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Yo-Yo Intermittent Recovery Level 2 Test in Pubescent Soccer Players with Relation to Maturity Category

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The purpose of this study was to investigate the influence of maturity category on the Yo-Yo intermittent recovery level 2 test (YYIR2) in pubescent soccer players. Twenty-six soccer players aged 12.7±0.2 yrs participated in the study and were divided into two groups (Under and Over) by maturity category according to their peak height velocity curves. Maximal oxygen consumption ($\dot{V}O_2$max), onset of blood lactate accumulation (OBLA), running economy (RE), fat-free mass (FFM), thigh muscle cross-sectional area (MCSA) by magnetic resonance imaging and distance in the five-jump test (5J) were measured to monitor the development of aerobic capacity and muscle strength, and correlations with the YYIR2 were investigated. The YYIR2 for Under and Over were 255.0±48.2 m and 336.0±71.1 m, respectively, and significant difference was found between the groups. The YYIR2 was significantly correlated with 5J, and the correlations with FFM and MCSA were also significant regardless of whether the data were expressed in absolute or relative value to height. In contrast, no relation with the YYIR2 was found in $\dot{V}O_2$max relative value to weight, OBLA and RE, it was suggested that the YYIR2 might not be a good indicator for aerobic development in pubescent soccer players. These results indicated that maturity category affected the YYIR2 of pubescent soccer players due to physique and the development of muscle strength.

Keywords: growth, development, peak height velocity (PHV), aerobic capacity, muscle strength

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1. Introduction

Recently, it has been recognized that high-level physical fitness is a required condition for success in soccer (Bangsbo, 1994; Helgerud, et al., 2001). High-level physical fitness is achieved through a synergy of training and the biological process of growth, and it is considered that long-term and well-planned training is necessary from a young age.

In order to realize efficient training, it is necessary to have a test that allows a proper evaluation of the physical fitness of players. There are various tests that measure the physical fitness of soccer players, with a representative example being the Yo-Yo intermittent recovery test (YYIR) (Krustrup, et al., 2003; 2006). The YYIR requires the player to shuttle a distance of 20m, rest during a 10-second active recovery period, then repeat, with the speed increasing gradually with each successive shuttle run. The Yo-Yo intermittent recovery level 2 test (YYIR2) correlates with maximal oxygen consumption ($\dot{V}O_2$max). In addition, it is reported that for individual soccer players performing at higher levels the YYIR2 yields better results and more accurately reflects physical fitness changes over the course of the season (Krustrup, et al., 2006). Moreover, it is reported that the test results correlate with performance values such as the number of sprints and the distance covered in a soccer game, and team score in the soccer league (Randers, et al., 2007). Because of the above, the YYIR2 has been employed extensively as a test to ascertain the physical fitness of soccer players. However, YYIR2 data has been obtained for the most part from adult soccer players, leaving researchers with a lack of data for youth soccer players, the athletes who require long-term

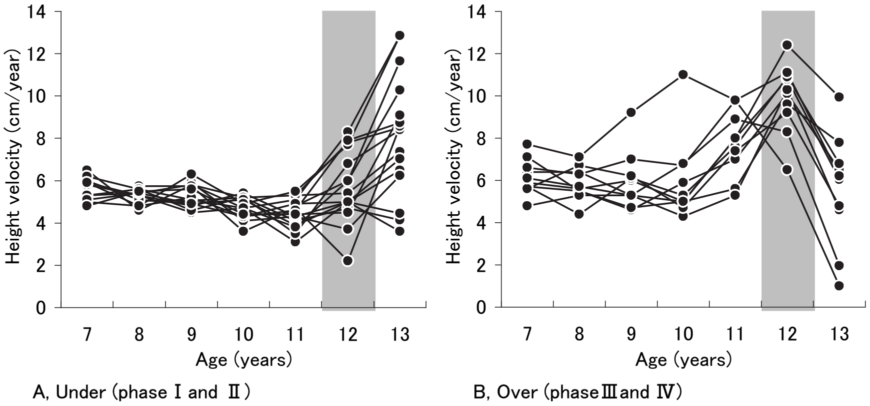

Figure 1 Classification of subjects.

training (JFA physical fitness project, 2005).

