Paper : Fitness and Conditioning

Relationship between Sprint Ability and Maturity in Elite and Sub-elite Pubescent Male Soccer Players

Kentaro Chuman[*], Yoshihiro Hoshikawa[**], Tomomi Iida[**] and Takahiko Nishijima[***]

[*] YAMAHA FOOTBALL CLUB CO., LTD.
[**] Sports Photonics Laboratory, HAMAMATSU PHOTONICS K. K.
[***] Institute of Health and Sport Science, University of Tsukuba
2500 Shingai, Iwata, Shizuoka, 438-0025 Japan
chumank@jubilo.com

[Received March 14, 2011 ; Accepted July 31, 2012]

The purpose of this study was to examine the relationship among chronological age (CA), peak height velocity age (PHVA) and sprint ability in elite and sub-elite pubescent soccer players. Subjects were 16 elite male soccer players aged 12.8 ± 0.2 years and 48 sub-elite male soccer players aged 12.8 ± 0.2 years in the U-13 (under 13 years old) category. Relative peak height velocity age (RPHVA) was calculated using the BTT model, and 20 m sprint time (sprint ability) was measured. Correlation analysis was performed to investigate the relationship between each age (CA, PHVA and RPHVA) and 20 m sprint time. Decision tree analysis and linear discriminant analysis were performed to examine the difference between elite and sub-elite pubescent soccer players. Decision tree analysis confirmed that the first factor in the selection result of pubescent elite soccer players was 20 m sprint time (≦3.29 sec). The second and third factors were 20 m sprint time (≦3.41 sec) and RPHVA (≦-0.44 years). In conclusion, the maturity exerted an influence on the sprint ability of pubescent male soccer players, and players with higher sprint ability compared with their maturity tended to be selected. These results suggest that the evaluation of pubescent soccer players should include sprint ability and maturity.

Keywords: peak height velocity (PHV), growth, development, linear discriminant analysis, decision tree analysis

[Football Science Vol.10, 10-17, 2013]

1. Introduction

Japanese soccer players who become professional traditionally do so at the age of 18 (high school graduation) or 22 (college graduation). Many soccer players is through selection when they advance from elementary school (11-12 years of age) to junior high school (12-13 years of age), from junior high school (14-15 years of age) to high school (15-16 years of age), and from high school (17-18 years of age) to university (18-19 years of age). Such selection results in three or four years of experience. It has been reported that success requires training over approximately 10 years or 10,000 hours (Ericsson et al., 1993). Therefore, it is essential that well-planned soccer training begin from the ages of 8 or 12. Selection when advancing from elementary school (11-12 years of age) to junior high school (12-13 years of age) is considered to be extremely important.

Hirose (2008) reported that the 30 m sprint times of selected players advancing from elementary school (11-12 years of age) to junior high school (12-13 years of age) were better than those of players that were not selected, indicating the impact of sprint ability on selection. It has been reported that sprint ability develops before and after peak height velocity age (PHVA) during adolescent growth spurts (Yagüe & Fuente, 1998). Chuman et al. (2009) reported a difference in PHVA of about four or five years in players of the same age, indicating a tendency for early-maturing players to reach PHVA before others and to have higher sprinting ability. However, selections are currently based on chronological age (CA), which has resulted in the selection of pubescent soccer players who have high sprint ability simply due to early maturation. According to Nishikawa & Miyagi (2008), many selected soccer players in the 7th and 8th grades belonging to academies of soccer clubs associated with the Japan Professional Football League (J-League) were born earlier in the year than others in the same grade. This suggests that selected players comprise a mixture of individuals who have high sprint ability because they were born earlier in the year or reach PHVA earlier than other candidates and those who have high sprint ability regardless of the timing of their birth or PHVA. It is also possible that different types of their players exist, such as those who were born earlier in the year than others at their age, but who reach PHVA later, and those who were born later in the year than others at their age, but who reach PHVA earlier. Therefore, it is necessary for selections to clearly indicate sprint ability, month of birth (or CA), and the PHVA of pubescent soccer players.

