper back in a pocket of a tailored vest (K-Sport/STATS Vest). Several studies have investigated the validity and reliability of GPS devices for measuring movements and speeds (Rampinini et al., 2015); a sample rate of 20 Hz is sufficiently accurate to quantify the very high intensity, acceleration, and deceleration running phases in team sports. For testing, we used MP3 track IR2.

Data Analysis

The external load measures, as the distance run at high speed (D_{SHI} ; $>16 \text{ km}\cdot\text{h}^{-1}$) (Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009), the distance run at very high-intensity speed (D_{S5} $> 20 \text{ km/h}$) (Rampinini et al., 2009), the number of very high-intensity accelerations (D_{A8} ; $\geq +3 \text{ m}\cdot\text{s}^{-2}$) and decelerations (D_{A1} ; $\leq -3 \text{ m}\cdot\text{s}^{-2}$) (Osgnach, Poser, Bernardini, Rinaldo, & di Prampero, 2010) were recorded. With regards to the predicted metabolic parameters, the average metabolic power (AMP;

$\text{W}\cdot\text{kg}^{-1}$) was calculated (Di Prampero, Botter, & Osgnach, 2015). Immediately after each match and training session, all players were asked to state their rate of perceived exertion (RPE) of the game just completed, using a printout of Borg's CR10 scale (Borg, 1998). Each subject was previously familiarized on the use of Borg's CR10 scale, including the anchoring procedures.

Statistical Analysis

We analysed variables with d-Cohen (effect size; ES), to compare two different parts of the season and Pearson's correlation coefficient (r). An alpha level of $p < 0.05$ was chosen. The statistical analyses were performed with SPSS (SPSS, Inc., Chicago, IL, USA). Data are presented as means \pm standard deviation. The effect size dimension is low from 0 to 0.4, moderate from 0.5 to 0.6, and large from 0.7 to 1.0.

Results

Regarding speed endurance training during a season (1 time per week), it is necessary to improve performance in IR2 test and during a match. After 12 weeks, maximal oxygen uptake and glycolytic enzyme activity improved. Every football coach and practitioner should include weekly speed endurance training production (W/R 1:5) or maintenance (W/R 1:2) to improve performance at very high intensities ($>20 \text{ km/h}$) in their players. In our research and experience, after 12 weeks training, the difference in IR2 performance, between first trial (pre-season) and second trial (in-season) is statistically meaningful (ES: 0.48; $p < 0.05$; 24%). During this period, our team perform 10 speed endurance production workouts (W/R 1:5), about once per week. For top-teams, Yo-Yo IR2 performance (28%) and sprinting distance (25%) during matches were greater ($p < 0.05$) than for bottom-teams. Comparing match performance before (T1) the second trial IR2 with match performance after second (T2) trial of this test, statistically meaningful changes are present Match performance before versus after the second test is different: distance covered at high intensity $> 16 \text{ km/h}$ (D_{SHI}) (ES:0.55; $p < 0.05$; Figure 4), and distance covered at very high intensity $> 20 \text{ km/h}$ (D_{S5}), (ES:0.46; $p < 0.05$; Figure 5) improve.

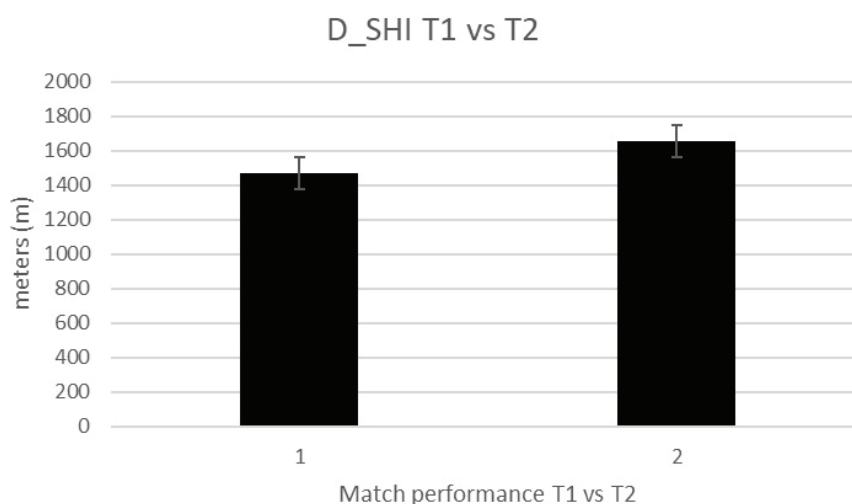


FIGURE 4. Match performance $D_{SHI} > 16 \text{ km/h}$ T1 vs T2 (ES:0.55; $p < 0.05$)

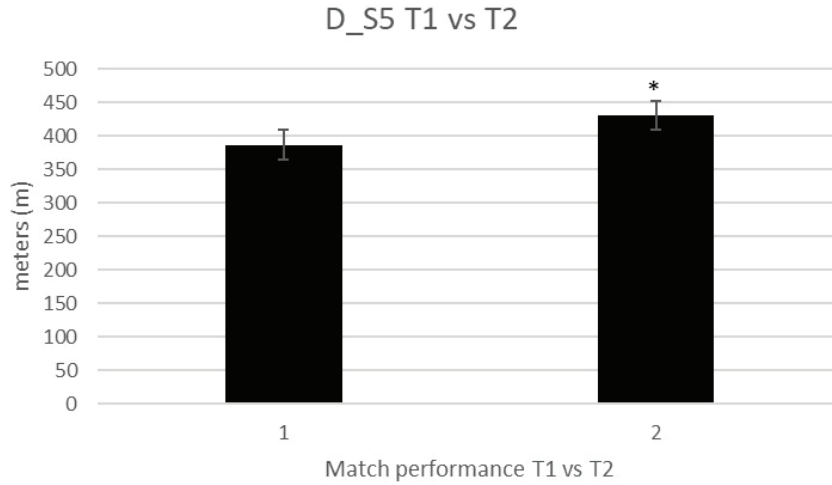


FIGURE 5. Match performance D_S5 >20 Km/h T1 vs T2 (ES:0.46; p<0.05)

At the same time, acceleration at a very high intensity (D_A8) (ES: 0.68; p<0.05; Figure 6), and the number of sprints at a very high intensity (NU_A8) improve (ES:2.67; p<0.05; Figure 7).