The YYIR2 is considered to be a good indicator of aerobic capacity in soccer players due to the fact that it correlates with $\dot{V}O_2$max, the number of sprints and the distance covered during the game (Krustrup, et al., 2006). However, because the YYIR2 includes acceleration at high speed, deceleration and turns, the results are also influenced by muscle strength. Therefore, performance on the YYIR2 is thought to reflect both aerobic capacity and the muscle strength of the player. The adolescent spurts in aerobic capacity and muscle strength occur at different timing and tempo. Maximum growth rate per year of $\dot{V}O_2$max appears at almost the same period as peak height velocity (PHV); however, marked increase in muscle strength takes place slightly later than $\dot{V}O_2$max and continues during late adolescence when fat-free mass (FFM) and muscle cross-sectional area increase becomes marked as the result of rising testosterone concentrations. (Malina and Bouchard, 1991).

Therefore, it is thought that the results of the YYIR2, which reflects both aerobic capacity and muscle strength in pubescent soccer players, might vary with physical maturity category. The purpose of this study was to report YYIR2 results for pubescent soccer players in consideration of maturation. For complementary reasons, we also examined correlation with each index of the YYIR2, aerobic capacity and muscle strength.

2. Methods

Subjects were 26 members of a youth (average age; 12.7±0.2) soccer club managed by a team belonging to the Japan Professional Football League (J league). Subjects were born between April 1994 and March 1995 and the measurement was carried out in April, immediately following junior high school enrollment. Subjects were all field players who had participated in competitive soccer training under instructors for an average of 6.7±1.4 years and a minimum of 4 years and passed the selection process based of soccer skill level. In addition, in the reference year in which measurement was carried out, the team won the J league U-13 in Tokai region. Subjects attended the soccer club training after obtaining permission from their guardians, and this study was carried out as a part of training under the direction of instructors.

The physical maturity category of subjects was determined by use of the individual PHV curves. The increase in height for subjects was calculated by obtaining the recorded height of each subject as measured in April of each year for the 7 years leading up to the time of this study, including the year in which the subjects reached 12 years of age. With reference to phases I - IV of the PHV curve reported by Murata (1988), subjects were categorized into two groups; namely, the Under Group, those subjects whose increase in height for the year at measurement (12 years of age) was under the PHV age of phases I and II, and the Over Group, those subjects whose increase in height for the year was over the PHV age of phases III and IV (**Figure 1 A, B**).

YYIR2 was selected in reference to the Evaluation of Physical Performance 2006 (JFA physical fitness project, 2005) in consideration of continuity for the future. YYIR2 was carried out in accordance with the manual attached to the CD (S&C Planning, L.P.). Briefly, subjects repeated the 20m shuttle run, starting at a signal from the CD, turning at a second signal from the CD and returning to the starting point before a third and final signal from the CD. The interval at which the three signals sounded decreased with each subsequent shuttle run. To rest, subjects jogged for 10 seconds between runs with the jog requiring subjects to travel to a cone placed 5m away and return to the starting position. In the event that a subject failed to return to the starting position prior to the third signal a total of two times, the measurement was concluded and the travel distances were recorded

Table 1 Descriptive statistics (N = 26).

Item	Total	Maturity category		P
		Under	Over	
Number	26	16	10	–
Height (cm)	152.8 ± 9.8	146.9 ± 6.0	162.4 ± 6.4	<.01
Weight (kg)	41.7 ± 8.9	36.6 ± 4.0	49.8 ± 8.7	<.01
YYIR2 (m)	286.2 ± 69.5	255.0 ± 48.2	336.0 ± 71.1	<.01
5J (m)	9.73 ± 0.85	9.30 ± 0.58	10.41 ± 0.76	<.01

Table 2 Descriptive statistics (N = 14).

Item	Total	Maturity category		P
		Under	Over	
Number	14	5	9	–
Height (cm)	157.2 ± 9.5	147.3 ± 3.6	162.7 ± 6.6	<.01
Weight (kg)	45.8 ± 9.6	37.6 ± 2.6	50.4 ± 9.0	<.01
$\dot{V}O_2max$ (L/min)	3.00 ± 0.60	2.38 ± 0.27	3.34 ± 0.42	<.01
$\dot{V}O_2max$ (ml/kg/min)	66.1 ± 7.2	63.1 ± 7.7	67.8 ± 6.8	.29
$\dot{V}O_2max$ (ml/kg$^{0.75}$/min)	170.9 ± 18.0	156.4 ± 17.8	179.0 ± 12.7	<.05
OBLA (m/min)	244.9 ± 17.2	240.8 ± 19.5	247.1 ± 16.6	.56
RE (ml/kg$^{0.75}$/m)	0.61 ± 0.05	0.57 ± 0.04	0.64 ± 0.04	<.01
FFM (kg)	39.5 ± 9.2	31.6 ± 3.3	43.8 ± 8.4	<.01
FFM (kg/m)	25.0 ± 4.4	21.4 ± 1.9	26.9 ± 4.1	<.01
MCSA (cm^2)	98.2 ± 23.4	78.4 ± 7.3	109.2 ± 22.0	<.01
MCSA (cm^2/m)	62.1 ± 11.4	53.2 ± 4.3	67.1 ± 11.2	<.01

as the results of the YYIR2.

