The Bias toward Biological Maturation through the Talent Selection in Japanese Elite Youth Soccer Players

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In the present study, we aimed to determine whether the advancement in skeletal age (SA) of youth soccer players relative to chronological age was dependent on the maturation spurt or selection bias toward biological maturation. These factors were investigated using cross-sectional and mixed longitudinal study designs. Height, body mass, SA, and maturation differences in 181 youth soccer players (age range; 9.3-16.0 years) were measured. SAs were assessed using the Tanner-Whitehouse three (TW3) and Japanese-standardized SA (J-SA) methods. Thirty-seven of the 181 players (age range; 9.6-13.0 years) then participated in a one-year follow-up study. The participants were divided into seven age groups (under 10 (U10)-U16). Cross-sectional differences in all measurements between the categories were compared with annual increment data. There were significant cross-sectional differences in height (14.9 vs. 10.9 ± 3.3 cm), body mass (13.4 vs. 8.2 ± 3.1 kg), and SA (J-SA: 1.7 vs. 1.0 ± 0.6 yrs; TW3: 2.6 vs. 1.5 ± 0.8 years) between the U12 and U13 groups (p < 0.01 each). Furthermore, these differences were higher than those for mixed longitudinal data. These findings imply that advanced biological maturation in youth soccer players may depend on selection bias towards the early biological maturation.

Keywords: talent identification, soccer, bone age, youth sports

1. Introduction

To develop the player who has excellence in soccer, four key stages are warranted, such as “detection”, “identification”, “selection” and “development”. The identification is determined as “the process of recognizing current participants with the potential to become elite player.” (William and Reilly, 2000) The “selection” refers to the process of identifying and selecting the players who have the possibility to be an elite player. Talent identifying and selecting process have very important role to develop the players who have excellence in soccer. Generally, a lot of teams and clubs select the players with the subjective assessment of scout and coaches (Williams and Reilly, 2000). However, when selecting the youth players, their subjective assessment biased toward the early biological maturation such as skeletal age, because it strongly correlates to a development of motor ability (Beunen et al., 1997a, b), and sometimes soccer skill (Malina et al., 2007). Thus, it has been reported that this bias result in the skewed distribution of maturation in same chronological age category; ie, Skeletal age (SA) of most player in post-puberty advances compared to chronological age (CA), conversely in pre-puberty SA tends to be lower than CA (Cacciari et al., 1990; Malina et al., 2000, Hirose, 2009).

However, when we discuss about the relation of skewed distribution of SA and bias toward early maturation in the talent selection process, two issues should be clarified. First, we should investigate the influence of developmental spurt of biological maturation. As Stratton et al. (2004) reports, the height growth spurts rapidly after 12 years old in boys. Since height development relates to SA (Beunen et al., 1978), these findings may imply the existence of a biological maturation spurt around this age range.
Previous studies have not been clarified the influence of maturation spurt because they investigated cross-sectional (Malina et al., 2000, 2007).

Second, we should investigate about Asian youth soccer population because the number of Asian soccer players has been grown up to occupying most (33%) of all players in the world. Moreover, Japan has 629,000 youth players and it is the first place in Asia and ninth place in the world (FIFA, 2007). However, we can find only one literature (Satake et al., 1986) about Japanese youth player. Clarifying the characteristics of SA of Japanese youth soccer players and adding to the knowledge obtained from previous researches, we can discuss clearly about the bias toward early maturation through talent selection process in youth soccer players.

When investigating the development of SA of Japanese youth soccer players, we should not ignore the population difference in maturation. Population characteristic or/and socio-economic differences strongly influence on the maturation (Freitas et al., 2004, Little and Malina, 2007). In the case of Japanese children, Radius-Ulna-Short bone (RUS) score of Tanner-Whitehouse (TW) 2 method tended to be lower than those of standard score in younger age (under twelve years of age) and exceeds in older age. Finally, RUS score reached adult value in one or two years earlier than that of European children (Ashizawa et al., 1996). In brief, using the TW2-SA lead us an under/over-estimation of skeletal maturity in Japanese adolescents during pre/mid-puberty comparing to those of TW2 standard.

