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I. Introduction

American football is a collision sport that requires specific physical attributes and high fitness levels, including sufficient weight combined with strength, power, speed, and quickness. Distinct physical profiles are also required for the different playing positions (Iguchi et al., 2011, Robbins, 2011, Vitale et al., 2016). In the evaluation of football talent in developing players, the National Football League (NFL) draft status (McGee and Burkett, 2003) and recruit rankings from high school (Ghigiarelli, 2011) consider greater physical performance to reflect a higher level of playing ability, regardless of the position.

While Japan is one of the leading nations in American football, there remains a large gap in performance between Japanese and American (U.S.) players (Yamashita et al., 2017). In fact, Japan has never won against a U.S. international team and no Japanese player has ever played in a regular-season game of the NFL. Previous research comparing top college U.S. players invited to the NFL tryout and Japanese national team candidates revealed that the Japanese players were physically smaller and shorter, as well as being slower and less powerful than their U.S. counterparts (Yamashita et al., 2017). In addition, a comparison of the physical characteristics (e.g., height and body mass), strength, and power between Division 1 collegiate teams in Japan and the U.S. revealed significant differences for all playing positions, with lower anthropometric characteristics and performance parameters for Japanese players (Iguchi et al., 2011). The findings of these studies indicate that the system of talent identification and development for American football used in the U.S. could be of benefit in Japan.

Previous research among U.S. high school American football players revealed that players with a high recruit ranking were taller, heavier, and faster than those with lower rankings (Ghigiarelli, 2011). Dupler et al. (2010) also reported an age difference, with players in grade 11 scoring higher on physical characteristics and performance parameters than grade 10 players. Moreover, these studies indicate that the talent identification and development system used in the U.S. is effective. To date, however, a similar evaluation has not been performed among high school American football players in Japan. As such, it is unknown which physical characteristics and performance parameters improve with age among these athletes, as well as how the performance parameters of the top Japanese high school players compare to their U.S. elite counterparts. This information is essential at this juncture of development of American Football in Japan to assist coaches and trainers with talent identification and athlete development to improve performance of Japanese American football teams relative to the U.S. Therefore, the purposes of this study were 1) to compare the physical characteristics between grade 10 and grade 11 high school American football players across different player positions and 2) to compare their physical characteristics to the normative values for U.S. elite high school players and national-level Japanese players.

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II. Materials and Methods

a) Participants

Two-hundred forty American football players participated in the tryouts for the 15th and 16th Pacific Rim Bowl (held on July 29, 2017, and July 27, 2019). The Pacific Rim Bowl is a friendly match played biannually between Ashland High School (Oregon, USA) and an all-star team from the Kansai High-school American Football Association, which is one of two high school American football associations in Japan. The Bowl aims to develop character and leadership and enhance cultural awareness among players from the two teams (Ashland Football Club, 2019). The roster selection includes multiple processes: football skill testing, physical performance testing, and interviews. Most of the athletes who participated in these two matches were considered to be above average to elite level football players.

In Japan, the tryouts were held at the American football field, the EXPO FLASH FIELD, in Osaka, Japan, in March 2017 and 2019. The 2017 and 2019 tryouts included 117 players from 26 high schools and 123 players from 30 high schools, respectively. We excluded data from 4 players who did not complete all selection processes due to injury. After these exclusions, our study sample included 101 grade 10 players and 135 grade 11 players, with 37 (37%) and 68 (50%) players, respectively, selected to the rosters.

A high school in Japan consists of a 3-year program, with the first, second, and third year corresponding to grades 10, 11, and 12, respectively, in U.S. high schools. We note that all players from Japan were in grade 10 or 11 at the time of the tryout and in grade 11 or 12 on game day as the school year begins in April in Japan.

Participants and their parent/guardian provided written informed consent for players to participate in the entire tryout process. The testing was conducted in accordance with the Declaration of Helsinki and was approved by our institutional ethics committee of the institute (H27-060).

b) Procedures

The testing included two anthropometric characteristics (height and body mass) and three physical performance measurements (broad jump, pro-agility shuttle, and the 40-yard sprint). Height was measured to the nearest 0.01 m and body mass to the nearest 0.1 kg. Each performance test was performed twice, with the best performance included in the analysis. Before all performance testing, participants completed a standardized warm-up designed by the coaching staff. All players wore their own cleats during the tests.

