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Aerobic Fitness and Yo-yo Continuous and Intermittent Tests Performances in Soccer Players: A Correlation Study

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Abstract. Castagna, C., F.M. Impellizzeri, K. Chamari, D. Carlomagno, and E. Rampinini. Aerobic fitness and yo-yo continuous and intermittent tests performances in soccer players: A correlation study. *J. Strength Cond. Res. 20(2):320–325. 2006.*—Yo-yo tests are very popular in soccer; however, no study has addressed details of their relation to canonical aspects of aerobic fitness. Furthermore, no information is available on the effect of the individual levels of lower limbs' explosive strength on yo-yo tests in soccer players. The purpose of this study was to examine the physiological determinants of Yo-yo Endurance Test Level 2 (YYETL2) and Yo-yo Intermittent Recovery Test Level 1 (YYIRTL1) in soccer players. Twenty-four soccer players (body mass, 74.6 ± 8.5 kg; height, 178.1 ± 4.5 cm; age, 25.6 ± 5.1 years) were tested for $\dot{V}O_2max$ and ventilatory threshold (VT) on a motorized treadmill. Lower-limb explosive strength was assessed using vertical countermovement jumps (CMJ) performed on a force platform. Results showed that YYETL2 and YYIRTL1 performances (m) were significantly related (r = 0.75, p = 0.00002). YYETL2 results were significantly related to $\dot{V}O_2max$, VT$\dot{V}O_2$, and speed at VT (r = 0.75, 0.76, and 0.83, respectively; p < 0.00002). Peak treadmill speed results were significantly related to YYETL2 and YYIRTL1 (r = 0.87 and 0.71, respectively; p < 0.0003). YYIRTL1 was related to CMJ peak power (r = 0.57; p = 0.003). These findings show that YYETL2 and YYIRTL1, although adopting similar starting and progression speeds, are influenced by different physiological variables. From these results, YYETL2 can be considered an aerobic fitness–related field test, whereas YYIRTL1 can be regarded as an aerobic–anaerobic, soccer-specific field test.

Key Words. field testing, shuttle running, intermittent exercise, association football

Introduction

Competitive soccer is an intermittent, high-intensity physical activity that requires well-developed aerobic and anaerobic fitness (15, 32–34). The relevance of aerobic fitness in soccer has been confirmed by descriptive (36), cross-sectional (39), and training studies (18). Furthermore, as soccer performance is characterized by several actions, such as sprinting, jumping, changes in direction, and tackling, muscular strength and power has also been shown to be important characteristics for soccer players (39).

Aerobic fitness (maximum oxygen uptake, lactate thresholds, and running economy; 30) can be accurately evaluated using a variety of laboratory protocols during treadmill-running until exhaustion. Although the values obtained with laboratory testing are considered the gold standard for the measurement of aerobic fitness, the procedures involved are time consuming and require trained personnel and expensive equipment. For these reasons, some field tests have been proposed as practical alternatives to laboratory assessments, and they are commonly used by coaches and applied sport scientists to evaluate aerobic training outcome in soccer players (12, 23). By far, the most popular tests for aerobic power ($\dot{V}O_2max$) are the 20-m shuttle run test (20MSRT; 23, 24) and the multistage fitness test (MSFT; 31). The latter being a modified version of the 20MSRT originally devised by Leger et al. (23, 24). More recently, Bangsbo (2, 3) suggested, for well-trained subjects, the Yo-yo Endurance Test Level 2 (YYETL2). Different from the MSFT and the 20MSRT that start at 8 and 8.5 km·h^{-1}, respectively, the YYETL2 uses an initial speed of 11.5 km·h^{-1}. The use of YYETL2 has been suggested with the aim of estimating $\dot{V}O_2max$ in well-trained players in the attempt to shorten assessment-session time (2, 3).