In addition, to obtain an index of muscle strength, subjects were required to perform a Five-jump test (5J) in which subjects started from the standing position and performed 5 step jumps, alternating between legs, and completed the fifth jump by landing on both legs. The shortest distance from the toe at the beginning of the first jump to the heel at landing after the fifth jump was measured and used as the result of the 5J. **Table 1** shows height, weight, YYIR2 and 5J for Under and Over.

FFM, thigh muscle cross-sectional area (MCSA), $\dot{V}O_2max$, onset of blood lactate accumulation (OBLA) and running economy (RE) were obtained for 14 of 26 test subjects. The values for Under and Over were 5 and 9, respectively. Percent body fat and FFM were determined using an air-displacement plethysmography (BodPod System, Life Measurement Inc.) The percent body fat was determined by Brozek formula. MCSA was obtained by magnetic resonance image (MRI) using a 0.2-T scanner (Signa Profile, GE Yokogawa Medical Systems, Ltd.). Firstly, longitudinal images of the thigh were obtained to identify the greater trochanter and lower end of the femur. Then, a transverse T1-image with a thickness of 10mm was obtained at the 50% region of the femur length (TR350ms, TE21ms, matrix 256x256, FOV 40cm, 2NEX). MCSA was calculated by separating out muscle, fat and femur from the image obtained and multiplying the total number of pixels of each part by the area per 1 pixel (1 pixel = 1.56 mm^2) which could be determined by the imaging conditions.

Aerobic capacity ($\dot{V}O_2max$, OBLA, RE) was evaluated by incremental test to exhausion on treadmill. The graded exercise test protocol was a 3-minute submaximal run followed by a one-minute rest, repeated 4 to 6 times. During the test, heart rate and oxygen uptake were monitored continuously and blood lactate was obtained immediately after each submaximal run (within 20 seconds). Submaximal running speeds were 180, 200, 220, 240, 260 and 280 m/min. Meta Max (Cortex Biophysic GmbH) was used for the measurement of oxygen uptake. Lactate Pro (Arkray, Inc) was used for the measurement of blood lactate. Blood samples at each speed were taken by finger prick more than 2 times and the average value was used for later analyses. When the blood lactate exceeded 5 mmol, submaximal running was halted and final running to exhaustion was performed to determine $\dot{V}O_2max$ after a 2-minute rest. The running speed for $\dot{V}O_2max$ was set to 280 m/min (260 m/min in the case of subjects showing more than 5 mmol lactate at submaximal running below 240 m/min) but the inclination was increased by 1% every min until volitional exhaustion after 3 min of the maximal running. $\dot{V}O_2max$ is indicated as absolute value, as ml/kg/min and as ml/kg$^{0.75}$/min (Chamari, et al., 2005). OBLA was determined as the running speed at which blood lactate corresponds to 4 mmol. As described in Chamari, et al., (2005) RE was obtained by dividing oxygen uptake expressed in ml/kg$^{0.75}$/min at 240 m/min into 240 m/min. **Table 2** shows the average values of 14 players for each measurement.

All measurement results are presented as means± standard deviation. Unpaired t-test was performed to compare each measurement value for Under and Over. A simple linear regression analysis was used to calculate the coefficients of correlation between each index of the YYIR2, aerobic capacity and muscle strength. SPSS 12.0J for Windows was used for all statistical analysis. Significance level was set at $p < 0.05$.

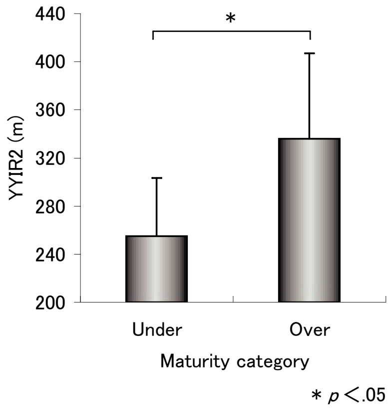

Figure 2 Influence of maturity category on YYIR2.

