Paper : Fitness and Conditioning

Reference Values for the 3200-m Run Test on a Soccer Field for Players at the Adolescent Growth Spurt

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The aim of the present study was to confirm the validity of the 3200-m run test on a soccer field, and provide reference values for this test in order to evaluate aerobic fitness in soccer players at the adolescent growth spurt. Forty-four male pubescent soccer players (7th grade), aged 12.8 ± 0.2 years, participated in this study for three years. They performed the 3200-m run test once a month for 30 months, as well as $\dot{V}O_2$max and V-OBLA tests at a laboratory once a year. In the 7th, 8th, and 9th grades, the 3200-m run test results correlated with V-$\dot{V}O_2$max (r = -0.62, -0.64 and -0.71, respectively) and V-OBLA (r = -0.58, -0.66 and -0.73, respectively). The content validity and criterion-related validity of the 3200-m run test to measure aerobic fitness in soccer players at the growth spurt were confirmed. We also demonstrated that this test was easy to prepare and measure, inexpensive, and may be included in aerobic training for players. Finally, reference values for the test for soccer players at these ages were provided.

Keywords: Aerobic fitness, Growth, Development, Longitudinal study

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1. Introduction

This study will provide reference values for the 3200-m run test on a soccer field in players at the adolescent growth spurt.

Soccer is a sport that requires repeated high-intensity runs of 15 to 20 m in approximately 2-second bursts (Bangsbo, 1994, Bradley et al., 2009). Professional soccer players at higher skill levels have been shown to engage in more high-intensity running during a game (Mohr et al., 2003). Therefore, players need to ascertain their ability to perform repeated high-intensity running without performance decrements, referred to as intermittent endurance, which is important for attaining a high competitive level as a soccer player.

Bangsbo developed the Yo-Yo intermittent recovery test (Yo-Yo IR test) to evaluate intermittent endurance in soccer players (Bangsbo et al., 2008). The Yo-Yo IR test has been confirmed to predict the distance a player covers by high-intensity running during a soccer game in a wide range of players, from pubescent to professional-level players (Bangsbo et al., 2008; Castagna et al., 2010; Randers et al., 2009). Furthermore, players with higher competitive levels have achieved better Yo-Yo IR test results and perform more high-intensity running during a game (Bangsbo et al., 2008; Randers et al., 2009). Therefore, the Yo-Yo IR test is recognized worldwide as a valid evaluation of intermittent endurance in soccer players.

Energy is mainly supplied through the anaerobic energy system during the high-intensity phase of intermittent running in a soccer game, and is supplied through the aerobic energy system, which resynthesizes the adenosine triphosphate (ATP) and phosphocreatine (PC) used in the high-intensity phase, during the recovery phase (Balsom et al., 1992). Therefore, an aerobic energy system with a higher capacity (aerobic fitness) allows players to recover faster and perform more repeated high-intensity running (Bangsbo et al., 2008; Krustrup et al., 2003, 2006; Rampinini et al., 2010; Ueda et al., 2011). These findings clearly demonstrate that soccer players need to increase aerobic fitness in order to acquire high-level intermittent endurance.

Aerobic fitness is highly trainable during the adolescent growth spurt, in which body size and function change the most during the lifetime of humans. Therefore, enhancing aerobic fitness during this period is considered an effective strategy for achieving superior intermittent endurance. However, we previously indicated that the Yo-Yo IR test was not a valid test for intermittent endurance in players during the growth spurt because the performance of this test by young players was markedly affected by leg muscle power, which has been strongly correlated with the stage of maturity and weakly associated with aerobic fitness (Chuman et al., 2011a, 2011b). This prevents its use in evaluating aerobic fitness in players during this period, in which large individual variations in maturation have been reported (Chuman et al., 2011a). In other words, while increasing aerobic fitness at this age is important for acquiring the intermittent endurance of a professional player, this alone does not contribute to enhanced intermittent endurance, and, as such, does not reflect Yo-Yo IR test results during the growth spurt. Therefore, in addition to the Yo-Yo IR test, aerobic fitness itself needs to be evaluated in a way that is not influenced by the stage of maturity.