In field settings, however, the use of sport-specific endurance tests as performance measures of tasks reproducing technical skills, movement patterns, and physiological demands of the competitive match-play is widespread (1, 4, 9, 10, 13–15, 21, 27, 35). The relevance of these specific endurance tests are commonly based on their logical validity. To date, only the Yo-yo Intermittent Recovery Test Level 1 (YYIRTL1) proposed by Bangsbo (2) has been both externally and internally validated (20, 21, 26). Starting at a speed similar to that used for YYETL2 (see Tables 1 and 2), YYIRTL1 consists of 2 × 20-m bouts of progressive speed shuttle-running, interspersed by 10 seconds of active recovery, performed until exhaustion following prerecorded acoustic signals (2). Recently, Krustrup et al. (21), using muscle biopsy and blood analysis, have shown that YYIRTL1 elicits maximal aerobic responses while significantly stressing the anaerobic energy system. This confirms that the physiological demands involved during this soccer-specific endurance test are similar to those taxed during a soccer-match (1). For these reasons, both the shuttle run tests (20MSRT and MSFT), as indirect measures of $\dot{V}O_2max$, and the YYIRTL1, as an indicator of soccer-specific endurance, are commonly used by coaches as practical measures of training outcomes (20, 21).

Match analysis has provided evidence that during competitive soccer, players perform a great deal of activ-

TABLE 1. Correlations between field-test performance and treadmill-test variables.*

Field-test performance	Treadmill-test variables			
	$\dot{V}O_2max$	VT $\dot{V}O_2$	vVT	PTV
YYIRTL1 (m)	0.46 $p = 0.02$	0.39 $p = 0.06$	0.69† $p = 0.0002$	0.71† $p = 0.0001$
YYETL2 (m)	0.75† $p = 0.00002$	0.76† $p = 0.00002$	0.83† $p = 0.000001$	0.87† $p = 0.00000002$

* $\dot{V}O_2$ = oxygen consumption per unit of time; VT = ventilatory threshold; vVT = speed of ventilatory threshold; PTV = peak treadmill velocity; YYIRTL1 = Yo-yo Intermittent Recovery Test Level 1; YYETL2 = Yo-yo Endurance Test Level 2.
† Significance at $p \leq 0.003$.

TABLE 2. Correlations between CMJ and field-tests performance and treadmill-test variables.*

CMJ variables	Running tests variables			
	YYIRT	YYET	vVT	PTV
CMJ height (cm)	0.50 $p = 0.01$	0.33 $p = 0.52$	0.08 $p = 0.45$	0.13 $p = 0.65$
CMJ PP (W·kg$^{-0.67}$)	0.57† $p = 0.003$	0.49 $p = 0.02$	0.18 $p = 0.80$	0.18 $p = 0.35$

* CMJ = countermovement jumps; YYIRT = Yo-yo Intermittent Recovery Test; YYET = Yo-yo Endurance Test; vVT = speed of ventilatory threshold; PTV = peak treadmill velocity; PP = peak power.
† Significance at $p \leq 0.003$.

ity involving turning and changes of directions over a variety of intensities (40). Recently, single-shuttle sprint performance was found to be strongly related to maximal squat performance and vertical jump in elite soccer players with high $\dot{V}O_2max$ values (38). Furthermore, studies that provided strength training to elite-level soccer players have shown that improvements in maximal and explosive strength parallel running-economy enhancements (19). From these results, it could be hypothesized that lower-limb explosive strength may positively affect performance in progressive, multistage, high-intensity field tests such as YYETL2 and YYIRTL1, which involve extensive, continuous and intermittent, shuttle running, respectively.

The relationships between continuous shuttle-run tests (such as the 20MSRT and MSFT) or intermittent shuttle-run tests (such as the YYIRTL1) and physiological assessments of aerobic fitness factors such as $\dot{V}O_2max$ has been already reported (21, 23, 29, 31, 37). However, to our knowledge, no study has examined the correlations between YYETL2 and YYIRTL1, and between those field tests and traditional physiological parameters of aerobic fitness (30) assessed in the laboratory, on the same group of soccer players. Therefore, the first aim of this study was to examine the relationship between the YYETL2 and the YYIRTL1, and between these 2 shuttle-run tests and $\dot{V}O_2max$ and ventilatory thresholds (VT). The knowledge of these correlations are necessary to understand whether the results of these field tests provide different or redundant information and to better appreciate the physiological characteristics involved in these 2 forms of shuttle-run tests. The second aim of this investigation was to examine the influence of lower limbs' muscular power, as measured using countermovement jumps in a progressive-shuttle running test.