Table 3 Relationships between YYIR2 and aerobic indices (N = 14).

Item	YYIR2 (m)
$\dot{V}O_2max$ (L/min)	0.67*
$\dot{V}O_2max$ (ml/kg/min)	−0.02
$\dot{V}O_2max$ (ml/kg$^{0.75}$/min)	0.29
OBLA (m/min)	0.23
RE (ml/kg$^{0.75}$/m)	0.19

*$p < .05$

Table 4 Relationships between YYIR2 and 5J and physical characteristics.

Item		YYIR2 (m)
Height (cm)	(N=26)	0.69*
Weight (kg)	(N=26)	0.68*
5J	(N=26)	0.46*
FFM (kg)	(N=14)	0.67*
MCSA (cm^2)	(N=14)	0.65*
FFM (kg/m)	(N=14)	0.67*
MCSA (cm^2/m)	(N=14)	0.65*

*$p < .05$

3. Results

YYIR2 for all subjects was 286.2±69.5 m. Under and Over were 255.0±48.2 m and 336.0±71.1 m, respectively, (**Table 1**), and Over showed significantly higher value than Under (**Figure 2**). In addition, Over showed significantly higher values than Under in height, weight, 5J (**Table 1**), absolute value of $\dot{V}O_2max$, $\dot{V}O_2max$ expressed in ml/kg$^{0.75}$/min, RE, absolute value of FFM, FFM expressed in kg/m, absolute value of MCSA and MCSA expressed in cm^2/m (**Table 2**).

Table 3 shows the relationships between YYIR2 and each index of aerobic capacity (N = 14). No index of aerobic capacity other than absolute value of $\dot{V}O_2max$ showed a significant correlation coefficient with YYIR2.

Table 4 shows the relationship of YYIR2 with physical characteristics, 5J (N = 26), FFM, MCSA (N = 14) and YYIR2. Between YYIR2 and 5J, there was a significant relationship with the correlation coefficient of 0.46. In addition, all of height, FFM and MCSA revealed a significant coefficient of correlation ($r = 0.65 \sim 0.69$). The coefficient for FFM and MCSA were nearly the same whether the values were expressed in absolute or relative values to height (kg/m and cm^2/m).

4. Discussion

Previous studies reported that in the case of professional soccer players, YYIR2 reflects the soccer sport level very clearly. (Krustrup, et al., 2006; Randers, et al., 2007). On the other hand, the JFA physical fitness project (2005) reported the results of YYIR2 for Japanese representatives showed that representative A was 1019m, U-18 (under 18 years of age) was 934.7m, U-15 was 780.7m, U-14 was 621.7m, U-13 was 633.3m and that over the age of U-14, it revealed a remarkable tendency for increase. This result, targeting top-ranked Japanese soccer players in each age range, revealed that it was strongly affected not only by sport level but also by age.

The YYIR2 result in this study was 286.2m, a significantly low result compared with Japanese representatives of U-13 at the same age. The primary reason for this result was believed to be the effect of the differences between subjects in relation to sport level. However, another factor was assumed to be the effect of the differences of physical maturation. The JFA physical fitness project (2005) reported height and weight of Japanese representatives of U-13 to be 168.4 cm and 55.2 kg, respectively, obviously higher than the average height (152.8 cm) and weight (41.7 kg) of the subjects in this study. Generally, in pubescence, even though chronological age was the same, there were large individual differences at approximately 4 to 5 years of age in the physical maturation. (Takaishi, et al., 1968). Malina, et al., (2000) examined the skeletal ages of elite youth soccer players in Portugal and reported that 65% of elite youth soccer players showed early maturation of greater than one year over actual age and that the height and weight of these individuals were high; therefore, it was assumed that these factors greatly affected the selection of soccer players. In addition, according to Hansen, et al., (1999), the testicular volume and level of testosterone of elite soccer players aged 10 to 12 years was higher compared with ordinary soccer players at the same ages; therefore, it was considered that of the individuals who were selected as elite soccer players in pubescence, many exhibited a tendency toward early maturity. It may be expected that one of the reasons the YYIR2 results of Japanese representatives of U-13 were superior to subjects of this study was the tendency toward early maturity.