To measure the broad jump, players placed their toes behind the start line and jumped forward, as far as possible, with arm swing and countermovement. Upon landing, athletes were allowed to fall forward and touch the ground if needed, but not backwards. The distance was measured from the start line to the heel, recorded to the nearest 0.01 m.

For the pro-agility shuttle, two coaches measured the time concurrently using handheld stopwatches (CASIO, Tokyo, Japan), with the average time recorded to the nearest 0.01 s. The shuttle run was performed between three lines, set 5 yards (4.57 m) apart. Each trial was performed as follows: initiated with the athlete straddling the middle line in a 'three-point stance' with the right hand touching the central line; first direction of the run to the right, with the right hand touching the 5-yard line; turn and run in the opposite direction (10 yards, 9.14 m), touching the far line with the left hand; with one last turn and run back to the center line.

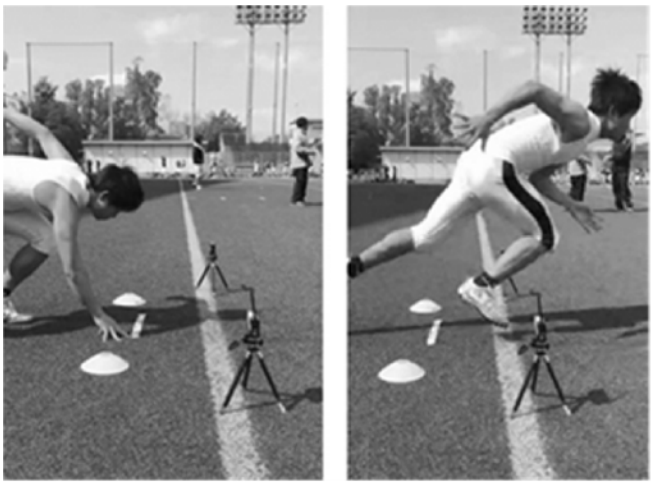

Fig. 1: The start of the 40-yard dash. Left; the three-point start, with the photo beam placed at the height of 0.3 m. Right; the moment at which the photocell beam is interrupted by a player's shin passing through it, which records the start of the dash.

The time of the 40-yard dash was measured using a photocell infrared gate (T.C. Timing System, Brawer, Utah, USA), recorded to the nearest 0.01 s. The gates were placed on the start line (10-yard line on the field), at the height of 0.3 m, with the other gate placed on the 40-yard line at the height of 1.0 m. Each sprint was started 0.3 m behind the initial timing gate, in a 3-or 4-point stance with the finger(s) placed on the line (Fig. 1).

For analysis, players were stratified into their playing position as previously defined (Yamashita et al., 2017): skill players (wide receivers, running backs, and defensive backs); big skill players (fullbacks, tight ends, and linebackers); and linemen (offensive and defensive lines). Quarterbacks, punters, and kickers (20 players) were not included as these require position-specific skills (Sierer et al., 2008).

In terms of talent identification, we quantified the number of participants who met criteria (defined as the average value) for each of the performance parameters from two previous studies: (1) U.S. high school players with a 2-star recruit ranking (Ghigiarelli, 2011) and (2) Japanese players who were candidates of the 2015 IFAF (International Federation of American Football) senior World Championship (Yamashita et al., 2017). We do note that our protocol of the 40-yard dash was different than the one used in these two studies and, therefore, a reference value for the 40-yard dash was not used. The star value was denoted as the number of stars obtained in the ranking, which range from 1 to 5 as per the 247Sports ranking definition. For example, in 2009, 5-star recruits (n=32), 4-star recruits (n=300), 3-star recruits (n=1339), and 2-star recruits (n=621) (247Sports, 2009).

c) Statistical analyses

We compared measured anthropometric characteristics and performance parameters between grade 10 and grade 11 players across the position categories. All measurements were reported as the mean ± SD. An independent *t*-test was used to evaluate age-specific differences, with Cohen's *d* used to determine the effect size of identified differences, as follows: $|d| \leqq 0.2$, a trivial effect; $0.2 < |d| \leqq 0.6$, a small effect; $0.6 < |d| \leqq 1.2$, a moderate effect; and $2.0 < |d|$, a large effect (Hopkins, 2010). The α-level was set at $p < 0.05$ for all analyses. Statistical analyses were performed using MATLAB 2019a (Math Works, Inc., Natick, MA, USA).