Aerobic fitness is a function of the respiratory, circulatory, and metabolic systems in a body. Maximal oxygen consumption ($\dot{V}O_2max$) is generally considered to be an index of the respiratory and circulatory systems because of the significant involvement of the lungs and heart in oxygen consumption (Maruyama, 2004). Since the accumulation of blood lactate varies in a manner that depends on the balance between the production and removal of lactate in muscles (Maruyama, 2004), running speed at the onset of the accumulation of blood lactate (V-OBLA) serves as an index of the metabolic system. The maturity status has been weakly associated with $\dot{V}O_2max$, which is expressed as a value relative to body mass (mL/kg/min), and V-OBLA in soccer players during puberty (Chuman et al., 2009); therefore, these indices need to be periodically measured in order to evaluate the development of aerobic fitness independent of the maturity of players during the growth spurt. However, these measurements require advanced equipment in a laboratory and, thus, are not available to most coaches and players. Therefore, a valid and relevant field test that reflects physiological indices such as $\dot{V}O_2max$ and V-OBLA and is fast, easy, and inexpensive to prepare and conduct measurements is needed.

The 3200-m run test satisfies the above conditions. The corners of a soccer field are often trimmed to create a running course for regular aerobic training, and, for this reason, the 3200-m run test on a soccer field was considered easy for coaches to conduct within daily soccer training. Therefore, the validity and efficiency of the 3200-m run test on a soccer field needs to be determined in players at the adolescent growth spurt. Furthermore, reference values must be simultaneously created in order to evaluate the individual development of aerobic fitness by setting age on the horizontal axis and absolute evaluation criteria on the vertical axis. A reference utilizing measurements that are not influenced by the stage of maturity enables an accurate evaluation of aerobic fitness by age. These reference values will contribute to the identification of talented young players and appropriate design of aerobic training to acquire high-level intermittent endurance.

In the present study, we attempted to examine the validity and efficiency of the 3200-m run test on a soccer field for measuring aerobic fitness in players at the adolescent growth spurt. We also aimed to create reference values for the test utilizing 30-month longitudinal data.

2. Methods

Subjects

Forty-four male pubescent soccer players (7th grade), aged 12.8 ± 0.2 years at the beginning of the study and who were members of U-13 team of a soccer club participating in Japan Professional Football League Division 1 (J1-League), took part in this study. Subjects were all field players who passed through a selection process to join the team. To ensure that our subjects were soccer players with high-level skills, we followed individual players for three years from the 7th to 9th grades, and no subject dropped out of team training. Subjects participated in training after parental consent. All measurements were performed as a part of team training under the supervision of the instructors. Training was conducted 5 to 6 times per week during which players regularly participated in one physical training session (interval or continuous training), three to four sessions for technical and tactical skills, and one game. The duration of one training session was 90 minutes from 7:00 to 8:30 PM on weekdays and during the daytime on weekends. Subjects performed the 3200-m run test once a month for 30 months from May of the 7th grade to October of the 9th grade. Laboratory testing was conducted within one week of the first 3200-m run test for each grade. The fiscal year was set from April 2 to April 1 of the following year (7th grade=13 years of age, 8th grade=14 years of age, and 9th grade=15 years of age).

Maturity Status

Peak height velocity (PHV) was used as an indicator of the physical maturity status of a subject. Age at PHV was determined from a subject's height growth velocity curves by age and height for nine years from 7 to 15 years of age utilizing the BTT method in the AUXAL 3 (SSI) longitudinal height analysis software program. Relative values calculated by deducting age at PHV from chronological ages at measurements were referred to as the PHV age in this study.

The 3200-m Run Test

The 3200-m run test was conducted on an artificial turf soccer field that was 105 m long and 68 m wide and was used for daily training. We removed 11.1 m from the four corners of the field to create an octagonal track with a circumference of 320 m (**Figure 1**). Subjects started running at a sign given by an instructor and ran 10 laps. The time required to run the 10 laps was measured with a stopwatch and recorded as the result of the 3200-m run test.

A 12-minute run test is also often employed to measure aerobic fitness in soccer players (Bartha et al., 2009). Prior to this study, we conducted 3200-m and 12-minute run tests on the same soccer field to evaluate the alternative validity of the tests. Twenty-five subjects were tested at the ages of 13 and 14 years old. In the 12-minute run test, markers were placed every 10 m on the 320 m track, as was done in the 3200-m run test, and distance a player ran during the 12-minute test was recorded to the nearest 10 m. The 12-minute run test was conducted within one week of the 3200-m run test.