Using YYIRTL1 and YYETL2 at similar speed progressions over the same running distance (20-m shuttle), our research hypothesis was that the 2 tests were linearly related and similarly affected by the physiological variables considered in this study.

METHODS

Experimental Approach to the Problem

In the present investigation, a nonexperimental, descriptive-correlation design was used to examine the relationship between 2 popular shuttle-run tests for aerobic fitness (YYETL2 and the YYIRTL1) and the associations of these shuttle run tests with $\dot{V}O_2max$, VT, peak treadmill velocity (PTV), and vertical jump ability. Testing sessions took place over 3 separate days (at least 72 hours apart), with subject participation being randomly assigned. The testing sessions consisted of the following: (a) Vertical jump and treadmill-testing, (b) YYETL2, and (c) YYIRTL1.

Recently, several authors have stressed the importance of expressing physiological variables in soccer players with scaled notations (9–11, 19, 38, 39). Following those suggestions, log–log regression analyses were performed to evaluate the b exponent value of the allometric function $Y = aX^b$ (17) for oxygen uptake, force, and power measurements. Regression analyses revealed b values similar to the theoretical (17) values only for maximal oxygen uptake (0.69 vs. 0.67). To avoid introducing new notations, we assumed the theoretical b value of 0.67, for all calculations.

Subjects

Twenty-four amateur soccer players from the same team (body mass, 74.6 ± 8.5 kg; height, 178.1 ± 4.5 cm; and age, 25.6 ± 5.1 years) were involved in the study. To be included in the study, participants had to possess official medical clearance at the beginning of the season according to national law, to ensure that they were in good health. This medical examination, which includes electrocardiogram, blood and urine analysis, and spirometry, was performed in medical centers certified by the National Ministry of Health. Informed written consent was obtained after verbal and written explanation of the experimental design and potential risks of the study. The local Institutional Review Board approved this study design.

TABLE 3. Yo-yo Intermittent Recovery Test Level 1 protocol. after each shuttle-run bout, player performs 10 seconds of active recovery jogging back and forth between 2 lines (cones) set 5 m apart.

Stage	Speed (km·h⁻¹)	Shuttle bouts (2 × 20 m)	Split distance	Accumulated distance
1	10	1	40	40
2	12	1	40	80
3	13	2	80	160
4	13.5	3	120	280
5	14	4	160	440
6	14.5	8	320	760
7	15	8	320	1,080
8	15.5	8	320	1,400
9	16	8	320	1,720
10	16.5	8	320	2,040
11	17	8	320	2,360
12	17.5	8	320	2,680
13	18	8	320	3,000
14	18.5	8	320	3,320
15	19	8	320	3,640

TABLE 4. Yo-yo Endurance Test Level 2 protocol.

Stage	Speed (km·h⁻¹)	Shuttle bouts (20 m)	Split distance	Accumulated distance
1	11.5	10	200	200
2	12	11	220	420
3	12.5	11	220	640
4	13	11	220	860
5	13.5	12	240	1,100
6	14	12	240	1,340
7	14.5	13	260	1,600
8	15	13	260	1,860
9	15.5	13	260	2,120
10	16	14	280	2,400
11	16.5	14	280	2,680
12	17	15	300	2,980
13	17.5	15	300	3,280
14	18	16	320	3,600

Before each testing session, subjects were instructed not to eat for at least 3 hours before testing and not to drink coffee or beverages containing caffeine for at least 8 hours before physical testing. Players were also asked to follow a nutritional plan developed to ensure an adequate carbohydrate intake in the week before testing (~60% of total energy intake). The assessments were performed at the same time of the day (from 5:00 to 7:00 PM for field tests and from 4:00 to 8:00 PM for laboratory tests), and subjects were blinded about the aims of the study. All of the testing procedures were completed in June before the play-off phase of the soccer competitive season.

Yo-yo Tests

The YYET test features 2 levels (L1 and L2) differing with respect to starting speed (2, 3). It has been suggested that L2 be used to estimate $\dot{V}O_2$max in well-trained players in an attempt to shorten assessment-session time (2, 3). Two levels that differ with respect to starting speed are also available for YYIRT (2, 3). In this investigation, following Krustrup and Bangsbo (20) and Krustrup et al. (21), we used the L1 version. Additionally, YYIRTL1 uses debut and stage progression speeds similar to that of YYETL2 (Tables 3 and 4). Therefore, we also decided to compare YYETL2 and YYIRTL1 to examine the likelihood of test redundancy.