III. Results

The comparison of physical characteristics and performance parameters between grade 10 and 11 players, for each position category are reported in Table 1. For linemen, only a moderate increase ($d = 0.62$) in weight was identified between grade 10 and 11 ($p < 0.05$), with no differences or moderate effects for all other measured variables ($p > 0.05$ or $|d| \leqq 0.6$). For big skill players, no differences or moderate effects were identified between grade 10 and grade 11 players. However, for skill players, except for body mass, all other variables were significantly greater for grade 10 than grade 11 players ($p < 0.05$); however, the effect size of these differences was small ($0.2 < |d| \leqq 0.6$).

Fig. 2 shows the scatter plots relating height to body mass and all three performance parameters for all Japanese high school players, grade 10 and grade 11 shown separately, by position categories. The mean ± SD for the Japanese athletes and for the 2-star U.S. high school players is indicated. The number (and proportion) of grade 10 and 11 players who met the pre-defined criteria for physical characteristics and performance parameters is reported in Table 2. Overall, only one player (in the big skill category) was heavier than the U.S. normative values. For linemen, thirteen (21.3%) players were better in broad jump than the U.S. and Japanese criteria and twenty-four (39.3%) were faster on the pro-agility shuttle than the U.S. criteria. For big skill players, 2.2-8.7% and 4.3-17.4% of the players were superior to the U.S. and Japanese criteria, respectively. For skill players, 0-28.2% and 5.5-20.9% of the players were superior to the U.S. and Japanese criteria, respectively.

Table 1: Physical characteristics and performance parameters for all three position categories for players in grade 10 and in grade 11.

Linemen (Offensive line, Defensive line)					
Variables\Grade	10th (n = 27)	11th (n = 34)	*d*	Magnitude	*p*
Height (m)	1.74 ± 0.06	1.77 ± 0.10	0.51	Small	0.054
Body mass (kg)	94.8 ± 11.6	102.4 ± 13.2	0.62	Moderate	0.020*
Broad jump (m)	2.17 ± 0.18	2.23 ± 0.23	0.26	Small	0.323
Pro-agility shuttle (s)	5.22 ± 0.39	5.08 ± 0.33	0.41	Small	0.113
40-yard dash (s)	5.41 ± 0.34	5.40 ± 0.37	0.01	Trivial	0.961
0-10 yard (s)	1.65 ± 0.09	1.67 ± 0.09	0.25	Small	0.329
10-40 yard (s)	3.76 ± 0.27	3.73 ± 0.29	0.10	Trivial	0.701

Big skill players (Full back, Tight end, Linebacker)					
Variables \ Grade	10th (n = 18)	11th (n = 28)	*d*	Magnitude	*p*
Height (m)	1.70 ± 0.05	1.73 ± 0.05	0.41	Small	0.181
Body mass (kg)	75.9.± 7.1	79.2 ± 7.9	0.44	Small	0.161
Broad jump (m)	2.45 ± 0.16	2.43 ± 0.14	0.09	Trivial	0.760
Pro-agility shuttle (s)	4.78 ± 0.21	4.76 ± 0.20	0.10	Trivial	0.734
40-yard dash (s)	5.08 ± 0.22	5.04 ± 0.17	0.20	Trivial	0.507
0-10 yard (s)	1.61 ± 0.07	1.58 ± 0.07	0.38	Small	0.217
10-40 yard (s)	3.47 ± 0.17	3.46 ± 0.13	0.08	Trivial	0.788
Skill players (Running back, Wide receiver, Defensive back)					
Variables \ Grade	10th (n = 45)	11th (n = 65)	*d*	Magnitude	*p*
Height (m)	1.72 ± 0.05	1.70 ± 0.05	0.43	Small	0.030*
Body mass (kg)	68.1 ± 6.0	70.1 ± 6.0	0.34	Small	0.086
Broad jump (m)	2.48 ± 0.13	2.53 ± 0.14	0.40	Small	0.046*
Pro-agility shuttle (s)	4.73 ± 0.23	4.63 ± 0.19	0.48	Small	0.013*
40-yard dash (s)	4.97 ± 0.15	4.89 ± 0.15	0.50	Small	0.012*
0-10 yard (s)	1.58 ± 0.07	1.56 ± 0.07	0.41	Small	0.038*
10-40 yard (s)	3.38 ± 0.11	3.33 ± 0.11	0.44	Small	0.025*