To correct this discrepancy, the TW2 method revised to the newest modality named TW3 method based not only English data but also American and Japanese data (Tanner et al., 2001). However, the applicability of TW3 for the Japanese children is still unclear. On the other hand, to control this discrepancy, Murata and colleagues (1992, 1993, 1997) proposed the Japanese standard skeletal age which modifying the TW2 skeletal age. This method uses same rating system of TW2 method in assessment of bone development score (ie, RUS score, Carpal score, and 20-bone score). It modifies the calculation table from bone development score to skeletal age. To take into account for the population and/or socio-economic environment, we should investigate the tendency of skeletal maturation in Japanese youth soccer player using the skeletal age standardized for the Japanese (J-SA). At least, we ought to investigate the characteristics of the skeletal maturations of youth soccer players with Japanese standardized skeletal age (J-SA) in addition to the investigation using TW3 method.

Therefore, in this study, we compared the TW3 and J-SA to clarify the characteristics of skeletal maturation in Japanese youth soccer player. Then we investigated the biological early maturation in Japanese youth soccer players and its relation to the maturity spurt and selection during puberty using mixed longitudinal study.

2. Method

2.1. Participants

This study was consisted of two component; cross-sectional study and mixed longitudinal study. Participants of cross-sectional study were 181 well-trained Japanese adolescent soccer players who lived in Tokyo and its suburb. Mean age of participants was 12.4 ± 1.7 years-old (range, 9.3 to 16.0 years-old). Then, from players aged ten to fourteen year-old, we recruited the players who participates the mixed longitudinal study. Finally thirty-seven players aged 9.6 to 13.0 year-old (11.3 ± 1.1) participated in the one year follow up study.

In cross-sectional study, all participants were divided into seven (U10-U16) categories according to their chronological age (e.g., age range for each category was as follows, 9 year-old includes 9.0- to 9.9-year-old players). In mixed longitudinal study, participants were divided into four (U10-U13) categories and each category included ten participants for U10-U11 and U11-U12, eight for U12-U13, and nine for U13-U14 category.

2.2. Measurement and Procedure

We measured height, body mass, and skeletal age at the beginning of the competition season (end of March to April). Then thirty-seven players were also re-measured at the beginning of the next competition season. Height was measured using a YL-65S stadiometer (Yagami, Nagoya, Japan) to the nearest 0.1 cm, and body mass was measured to the nearest 0.1 kg using a TBF-551 body fat monitor (Tanita, Tokyo, Japan).

The radiographs of left hand and wrist of individuals were taken. At first, Radius-ulna-short bone
(RUS) score of twenty players of all participants (11%) was rated by two technicians independently according to the method of Tanner-Whitehouse (Tanner et al., 1983) method. The correlation between two technician’s RUS score was very high \( r = 0.98, p < 0.01 \). Then to revise the inter-observer variations, re-evaluation was performed when a large difference \( (\geq 0.5 \text{ years in Japanese skeletal age}) \) was recognized between both assessments. The RUS score were calculated into skeletal age using TW3 (Tanner et al., 2001) and Japanese standardized score were calculated into skeletal age using TW3 was recognized between both assessments. The RUS score of twenty players of all participants were classified as late, average, or early maturing. Average was determined as SA within ±1.0 year of CA. Player whose SA was younger than CA by more than 1.0 years was defined as late maturing. Early maturing was defined as SA in advance of CA by more than 1.0 year. Players who reached 1000 points in RUS score were simply determined as ‘‘Mature’. This categorization has been represented in many literatures (Krogman, 1959; Malina et al., 2000, 2007).

According to their maturation status (SA-CA), participants were classified as late, average, or early maturing. Average was determined as SA within ±1.0 year of CA. Player whose SA was younger than CA by more than 1.0 years was defined as late maturing. Early maturing was defined as SA in advance of CA by more than 1.0 year. Players who reached 1000 points in RUS score were simply determined as ‘‘Mature’’. This categorization has been adopted in many literatures (Krogman, 1959; Malina et al., 2000, 2007).

The comparison in skeletal age and maturation difference was not undergone in U16 category since five of seven players were already fully matured.