To establish reference values for the 3200-m run test results in players at the growth spurt, we used mean values (M) and standard deviations (SD) for each grade, setting M-1.5 SD or lower as A, between M-1.5 SD and M-0.5 SD as B, between M-0.5 SD and M+0.5 SD as C, between M+0.5 SD and M+1.5 SD as D, and M+1.5 SD or higher as E. We applied a quadratic regression curve for the four SDs to smoothen the reference values of a five-grade evaluation system. When the point of the quadratic regression curve appeared before October of their 15th year of age, we adjusted the reference values after the point to be constant.

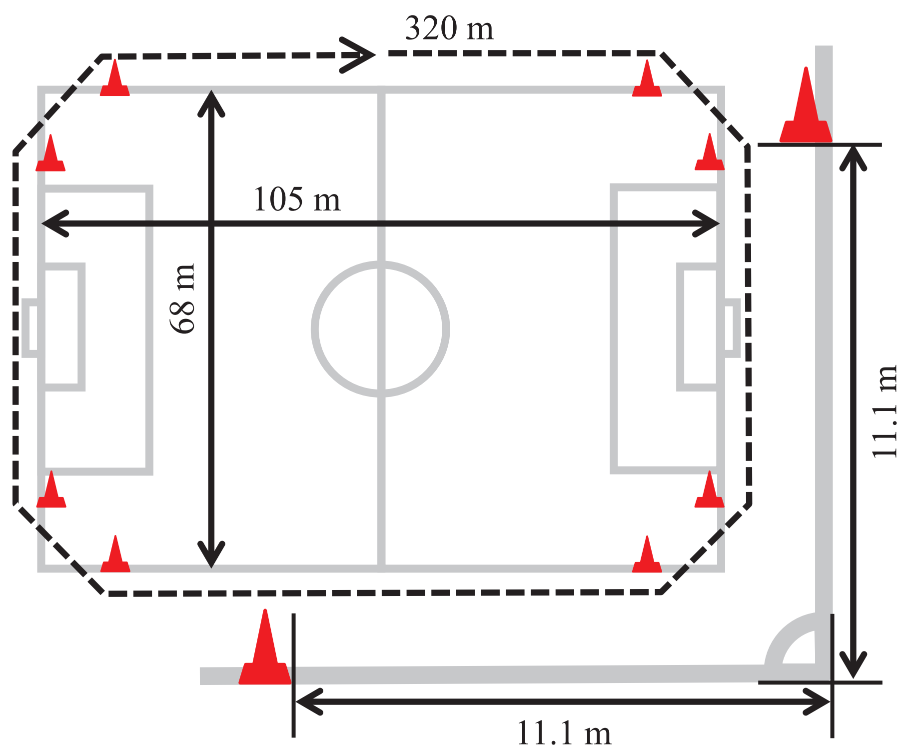

Figure 1 Creation of a track for the 3200-m run test on a soccer field

Laboratory Testing

A graded exercise test was performed on a treadmill to determine aerobic fitness in the laboratory. During the graded exercise test, a three-minute session of submaximal running with a one-minute rest interval was repeated four to six times to measure heart rate, oxygen uptake, and blood lactate concentration at each running speed. The running speeds were set at 180, 200, 220, 240, 260, and 280 m per minute. Met Max (Cortex Biophysic GmbH) was used to measure oxygen uptake, and Lactate Pro (Arkray, Inc.) was used to measure blood lactate concentrations. More than two blood samples were collected from a finger puncture site within 20 seconds after the submaximal run at each speed, and the mean value was used as the blood lactate concentration at each speed. Submaximal running ended when the blood lactate concentration exceeded 5 mmol/L. After a two-minute rest period, the speed was set to 280 m per minute to exhaust the subjects with the grade increasing by 1% every minute after three minutes. However, when submaximal running ended at a speed of 240 m per minute or lower, we set the speed to 260 m per minute to exhaust the subjects. In most cases, the $\dot{V}O_2$max was determined by the criterion of an increase in oxygen uptake of 80 mL/min or lower in spite of an increase in exercise intensity. In other cases, $\dot{V}O_2$max meet the criteria shown below.