In fact, the chronological age of the subjects in this study was from 12 to 13 years of age (seventh grade); however, corresponding with average PHV curve for Japanese reported by the Ministry of Education, Culture, Sports, Science and Technology (2007), the biological age of the subjects was assumed to vary 9 to 14 yeas of age.

Therefore, in this study, subjects were divided into Under and Over groups depending on the occurrence of PHV and comparisons between the group were carried out. As a result, Over showed significantly higher values in YYIR2 than Under (**Figure 2**). These results indicate that the difference of maturity category had a marked affect on the result of YYIR2, which was similar to the results of YYIR2 of Japanese representatives in each age.

According to previous studies (Krustrup, et al., 2006), YYIR2 reflects both aerobic capacity and muscle strength in soccer players. However, for the age of the subjects in this study, YYIR2 and aerobic capacity revealed a significant relationship only for absolute value of $\dot{V}O_2$max, and there was no relationship between $\dot{V}O_2$max expressed in ml/kg/min and ml/kg$^{0.75}$/min, OBLA or RE (**Table 3**). Considering well-known effects of height and weight on the absolute value of $\dot{V}O_2$max in pubescence individuals, (Krahenbuhl, et al., 1985), YYIR2 and the absolute value of $\dot{V}O_2$max were considered to have a simple correlation because of the higher value of Over in height and weight compared with Under (**Table 2**). Conversely, YYIR2 could not predict aerobic capacity of soccer players in pubescence.

On the other hand, there were significant correlations between YYIR2 and 5J, which is an index of muscle strength, FFM and MCSA, which have a direct affect on muscle strength (**Table 4**). Generally, in pubescence, the higher the maturity category is, the larger the physical characteristics are (Malina, et al., 2000). Therefore, not only the maturity category but also the size of physical characteristics influenced higher YYIR2 performance was also to be considered. Actually, YYIR2 correlated significantly with height in this study and it was possible to interpret that height worked favorably and prompted a strong correlation. However, coefficients of correlation between YYIR2 and FFM or MCSA were also significant in terms of the relative values to height being the same degree as absolute value (**Table 4**). Fukunaga, et al., (1992) reported that even in elementary school boys subjects classified into higher maturity categories determined by skeletal age showed a greater degree of muscle hypertrophy to resistance training. In this study, MCSA per height for Under and Over were 53.2±4.3 and 67.1±11.2 cm^2/m, respectively, and even in terms of relative value to height, Over was significantly larger than Under. Thus, it was considered that there were great differences between Over and Under for muscle growth. In addition, muscle growth was not only morphological growth that could be observed by muscle cross-sectional area, but also both mechanical (Fuchimoto and Kaneko, 1981; Chuman, et al., 2004) and biochemical growth (Lexell, et al., 1992) and these aspects of muscle growth were direct factors in the improvement of muscle strength. Taking these points together, it is valid to conclude that not only the physical characteristic of height in Over, but also the high maturity category and the increased muscle strength by maturation favorably influenced YYIR2.

The 20m shuttle runs for YYIR2 were repeated with short rest intervals. The average speeds of the second and the third run were 250 and 267 m/min respectively. However, in fact, YYIR2 includes acceleration, deceleration and turns within the 20m and requires subjects to instantaneously increase speed. Mohr, el al., (2003) categorized the running speed of professional soccer players during games into moderate, for speeds in excess of 250 m/min, and high, for speeds greater than 300 m/min. The average OBLA of subjects in this study was 244.9 m/min. In consideration of this, the YYIR2 running speed for the subjects in this study was considerably fast, exceeding the OBLA level, and, when running at this speed, turns and re-acceleration revealed marked muscle strength. In immature muscle before pubescence, the fast-twitch fiber, which is strongly associated with muscle strength, is less developed than in grown muscle (Lexell, et al., 1992). Muscle strength and muscle contraction speed were greater in fast-twitch fiber than in slow-twitch fiber (Oishi, 1999), muscle strength, muscle contraction speed and muscle power, which is a product of muscle strength and muscle speed, increase during and after pubescence when fast-twitch fiber is undergoing significant development (Fuchimoto and Kaneko, 1981; Asai and Aoki, 1996). These facts suggested that YYIR2, which is a test that included acceleration, deceleration and turns, is easily influenced by the muscle strength of soccer players in pubescence.

From the above, it is suggested that the YYIR2 results of soccer players in pubescence has little relationship with aerobic capacity; however, the difference in each physical maturity category and muscle strength involved exerted an affect. Therefore, it is necessary to consider player maturity in evaluating the YYIR2 for soccer players in pubescence.