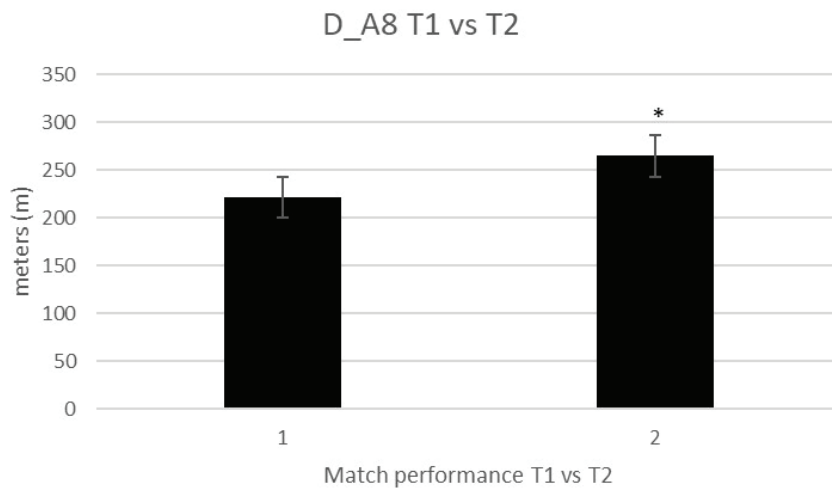


FIGURE 6. Match performance D_A8 >3m/s² T1 vs T2 (ES:0.68; p<0.05)

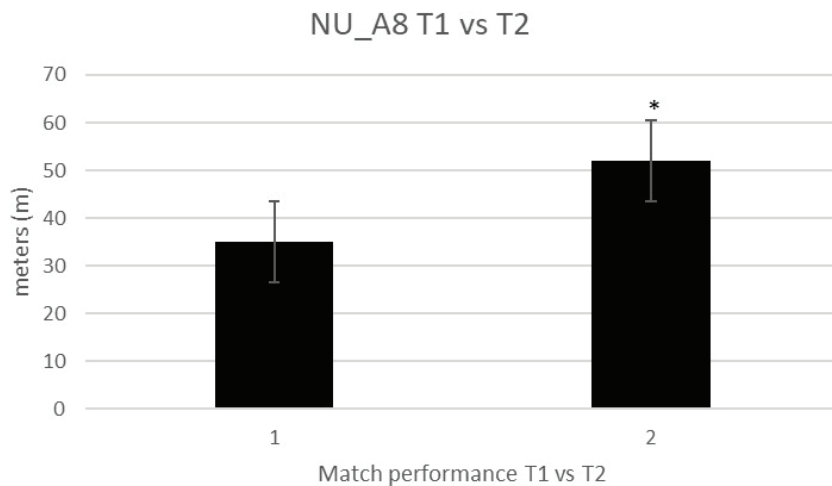
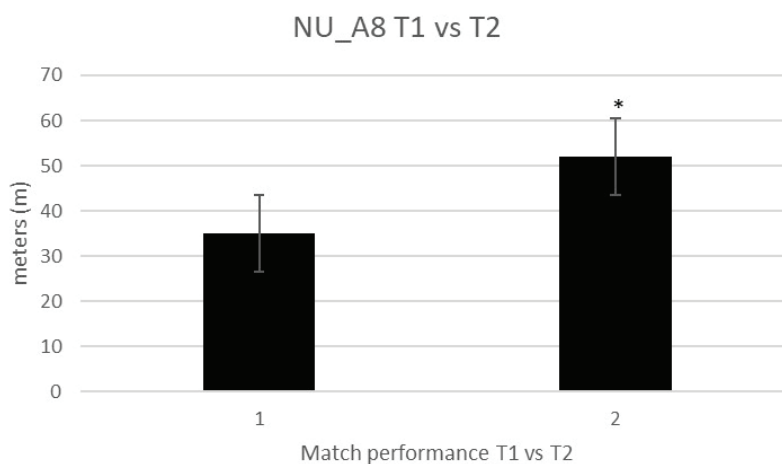


FIGURE 7. Match performance NU_A8 >3m/s² T1 vs T2 (ES:2.67; p<0.05)

FIGURE 8. Performance IR2 T1 vs T2 (ES: 0.48; $p < 0.05$)

Discussion

For elite and sub-elite players, Yo-Yo IR2 performance was correlated ($p < 0.05$) with Yo-Yo IR1 performance ($r = 0.74$ and 0.76) and mean RSA time ($r = -0.74$ and -0.34). We conclude that the Yo-Yo IR2 test has a high discriminant and concurrent validity, as it discriminates between players of different within- and between-league competitive levels and is correlated to oth-

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Conflict of Interest

The authors declare that there are no conflicts of interest.

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