

EFFECTS OF INTERMITTENT-ENDURANCE FITNESS ON MATCH PERFORMANCE IN YOUNG MALE SOCCER PLAYERS

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ABSTRACT

Castagna, C, Impellizzeri, F, Cecchini, E, Rampinini, E, and Barbero Alvarez, JC. Effects of intermittent-endurance fitness on match performance in young male soccer players. *J Strength Cond Res* 23(7): 1954–1959, 2009—The purpose of this study was to examine the effect of specific endurance (Yo-Yo Intermittent recovery test level 1, Yo-Yo IR1) on match performance in male youth soccer. Twenty-one young, male soccer players (age 14.1 ± 0.2 years) were involved in the study. Players were observed during international championship games of corresponding age categories and completed the Yo-Yo IR1 on a separate occasion. Physical (distance coverage) and physiological match demands were assessed using Global Positioning System technology and heart rate (HR) short-range telemetry, respectively. During the match (two 30-minute halves), players covered $6,204 \pm 731$ m, of which 985 ± 362 m (16%) were performed at high intensities (speed >13 km·h⁻¹, HIA). A significant decrement (3.8%, $p = 0.003$) in match coverage was evident during the second half. No significant ($p = 0.07$) difference between halves was observed for HIA ($p = 0.56$) and sprint (speed >18 km·h⁻¹, SPR) distances. During the first and second halves, players attained the 86 ± 5.5 and $85 \pm 6.0\%$ of HRmax ($p = 0.17$), respectively. Peak HR during the first and second halves were 100 ± 4 and $99.4 \pm 4.7\%$ of HRmax, respectively. Yo-Yo IR1 performance (842 ± 352 m) was significantly related to match HIA ($r = 0.77$, $p < 0.001$) and total distance ($r = 0.65$, $p = 0.002$). This study's results showed that specific endurance, as determined by Yo-Yo IR1 performance, positively affects physical match performance in male young

soccer players. Consequently, the Yo-Yo IR1 test may be regarded as a valid test to assess game readiness and guide training prescription in male youth soccer players.

KEY WORDS association football, fitness, match analysis, coaching, Yo-Yo test

INTRODUCTION

Soccer is a multifaceted sport that requires well-developed physical fitness to be successfully played (28). Although no comparative studies have been performed, physiological match demands (% of maximal heart rate and maximal aerobic power) have been reported to be similar across competitive levels and gender in soccer (28), with any differences being attributable mainly to game intensity (distance covered at high intensity) as a reflection of players' fitness level (17,28).

The ability to perform intermittent, high-intensity exercise for prolonged periods plays a key role in competitive soccer (15–17,19,20). As a consequence, training and testing strategies have been proposed to monitor and enhance players' ability to perform high-intensity activities during the match (12,14,23).

Recently, with the aim to assess the intermittent endurance ability of soccer players in field condition, the Yo-Yo intermittent recovery test (Yo-Yo IR1) has been developed (4). The construct validity of the Yo-Yo intermittent recovery test (level 1, Yo-Yo IR1) as a measure of match-related physical performance has been demonstrated by studies showing a significant correlation between the Yo-Yo IR1 and the distance covered at high intensity during the match (15–17). Furthermore, improvement in Yo-Yo IR1 performance (distance covered) as a result of a high-intensity interval-training intervention was associated with changes in the amount of high-intensity activity performed during the match (15).

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Although talent selection is an uncertain procedure because there are many different factors that are involved in the development of a prospective player, knowledge of fitness profiles of successful players has been indicated as a valuable resource to guide talent selection and subsequent coaching (2,26,28,34). Additionally, the assessment of the changes induced by different training strategies on physical components relevant for soccer performance is important in the control of the training process (13). Therefore, the identification of valid field tests that enable the assessment of soccer-specific endurance in young soccer players is of paramount importance. Information in this context would be of particular interest to coaches and sport scientists for the development of talent selection procedures and to control training process (26).