Decision tree analysis is useful for such clarification and classification. Decision tree analysis is a widely used data mining and a statistical method. Suzuki (2009) pointed out the high potential for decision tree analysis in the field of physical education and sports science. The use of decision tree analysis in this study allowed us to classify soccer players according to CA, PHVA, and sprint ability with relation to soccer selection result. Additionally, the results of analysis provide extremely easy-to-understand standards.

The purpose of this study was to examine the relationship among selection result, CA (or month of birth), PHVA, and sprint ability in elite and sub-elite pubescent soccer players.

2. Methods

The subjects of this study were 16 elite field players (12.8 ± 0.2 years of age) and 48 sub-elite field players (12.8 ± 0.2 years of age) in U-13 (7th grade) group belonging to soccer club of J-League Division 1. A total of 237 field players participated in selection and 16 elite players and 50 sub-elite players were chosen. Players were evaluated in 8-a-side soccer games by approximately 30 instructors with Japan Football Association (JFA) licenses. Player selection was based on four-step performance assessment and discussion among the instructors. Birth date, height, and weight of participants at selection were acquired by questionnaire. Height, weight, and 20 m sprint time of elite and sub-elite players were measured in April, immediately after entering junior high school or joining a soccer club, which was four months after selections held in December under the supervision of instructors from the soccer club. Subjects participated in the selection and measurement with the consent of their guardians. In addition, the birth date, height and weight of 171 non-elite players who were not selected were used for comparison. This study was approved by the ethical committee of University of Tsukuba.

PHVA calculation was based on height and age for the seven years between the ages of 7 and 13 with BTT model in AUXAL 3 (SSI), longitudinal height analysis software. Relative PHVA (RPHVA) at the measurement of 20 m sprint was calculated by subtracting PHVA from CA. We used the height acquired from the School Health Examination Survey and we measured the heights of 13-year-old students at the time of 20 m sprint.

We measured 20 m sprint time to examine sprint ability. The 96% of sprints during soccer games are shorter than 30 m with an average of 10-15m (Mohr et al. 2003). Brocherie et al. (2003) argued that the 30 m sprint was too long for soccer players, and cited the Japan National Football Team use of 20 m sprint time for evaluation. Therefore, we concluded that the 20 m sprint would be appropriate for the purpose of this study. Subjects wore soccer shoes and ran the 20 m sprint on artificial turf. Measurement was by light-section method, which entailed placing a pair of optical sensors (for emission and reception of light) vertically facing the track at the 20 m point. A start signal is sent when the subject's rear foot completely leaves the ground at the start point, and the time from the start signal to when the subject passed each optical sensor was measured. The sensors were positioned at a height of 1.2 m. The reliability of measurement values obtained by this method has already been confirmed (Hoshikawa et al., 2012). A standing start was used and each subject took a stationary position and started running independently. Each subject ran the 20 m sprint at least twice with an approximately two-minute interval in between. The fastest 20 m sprint time for each subject was recorded for the analysis.

All measurements were indicated as mean value ± standard deviation. T-test and one-way layout ANOVA were carried out for comparison of mean difference for each measurement item. Pearson's correlation coefficient was used to examine the relationship between measurement items. To examine factors for classifying elite and sub-elite players, we carried out decision tree analyses using C&RT algorithms using selection result as dependent variable and 20 m sprint time and RPHVA as independent variables. To create an ordinal scale, we assigned 1 point to elite and 0 points to sub-elite. When selecting bifurcation variables and determining values, we used the Gini coefficient to acquire improvement of error to the impurity level before and after bifurcation. Furthermore, estimation error was also acquired to indicate the ratio of erroneous classifications of elite and sub-elite soccer players through decision tree analysis. Because the number of subjects was low, we also carried out linear discriminant analysis to confirm the results of decision tree analysis (Suzuki, 2009). To examine the difference in mean values for dependent variable between elite and sub-elite players, we used Wilks' lambda. SPSS 12.0J for Windows and SPSS Answer Tree 3.1J were used for statistical analysis. Significance was set at 5 % ($p < 0.05$).