All players were familiar with the testing procedures as part of their usual fitness assessment program. The yo-yo tests consisted of 20-m shuttle runs performed at increasing velocities, with 10 seconds of active recovery between runs (YYIRTL1) or continuous running (YYETL2), until exhaustion. Audio cues of the yo-yo endurance test were recorded on a CD (www.teknosport.com, Ancona, Italy) and broadcasted using a portable CD player (Az1030 CD player; Phillips, Best, The Netherlands). The test was considered ended when the participant twice failed to reach the front line in time (objective evaluation) or the participant felt unable to complete another shuttle at the dictated speed (subjective evaluation). The total distance covered during the YYIRTL1 and YYETL2 (including the last incomplete shuttle) was considered as the testing score (2, 3).

Each subject's maximal running velocity (Vmax) was also determined for the treadmill test and YYETL2 from the equation developed by Kuipers et al. (22): Vmax (km·h⁻¹) = V + 0.5 × (n/60). In this equation, V represents the velocity during the next-to-last exercise stage; the 0.5 value represents the increase in velocity after each 1-minute stage in km·h⁻¹; n represents the number of seconds attained during the last stage; and 60 is the number of seconds corresponding to each stage. The speed attained during the last 2 × 20-m bout was considered Vmax during YYIRTL1.

Field testing sessions were performed on the football pitch where players undertake their daily training sessions. Reliability of the field tests considered in this study are reported elsewhere (21, 23, 31, 37).

Aerobic Fitness Assessment

Maximum oxygen uptake was determined using an incremental running test on a motorized treadmill (RunRace, Technogym, Gambettola, Italy) at an inclination of 1%. After 10 minutes at 8 km·h⁻¹, the test began at 9 km·h⁻¹, and the velocity was increased by 1 km·h⁻¹ every 1 minute, so that exhaustion was reached in 8–12 minutes. Achievement of $\dot{V}O_2$max was considered as the attainment of at least 2 of the following criteria: (a) a plateau in $\dot{V}O_2$ despite increasing speeds, (b) a respiratory exchange ratio above 1.10, or (c) a heart rate (HR) ±10 beats·min⁻¹ of age-predicted maximal HR (220-age). Expired gases were analyzed using a breath-by-breath, automated gas-analysis system (VMAX29, Sensormedics, Yorba Linda, CA). Before each test, flow and volume were calibrated using a 3-L capacity syringe (Sensormedics, Yorba Linda, CA). Gas analyzers were calibrated using 2 tanks of oxygen (O_2) and carbon dioxide (CO_2) of known concentrations (Sensormedics, Yorba Linda, CA).

Ventilatory threshold and respiratory compensation point (RCP) were detected by combining 3 common methods for the determination of gas-exchange thresholds, according to Gaskill et al. (16): (a) ventilatory equivalent, (b) excess CO_2, and (c) *V*-slope method. Therefore, VT was visually detected as the intensity corresponding to (a) an increase in $\dot{V}E/\dot{V}O_2$ with no increase of $\dot{V}E/\dot{V}CO_2$, (b) the first sustained rise in excess CO_2, and (c) the first increase in the slope of the $\dot{V}CO_2$ vs. $\dot{V}O_2$ plot. Respiratory compensation point was determined as the intensity corresponding to (a) an increase in both $\dot{V}E/\dot{V}O_2$ and $\dot{V}E/\dot{V}CO_2$, (b) the second sustained rise in excess CO_2, and (c) the second increase in the slope of the $\dot{V}CO_2$ vs. $\dot{V}O_2$ plot. VT and RCP were detected by 2 independent experienced investigators. If the $\dot{V}O_2$ at VT and RCP determined by the 2 investigators was within 3%, the mean value of the 2 investigators was used. When difference exceeded 3%, a third investigator was asked to determine VT and RCP. The combination of these 3 methods of gas-exchange threshold detection has been demonstrated to improve the accuracy and the reliability of ventilatory threshold identification (16).

