Anthropometric and Physical Fitness in Japanese Prospective Collegiate Soccer Player

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Anthropometric and physical fitness characteristics are useful indicators for identifying talent in young soccer players. However, there is no information about anthropometric and physical fitness in Japanese prospective collegiate soccer players. The purpose of this study was to investigate the differences of anthropometric and physical fitness characteristics in the collegiate period between players who advanced to the professional league and those who did not. One hundred six male Japanese soccer players from one collegiate soccer team participated in this study. Nineteen of the 106 players were classified as "advanced" who had successfully signed a contract with a professional club. The remaining 87 "nonadvanced" players did not acquire a professional contact. Anthropometric (height, mass, body mass index, percent body fat, lean body mass and lean body mass relative to body height) and physical fitness (5-, 10-, 20-meter sprint and vertical jump) data were measured. Unpaired t-test and logistic regression method were used for analysis. The body height, body mass, body mass index, lean body mass, lean body mass relative to body height, and vertical jump performance were significantly different between advanced and nonadvanced players ($p < 0.05$). The lean body mass relative to body height and vertical jump height (OR ; 1.414, 1.134, respectively) exerted significant positive effects on advancement to the professional level, after adjusting for body height, percent body fat, and 10-m sprint speed. These findings suggest that each of lean body mass relative to body height and vertical jump ability can be one of the predictors for becoming a Japanese professional soccer player after college graduation.

Keywords: collegiate player, predictor, professional soccer league, anthropometric, physical fitness

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1. Introduction

Soccer is one of the most popular sports worldwide. In Japan, more than 960,000 players who were registered with the Japan Football Association (JFA) played soccer in 2014 (Japan Football Association, 2016), and took part in some competitions (i.e., tournament or league match) in each of the categories. The J-League is the top professional football league in Japan, and is affiliated with the JFA. Compared with the top professional league in Europe, the J-League has more players with a college education. Of the total professional players in the J-League, those who had experience in collegiate soccer as an amateur player accounted for 39.2% (Tachibanaki & Saito, 2012). Therefore, collegiate players who hope to advance to the professional level have to exhibit high-quality performances during their senior year in order to be selected for teams in the J-League.

Anthropometric and physical fitness characteristics are useful indicators for identifying talent in young soccer players. In almost all previous studies, players who were younger than 16 years were identified as subjects for talent identification (Franks et al., 1999; Reilly et al., 2000; Gil et al., 2007; le Gall et al., 2010). In a study that investigated the factors for the selection to professional teams of Japanese youth club players under 18 years old (Tsukoshi & Asai, 2010), body weight, sprint speed, agility, and jump performance were identified as important factors for advancement.

A cross-sectional study demonstrated that the body

height and body weight of soccer players over 23 years old were greater than those of players under 19 years old (Hoshikawa, 2009a). The anthropometric and fitness profiles of professional soccer players also tended to differ from those of youth soccer players (Tsukoshi & Asai, 2010). These findings indicate that the criteria for spotting talent in collegiate players (age : 18 to 22 years old) may be unequal to those for young soccer players. In addition, professional soccer players selected in top-team were heavier body weight, faster sprint time, and higher vertical-jump height compared with those in satellite-team (Tsukoshi & Asai, 2010). This indicates that body mass, speed and power are important parameters in professional level. However, the factors for the identification of talent among collegiate players in their senior year, especially for entry to Japanese professional leagues, remain unknown.

The purpose of this study was to investigate the differences of anthropometric and fitness characteristics in the collegiate period between players who advanced to the J-League and those who did not. We hypothesized that body size, and sprint and/or jump ability during the senior year of players could be predictors for advancing to the professional level after graduation.