1) The respiratory exchange ratio was 1.10 or greater.
2) Heart rate reached within the maximal heart rate estimated by age (220 – age) ±10 beats/min.
3) Blood lactate concentration was 8 mmol/L or greater.

In this study, $\dot{V}O_2$max was expressed as a value divided by body mass (mL/kg/min), and the running velocity at $\dot{V}O_2$max (V-$\dot{V}O_2$max) and 4 mmol/L of blood lactate concentration (V-OBLA) were also recorded.

Statistical Analysis

Data are shown as means ± standard deviations (**Table 1**). The 3200-m run test results are shown in a sexagesimal system for ease of use as reference values (**Table 2, 4**). A one-way ANOVA with repeated measures was used at each measurement to examine differences among grades. When a significant difference was observed among grades, a multiple comparison test was conducted with the Bonferroni method as a post-hoc test. Pearson's correlation coefficient was used to examine the relationship between the measurements. Statistical analyses were conducted with SPSS 12.0J. Significance was set at $\alpha = 0.05$.

Seventy-nine (6.0%) out of 1320 trials in the 3200-m run test were not performed due to non-participation caused by poor physical condition or injury. The missing values were complemented by the mean test result values before and after the month in which the relevant subjects were unable to participate in the test.

3. Results

A correlation was observed between the 3200-m run test and 12-minute run test, as shown in **Figure 2** ($r = 0.90$).

Table 1 Descriptive statistics (N=44)

Item	Grade			ANOVA ($p < 0.05$)
	7th	8th	9th	
Chronological age (years old)	12.8 ± 0.2	13.8 ± 0.2	14.8 ± 0.2	—
PHV age (years old)	0.0 ± 1.1	1.0 ± 1.1	2.0 ± 1.1	—
Height (cm)	157.8 ± 8.2	164.1 ± 7.2	168.6 ± 6.1	13 < 14 < 15
Body mass (kg)	46.1 ± 7.9	51.7 ± 8.3	56.6 ± 7.6	13 < 14 < 15
$\dot{V}O_2$max (mL/kg/min)	65.7 ± 5.2	67.3 ± 6.3	68.1 ± 6.2	13 < 14 < 15
V-$\dot{V}O_2$max (m/min)	275.6 ± 24.1	295.5 ± 23.2	308.1 ± 21.6	13 < 14 < 15
V-OBLA (m/min)	240.0 ± 18.0	253.4 ± 18.2	263.1 ± 17.6	13 < 14 < 15

Table 2 3200-m run test results by month (N=44)

Month	7th grade			8th grade			9th grade		
	Times	Ave	SD	Times	Ave	SD	Times	Ave	SD
April	—	—	—	12	12'40"	42"	24	12'25"	41"
May	1	13'33"	35"	13	12'43"	45"	25	12'26"	45"
June	2	13'27"	45"	14	12'40"	43"	26	12'20"	50"
July	3	13'26"	44"	15	12'47"	50"	27	12'20"	45"
August	4	13'27"	43"	16	12'52"	44"	28	12'37"	47"
September	5	13'19"	42"	17	12'53"	48"	29	12'17"	40"
October	6	13'03"	44"	18	12'28"	47"	30	12'12"	39"
November	7	13'06"	42"	19	12'44"	56"	—	—	—
December	8	12'52"	46"	20	12'37"	43"	—	—	—
January	9	12'56"	47"	21	12'44"	49"	—	—	—
February	10	12'47"	43"	22	12'30"	49"	—	—	—
March	11	12'44"	40"	23	12'25"	45"	—	—	—