Peak treadmill velocity was considered as the maximal speed attained by players once $\dot{V}O_2$max had been attained (28). PTV was calculated and used in this study because it has been previously proposed as an integrated measure of aerobic performance, concurrently accounting for running economy and $\dot{V}O_2$max (28).

Vertical Jumping

Counter-movement vertical jumps (CMJ) (6) were measured using a force platform (Quattro Jump, Kisler, Winterthur, UK) 30 minutes before the treadmill-test protocol. Subjects jogged for 10 minutes on a motorized treadmill (RunRace, Technogym, Gambettola, Italy) before testing and then performed self-administered submaximal CMJs (2–3 repetitions) as practice and specific additional warm-up. No stretching exercises were allowed before the test. Subjects were asked to keep hands on their hips to prevent influence of arm movements on vertical jumps and to avoid confounding variable coordination influences (6). Each subject performed at least 5 maximal CMJs starting from a standing position, with 2 minutes recovery in between. Players were asked to jump as high as possible. The mean jump height, peak power (CMJPP), and peak force·body mass$^{-0.67}$ (CMJPF) of the best 3 jumps was used for calculations.

Statistical Analyses

Data are reported as mean ± *SD*. Before using parametric tests, the assumption of normality was verified using the Shapiro-Wilk *W*-test. Pearson's product-moment correlations were used to examine the relationships between the YYETL2 and the YYIRTL1, and among those 2 shuttle-run tests and $\dot{V}O_2$max, ventilatory thresholds, and vertical jumps. Comparison between field-test variable means was performed using unpaired *t*-tests. One-way ANOVA was used to test differences between PTV, YYETL2, and YYIRTL1 maximal speeds. Post hoc analyses were carried out using the Tukey HSD test. The Bland-Altman (5) limits-of-agreement method was used to examine individual differences between YYETL2 estimated (3, 31) and actual $\dot{V}O_2$max values (ml·kg^{-1}·min^{-1}). Significance was set at 0.05 ($p \leq 0.05$). A Bonferroni correction for the number of correlation pairs was used. The resulting *p*-level was $p \leq 0.003$.

RESULTS

Mean and *SD* values of the variables considered in this study are shown in Table 5. PTV results were not significantly different from YYIRTL1 speed at exhaustion (p = 0.32). YYETL2 maximal speed results were significantly slower than those attained during treadmill and YYIRTL1 (p = 0.0001). No significant differences were found in $\dot{V}O_2$max between the treadmill and estimated YYETL2 (p = 0.10). Figure 1 depicts the Bland-Altman plot of treadmill $\dot{V}O_2$max (ml·kg^{-1}·min^{-1}) and estimated YYETL2 $\dot{V}O_2$max (ml·kg^{-1}·min^{-1}) values.

YYETL2 and YYIRTL1 performance results were significantly correlated (r = 0.75, p = 0.00002, $\mathbf{r}^2$ = 0.56). Correlations among aerobic fitness parameters determined during the incremental treadmill test and field test performances are shown in Table 1. Correlations among CMJ performance and field test and treadmill test variables are shown in Table 2.

TABLE 5. Descriptive statistics of the variable of this study.*

Variables	Mean ± *SD*
BM (kg)	74.6 ± 8.5
CMJ height (cm)	46.87 ± 4.38
CMJ PP (W·kg$^{-0.67}$)	53.35 ± 6.27
CMJ PF (*N*·kg$^{-0.67}$)	27.56 ± 2.38
$\dot{V}O_2$max (ml·kg$^{-0.67}$·min^{-1})	213.7 ± 15.0
$\dot{V}O_2$max (ml·kg^{-1}·min^{-1})	56.28 ± 4.41
$\dot{V}O_2$max-Est (ml·kg^{-1}·min^{-1})	57.46 ± 4.08
VT $\dot{V}O_2$ (ml·kg$^{-0.67}$·min^{-1})	181.1 ± 16.2
VT $\dot{V}O_2$ (ml·kg^{-1}·min^{-1})	47.64 ± 4.21
YYETL2 distance (m)	1,331 ± 291
YYIRTL1 distance (m)	2,138 ± 364
YYIRTL1 velocity (km·h^{-1})	16.81 ± 0.62
YYETL2 velocity (km·h^{-1})	14.15 ± 0.65
PTV (km·h^{-1})	17.28 ± 1.45
*v*VT (km·h^{-1})	13.78 ± 1.37

* BM = body mass; CMJ = countermovement jumps; PP = peak power; PF = peak force; $\dot{V}O_2$ = oxygen consumption per unit of time; Est = estimated; VT = ventilatory threshold; YYET = Yo-yo Endurance Test; L1 = level 1; L2 = level 2; YYIRT = Yo-yo Intermittent Recovery Test; PTV = peak treadmill velocity; *v*VT = speed of ventilatory threshold.