2. Methods

2.1. Subjects

One hundred six male Japanese soccer players from one collegiate soccer team participated in this study. The participants left their respective team after graduation during the 2005 to 2015 season. Goalkeepers were excluded in this research because their playing style and characteristics were obviously different from those of field players. All of the players were well trained and belong to the Kanto University Football Association, the top collegiate amateur league in East Japan. Although the participants did not perform the exact same training protocol because of the variations in field-based data during the 10-year measurement period, their annual training programs, which were developed according to the schedule of the Kanto University Football League, were largely similar. Players with medical problems (e.g., injury, illness, and deconditioning) were also excluded from this study. All participants were free of subjective symptoms that could interfere with their performance.

The anthropometric and physical data were collected during the players' senior year of college. These were preexisting data from the regular testing that one team performed for training purposes. A collegiate soccer team approved the use of their data for this study. All participants received an explanation of all experimental procedures, and provided informed consent before the analysis was started. The ethics committee of our university approved this research.

For the purpose of this study, players who graduated from college were divided into two groups for comparison. Nineteen of the 106 players were classified as "advanced." These included players who had successfully signed a contract with a professional club belonging to division 1 or 2 of the J-League. The remaining 87 "nonadvanced" players did not acquire a professional contact.

2.2. Data collection

This research was a retrospective study that used multiyear data that were not collected in the exact same conditions. The measurements were also not conducted in exactly the same period each year because of the differences in team schedule. All data were collected between March and August. During this period, team training consisted of soccer-specific training combined with general field-based running training according to physical periodization. All data were collected by the specialized staff (conditioning coach and athletic trainer). The measurement protocol consisted of anthropometric measurements and physical fitness tests.

2.2.1. Anthropometric measurements

Before the physical fitness test, the players' height, body mass, percent body fat, and body mass index (BMI) were determined in an indoor environment. Body mass and percent body fat were measured and estimated by using a bioelectrical impedance analyzer (InBody Co., Ltd.). Although underwater weighting method and dual-energy x-ray absorptiometry (DEXA) are considered highly accurate and precise methods for the assessment of body composition, these are difficult to use in the general population. Jensky-Squires et al. (2008) demonstrated a very strong correlation between DEXA and In-Body in the measurement of percent body fat among men aged 18-35 years. Therefore, a bioelectrical impedance

analyzer can be used in a valid and reliable way.

The lean body mass was calculated by using the body mass and percent body fat. To normalize the differences in body height among the players, the lean body mass relative to body height was also calculated as described in a previous study (Hoshikawa, 2009a, b).

2.2.2. Physical fitness tests

All players participated in a 10-15 min standardized warm-up supervised by a conditioning coach. The physical fitness tests were conducted outdoors on an artificial turf pitch. The players straight sprint speed and jump ability were evaluated on the basis of the physical measurement guidelines from the JFA (2006). The participants were allowed to perform several preparatory trials in order to elucidate the appropriate technique. All tests were performed twice with a rest time of at least 2 min between tests. The best score was used for data analysis.

Straight sprint performance was evaluated with a 20-m sprint test. Infrared timing gates (TC timing system, Brower Timing Systems) were positioned at the start line and at 5, 10, and 20 m, at a height of approximately 1 m. The participants were instructed to run through the final pair of sensors with maximum effort. Timing was started when the laser of the starting gate was broken. Jump ability was evaluated by using the counter movement jump test with backward and forward arm swing. A digital vertical jump meter (Jump MD, Takei Scientific Instruments Co., Ltd.) was used in this test. A measuring tape was fastened to the abdomen of the participant and a string was tied from the measuring tape to the center of the jumping board. The participant subsequently jumped as high as possible. Jumping performance was recorded as the distance between the standing and jumping heights as determined from the tape measurement.

Agility and aerobic performance were also measured in the physical fitness tests. Unfortunately, these tests have shown some variations every few years; for example, the pro-agility test, zigzag agility test, and 10 m × 2 shuttle test (Sasaki et al., 2013) or 10 m × 5 shuttle test (JFA, 2006) were used to measure agility performance, and the multistage shuttle run test or Yo-Yo intermitted recovery test (JFA, 2006) was conducted to evaluate aerobic performance. Therefore, no common parameters of agility and aerobic ability could be used for data analysis in this study.