Despite the popularity of the Yo-Yo IR1 in soccer (4) and its suggested applicability for talent detection and selection (26), no study has addressed the validity of the Yo-Yo IR1 in youth soccer. Therefore, the purpose of this study was to examine the population validity of the Yo-Yo IR1 in young male soccer players (convergent evidence to construct validity) (32). We hypothesized a significant relationship between physical match demands and Yo-Yo IR1 performance in youth soccer players (28).

METHODS

Experimental Approach to the Problem

Population validity usually refers to the extent to which the results of a study can be generalized from the specific sample that was studied to a larger group of subjects (32). The association between Yo-Yo IR1 performance (distance covered) and match performance has been shown in adult male and female professional soccer players (4). Therefore, to verify the population validity of the Yo-Yo IR1 for young male soccer players, we examined the construct validity of the test as an indicator of physical match performance in young players by assessing the degree of association between match physical demands (distance covered in selected match

activities) and Yo-Yo IR1 performance (convergent evidence) (28). Evidence for the construct validity of a field test is of great importance in sport science because it assesses the relevance of a field test to a given sport discipline in special populations (test specificity) (5,23).

In this investigation, a nonexperimental, descriptive–correlation design was used to examine the relationship between Yo-Yo IR1 and physical match performance in young male soccer players. Players’ physical load, measured as time and distance spent in selected match activities, was assessed using Global Position System technology (GPS, SPElite, GPSPORTS, Australia). Physiological stress was assessed by monitoring heart rate (HR) during competitions (11,12).

Subjects

Twenty-one soccer players (age 14.1 ± 0.2 years, height 1.65 ± 5.1 cm, body mass 52.5 ± 25 kg) were randomly chosen among members of a national youth soccer academy (Federazione Sammarinese Giuoco Calcio, San Marino). Players (7 forwards, 7 midfield, and 7 defenders) possessed at least 4 years of experience in soccer training and competitions and took part in national and international championships at the time of the investigation. Players trained 3 times a week (~90 minutes per session) with a competitive match taking place during the weekend. Training sessions consisted mainly of technical and tactical skill development (80% of the training time). Physical conditioning was performed 2 times a week and was aimed toward anaerobic and aerobic performance development (3). Anaerobic training consisted of plyometrics and sprint training drills (3). Aerobic fitness was developed using small-sided games (25) and short or long interval running (14).

Testing procedures were performed during the last stage of the competitive season (April–May 2007). Written informed consent was received from all players and parents after verbal and written explanation of the experimental design and potential risks of the study. The local Institutional Review Board approved the study. All players were familiarized with the testing procedures used in this study through preinvestigation familiarization sessions.

Performance Analyses

In this study the players’ activity profile was assessed using GPS technology. During competitive matches players wore a GPS device, inserted in a purpose-built backpack, that enabled speed and distance recording (1 Hz). Players’ accelerations were also recorded using a triaxial built-in accelerometer with an operational sampling rate of 100 Hz (GPS, SPElite, GPSPORTS, Australia).

TABLE 1. Match analysis data ($n = 21$).

Variable (m)	First half	Second half	Total
Walking	245 ± 45	263 ± 61	508 ± 98
Jogging	1505 ± 124	1,476 ± 176	2,981 ± 272
MIR	905 ± 313*	789 ± 271	1,694 ± 565
HIR	361 ± 134	380 ± 160	741 ± 280
Sprinting	129 ± 87	105 ± 62	234 ± 137
HIA	490 ± 192	485 ± 198	975.6 ± 368
TD	3,149 ± 368*	3,024 ± 387	6,173 ± 734

* $p = 0.003$.

MIR = medium-intensity running; HIR = high-intensity running; HIA = high-intensity activity.