3. Results

Table 1 shows descriptive statistics at selection. According to the one-way layout ANOVA, the CA of elite (12.3 years of age) and sub-elite (12.3 years of age) was significantly higher than the CA of non-elite (12.2 years of age) ($F_{2, 236} = 5.3$, $p < 0.05$). In regard to height, elite players (1.55 m) were significantly taller than sub-elite (1.50 m), and sub-elite players were significantly taller than non-elite (1.47 m) ($F_{2, 236} = 15.2$, $p < 0.05$). In regard to weight, elite (41.9 kg) and sub-elite (38.7 kg) players were significantly heavier than non-elite (36.6 kg) ($F_{2, 236} = 8.7$, $p < 0.05$).

Figure 1 shows month of birth in the subjects. Among 171 non-elite players, 75 (43.9 %) were born between April and July, 69 (40.4 %) were born between August and November, and 27 (15.8 %) were born between December and March. Among 50 sub-elite players, 32 (64.0 %) were born between April and July, 13 (26.0 %) were born between August and November and 5 (10.0 %) were born between December and March. Among 16 elite players, 11 (68.8 %) were born between April and July, 4 (25.0 %) were born between August and November, and only 1 (6.3 %) was born between December and March. According to the Monthly Vital Statistics Reports of Ministry of Health, Labour and Welfare (1997), the number of births in the 1997 was 1,195,010, including 408,106 (34.2 %) born between April and July, 398,699 (33.4 %) born between August and November, and 388,205 (32.5 %) born between December and March.

Table 2 shows the descriptive statistics for elite and sub-elite player at the measurement of 20 m sprint. The overall RPHVA of subjects in this study was 0.0 ± 1.0 years of age, that of elite and sub-elite players were 0.3 ± 1.1 and -0.1 ± 0.9 years of age, respectively, which did not show any significant difference ($t_{1, 62} = -4.5$, $p < 0.05$). There were no significant differences in height and weight between elite and sub-elite players.

Table 3 shows the correlation between 20 m sprint time and age in subjects of this study. Significant correlation coefficients were found between 20 m sprint time and CA ($r = -0.32$), between 20 m sprint time and PHVA ($r = 0.49$), and between 20 m sprint time and RPHVA ($r = -0.55$) ($p < 0.05$). The coefficients of determination were 10.2, 24.0, and 30.3, respectively.

Figure 2 shows the results of decision tree analysis by means of C&RT using selection result as dependent variable and 20m sprint time and RPHVA as independent variables. The first condition for classification as an elite player was a 20 m sprint time of faster than 3.29 sec. The rate of classification as elite player was 54.6 % at 3.29 sec or faster, and 9.5 % at 3.29 sec or slower. The second condition

Table 1 Descriptive statistics at selection

Item	Elite	Sub-elite	Non-elite	*F*	Post-hoc
CA (years old)	12.3 ±0.2	12.3 ±0.2	12.2 ±0.2	5.3*	Elite, Sub>Non
Height (m)	1.55±0.9	1.50±0.7	1.47±0.6	15.2*	Elite>Sub>Non
Body mass (kg)	41.9±7.9	38.7±5.4	36.6±5.2	8.7*	Elite, Sub>Non

*; $p < 0.05$

for classification as an elite player was a 20 m sprint time of 3.41 sec or faster. The rate of classification as elite player with a 20 m sprint time of 3.41 sec or faster was 20.0 % and 0.0 % at 3.41 sec or slower. The third condition for classification as an elite player was RPHVA, which was -0.44 years of age. The rate of classification as elite player with RPHVA was 50.0 % at -0.44 years of age or younger, and 0.0 % at -0.44 years of age or older. Error of estimation (error rate) was 21.9 %.

Figure 3 shows linear discriminant analysis between elite and sub-elite players utilizing selection result as dependent variable, and 20 m sprint time and RPHVA as independent variables. Wilks' lambda was 0.743 ($p < 0.05$) and showed significant values.