2.3. Data analysis

All data were described as mean ± s. The correlation between chronological age and skeletal age was analyzed using Pearson correlation coefficients. Statistical differences in chronological age, J-SA and TW3 were analyzed by analysis of variance (ANOVA) followed by Scheffé test. The difference in maturation difference between two procedures was analyzed using t-test. The differences in distribution of maturation status in each age category among two procedures were analyzed by qui squared test. The difference in annual increment of skeletal age among each age category was analyzed by Kruskal-Wallis test followed by the Scheffé test. Values of \( p < 0.05 \) were considered statistically significant.

This study complied with the requirements for human experimentation of our faculty. The subjects and their parents were fully informed about the procedures and the purpose of this study. Written informed consent was obtained from all participants and their parents.

3. Result

3.1. Cross-sectional and mixed longitudinal change of skeletal age

The average and standard deviation of chronological age, TW3, J-SA and maturation difference is represented in Table 1.

Skeletal age of TW3 was significantly younger approximately 1.0 to 0.6 years than those of chronological age in U10 (TW3 vs. CA; 8.8±0.9 year-old vs. 9.8±0.2 year-old., \( p < 0.01 \)), U11 (10.0±1.0 year-old vs. 10.6±0.3 year-old, \( p < 0.05 \)) and U12 (11.1±1.3 year-old vs. 11.7±0.1 year-old, \( p < 0.05 \)) age category, whereas no significant difference was observed between J-SA and chronological age (U10: 9.4±1.3 year-old vs. 9.8±0.2 year-old, U11: 10.9±1.0 year-old vs. 10.6±0.3 year-old, U12: 11.9±1.0 year-old vs. 11.7±0.1 year-old, respectively). However in U13 age category, skeletal age of both

<table>
<thead>
<tr>
<th>Age group</th>
<th>N</th>
<th>Chronological age (yrs.)</th>
<th>J-SA</th>
<th>TW3</th>
<th>F value</th>
<th>Maturation difference (yrs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>J-SA</td>
</tr>
<tr>
<td>U10</td>
<td>17</td>
<td>9.8±0.2</td>
<td>9.4±1.3</td>
<td>8.8±0.9**&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.65**</td>
<td>−0.4±1.2</td>
</tr>
<tr>
<td>U11</td>
<td>28</td>
<td>10.6±0.3</td>
<td>10.9±1.0***</td>
<td>10.0±1.0**&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.09**</td>
<td>0.3±1.0</td>
</tr>
<tr>
<td>U12</td>
<td>44</td>
<td>11.7±0.1</td>
<td>11.9±1.0**&lt;sup&gt;c&lt;/sup&gt;</td>
<td>11.1±1.3**&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.02**</td>
<td>0.2±0.9</td>
</tr>
<tr>
<td>U13</td>
<td>31</td>
<td>12.7±0.2</td>
<td>13.6±0.7**&lt;sup&gt;c&lt;/sup&gt;</td>
<td>13.7±1.1**&lt;sup&gt;c&lt;/sup&gt;</td>
<td>18.40**</td>
<td>0.9±0.7</td>
</tr>
<tr>
<td>U14</td>
<td>28(1)</td>
<td>13.7±0.3</td>
<td>14.1±0.9</td>
<td>14.3±1.3</td>
<td>2.80</td>
<td>0.4±0.9</td>
</tr>
<tr>
<td>U15</td>
<td>26(3)</td>
<td>14.7±0.3</td>
<td>14.6±0.7</td>
<td>15.1±0.9</td>
<td>3.27*</td>
<td>−0.1±0.7</td>
</tr>
<tr>
<td>U16</td>
<td>7(5)</td>
<td>15.8±0.3</td>
<td>(14.8±0.4)</td>
<td>(15.4±0.6)</td>
<td>—</td>
<td>(−0.8±0.2)</td>
</tr>
</tbody>
</table>

**<sup>c</sup> P < 0.01 vs CA, **<sup>c</sup> P < 0.05 vs CA; *** P < 0.01 vs TW3 (ANOVA among CA, J-SA, and TW3)

++ P < 0.01 (t-test between J-SA and TW3)
TW3 (13.7±1.1 year-old, p<0.01) and J-SA (13.6±0.7 year-old, p<0.01) was significantly older approximately 1 year than their individual chronological age (12.7±0.2 year-old). Then skeletal age of TW3 and J-SA tended to be similar in older age categories. In regard to the maturation difference, TW3 was significantly lower than that of J-SA (p<0.01) in U11 and U12.