' = minute; " = second

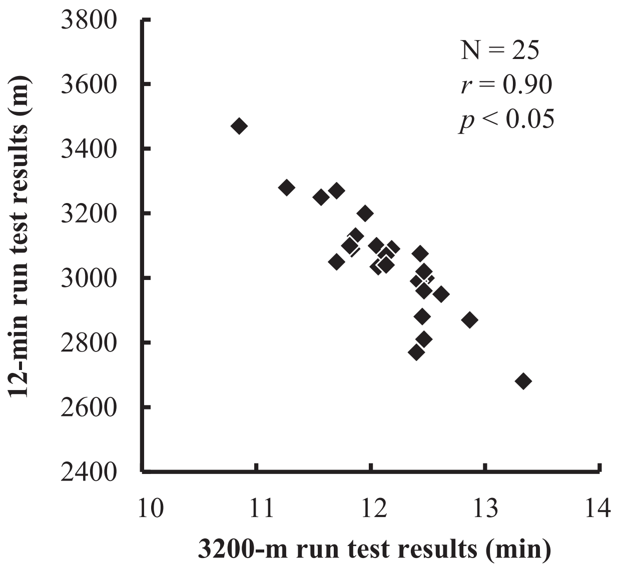

Figure 2 The relationship between 3200-m run and 12-min run tests for soccer players at the adolescent growth spurt

Table 3 Correlations between the 3200-m run test, maturity, and aerobic fitness (N=44)

Item	3200-m run test results		
	7th grade	8th grade	9th grade
PHV age	-0.27	-0.02	-0.03
V-$\dot{V}O_2$max	**-0.62 ***	**-0.64 ***	**-0.71 ***
V-OBLA	**-0.58 ***	**-0.66 ***	**-0.73 ***

*; $p < 0.05$

Table 1 shows the descriptive statistics for the subjects. Subject $\dot{V}O_2$max values at the 7th, 8th, and 9th grades were 65.7, 67.3, and 68.1 mL/kg/min, respectively; V-$\dot{V}O_2$max values were 275.6, 295.5, and 308.1 m/min, respectively; V-OBLA values were 240.0, 253.4, and 263.1 m/min, respectively. The results of a one-way ANOVA revealed significant differences among all these measurements. Values were higher in the 9th grade than in the 8th grade, and were higher in the 8th grade than in the 7th grade.

Table 2 shows the longitudinal 3200-m run test results of the subjects from May of the 7th grade to October of the 9th grade. The mean values of the 3200-m run test were between 13 minutes 33 seconds and 12 minutes 11 seconds. A one-way ANOVA revealed a significant difference between the measurement periods.

Table 3 shows the relationships among the 3200-m run test, PHV age, and laboratory measures of aerobic fitness. No correlation existed between the 3200-m run test results in the 7th, 8th, and 9th grades and PHV age. However, a correlation was observed between the 3200-m run test results and V-$\dot{V}O_2$max at all ages (r = -0.62, -0.64, -0.71, respectively), and also between the 3200-m run test results and V-OBLA at all ages (r = -0.58, -0.66, -0.73, respectively).

Figure 3 shows the reference values created from the 3200-m test results. Quadratic regression equations for each SD (+1.5, +0.5, -0.5, -1.5), which are the reference values of a five-grade evaluation system, were as follows:

+1.5 SD: $y = 0.0273x^2 - 2.9963x + 871.52$
+0.5 SD: $y = 0.0549x^2 - 3.9705x + 833.25$
-0.5 SD: $y = 0.0825x^2 - 4.9447x + 794.97$
-1.5 SD: $y = 0.1101x^2 - 5.9188x + 756.70$

where y is the 3200-m run test results, and x is the number of measurements.

A list of the reference values acquired from these regression equations is shown in **Table 4**.

4. Discussion

The aim of the present study was to examine the validity of the 3200-m run test on a soccer field. We also provided the reference values to evaluate the development of aerobic fitness in soccer players at the adolescent growth spurt by utilizing 30-month longitudinal data from this study. We initially examined the validity of the 3200-m run test. During a soccer game, players run in both offensive and defensive phases, typically moving between 9 and 12 km during the 90-minute period. The 3200-m run test had the same running feature as soccer games; therefore, it satisfied content validity.

Aerobic fitness is dependent on the respiratory, circulatory, and metabolic systems in the body. $\dot{V}O_2$max is generally considered to be an index of the respiratory and circulatory systems (Maruyama, 2004), while V-OBLA serves as an index of the metabolic system. A correlation was observed between the 3200-m run test results and V-$\dot{V}O_2$max and V-OBLA at all ages (**Table 3**), with the correlation coefficient increasing with age; namely, r = -0.62 and -0.58, respectively, at the 7th grade, r = -0.64 and -0.66, respectively, at the 8th grade, and r = -0.71 and -0.73, respectively, at the 9th grade. The performance of the 3200-m run test may have been limited by the lower function of V-$\dot{V}O_2$max or V-OBLA. In other words, aerobic fitness training