*Data are mean ± SD. * $p < 0.05$.*

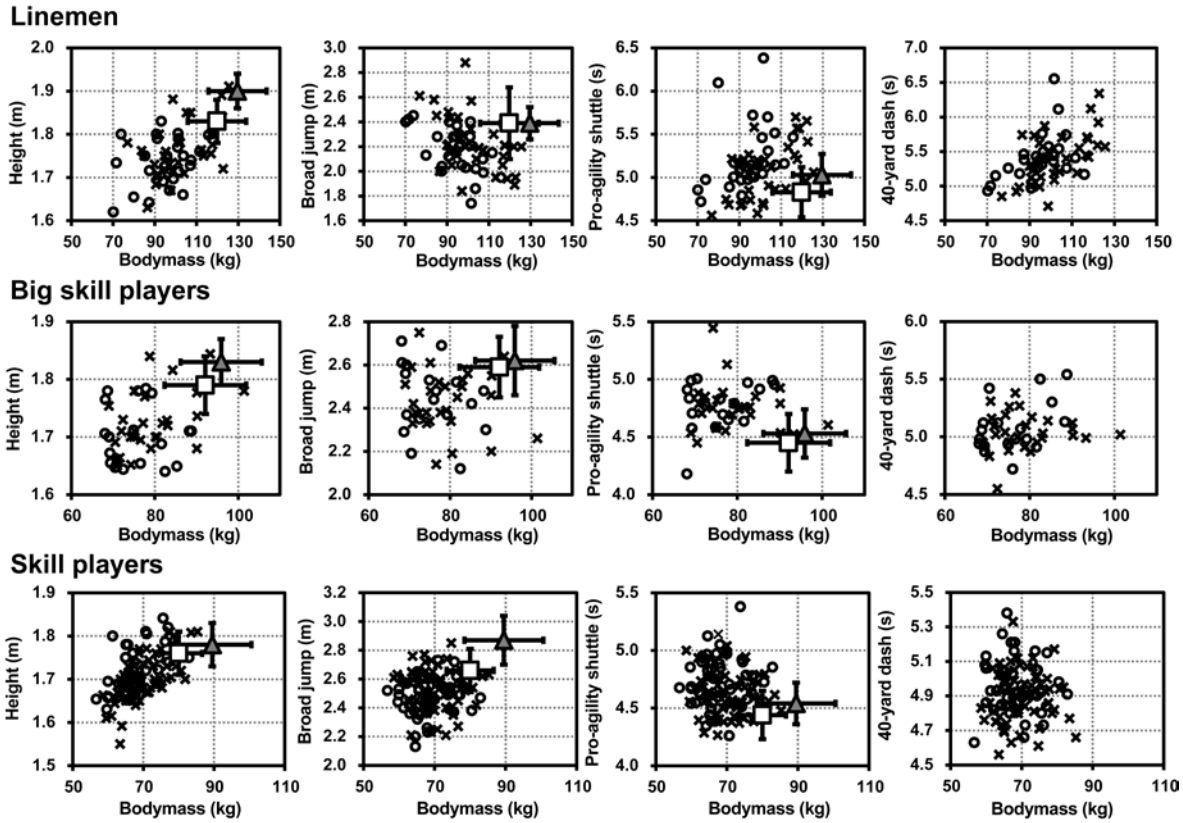

Fig. 2: Scatter plots of body mass versus height and performance measures, by position category, for grade 10 (0) and grade 11 (x) players; white square, normative values for the Japanese national team candidates from Yamashita et al. (2017) (mean ± SD); gray delta, normative values for U.S. 2-star high school players from Ghigiarelli (2011) (mean ± SD).

IV. Discussion

We aimed to compare the anthropometric and performance parameters between American football players in grade 10 and 11, and to compare their physical characteristics to the normative values for U.S. and Japanese players. The only between-grade difference was body mass for linemen. Grade 11 linemen were heavier than grade 10 linemen but, the average body mass of U.S. 2-star offensive linemen was 129.6 kg (Ghigiarelli, 2011), which was much heavier than the average body mass of our Japanese linemen (102.4 kg in grade 11). American football is a contact sport, and heavier players are generally better in any type of collision. This difference in body mass was likely associated with a greater average height among U.S. linemen (1.90 m and 1.95 m for 2-star and 5-star high school offensive linemen, respectively, in Ghigiarelli (2011)) compared to 1.74 m in our study sample.

Table 2: The number (and proportion) of Japanese grade 10 and 11 high school players who met the criteria.