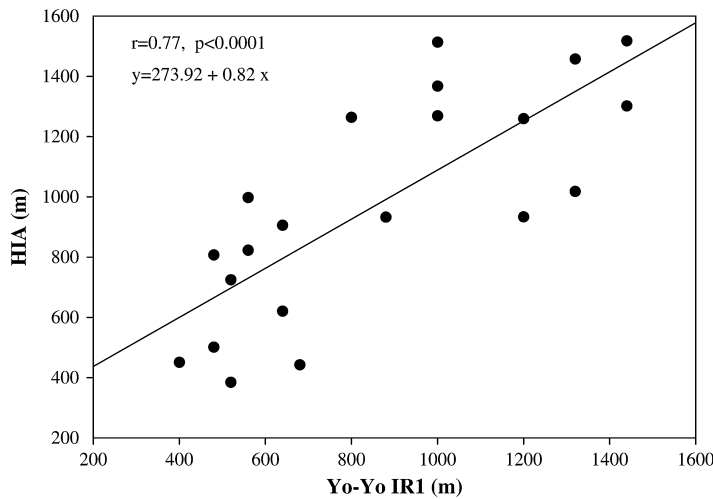


Figure 1. Individual relationship between match high-intensity activity (HIA) and Yo-Yo intermittent recovery test performance (Yo-Yo IR1).

Validity of the GPS system used has been reported elsewhere (10,21,22,30,37).

Match activities were determined according to Castagna et al. (6):

1. Standing (ST, speed from 0 to 0.4 km·h⁻¹);
2. Walking (W, speed from 0.4 to 3.0 km·h⁻¹);
3. Jogging (J, speed from 3.0 to 8.0 km·h⁻¹);
4. Medium-intensity running (MIR, speed from 8.0 to 13.0 km·h⁻¹);

competitive match. The match activities' intraclass correlation coefficient (ICC) and coefficient of variation (CV) ranged between 0.92 and 0.98 and 13%, respectively.

Heart Rate

Heart rates were monitored with short-range telemetry every 5 seconds during the matches (GPS Elite, Gpsports, Australia) and with Yo-Yo IR1 (Polar Team-System, Kempele, Finland). Data analyses were performed with dedicated software packages (GPS Elite and Polar Team-System, respectively).

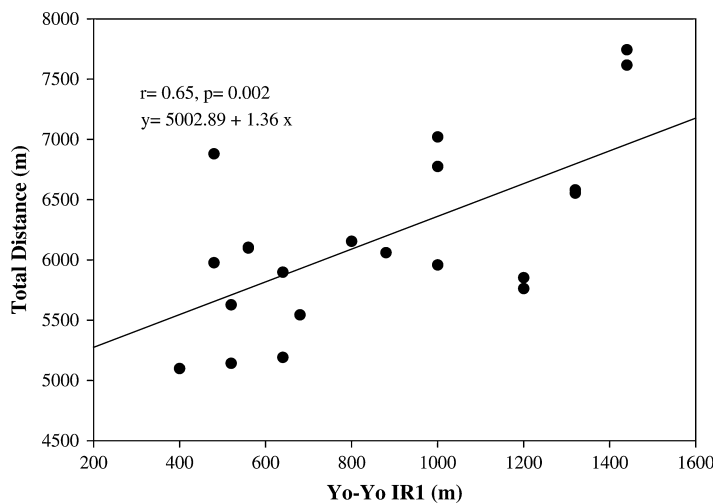


Figure 2. Individual relationship between total match distance and Yo-Yo intermittent recovery test performance (Yo-Yo IR1).

5. High-intensity running (HIR, speed from 13.0 to 18.0 km·h⁻¹);
6. Sprinting (SPR, speed >18.0 km·h⁻¹);
7. High-intensity activity (HIA; HIR+SPR).

The competitive matches (11 vs. 11) were played at the same hour of the day (1530) on a regular size, synthetic-grass soccer pitch with each half lasting 30 minutes (10-minute interval). Air temperature and relative humidity during the matches were $23.5 \pm 05^\circ\text{C}$ and $35 \pm 10.5\%$, respectively. To avoid dehydration, ad libitum drinking was permitted for the players. A minimum of 5 and a maximum of 8 players were observed during the same

Yo-Yo IR1

The Yo-Yo IR1 was performed according to the procedures suggested by Krustup et al. (16) and Castagna et al. (8). Yo-Yo IR1 performance was assessed 10 to 15 days before or after the competitive matches. Peak Yo-Yo IR1 HR was assumed as players' maximal HR value (HRmax) according to Krustup et al. (16). Reliability of Yo-Yo IR1 was established in 18 participants tested 3 weeks apart. Results showed a ICC of 0.98 ($p < 0.0001$) with a CV of 3.5%.