These tendencies were also recognized in the scatter plot of each skeletal age comparing to their chronological age. Although the linear correlation between skeletal age and chronological age were similar between two procedures (J-SA; r=0.863, TW3; r=0.878, p<0.01, respectively), the slope of co-variation was different. In regard to the TW3, the slope of co-variation showed that skeletal age of players younger than 12.4 years-old tended to be lower than their chronological age and to be higher in older age range. On the other hand, in J-SA, the slope of the co-variation was almost parallel or equal to the y=x, which reflected chronological age equal to the skeletal age (Figure 1-a, b).

In regard to the annual increment of skeletal age, J-SA (U10 to U11; 0.9±0.7 yrs., U11 to U12; 1.4±0.9 yrs., U12 to U13; 1.0±0.6 yrs., and U13 to U14; 1.2±0.5 yrs.) and TW3 (1.1±0.6 yrs., 1.1±0.6 yrs., 1.5±0.8 yrs., and 1.5±0.6 yrs., respectively) showed no significant increment comparing to those of chronological age (1.0±0.1 yrs., 0.9±0.1 yrs., 0.9±0.0 yrs., and 0.9±0.1 yrs., respectively) except for the U14 to U15 in TW3 (p<0.05) (Figure 2). Especially from U12 to U13 age category, cross-sectional difference in J-SA (1.7 yrs.) and TW3 (2.6 yrs.) were larger than that of annual increment value (1.0 yrs. and 1.5 yrs., respectively).

3.2. Cross-sectional and mixed longitudinal change in height and body mass

The mean height and body mass in each age category were represented in Table 2. In this age range, U12 (147.0±6.4 cm) was 5.9 cm taller than U11.
Table 2  Means ± s values for height (cm) and body mass (kg) per age category

<table>
<thead>
<tr>
<th>Age group</th>
<th>Height</th>
<th>Body mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>U10</td>
<td>136.8 ± 3.9**12,13,14,15,16</td>
<td>30.8 ± 2.6**12,13,14,15,16</td>
</tr>
<tr>
<td>U11</td>
<td>141.1 ± 5.6**12,13,14,15,16</td>
<td>33.3 ± 3.8**13,14,15,16</td>
</tr>
<tr>
<td>U12</td>
<td>147.0 ± 6.4**13,14,15,16</td>
<td>37.3 ± 4.3**13,14,15,16</td>
</tr>
<tr>
<td>U13</td>
<td>161.9 ± 6.3**15,16</td>
<td>50.7 ± 5.6**15,16</td>
</tr>
<tr>
<td>U14</td>
<td>163.2 ± 7.5**16</td>
<td>50.7 ± 7.5**15,16</td>
</tr>
<tr>
<td>U15</td>
<td>168.9 ± 5.4</td>
<td>59.0 ± 7.7</td>
</tr>
<tr>
<td>U16</td>
<td>176.6 ± 4.1</td>
<td>65.1 ± 3.7</td>
</tr>
</tbody>
</table>

**P<0.01, *P<0.05 (the number described near the * means age category)

(141.1 ± 5.6 cm) (p<0.05). Then U13 was 14.9 cm taller than U12 significantly (p<0.01). In mixed longitudinal data, the height increased significantly from 12 to 13 years of age (10.9 ± 3.3 cm, p<0.01) comparing to that of 10-11 yrs. (5.4 ± 1.2 cm), 11-12 yrs. (6.4 ± 1.6 cm), and 13-14 yrs. (6.2 ± 2.3 cm) group (Figure 3a). Especially from U12 and U13 age category, cross-sectional difference (14.9 cm) was larger in 4.0 cm than that of annual increment value (10.9 cm).