2.3. Data analysis

All data are expressed as mean and standard deviation for the groups of advanced and nonadvanced players. An unpaired t-test was used to analyze the differences between these two groups of players. To investigate the relationship between attaining a professional career and the anthropometric and physical characteristics, simple logistic regression analyses were performed for estimating the odds ratios (ORs) and 95% confidence intervals (CIs). Generally, the OR is used as an index for measuring the probability of an event occurring (Journal of Tropical Pediatrics, 2016). In this research, we checked which parameter increase the probability of advancement to the professional level by ORs. In a simple logistic regression analysis, we can calculate the crude OR for each one separately, and confirm the relationship among each independent variable. In addition, a multiple logistic regression analysis was also performed by using body height, percent body fat, lean body mass relative to body height, 10-m sprint time, and vertical jump height. By using a multiple logistic regression, we can measure the adjusted OR with considering the effects of several variables. The correlation coefficients between the lean body mass relative to body height and body mass, lean body mass, and BMI ranged from 0.765 to 0.961. The correlation coefficients among the three sprint times (5-m, 10-m, and 20-m sprint times) ranged from 0.814 to 0.908. In the soccer games, sprint in an almost 10-m distance is most commonly used. Consequently, to avoid multicollinearity, body mass, lean body mass, BMI, and 5-m and 20-m sprint times were excluded in the multiple logistic regression analysis. All statistical procedures were performed by using the IBM SPSS Statistics (ver. 22.0 for Windows) software. The statistical significance for all tests was set at $p < 0.05$.

As the pilot trial, the intraclass correlation coefficients (ICCs) were calculated to assess the reproducibility of the physical fitness measurements. Fleiss (1981) presented the ICC as poor (< 0.40), fair (0.40-0.59), good (0.60-0.75), and excellent (> 0.75). All primary variables reached good to excellent : 5-m sprint (ICC = 0.744), 10-m sprint (ICC = 0.816), 20-m sprint (ICC = 0.856), and vertical jump (ICC = 0.862).

3. Results

Table 1 presents the differences of anthropometric and fitness characteristics between advanced and nonadvanced players. Body height ($p < 0.01$, $d = 0.804$), body mass ($p < 0.01$, $d = 0.907$), and BMI ($p < 0.05$, $d = 0.549$) differed within the two groups. A lean body mass ($p < 0.01$, $d = 0.979$) and a lean body mass relative to body height ($p < 0.01$, $d = 0.976$) in the advanced group were larger than in the nonadvanced group. Especially, the lean body mass relative to body height was 35.8 ± 2.1 kg/m in the advanced group and was 33.7 ± 2.2 kg/m in the nonadvanced group. Furthermore, the vertical jump height of the advanced group was higher than that of the nonadvanced group ($p < 0.01$, $d = 0.864$).

The crude relationship between the players' characteristics in their senior year of college and those during their advancement to the professional league are shown in **Table 2.** Anthropometric characteristics such as tall body height (OR, 1.192; 95% CI, 1.060–1.341), heavy body mass (OR, 1.194; 95% CI, 1.074–1.327), large BMI (OR, 1.581; 95% CI, 1.042–2.401), heavy lean body mass (OR, 1.234; 95% CI, 1.092–1.394), and high lean body mass relative to body height (OR, 1.448; 95% CI, 1.130–1.959) were significantly associated with advancement to the professional level. With regard to physical characteristics, vertical jump ability was significantly associated with success in securing a contract with a professional club after graduation (OR, 1.149; 95% CI, 1.046–1.263; $p = 0.004$). The results of a stepwise multiple logistic regression analysis are shown in **Table 3.** The lean body mass relative to body height (OR, 1.414; 95% CI, 1.027–1.947, $p = 0.034$) and vertical jump height (OR, 1.134; 95% CI, 1.011–1.271, $p = 0.032$) exerted significant positive effects on advancement to the professional level, after adjusting for body height, percent body fat, and 10-m sprint speed. That means that for an increase of 1 kg/m in lean body mass relative to body height and for an increase of 1 cm in vertical jump height, the corresponding increase in the probability of advancement to the professional level is 1.41 times (41%) for lean body mass relative to body height and 1.13 times (13%) for vertical jump height.