Statistical Analyses

Results are presented as mean \pm SD. Data sets were checked

for normality using the Shapiro-Wilks normality test and visual inspection. Differences between the first and second half were analyzed using paired *t*-tests. Relationships between variables were assessed using Pearson's product moment correlation. Fifteen preplanned comparisons were considered for this study. Accordingly, correction for multiple comparisons was undertaken using the Bonferroni method with a resulting operational alpha level of 0.003 ($p = 0.05/15$).

RESULTS

During the match players covered $6,204 \pm 731$ m, of which 985 ± 362 m (16%) were performed at HIA. A significant decrement (3.8%, $p = 0.003$) in match coverage was evident during the second half. Players covered significantly less (12.8%, $p = 0.003$) ground at MIR during the second half. No significant between-half differences were observed for HIA ($p = 0.56$) and SPR ($p = 0.07$). Details of match activities are presented in Table 1. During the first and second half players attained the 86.2 ± 5.5 and $85.1 \pm 6.0\%$ of HRmax ($p = 0.17$), respectively. Peak HR during the first and second halves were 100 ± 4 and $99.4 \pm 4.7\%$ of HRmax, respectively.

Yo-Yo IR1 performance (842 ± 352 m) was significantly related to match HIA ($r = 0.77$, $p < 0.0001$, Figure 1), match HIR ($r = 0.71$, $p = 0.0003$), and total distance ($r = 0.65$, $p = 0.002$, Figure 2).

DISCUSSION

The main finding of this study was that the individual level of intermittent-endurance fitness (i.e., Yo-Yo IR1 distance) of the players was significantly correlated with several physical match variables. This confirmed our hypothesis and provided evidence for the construct validity of the Yo-Yo IR1 as an indicator of match-related physical performance in young male soccer players, thus extending previous findings reported for adult male and female soccer players (16,17).

Indeed, the strong correlation ($r = 0.77$, $p < 0.001$) found between HIA and Yo-Yo IR1 performance is similar to that reported by Krstrup et al. (16,17) for adult male ($r = 0.71$, $p < 0.05$) and female ($r = 0.76$, $p < 0.05$) soccer players. However, a higher association ($r = 0.65$, $p = 0.002$) was found between total distance covered and Yo-Yo IR1 in young soccer players when compared to adult male ($r = 0.54$, $p < 0.05$) and female ($r = 0.56$, $p < 0.05$) professional players (16,17).

In the present study we measured the physical match performance using a GPS system. Although various studies have provided preliminary results on the accuracy of GPS technology, the 1-Hz sampling rate may not be adequate to measure running activities at very high speeds such as sprinting. This may partially explain the lack of association between sprinting distance and Yo-Yo IR1 performance, in spite of a significant association with both HIR and HIA.

Indeed, HIR and HIA constituted a larger range of speed and total distance covered (12 and 16% of total distance)

when compared to sprinting distance, which corresponded to only 4% of total distance. Therefore, lack of accuracy at high speed might have affected the correlation analysis, obscuring a possible association with sprinting. Therefore, future studies using other systems (24,33) might be necessary to confirm our findings. However, to date no gold standard systems exist for the measurement of physical performance during a soccer match. Several methods—such as manual time motion analysis or computerized semi-automatic video match analysis image recognition systems—have been used (1,14,24,33,36), and to the authors' knowledge no studies have fully examined the accuracy of such methods (28).

This study is the first to report on Yo-Yo IR1 performance values for young soccer players. Our results showed that young soccer players may cover distances in the range of 400 to 1,500 m on the Yo-Yo IR1. This is a significantly lower distance compared to those reported for moderately active adult male subjects (1,793 m, 600–2,320 m) and elite-level male (2,040–2,260 m) and female (1,379 m, 600–1,960 m) soccer players (16,17,19). However, these values are similar to those reported by Thomas et al. (31) for female field hockey players (840 ± 280 m) and adult (24.4 \pm 6.0 years) male recreational team sports players ($1,010 \pm 419$ m). Of note, the Yo-Yo IR1 distance covered by young soccer players was comparable to that reported for male adult elite team sport players (708 ± 157 m) and adult second-division male soccer players (771 ± 26 m) during level 2 of the Yo-Yo intermittent recovery test (Yo-Yo IR2) (18,31). In contrast to level 1, the Yo-Yo IR2 features higher running speeds over the 2×20 -m shuttle running bouts, allowing the same 10-second recovery time after each 40 minutes (18).