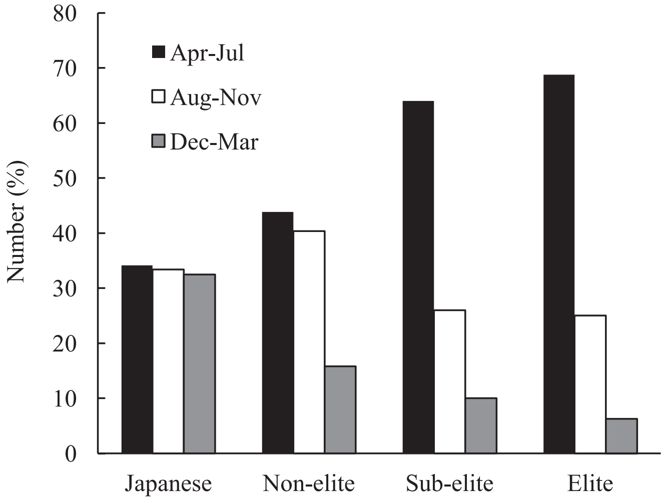

Figure 1 Month of birth in the subjects groups.

Discriminant function

Discriminant score (Z) = 8.949×20 m sprint time (sec) + 0.32×RPHVA (years of age) – 30.15

Standardized discriminant function

Discriminant score (Z) = 1.133×20 m sprint time (sec) + 0.312×RPHVA (years of age)

Discriminant rate was 75.0 %. Fourteen among 16 elite players (87.5 %) were classified as elite, and two (12.5 %) were classified as sub-elite. Among 48 sub-elite, 34 (70.8 %) were classified as sub-elite players and 14 (29.2 %) as elite players (**Table 4**).

4. Discussion

Soccer selection was carried out in accordance with CA (that is, the same school year). According to the month of birth, the players in elite and sub-elite groups born between April and July, which represent the first four months of the school year, were 68.8 % and 64.0 %, respectively. On the other hand, the player in elite and sub-elite groups who were born between December and March, which are the last four months of the school year, were only 6.3 % and 10.0 %, respectively (**Figure 1**). Nishikawa & Miyagi (2008) reported that high-level soccer players among 7th and 8th graders belonging to academy of J-League club, those born between April and June, which represents the first three months of the school year, were 6.0 and 9.4 times as many, respectively, as those born between January and March of the following year, which represents the last three months of the

Table 2 Descriptive statistics for elite and sub-elite groups.

Item	Pubescent male soccer players			t
	Total (N=64)	Elite (N=16)	Sub-elite (N=48)	
CA (years old)	12.8 ± 0.2	12.8 ± 0.2	12.8 ± 0.2	1.0
PHVA (years old)	12.8 ± 0.9	12.6 ± 1.0	12.9 ± 0.9	-1.2
RPHVA (years old)	0.0 ± 1.0	0.3 ± 1.1	-0.1 ± 0.9	1.4
Height (m)	1.56 ± 0.8	1.59 ± 0.9	1.56 ± 0.7	1.6
Body weight (kg)	44.6 ± 7.3	47.1 ± 8.6	43.7 ± 6.7	1.6
20 m sprint time (sec)	3.37 ± 0.15	3.25 ± 0.09	3.41 ± 0.14	-4.5*

*; $p < 0.05$

Table 3 Correlation coefficients.

Item	20 m sprint (sec)
CA (years old)	-0.32 *
PHVA (years old)	0.49 *
RPHVA (years old)	-0.55 *