4. Discussion

This is the first study that sought to determine the

Table 1 Anthropometrical and physical characteristics of players who advanced and those who did not advance to the Japanese professional football league after graduation

	Advanced (N=19)	Non-Advanced (N=87)	Effect size Cohen's *d*
Body height (cm)	177.7 ± 4.5	174.0 ± 4.7 #	0.804
Body mass (kg)	72.4 ± 6.5	67.1 ± 5.1 #	0.907
Body mass index (kg/m^2)	22.9 ± 1.6	22.1 ± 1.3 *	0.549
Percent body fat (%)	11.8 ± 3.1	12.1 ± 2.6	0.105
Lean body mass (kg)	63.7 ± 4.8	59.0 ± 4.8 #	0.979
Lean body mass per height (kg/m)	35.8 ± 2.1	33.7 ± 2.2 #	0.976
5-m sprint time (sec)	1.04 ± 0.08	1.07 ± 0.08	0.375
10-m sprint time (sec)	1.78 ± 0.10	1.81 ± 0.10	0.300
20-m sprint time (sec)	3.02 ± 0.13	3.08 ± 0.12	0.479
Vertical jump height (cm)	63.5 ± 4.8	58.9 ± 5.8 #	0.864

Note: Data are presented as mean ± standard deviation. Significant difference between groups using unpaired t-test (*: $p<0.05$, #: $p<0.01$).

Table 2 Crude relationship between anthropometric and physical characteristics in the senior year and advancement to the Japanese professional football league after graduation

Variables	Crude odds ratio	95% confidence interval	*p* value
Body height	1.192	1.060 - 1.341	0.003
Body mass	1.194	1.074 – 1.327	0.001
Body mass index	1.582	1.042 – 2.401	0.031
Percent body fat	0.967	0.804 – 1.163	0.721
Lean body mass	1.234	1.092 – 1.394	0.001
Lean body mass per height	1.488	1.130 – 1.959	0.005
5-m sprint time	0.011	0.000 – 7.285	0.173
10-m sprint time	0.029	0.000 – 4.714	0.173
20-m sprint time	0.019	0.000 – 1.348	0.068
Vertical jump height	1.149	1.046 – 1.263	0.004

Note: Simple logistic regression analysis was performed to compare advanced and non-advanced players.

Table 3 Multiple logistic regression analysis of variables associated with advancement to the Japanese professional football league after graduation

Variables	Adjusted odds ratio	95% confidence interval	*p* value
Body height	1.100	0.951 – 1.272	0.198
Percent body fat	1.063	0.855 – 1.321	0.583
Lean body mass per height	1.414	1.027 – 1.947	0.034
10-m sprint time	0.110	0.000 – 66.049	0.499
Vertical jump height	1.134	1.011 – 1.271	0.032

Nagelkerkes's $R^2 = 0.322$

predictors for advancement to a professional career among college-aged soccer players in Japan. Although there are several collegiate soccer teams in Japan, there are no available data on professional players with previous experience in the collegiate league as amateur players. Moreover, it is also unclear which variables are correlated with the selection of future professional player in the J-League. In this study, we investigated the differences of anthropometric and fitness characteristics in the collegiate period between players who advanced to the J-League and those who did not. The associations between the anthropometric and physical characteristics of male soccer players in their senior year of college and those during advancement to a professional career were also analyzed by using logistic regression analyses. Especially, we employed easy-to-use variables that can be collected in the general soccer field. These data are useful because they can help coaches in developing collegiate players until their graduation.