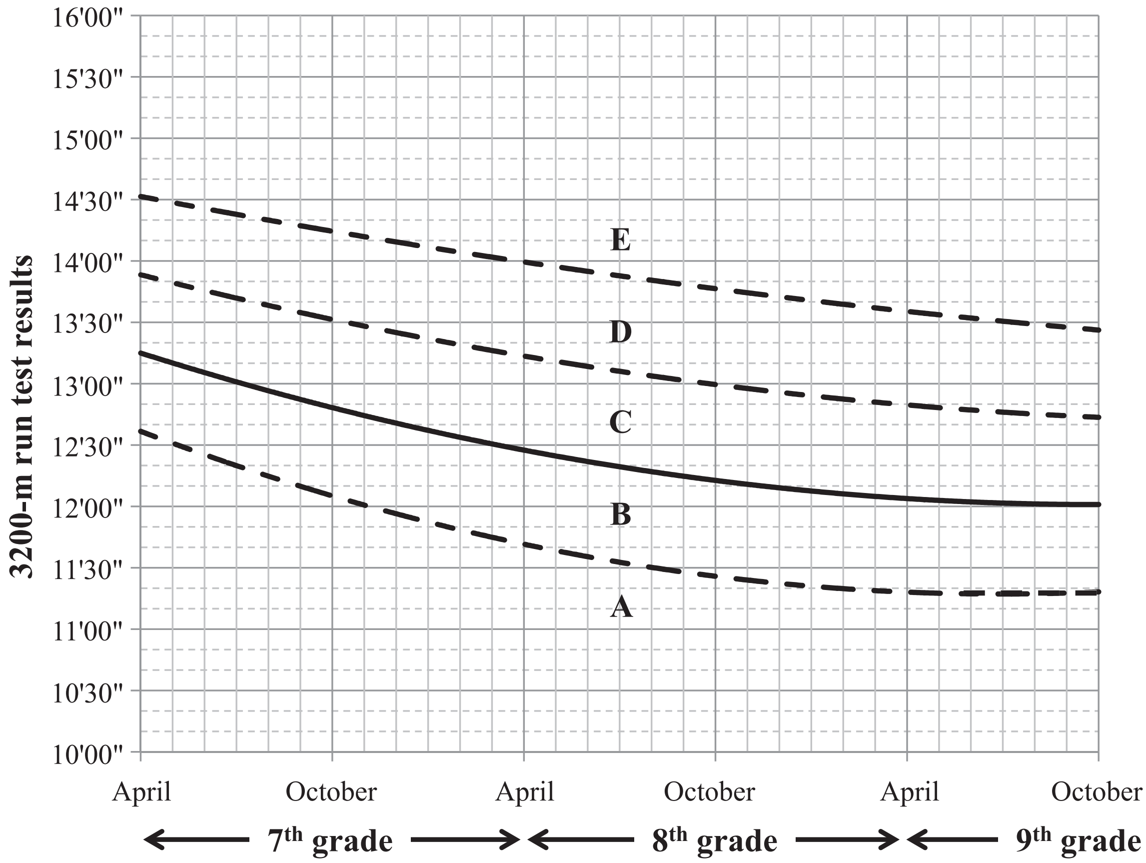

Figure 3 Reference values for the 3200-m run test for soccer players at the adolescent growth spurt

Table 4 Reference values for the 3200-m run test for soccer players at the adolescent growth spurt