In regard to the body mass, significant inter-age difference was observed between U12 (37.3 ± 4.3 kg) and U13 (50.7 ± 5.6 kg) (13.4 kg, p<0.01), U14 (50.7 ± 7.5 kg) and U15 (59.0 ± 7.7 kg) (8.3 kg, p<0.01) (F = 107.2, p<0.001) (Figure 3b). However, annual increment in body mass was not differ between each age category (U10-U11; 5.3 ± 2.5 kg, U11-U12; 4.5 ± 2.1 kg, and U12-U13; 8.2 ± 3.1 kg, and U13-U14; 4.8 ± 3.3 kg respectively).

3.3. Comparison of maturation stage between TW3 and J-SA

The discrepancy in distribution of maturation stage was recognized between TW3 and J-SA from U12 to U15 age categories (Table 3). In U12, TW3 (36.4%) determined players’ maturation as late, representing four times the value of that of J-SA (9.1%) (x² = 9.53, p<0.01). On the other hand, in older age categories, TW3 tended to classify the player’s maturation as early (U14; 35.7%, and U15; 23.1%), representing approximately twice of that of J-SA (17.9%, and 0.0%, respectively).

3.4. Characteristic of birth-month distribution in cross-sectional study

In cross-sectional study, thirteen of thirty-one players in U13 age category were selected from U12 category and 84.6% of them were born in first half of the school year (April to September) (Table 4). While, the eighteen players in U13 age category were recruited from other team and 77.8% of them were born in first half of the school year. As well as the U13 age category, 9 of 28 (for U14) and 12 of 31 (for U15) players were selected from U12 category and 88.9% (U14) and 66.7% (U15) were born in first half of the school year. Then nineteen players in both U14 and U15 category were recruited from other
Table 3  Distribution of maturation status in each age category

<table>
<thead>
<tr>
<th>Age group</th>
<th>Procedure</th>
<th>Late</th>
<th>Average</th>
<th>Early</th>
<th>Mature</th>
<th>Total</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>U10</td>
<td>J-SA</td>
<td>6 (35.3)</td>
<td>9 (52.9)</td>
<td>2 (11.8)</td>
<td>0 (0.0)</td>
<td>17</td>
<td>2.66</td>
</tr>
<tr>
<td></td>
<td>TW3</td>
<td>9 (52.9)</td>
<td>8 (47.1)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>17</td>
<td>2.66</td>
</tr>
<tr>
<td>U11</td>
<td>J-SA</td>
<td>3 (10.7)</td>
<td>21 (75.0)</td>
<td>4 (14.3)</td>
<td>0 (0.0)</td>
<td>28</td>
<td>3.17</td>
</tr>
<tr>
<td></td>
<td>TW3</td>
<td>8 (28.6)</td>
<td>18 (64.3)</td>
<td>2 (7.1)</td>
<td>0 (0.0)</td>
<td>28</td>
<td>3.17</td>
</tr>
<tr>
<td>U12</td>
<td>J-SA</td>
<td>4 (9.1)</td>
<td>31 (70.5)</td>
<td>9 (20.5)</td>
<td>0 (0.0)</td>
<td>44</td>
<td>9.53**</td>
</tr>
<tr>
<td></td>
<td>TW3</td>
<td>16 (36.4)</td>
<td>23 (52.3)</td>
<td>5 (11.4)</td>
<td>0 (0.0)</td>
<td>44</td>
<td>9.53**</td>
</tr>
<tr>
<td>U13</td>
<td>J-SA</td>
<td>2 (6.5)</td>
<td>11 (35.5)</td>
<td>18 (58.1)</td>
<td>0 (0.0)</td>
<td>31</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>TW3</td>
<td>3 (9.7)</td>
<td>8 (25.8)</td>
<td>20 (64.5)</td>
<td>0 (0.0)</td>
<td>31</td>
<td>0.78</td>
</tr>
<tr>
<td>U14</td>
<td>J-SA</td>
<td>2 (7.1)</td>
<td>20 (71.4)</td>
<td>5 (17.9)</td>
<td>1 (3.6)</td>
<td>28</td>
<td>3.82</td>
</tr>
<tr>
<td></td>
<td>TW3</td>
<td>4 (14.3)</td>
<td>13 (46.4)</td>
<td>10 (35.7)</td>
<td>1 (3.6)</td>
<td>28</td>
<td>3.82</td>
</tr>
<tr>
<td>U15</td>
<td>J-SA</td>
<td>3 (11.5)</td>
<td>20 (76.9)</td>
<td>0 (0.0)</td>
<td>3 (11.5)</td>
<td>26</td>
<td>7.44</td>
</tr>
<tr>
<td></td>
<td>TW3</td>
<td>1 (3.8)</td>
<td>16 (61.5)</td>
<td>6 (23.1)</td>
<td>3 (11.5)</td>
<td>26</td>
<td>7.44</td>
</tr>
<tr>
<td>U16</td>
<td>J-SA</td>
<td>0 (0.0)</td>
<td>2 (28.6)</td>
<td>0 (0.0)</td>
<td>5 (71.4)</td>
<td>7</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>TW3</td>
<td>0 (0.0)</td>
<td>2 (28.6)</td>
<td>0 (0.0)</td>
<td>5 (71.4)</td>
<td>7</td>
<td>N.S.</td>
</tr>
</tbody>
</table>