Given the higher physiological demands, the Yo-Yo IR2 has been indicated as a more anaerobic-based field test (18). Consequently, it could be speculated that for young soccer players, the physiological requirements of the Yo-Yo IR1 are less aerobic than those reported for adult subjects (16,18). Although the Yo-Yo IR1 test may be more demanding than other forms of shuttle running tests for endurance (7,8,35) usually suggested for young soccer players (26), the Yo-Yo IR1 requires a reduced testing time per player. This may be considered as a practical added value of the Yo-Yo IR1, along with its documented significant association with match high-intensity performance, to warrant the use of the Yo-Yo IR1 test for talent selection and development in youth soccer (26). The average distance covered by the players of this study was similar to what was reported by Castagna et al. (6) in younger (12 years) male soccer players ($6,204 \pm 731$ vs. $6,175 \pm 318$ m, respectively). However, in contrast to Castagna et al. (6), a significant decrement (3.8%, $p = 0.003$) of total coverage was detected during the second half.

According to Castagna et al. (6), no between-half effect was found for HIA, despite a significant MIR decrement during the second half. In this study the percentage of distance covered with HIA was larger than that reported in younger soccer players (16 vs. 9%) (6), which may suggest an age

effect on game intensity. This is in line with Strøyer et al. (29), who reported a difference in absolute work rate (time spent in given match categories) in young soccer players of different maturation age.

These findings seem to confirm the existence of a sort of “sparing behavior” adopted by young soccer players during the second half, limiting lower-intensity activities to sustain game tempo throughout the match (6). This strategy spontaneously adopted by players seems not to be fitness level dependent because no relationships were found between Yo-Yo IR1 performance and first- vs. second-half decrements in HIA. Nevertheless, because the players’ physical fitness was strongly related to the amount of HIA performed, the need for a well-developed intermittent-endurance fitness, even at the youth level, is warranted.

Several authors have suggested that soccer demands are similar across genders and competitive levels, with the difference occurring predominantly in match tempo (17,28). This studies findings are in line with this assumption because the mean %HRmax attained during the match was similar to those reported in elite male and female adult soccer players (17,28) and elite young soccer players (29). Additionally the total distance covered during the match was proportionally lower than that estimated for a 90-minute match in adult soccer players (9,24) and late adolescent soccer players (14).

Differences in physical fitness may be a plausible explanation of the gender and competitive level work-rate dissimilarities reported (28). In light of the Krustup et al. (17) findings that reported gender difference in Yo-Yo IR1 performance parallel to dissimilarities in match HIA, this study’s results seem sustainable. However, a definitive inference will be possible only with gender and competitive-level cross-sectional designs considering match-analysis and fitness-level comparisons.

PRACTICAL APPLICATIONS

Young soccer players should not be regarded as miniature adult players because remarkable discrepancies in physical and anthropometrical variables between the 2 populations are evident (26,27). However, coaches and strength and conditioning professionals should develop the technical skills and fitness abilities of the prospective players to cope with adult soccer demands (26,27).

It is interesting that this and other studies’ findings seem to suggest that youth soccer places on players the same relative physical demands seen in adult soccer (28). This suggests that young players, like their adult counterparts, require a well-developed physical fitness (mainly intermittent, high-intensity endurance) to play in the corresponding age category. Furthermore, the variety of maturation status present during the childhood and adolescence may even increase game demands when players of different growing stage face together (29).

In light of the results of this study, the Yo-Yo IR1 may be considered as a valid test for the assessment of match-related

physical fitness in young male soccer players. Therefore, the Yo-Yo IR1 should be considered as a valuable resource for coaches, fitness trainers, and sport scientists who deal with male youth soccer players in the attempt to assess young soccer players’ readiness to compete and to guide the attainment of the fitness requirements suggested for adult soccer (16,19).

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