First, we confirmed the anthropometric and fitness characteristics of players in the collegiate period. Advanced players had higher and heavier physique, and had greater jump ability than nonadvanced players. These differences in senior-year players are the essential factors in selecting potential professional players. Compared with previous research involving top-team players who belonged to a division 1 of the J-League (Tsukoshi & Asai, 2010), the body height, percent body fat, and 10-m sprint time of the professionals (178.9 ± 4.8 cm, 11.2 ± 3.1%, and 1.75 ± 0.09 s, respectively) were similar to the results of the advanced players in our research (177.7 ± 4.5 cm, 11.8 ± 3.1%, and 1.78 ± 0.10 s, respectively). In contrast, the J-League top-team players were heavier (body mass : 75.2 ± 6.5 kg and lean body mass : 66.2 ± 5.9 kg) and had greater jumping ability (vertical jump height : 68.9 ± 4.7 cm) than the advanced players in this study (72.4 ± 6.5 kg, 63.7 ± 4.8 kg, and 63.5 ± 4.8 cm, respectively). These indicate that rookies from collegiate teams are disadvantaged in terms of body composition and power, which is one of the differences between elite professionals and amateurs. Furthermore, the BMI of advanced players (22.9 ± 1.6 kg/m^2) was similar to that of elite soccer players in European Leagues (23.0 ± 1.2 kg/m^2) meanwhile the stature and body mass in collegiate players were smaller compared with European League players (181 ± 6 cm, 75.5 ± 6.3 kg, respectively) (Bloomfield et al., 2005). The difference between advanced and nonadvanced players in BMI, therefore, suggest that body size (BMI > almost 23 kg/m^2) may be easy-to-use check point for prospective elite soccer players.

With regard to the anthropometric characteristics in the simple logistic regression analysis, body size parameters such as body height, body mass, and BMI were significantly associated with advancement to the professional level in Japan. These findings support those of previous studies (Gil et al., 2007; le Gall et al., 2010; Tsukoshi & Asai, 2010) that indicated that players with higher levels of play differed in stature and/or body mass from those not selected for a professional career. Bloomfield et al. (2005) also showed that there were differences in the stature, body mass and BMI of players between the four European Leagues; i.e. the BMI in the Bundesliga and La Liga players were significant greater than that of Premier League and Serie A players. These differences may be observed in division-1 and division-2 of J-League, therefore, basic body size such as stature, body mass and BMI are essential parameters for increasing the probability of advancement to the professional level. Moreover, a lean body mass and a lean body mass relative to body height were also associated with the advancement to professional soccer after graduation. A lean body mass was correlated with performance parameters such as linear sprint time (Amonette et al., 2014) or lower extremity force/power production (Stephenson et al., 2015). Improving body size such as lean body mass, therefore, may have a direct effect of promoting the possibility of advancing to the professional level. On the other hand, body fat did not significantly affect professional advancement. Among the English Premier League soccer players, there were no differences in percent body fat observed according to playing positions or international status (Sutton et al., 2009). Previous results suggested that low body fat is required to compete in elite soccer competitions, and systematic group training reduces the variabilities between individuals. Therefore, the percent body fat during the senior year of college did not correlate with the advancement to a professional soccer career.

Concerning the physical characteristics, vertical jump height was significantly associated with the possibility of being selected as a professional player. In contrast, straight speed such as that of the 5-, 10-, and 20-m sprints did not have a significant relationship with advancement to professional soccer. These results were similar to those reported in previous studies. In a study involving Australian football players, Veale et al. (2009) found that the vertical jump height, and not the 20-m sprint speed, was particularly important in the selection process. Among Japanese youth soccer players, the 10-m sprint time also did not differ between the selected and nonselected groups. Nevertheless, the vertical jump height differed between the groups (Tsukoshi & Asai, 2010). In fact, there was a significant variation in the sprint time among collegiate players regardless of the soccer skill or playing position. These findings suggest that, among collegiate soccer players, improving power training through jump exercises may be effective for future advancement to the professional level.