The value which described in ( ) indicates the percentage (%) to the total number.

Table 4  The number of players from elite U12 category/ other team at the selection for U13 age category and distribution of birth half

<table>
<thead>
<tr>
<th></th>
<th>U13</th>
<th>U14</th>
<th>U15</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Elite U12</td>
<td>13</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Apr.-Sep.</td>
<td>11 (84.6%)</td>
<td>8 (88.9%)</td>
<td>8 (66.7%)</td>
</tr>
<tr>
<td>From other team</td>
<td>18</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Apr.-Sep.</td>
<td>14 (77.8%)</td>
<td>15 (78.9%)</td>
<td>15 (78.9%)</td>
</tr>
</tbody>
</table>

team and 78.9% of them were born in first half of the school year.

On the other hand, 28 of 44 players were selected to U13 category as the elite player while 16 players were unselected. Then 22 of 28 (78.6%) selected players were born in first half of the school year whereas 8 of 16 (50.0%) unselected players were born in first half of the school year.

4. Discussion

In previous study, we investigated the characteristics of skeletal maturation of Japanese youth soccer players using two evaluating procedures; TW3, and J-SA. At first, we investigated the discrepancy of assessment of skeletal age between TW3 and Japanese standardized procedure (J-SA), because maturation pattern of Japanese children and European children is not homogeneous (Ashizawa, et al., 1996). Our finding indicated that the trend in evaluated value of skeletal age using J-SA and TW3 was similar. It might be result of the affinity in the sample of population which bases the evaluation of skeletal age, in addition to the similarity in rating system. TW3 are based on adolescents from Europe (Great Britain, Belgium, Italy, Spain), South America (Argentina), USA, and Japan. The sample of this study was solely Japanese youth soccer players. Thus the sample of this study may have closer affinity to the TW3 comparing to the reference sample of TW2 (only using the European data). However, there was still difference in evaluated skeletal age between two procedures, ie; TW3 determined the skeletal maturation as “late” compared to that of J-SA in younger age group. Ashizawa et al. (1996) reported that the RUS score of Japanese children were lower than that of the European (British and Belgium) standard score until 11.5 years old. Then the Japanese skeletal maturation exceeded drastically the standard score. Our result might reflect this population difference in maturation through puberty. In other words, the difference in evaluated value of skeletal age between TW2 and J-SA are still remaining in TW3.

It has been reported that the difference in environment, socio-economic status (Little and Malina, 2007; Freitas et al., 2004) and/or gene (Little and Malina, 2007) result in the discrepancy of the mature-
ration process. Since the Japanese is not the exception of these (Ashizawa et al., 1996; Murata, 1997; Takai, 1990), Murata and colleagues proposed the Japanese standardized skeletal age based on the Tanner-Whitehouse method (Murata et al., 1993, 1997). Therefore, we should investigate the characteristics of skeletal maturity in Japanese adolescent soccer players using J-SA. At least we should evaluate their skeletal age using both J-SA and TW3 and compare their trend to understand the maturational characteristic in Japanese adolescent soccer players.