Grade	Month	3200-m run test results				
		A	B	C	D	E
7th	May	~12'30"	12'31"~13'10"	13'11"~13'49"	13'50"~14'28"	14'29"~
	June	~12'25"	12'26"~13'05"	13'06"~13'45"	13'46"~14'25"	14'26"~
	July	~12'19"	12'20"~13'00"	13'01"~13'41"	13'42"~14'22"	14'23"~
	August	~12'14"	12'15"~12'56"	12'57"~13'38"	13'39"~14'19"	14'20"~
	September	~12'09"	12'10"~12'52"	12'53"~13'34"	13'35"~14'17"	14'18"~
	October	~12'05"	12'06"~12'48"	12'49"~13'31"	13'32"~14'14"	14'15"~
	November	~12'00"	12'01"~12'44"	12'45"~13'28"	13'29"~14'11"	14'12"~
	December	~11'56"	11'57"~12'40"	12'41"~13'24"	13'25"~14'09"	14'10"~
	January	~11'52"	11'53"~12'37"	12'38"~13'21"	13'22"~14'06"	14'07"~
	February	~11'48"	11'49"~12'33"	12'34"~13'19"	13'20"~14'04"	14'05"~
	March	~11'44"	11'45"~12'30"	12'31"~13'16"	13'17"~14'01"	14'02"~
8th	April	~11'41"	11'42"~12'27"	12'28"~13'13"	13'14"~13'59"	14'00"~
	May	~11'38"	11'39"~12'24"	12'25"~13'10"	13'11"~13'57"	13'58"~
	June	~11'35"	11'36"~12'21"	12'22"~13'08"	13'09"~13'54"	13'56"~
	July	~11'32"	11'33"~12'19"	12'20"~13'06"	13'07"~13'52"	13'53"~
	August	~11'30"	11'31"~12'16"	12'17"~13'03"	13'04"~13'50"	13'51"~
	September	~11'27"	11'28"~12'14"	12'15"~13'01"	13'02"~13'48"	13'49"~
	October	~11'25"	11'26"~12'12"	12'13"~12'59"	13'00"~13'46"	13'47"~
	November	~11'23"	11'24"~12'10"	12'11"~12'57"	12'58"~13'44"	13'45"~
	December	~11'22"	11'23"~12'09"	12'10"~12'55"	12'56"~13'42"	13'43"~
	January	~11'20"	11'21"~12'07"	12'08"~12'54"	12'55"~13'40"	13'41"~
	February	~11'19"	11'20"~12'06"	12'07"~12'52"	12'53"~13'38"	13'39"~
	March	~11'18"	11'19"~12'04"	12'05"~12'50"	12'51"~13'37"	13'38"~
9th	April	~11'18"	11'19"~12'03"	12'04"~12'49"	12'50"~13'35"	13'36"~
	May	~11'17"	11'18"~12'02"	12'03"~12'48"	12'49"~13'33"	13'34"~
	June	~11'17"	11'18"~12'02"	12'03"~12'47"	12'48"~13'32"	13'33"~
	July	~11'17"	11'18"~12'01"	12'02"~12'46"	12'47"~13'30"	13'31"~
	August	~11'17"	11'18"~12'01"	12'02"~12'45"	12'46"~13'29"	13'30"~
	September	~11'17"	11'18"~12'00"	12'01"~12'44"	12'45"~13'27"	13'28"~
	October	~11'17"	11'18"~12'00"	12'01"~12'43"	12'44"~13'26"	13'27"~

' = minute; " = second

increased the function that limited the 3200-m run test results in individual subjects and may have been the reason for the high correlation coefficient of the 3200-m run test with V-$\dot{V}O_2$max and V-OBLA in the present study. The relationship between the 3200-m run test and V-$\dot{V}O_2$max and V-OBLA has not yet been examined in pubescent soccer players; however, Weltman et al. (1987) investigated the relationship between the 3200-m run test results and physiological indices in 42 male runners, and reported that it was possible to estimate $\dot{V}O_2$max or V-$\dot{V}O_2$max and V-OBLA from their 3200-m run test results. They subsequently confirmed these findings in females (Weltman et al., 1989, 1990). Taken together with the results of the present study, we concluded that the 3200-m run test reflected aerobic fitness adequately in soccer players during the growth spurt.

However, the focus of the present study was to develop a method that evaluated the development of aerobic fitness in pubescent soccer players without being affected by the stage of maturity. We previously indicated that although the Yo-Yo IR test evaluates intermittent endurance in soccer players, this test alone may lead to the development of aerobic fitness being overlooked because Yo-Yo IR test results in pubescent soccer players are more strongly influenced by maturity than aerobic fitness (Chuman et al., 2009). As marked improvements in aerobic fitness are essential during this period for achieving superior intermittent endurance in post-maturity, a valid test needs to be carefully chosen by the coaches responsible for young players, particularly at this age.