*; $p < 0.05$

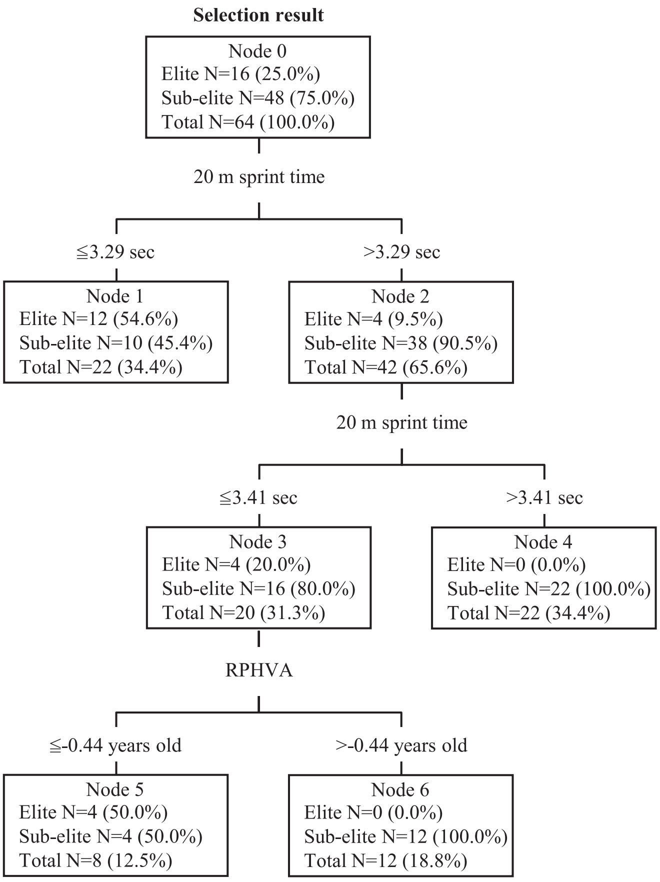

Figure 2 The result of decision tree analysis by means of C&RT.

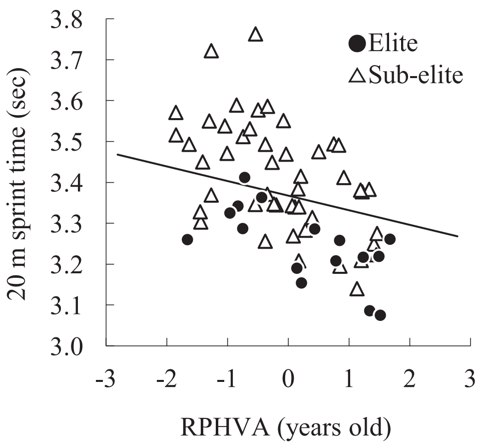

Figure 3 Linear discriminant analysis in elite and sub-elite groups.
Wilks' lambda= 0.743($p<0.05$)
Z = 8.949 × 20m sprint time(sec) + 0.32 × RPHVA - 30.15

school year. In addition, Helson et al. (2000) reported that when the birth month of players in a selection was set from August to July of the following year, the majority of players were born between August and October; however, when the birth month of players in a selection was set according to the FIFA guidelines from January to December, the majority of those players were born between January and March, which matched the results for the effect of relative age for elite and sub-elite groups in this study. Furthermore, according to the birth month of non-elite players who were not selected, the rate of those born between April and July, which represents the first four month of the school year, was 43.9 %, which was higher than that of those who were born between December and March in the following year, the last four months of the school year (15.8 %) (**Figure 1**). According to the report of Ministry of Health, Labour and Welfare (1997), birth months in the Japanese people of the same school year (the 1997) were unbiased. Therefore, it is clarified that the effects of relative age were already seen in the pubescent soccer players who participated in the selections and became stronger as the level of the skill increased.

In this study, we measured 20 m sprint time of elite and sub-elite players aged 12-13 years and examined the relation of sprint time to CA, PHVA, and RPHVA. As a result, we observed a significant correlation coefficient in the relationship between 20 m sprint time and CA, PHVA, and RPHVA (r= -0.32, 0.49, and -0.55) (**Table 3**). Hoshikawa et al. (2012) measured 20 m sprint time for 927 high-level soccer players from elementary school 5th graders to professionals, and suggested the necessity of considering the difference in maturation when evaluating 20 m sprint time of 7th and 8th graders, who are entering the growth spurt stage and whose physical condition is undergoing remarkable change in a short period of time. The selection of pubescent soccer players is usually based on CA, whose range is a maximum of one year. In this study, the coefficient

Table 4 Distinction between elite and sub-elite groups.