On the other hand, the early maturation in soccer players during puberty which recognized in European players (Cacciari et al., 1990; Malina et al., 2000) was also recognized in Japanese youth soccer players with J-SA. Especially between U12 and U13 age category, the cross-sectional difference was remarkably in J-SA (1.7 years) and TW3 (2.6 years) comparing to those of annual increment value (1.1 years and 1.5 years, respectively). The cross-sectional difference in height (14.9 cm) and body mass (13.4 kg) between U12 and U13 also exceeded its annual increment (10.0 cm and 7.4 kg) in same age range. These results may imply that skeletal and physical maturation spurt do not explain the early maturation in skeletal age and body size of youth soccer players recognized in cross-sectional study.

In this regard, it is significant to investigate whether early maturation in post-puberty arises from the bias toward early maturation through the selection process or not. To discuss this issue, Japanese standard maturation and development data such as average height and body mass obtained from “almanac of data on Japanese children” (Minister of education, culture, sports, science and technology-Japan, 2009) are available. Comparing the height of elite youth soccer players to general boys, height in U10 (136.8 ± 3.9 cm for soccer players, 133.5 ± 5.8 cm for normal boys), U11 (141.1 ± 5.6 cm, 138.9 ± 6.2 cm), U12 (147.0 ± 6.4 cm, 145.1 ± 7.1 cm) did not show the remarkable difference. However, youth soccer players in U13 (161.9 ± 6.3 cm) were approximately 10 cm higher than Japanese general boys (152.6 ± 8.1 cm). These findings might imply the highly demand for the body size in youth elite soccer players’ selection process. Moreover, this tendency also might imply the bias toward early biological maturation because body size correlates strongly to the biological maturations.

Moreover, our result of birth-month distribution (Table 4) supports our hypothesis that early matured players were favored through the selecting process. In general, player’s population should be distributed each 50% in first half (April to September) and second half (October to March) of the school year (Hirose, 2009). However, in present study, approximately 70 to 80% of selected players were born in first half of the school year. Players born early in the school year tend to be taller, heavier and more biologically matured (Helsen et al., 2005). Due to this consideration, skewed distribution in present study might indicate that early matured players were favored through the selecting process.

These findings lead the conclusion that the advance in biological maturation recognized in Japanese youth soccer players during puberty, especially between U12 and U13 age category, might result from the highly demand for the biological advancement in the selection. In Japan, the recruitment of youth soccer players is mostly undergone between U12 and U13 category (Hirose, 2009). Once player success the selection, in general, they are able to train until U15 age category at the same team. However, around this age range, large individual difference between skeletal age and chronological age exist. This maturation difference correlates strongly to body size and motor abilities. Therefore, the early-matured players with advancement in physical and motor ability were unconsciously favored in the selection. However, it is necessary to keep in mind that we could not completely reveal the developmental characteristics of skeletal age because we adapted the mixed-longitudinal study design. Therefore, to reveal this issue, further longitudinal study should be warranted. In addition, we need further research about the effect of this bias on the soccer performance. In previous studies, the biases toward early maturation through the selection process have been reported in the “high performance football countries” such as Brazil, Germany and England as well as Japan (Dudink, 1994; Helsen et al., 2005; Musch and Hay, 1999). Unfortunately our findings could not clarify this issue.

In any event, above trend is far from the ideal to give every child equal opportunities in training and potential to attain excellence. Moreover, the late matured players catch up to their peers skeletally in late-adolescent and their physical and motor ability also may catch up or sometime exceed those of early
maturation players in their future (Beunen et al., 1997a). Hence coaches should understand that biases toward biological and physical maturation influence on their evaluation. To apply this knowledge into the talent selection, coaches should take into consideration the individual biological maturation when evaluating the player’s physiological and physical characteristics.

In conclusion, this study showed clear discrepancy in skeletal maturation between TW3 and J-SA. This finding might propose that the characteristics of skeletal maturation in Japanese youth soccer players should be clarified using Japanese standardized skeletal age in addition to the TW3. Moreover, the skeletal maturation spurt did not explain the advance in skeletal maturation recognized in elite youth soccer players. In other words, this result may imply the existence of bias toward the physical and biological advancement in talent selection process. Hence coaches should understand the biological maturation of adolescent soccer players to estimate the physical improvement in their future.

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