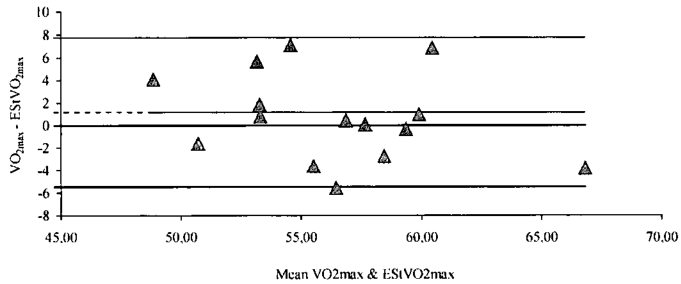

FIGURE 1. Bland-Atman plot of treadmill $\dot{V}O_2$max vs. Yo-yo Endurance Test Level 2–estimated $\dot{V}O_2$max. Bias, 1.17; limits of agreement, 7.79 − 5.44 ml·kg^{-1}·min^{-1} (p = 0.10).

DISCUSSION

This is the first study that has compared YYETL2 and YYIRTL1 in a soccer population within the same research design. Additionally, in this investigation, YYIRTL1 criterion validity was, for the first time, addressed in a population of soccer players. The latter issue is of particular interest in soccer because YYIRTL1 has been tested only for direct validity in soccer players (21, 26).

The results of this study show that YYETL2 and YYIRTL1 performance are significantly related. However only 56% of the shared variance may explain the variations in these 2 tests. This finding supports the likelihood of basic physiological differences between YYETL2 and

YYIRTL1 and suggests that using both field tests does not yield redundant information to coaches.

Results revealed that only YYETL2 was significantly correlated to $\dot{V}O_2$max in soccer players. However, the strength of the relationships found in this study is lower than those currently reported for 20MSRT and MSFT in the normal (23, 29, 31) and soccer populations (37). Analysis of common variance using the coefficient of determination revealed that only 56% of $\dot{V}O_2$max variations explain the changes in YYETL2 performance.

The finding that YYIRTL1 was not significantly related to $\dot{V}O_2$max contrasts with that reported by Krustrup et al. (21) who found a correlation coefficient of 0.71 ($p < 0.05$) in a group ($n = 15$) of habitually active subjects ($\dot{V}O_2$max = 50.5 ml·kg^{-1}·min^{-1}). These results suggest that YYIRTL1 may be regarded as a soccer-specific field test.

YYETL2 was shown to be more influenced than YYIRTL1 by submaximal components of aerobic fitness. Indeed, the distance covered during YYETL2 was significantly correlated with both VT $\dot{V}O_2$ and speed at VT (vVT) (explained variance ranging from 58 to 69%). YYIRTL1 results were only moderately affected by vVT ($r^2 = 0.48$; $p < 0.003$). These findings reveal that YYIRTL1 and YYETL2 are influenced by different physiological components, suggesting their selective usage in soccer. With respect to that, YYETL2 seems to be more of an aerobic fitness–dependent test than YYIRTL1. On the other hand, the finding that explosive power was related to YYIRTL1 performance further supports the soccer specificity of YYIRTL1. In fact, during competitive soccer, players perform a great deal of activity involving turning and changes of directions over a variety of intensities (40), which require muscular power and strength. Additionally, studies have shown that vertical jump performance is competitive level–dependent in soccer (39). The significant correlation found in the present study between YYIRTL1 and vertical jump performance (CMPP), suggests that the player's level of maximal muscular power, expressed during fast stretch-shortening actions, affects performance during high-intensity shuttle intermittent exercise. Therefore, both tests have been shown to be influenced by peripheral physiological variables. However, the nature of the peripheral variables are greatly different. Indeed, the YYIRTL1 was influenced by neuromuscular efficiency (explosive power level), whereas YYETL2 was more affected by submaximal aerobic fitness–related variables (VT expressions). Because VT is considered a more sensitive variable to seasonal variations in the working capacity of soccer players when compared with $\dot{V}O_2$max (7, 8), YYETL2 might provide a useful tool for assessing aerobic fitness adaptation during the season. In this regard, sound training studies should be performed to test YYETL2 sensitivity to VT across the soccer season. We conclude that YYETL2 can be considered an aerobic fitness–related field test, whereas YYIRTL1 can be regarded as an aerobic–anaerobic, soccer-specific field test.