Group	Decision tree analysis		Linear discriminant analysis	
	Elite	Sub-elite	Elite	Sub-elite
Elite (N=16)	16 (100.0%)	0 (0.0%)	14 (87.5%)	2 (12.5%)
Sub-elite (N=48)	14 (29.2%)	34 (70.8%)	14 (29.2%)	34 (70.8%)

of determination of 20 m sprint time was higher for PHVA (24.4 %) than for CA (10.2 %). Therefore, the sprint ability of pubescent soccer players was influenced more by PHVA than by CA. However, coefficient of determination of RPHVA considering these factors was 30.3 %, which was the highest. This clarified that the maturity has an influence on sprint ability of pubescent soccer players.

Comparison of RPHVA and 20 m sprint time between the elite and sub-elite soccer players in this study revealed no significant difference in RPHVA (**Table 2**). Hansen et al. (1999) compared testicular volume and testosterone concentration of elite and non-elite soccer players between 10 and 12 years of age and reported that both testicular volume and testosterone concentration of elite soccer players exceeded those of non-elite players, indicating a tendency for elite players to enter puberty earlier. The RPHVA of subjects in this study was 0.3 years of age in elite and -0.1 years of age in sub-elite players, which showed no significant difference; however, the RPHVA of elite players was higher than that of sub-elite players.

Meanwhile, a significant difference in 20 m sprint time between elite and sub-elite players was observed (**Table 2**). Hirose (2008) measured 30 m sprint time of 12-year-old (6^{th} grade) soccer players in a selection and reported that the 30 m sprint times of selected players was significantly faster than those of non-selected players. In addition, Takeuchi et al. (2009) held a selection for 5^{th} grade players from seven teams to examine the difference between selected and non-selected players. As a result, 50 m sprint time was extracted as a factor related to the selection of players. Nishijima et al. (2002) examined the factors used by coaches for evaluating youth soccer players, and extracted three major factors; physical ability, individual skill, and individual tactics. Nishijima et al. (2002) argued that speed, a sub-factor of physical ability, exerts an influence on individual skill and tactics, which means that evaluation of individual skill and tactics in youth soccer players includes the evaluation of speed represented by sprint ability. These facts suggested that players with high sprint ability tend to be selected in young soccer player selections.

In this study, we conducted decision tree analysis using elite and sub-elite players as dependent variables, and RPHVA and 20 m sprint time as independent variables (**Figure 2**). As a result revealed a 20 m sprint time of 3.29 sec or faster as the standard value for selection as elite players. In addition, the tendency for players with a 20 m sprint time of 3.41 sec or faster and an RPHVA -0.44 years old or younger to be selected as elite players was also revealed. The selection error rate under those standard values was 21.9 %, and 14 sub-elite players were classified as elite players by error (**Table 4**). According to the 5-level reference values (field players) of Hoshikawa et al. (2012), 3.13 sec or faster was classified as “fast”, 3.13-3.27 sec was classified as “relatively fast”, 3.27-3.41 sec was classified as “average”, 3.41-3.55 sec was classified as “relatively slow”, and 3.55 sec or slower was classified as “slow”. Therefore, it is possible for “relatively fast” and “fast” players in the 7^{th} grade with relatively high-level skill to be selected as elite players, and it is possible for “average” players to be selected as elite players only if they tend to show delayed puberty. As described above, pubescent soccer players with high sprint ability tend to be selected. Players with delayed puberty show lower sprint ability than players with early puberty; however, Lefevre et al. (1990) reported that jump ability (vertical jump test), deeply related to sprint ability, in children with delayed puberty would catch up with that in children with early puberty along with the advancement of their maturity. These factors suggested that pubescent soccer players classified as elite have high sprint ability, and even if their sprint ability is medium level, they are possibly selected as elite if they show delayed puberty.