Criteria \ Variables	Body mass	Height	Broad jump	Pro-agility	Mass & Height	Mass & Broad jump	Mass & Pro-agility
Linemen (Offensive line, Defensive line) (n = 61)							
U.S. offensive line	0 (0%)	1 (1.6%)	13 (21.3%)	24 (39.3%)	0 (0%)	0 (0%)	0 (0%)
JPN linemen	4 (6.6%)	8 (13.1%)	13 (21.3%)	11 (18.0%)	0 (0%)	0 (0%)	0 (0%)
Big skill players (Full back, Tight end, Linebacker) (n = 46)							
U.S. linebacker	1 (2.2%)	2 (4.3%)	4 (8.7%)	3 (6.5%)	0 (0%)	0 (0%)	0 (0%)
JPN big skill players	2 (4.3%)	3 (6.5%)	8 (17.4%)	2 (4.3%)	1 (2.2%)	1 (2.2%)	0 (0%)
Skill players (Running back, Wide receiver, Defensive back) (n = 110)							
U.S. running back	0 (0%)	15 (13.6%)	0 (0%)	31 (28.2%)	0 (0%)	0 (0%)	0 (0%)
JPN skill players	6 (5.5%)	23 (20.9%)	11 (10.0%)	17 (15.5%)	3 (2.7%)	0 (0%)	0 (0%)

U.S.; 2-star U.S. high school players from Ghigiarelli (2011). JPN; Japanese national team candidates from Yamashita et al. (2017).

The absence of differences in measured outcomes between grade 10 and grade 11 players in our study is in agreement with findings from a previous study of top- and middle-level senior American football players in Japan (Yamashita et al., 2017). In Japan, there are 4,000 American football players in high schools and 10,000 players in universities (JAFA, 2009). This relatively small number of athletes in this sport will lessen the competitive selection based on physical characteristics and performance parameters (Yamashita et al., 2017). By comparison, in the U.S., grade 11 players perform significantly better on the 40-yard dash and pro-agility shuttle run than players in grade 10 (Dupler et al., 2010). These results reflect differences in athlete development systems between Japan and the U.S., as well as the difference in participation level. In the U.S., there are more than one million American football players in high schools (NFHS, 2018) and approximately 20,000 in Division 1 universities (Irick, 2018). These large populations and competitive environments lead to early talent identification and between player development systems.

Generally, body mass negatively affects sprinting and change of direction speed (Davis et al., 2004). Our results showed that only 0-5.5% of players in each position category were heavier than the U.S. or Japanese normative values, but up to 21.3% and 4.3-39.3% of them showed the better value in the broad jump and pro-agility shuttle, respectively. However, our results indicate a need for Japanese high school players to be both heavier and faster to improve their competitiveness. The National Strength and Conditioning Association (NSCA) presented a position statement on long-term athlete development (LTAD) advocating for the implementation of systematic training and education programs by qualified professionals, along with various types of physical conditioning, to improve physical fitness, performance, and competitiveness (Lloyd et al., 2016, Lloyd et al., 2015). Resistance training in youth athletes can improve sprint speed, change of direction speed, and power (Loturco et al., 2019, McQuilliam et al., 2020). However, a survey of American football teams in Japanese universities revealed that approximately 90% of skill coaches are volunteers (Matsuo et al., 2019). Moreover, reports on strength and conditioning coaching in Japan have neither been provided for universities nor high schools. Considering that the coaching level is likely lower at the high school than the university level, it is not surprising that Japanese high school players, on average, do not attain or exceed the performance of Japanese national team candidates. It is remarkable, however, that U.S. 2-star high school players (approximately top 1600 to 2300 in all recruit rankings) posted better results on

most of the measured outcomes than the Japanese national team candidates. To succeed internationally, and against the U.S. more specifically, Japanese high school players must have similar physical performances to the national team, which will require advancing athlete development programs in Japan for American football.

The limitations of our study need to be acknowledged. First, this was a cross-sectional study comparing athletes in grades 10 and 11; however, no longitudinal data were obtained to evaluate the natural growth on measured outcomes. Second, the Pacific Rim Bowl occurs only biannually and, thus, only 101 grade 10 players were eligible to tryout, with only 37 (37%) selected, compared to 135 grade 11 players at the tryout and 68 (50%) selected. Careful evaluation and selection of grade 10 players will be required to avoid this bias in the future.

In conclusion, the difference between grade 10 and 11 was only body mass for linemen, with no moderate effects for all other measured variables. No Japanese players were better in both mass and performance measures than U.S. elite high school players. Our findings indicate the need for improved talent identification and athlete development programs, which reflect systems in place in the U.S., if the physical and performance characteristics and competitiveness of American football players in Japan are to improve.

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