While we previously reported that PHV age influenced Yo-Yo IR test results (Chuman et al., 2009), a correlation was not observed between PHV age and the 3200-m run test at any grade in the present study (**Table 3**). The Yo-Yo IR test involves a 20-m straight-line run and return during which players have to accelerate, decelerate, change direction, and re-accelerate within a given time, thereby requiring the exertion of a substantial amount of leg muscle power. Therefore, late-maturing players whose muscle power has not yet fully developed cannot change direction quickly. Since the 3200-m run test used in the present study does not include direction changes, the results obtained in this test are dependent to a lesser extent on the stage of maturity. As such, the 3200-m run test was considered to satisfy criterion-related validity as an aerobic fitness test in players during the spurt period.

We also examined the efficiency of the 3200-m run test. $\dot{V}O_2$max and V-OBLA should be measured periodically in order to evaluate the development of aerobic fitness during puberty. However, these laboratory-level measurements are time-consuming and expensive. A test needs to be developed that is quick, easy, and inexpensive for frequent use in team training for soccer. The four corners of the soccer field are often removed to create a track to conduct physical training for soccer players. Therefore, the 3200-m run test can be conducted on the same field without the need to transport players to a field track (**Figure 1**).

The 3200-m run test requires eight cones measuring 60 cm or less in height and one stopwatch. No CD player or speakers are required. Preparation for the test involves the placement of the eight cones rather than the creation of a track for individual players. In addition, the 3200-m run test can be conducted by a single recorder who measures multiple players at the same time and does not need difficult judgments on the part of the recorder. While the 12-minute run is more commonly used than the 3200-m run to measure the aerobic fitness of soccer players, it requires markers for every 10 meters and one recorder for each player. The 3200-m run test is more convenient than the 12-minute run test due to its ease of preparation and conduct. The 3200-m run test results strongly correlated with the 12-minute run test results (r = 0.90) and its alternative validity was confirmed (**Figure 2**). As we demonstrated, the 3200-m run test on a soccer field was easy to prepare and conduct, was inexpensive, and was determined to be efficient as a field test.

Furthermore, the 3200-m run test conducted within a training session works as aerobic fitness training for players. Nagahama et al. (1991) imposed 20-minute continuous running training set to the velocity of OBLA twice a week for nine weeks on university soccer players. They reported that this training improved V-OBLA and increased the distance covered during soccer games. Comparisons between running speeds in the 3200-m run test and V-OBLA by grade revealed an average difference of only 2.7 m/min in the present study. This difference was equivalent to 0.6 seconds per 320 m, indicating that the 3200-m run test was performed approximately under the speed of V-OBLA, and that the test itself can be used for training and will improve V-OBLA and performance during games. These results suggest that the 3200-m run test on a soccer field is a highly efficient means of evaluating aerobic fitness in young soccer players during the growth spurt.

We conducted the 3200-m run test on subjects every month for up to 30 months from May of their 13th year of age to October of their 15th year of age. A one-way ANOVA with repeated measures revealed a significant difference in the 3200-m run test results, with a reduction in time of 1 minute 21 seconds on average from 13 minutes 33 seconds in the first test to 12 minutes 12 seconds in the final test. The effect size of the test results between the first and final times was 2.19, which was considered to be "significantly large" according to the effect size criteria by Demura and Yamaji (2011). It should be noted that reference values for the 3200-m run test established through this study were based on 30-month longitudinal data which were gathered from elite young players aiming to become professional. These reference values were also characterized by the values varying every month during the adolescent growth spurt. The use of these values enables an accurate evaluation of aerobic fitness at the month of the measurement, and makes it possible to identify players with high-level aerobic fitness even though they have not yet developed the same aerobic fitness as older players. The accurate evaluation of each player at each time will be helpful for coaches designing long-term strategies for fitness training to match the individual player's needs at different stages of maturity, and this will enable them to efficiently acquire the high-level intermittent endurance required in post-maturity.

In conclusion, the validity and efficiency of the 3200-m run test on a soccer field were confirmed for the measurement and evaluation of aerobic fitness in soccer players during the adolescent growth spurt. In addition, reference values for the test were provided utilizing longitudinal data obtained over a period of 30 months. With these reference values, it is possible to plan aerobic fitness training for individual players during the growth spurt, in which trainability for aerobic fitness is high. It is desirable for soccer players during this period to advance their aerobic fitness as a foundation for the intermittent endurance required to become professional players.

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