As Suzuki (2009) pointed out, it is necessary to carry out linear discriminant analysis to confirm the results of decision tree analysis when the number of subjects is low. Therefore, we confirmed the results of decision tree analysis utilizing a linear discriminant analysis (**Figure 3**). As a result, 75.0 % of subjects were correctly classified into elite and sub-elite groups with discriminant function (**Table 4**). According to 20 m sprint time and RPHVA in the elite group, it was predicted that 87.5 % of the players would be classified as elite. According to 20 m sprint time and RPHVA in sub-elite group, it was predicted that 70.8 % players would be classified as sub-elite. Similar to decision tree analysis results, players selected as elite had been classified as fast in the 20 m sprint time. Moreover, the players with average sprint time were selected if their RPHVA was young, which means they experienced delayed puberty. In other words, players with higher sprint ability compared with RPHVA were selected as elite.

However, 14 out of 28 players (50.0% of players who were predicted to be elite) had higher sprint ability compared with their RPHVA, but were not selected as elite (**Table 4**). On the other hand, only 2 out of 36 players (5.6% of players who were predicted to be sub-elite) were elite. These results indicated that players with higher sprint ability compared with their RPHVA tend to be selected; however, they were not always selected as elite. Sprint ability is an extremely important factor for soccer players; however, evaluation factors for youth soccer players include not only physical ability, but also individual skill and tactics (Nishijima et al., 2002). Therefore, soccer players with high individual skill and tactics as well as with higher sprint ability compared with their RPHVA are chosen in the selections for pubescent male soccer players. In other words, it was suggested that sprint ability is a necessary condition, but not a sufficient condition.

There was a tendency for soccer players with early puberty to be chosen in the selections for pubescent soccer players (Hansen et al., 1999; Malina et al., 2000). The reason for this is, as was mentioned above, players with high sprint ability were likely to be chosen in soccer selections (Hirose, 2008; Takeuchi et al., 2009), and players with earlier puberty have higher sprint ability (**Table 3**). Therefore, it is also possible that promising players with excellent skill and tactics have low sprint ability due to delayed puberty and, therefore, may not be chosen during selections. In order to avoid such errors, it is very important to consider the RPHVA of pubescent soccer players. JFA Certified Instructor Education Seminars include lectures regarding growth and development, which contributes to increased awareness of the importance of acquiring knowledge regarding differences in abilities between pubescent soccer players with early and delayed puberty. This study examined selection evaluation by individuals certified as JFA instructors, which may have influenced the selection of soccer players with higher sprint ability compared with their RPHVA. However, whether these results were coincidental, or whether the players selected as elite are promising players could not be determined by the above results in this study, which is a limitation of this study. This study, however, was examined utilizing selection result as dependent variable and RPHVA and 20m sprint time as independent variables, and showed the current status of selections in pubescent soccer players, which provides a foundation for future study. It is necessary to conduct longitudinal surveys on such players and studies regarding selections for pubescent soccer players.

It was concluded that the maturity exerted an influence on the sprint ability of pubescent male soccer players (12-13 years of age), and players with higher sprint ability compared with their maturity tended to be selected. These results suggest that the evaluation of pubescent soccer players should include sprint ability taking maturity status into consideration.

Acknowledgment

This study was supported by funding from the YAMAHA Motor Foundation for Sports. We would like to express our deep appreciation for the invaluable support provided by the people involved.

Reference

Brocherie, F., Morikawa, T., Hayakawa, N. & Yasumatsu, M. (2003) Anaerobic performance of pre-season in Japanese elite soccer players. JFA news, 227: 52-56. (in Japanese)

Chuman, K., Hoshikawa, Y. & Iida, T. (2009) Yo-Yo intermittent recovery level 2 test in pubescent soccer players with relation to maturity category. Football Science, 6: 1-6. http://www.shobix.co.jp/jssf/index.cfm?page=3&JournalNo=2009

Ericsson, K., Krampe, R. & Tesch-romer, C. (1993) The role of deliberate practice in the aquisition of expert performance. Psychological Review, 100(3): 363-406.

Hansen, L., Bangsbo, J., Twisk, J. & 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.

Helson, W.F., Hodges, N.J., Van Winckel, J. & Starkes, J.L. (2000) The roles of talent, physical precocity and practice in the development of soccer expertise. Journal of Sport Sciences, 18(9): 727-736.