In the present study, we performed a multiple logistic regression analysis to seek the predictors for advancing to the professional level after graduation. As shown in **Table 3**, lean body mass relative to body

height and vertical jump height during the senior year were significant predictors of advancement to the professional league for male collegiate soccer players in Japan, after adjusting for body height, percent body fat, and 10-m sprint speed. This indicates that players and coaches should focus on the development of the physique and power of the players until their collegiate period to promote their chances of advancing to the professional level. Hoshikawa (2009a) reported that the lean body mass in over 23-year-old professional players was higher than that in under 22-year-old soccer players (mixed professionals and amateurs), and suggested that this result might have been caused by bias in professional selection. More than 36 kg/m lean body mass relative to body height is suggested as a standard for professional field players (Hoshikawa, 2009b). In this study, the lean body mass relative to body height of advanced players was 35.8 ± 2.1 kg/m, whereas that of nonadvanced players was 33.7 ± 2.2 kg/m on average, showing a significant difference between the two groups. Additionally, vertical jump performance was selected and 10-m sprint speed was excluded as the predictor in the fitness test in the present study. Vaeyens et al. (2006) reported that sprint ability was found to discriminate between competitive standards only in preadolescent soccer players (i.e., age under 13–14 years). This finding supports our results in subjects who were postpubescent (senior) soccer players. Cometti et al. (2001) also showed that the 30-m sprint time in French senior soccer players was not different among elite, subelite, and amateur players. Meanwhile, the discriminant variables for the selection of professional players (vertical jump and standing five-step broad jump) were higher than those in youth and junior youth players in the study by Tsukoshi and Asai (2010). The vertical jump performance of professional soccer players was also shown to be relatively stable at various stages of the competitive season (Thomas & Reilly, 1979). Therefore, a high lean body mass relative to body height and a high jumping ability are key factors in advancing to the professional level for collegiate soccer players.

Some limitations must be kept in mind when interpreting the results of the present study. Most important, only the time of short sprints and the vertical jump height during the physical fitness test were used for the statistical analyses because these parameters were collected constantly during the same procedure. Indeed, the coefficient of determination in the multiple logistic regression analysis was not high (Nagelkerkes's $R^2 = 0.322$). Other physical abilities such as agility, endurance, or a relatively long sprint (i.e., over 30 m linear sprint), and soccer-specific skills or technique may be associated with advancement to the professional level. Secondly, the data in this research were continually measured for 10 years. Therefore, it is undeniable that the tactics and physical demand of the soccer game may have changed during the 10 years of measurement. The required ability to advance the professional level should be confirmed by data covering a shorter period in future research. Finally, we used the lean body mass relative to body height as a physique parameter so as to cancel the influence of body size among the players. However, the lean body mass relative to body height was strongly related to the body mass, lean body mass, and BMI (r = 0.765 to 0.961). Another parameter should be developed for minimizing the influence of body size in the future.

5. Conclusion

This study reported the differences of anthropometric and fitness characteristics in the collegiate period between players who advanced to the J-League and those who did not. The body height, body mass, BMI, lean body mass, lean body mass relative to body height, and vertical jump performance were significantly different between advanced and nonadvanced players. Through multiple logistic regression analysis, lean body mass relative to body height and vertical jump height in senior-year players were identified as significant predictors of advancing to professional soccer in Japan, after adjusting for body height, percent body fat, and 10-m sprint speed. These findings suggest that each of lean body mass relative to body height and vertical jump ability can be one of the predictors for becoming a Japanese professional soccer player after college graduation.

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Membership in Learned Societies:
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- Japanese Society of Physical Fitness and Sports Medicine
- Japan Society of Physical Education, Health and Sport Sciences
- Japanese Society of Clinical Sports Medicine
- Japanese Society for Clinical Biomechanics
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