PRACTICAL APPLICATIONS

Coaches and fitness trainers can estimate $\dot{V}O_2$max (ml·kg^{-1}·min^{-1}) from MSFT and YYET performance using a similar nomogram (3, 31). Differently from what re-

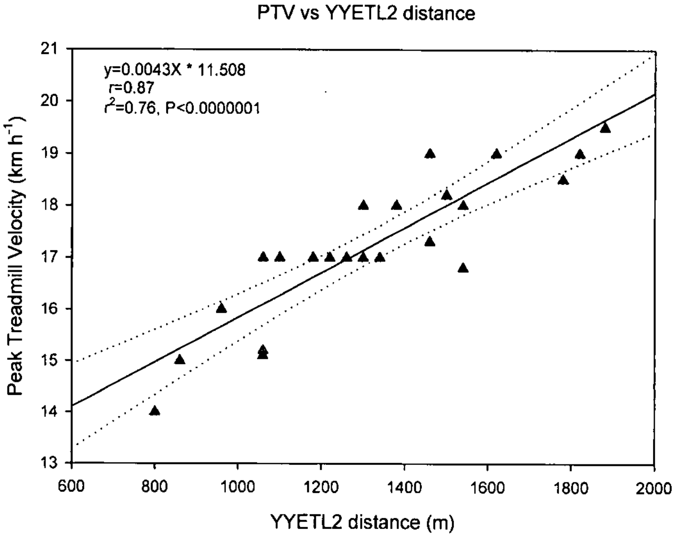

FIGURE 2. Scatterplot of peak treadmill velocity (PTV; km·h^{-1}) vs. Yo-yo Endurance Test Level 2 (YYETL2) distance covered (m). *SE y* = ±0.690 km·h^{-1}.

ported by Metaxas et al. (25) for elite-level soccer players, the results of this study showed that no group difference occurred between actual (treadmill protocol $\dot{V}O_2$max expressed in ml·kg^{-1}·min^{-1}) and a nomogram-estimated $\dot{V}O_2$max. However, Bland-Altman's limits of agreement showed that individual differences of about ±12% (confidence interval [*CI*] = 95%) of actual value, with 68% of cases ranging between 6% of the actual value (Figure 1). For these reasons, the validity of continuous shuttle-run tests to individually estimate actual $\dot{V}O_2$max values is questionable. On the other hand, the significant correlations found between $\dot{V}O_2$max and VT suggest that these field tests importantly involve the aerobic energy system and, as a consequence, can be considered valid field tests of generic (YYETL2) and soccer-specific (YYIRTL1) endurance ability (20, 21, 26).

The good correlation found among YYETL2 performance and vVT and PTV variables (Figure 2) may suggest that YYETL2 performance could be used as guiding tool when line running for $\dot{V}O_2$max and VT training is necessary. However, caution should be observed because players ($n = 7$) with the same PTV (17 km·h^{-1}) were observed to have differences in YYETL2 performance as great as 280 m (coefficient of variation [*CV*] = 8.5%).

In light of this study's findings, we suggest the use of YYETL2 at the beginning of the training period (preseason training) for generic soccer-player aerobic-fitness assessment. This way the obtained result can be used for a reasonably accurate training prescription. Approaching the competitive season, and during it, coaches and fitness trainers can take advantage of YYIRTL1 to test soccer-specific endurance of players, with information about both aerobic and anaerobic capacities. To have a global idea of the physical requirements of preparedness, coaches and fitness trainers can use the data reported here (Table 5) or use the equation reported by Krustrup et al. (21). Explosive strength training is suggested for improving the ability of soccer players to move efficiently during the match with high-intensity shuttle running (21).

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