Hirose, N. (2008) Talent selection and development of soccer players. Training Science, 20(4): 253-259. (in Japanese)

Hoshikawa, Y., Iida, T., Komori, S., Chuman, K., Shibukawa, K. & Kikuchi, S. (2012) Development of a 20-meter sprint time evaluation chart for junior and professional soccer players. Japan journal of physical education, health and sport sciences, 57: 249-260. (in Japanese and English abstract)

Lefevre, J., Beunen, G., Steens, G., Claessens, A. & Renson, R. (1990) Motor performance during adolescence and age thirty as related to age at peak height velocity. Annals of Human Biology, 17(5): 423-435.

Malina, R.M., Pena Reyes, M.E., Eisenmann, J.C., Horta, L., Rodrigues, J. & 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 Health, Labour and Welfare (1997) A monthly report of statistics on the movement of the population. (in Japanese) http://www.mhlw.go.jp/toukei/list/81-1a.html

Mohr, M., Krustrup, P. & Bangsbo, J. (2003) Match performance of high-standard soccer players with special reference to

development of fatigue. Journal of Sports Sciences, 21: 519-528.
Nishijima, T., Hisaoka, Y., Suzuki, K., Ohtsuka, K. & Matsumoto, M. (2002) The structure of soccer talent assessment by coaches. Japan Journal of Sport Coaching, 1(1). http://www.taiiku.tsukuba.ac.jp/sc/1_1E/09/index-e.html
Nishikawa, S. & Miyagi, O. (2008) Development of players from month of birth. Science of football, 3(1): 15-18. (in Japanese)
Suzuki, K. (2009) Application of decision tree analysis in health and sports science: Introduction and instructions of analytic procedures. Japan journal of test and evaluation in health and physical education, 8: 89-95. (in Japanese and English abstract)
Takeuchi, S., Watanabe, M. & Takai, S. (2009) The factors to select elite players of a junior soccer team. Training Science, 21(3): 289-296. (in Japanese)
Yagüe, P.H. & De La Fuente, J.M. (1998) Changes in height and motor performance relative to peak height velocity: a mixed-longitudinal study of Spanish boys and girls. American Journal of Human Biology, 10: 647-660.

Name:
Kentaro Chuman

Affiliation:
YAMAHA FOOTBALL CLUB CO., LTD.

Address:
2500 Shingai, Iwata-shi, Shizuoka 438-0025 Japan

Brief Biographical History:
2003-2005 Master's Program in Health and Physical Education, University of Tsukuba
2009-2012 Doctoral Program in Physical Education, Health and Sport Sciences, University of Tsukuba
2004-2010 Physical Coach, Jubilo Iwata Youth Academy
2011- Scout & Physical Adviser, Jubilo Iwata

Main Works:
- Chuman, K., Takahashi, S. & Nishijima, T. (2004) Dynamic characteristics of muscle in preadolescent boys. Human Performance Measurement 1: 30-35.
- Chuman, K., Takahashi, S., Nakano, T. & Nishijima, T. (2005) Dynamic causal structure analysis of condition fluctuation factors in a soccer player. Football Science 2: 1-7.
- Chuman, K., Hoshikawa, Y. & Iida, T. (2009) Yo-Yo intermittent recovery level 2 test in pubescent soccer players with relation to maturity category. Football Science 6: 1-6.
- Chuman, K., Hoshikawa, Y., Iida, T. & Nishijima, T. (2011) Relationships between Yo-Yo intermittent recovery tests and development of aerobic and anaerobic fitness in U-13 and U-17 soccer players. International Journal of Sport and Health Science 9: 91-97.
- Chuman, K., Hoshikawa, Y., Iida, T. & Nishijima, T. (2011) Yo-Yo intermittent recovery level 2 test performance and leg muscle growth in a six-month period among pubescent soccer players at different stages of maturity. International Journal of Sport and Health Science 9: 105-112.

Membership in Learned Societies:
- Japanese Society of Science and Football