References

Asai, H., and Aoki, J. (1996) Force development of dynamic and static contractions in children and adults. International Journal of Sports Medicine, 17: 170-174.

Bangsbo, J. (1994) The physiology of soccer with special reference to intense intermittent exercise. Acta Physiologica Scandinavica, 151, Suppl. 619: 1-153.

Chamari, K., Hachana, Y., Kaouech, F., Jeddi, R., Moussa-Chamari, I., and Wisløff, U. (2005) Endurance training and testing with the ball in young elite soccer players. British Journal of Sports Medicine, 39 (1): 24-28.

Chuman, K., Takahashi, S., and Nishijima, T. (2004) Dynamic characteristics of muscle in preadolescent boys. Human Performance Measurement, 1: 30-35.

Fuchimoto, T., and Kaneko, M. (1981) Force, velocity and power relationships in different age groups. Japanese Journal of Physical Education, 25: 273-279. (in Japanese with English abstract)

Fukunaga, T., Funato, K., and Ikegawa, S. (1992) The effects of resistance training on muscle area and strength in prepubescent age. The Annals of Physiological Anthropology, 11 (3): 357-364.

Hansen, L., Bangsbo, J., Twisk, J., and Klausen, K. (1999) Development of muscle strength in relation to training level and testosterone in young male soccer players. Journal of Applied Physiology, 87 (3): 1141-1147.

Helgerud, J., Engen, L.C., Wisloff, U., and Hoff, J. (2001) Aerobic endurance training improves soccer performance. Medicine and Science in Sports and Exercise, 33: 1925-1931.

JFA physical fitness project (2005) Evaluation of physical performance 2006. JAPAN FOOTBALL ASSOCIATION. (in Japanese)

Krahenbuhl, G.S., Skinner, J.S., and Kohrt, W.M. (1985) Developmental aspects of maximal aerobic power in children. Exercise and Sport Sciences Reviews, 13: 503-538.

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Pedersen, K.P., and Bangsbo, J. (2003) The Yo-Yo intermittent recovery test: physiological response, reliability, and validity. Medicine and Science in Sports and Exercise, 35: 697-705.

Krustrup, P., Mohr, M., Nybo, L., Jensen, M.J., Nielsen, J.J., and Bangsbo, J. (2006) The Yo-Yo IR2 test: physiological response, reliability, and application to elite soccer. Medicine and Science in Sports and Exercise, 38: 1666-1673.

Lexell, J., Sjöström, M., Nordlund, A., and Taylor, C.C. (1992) Growth and development of human muscle: a quantitative morphological study of whole vastus lateralis from childhood to adult age. Muscle and Nerve, 15: 404-409.

Malina, R.M. and Bouchard, C. (1991) Growth, maturation and physical activity. Human Kinetics, Champaign.

Malina, R.M., Peña Reyes, E.M., Eisenmann, C.J., Horta, L., Rodrigues, J., and Miller, R. (2000) Height, mass and skeletal maturity of elite Portuguese soccer players aged 11-16 years. Journal of Sports Sciences, 18: 685-693.

Ministry of Education, Culture, Sports, Science and Technology (2007) Report on the survey of school health 2006. Ministry of Education, Culture, Sports, Science and Technology. (in Japanese)

Mohr, M., Krustrup, P., and Bangsbo, J. (2003) Match performance of high-standard soccer players with special reference to development of fatigue. Journal of Sports Sciences, 21: 519-528.

Murata, M. (1988) Physiological characteristics of growth and development in Japanese children. -comparison between Japanese and Chinese-. Clinical Sports Medicine, 5: 979-984. (in Japanese)

Oishi, Y. (1999) Structure and function of skeletal muscle. (In) Exercise physiology 20 lecture. Bookstore Asakura. Tokyo. pp. 1-8. (in Japanese)

Randers, B.M., Rostgaard, T., and Krustrup, P. (2007) Physical match performance and yo-yo IR2 test results of successful and unsuccessful football teams in the Danish premier league. In: VI th World Congress on Science and Football. Journal of Sports Science and Medicine, Suppl. 10: 70.

Takaishi, M., Ohmori, S., Eguchi, A., and Fujita, Y. (1968) Studies on patterns of physical growth at adolescence. -part 1 height velocith and weight velocity in boys-. Japanese Journal of child Health, 26: 57-63. (in Japanese)

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