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PHYSIOLOGICAL PROFILE OF NATIONAL-LEVEL JUNIOR AMERICAN FOOTBALL PLAYERS IN AUSTRALIA

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Abstract This study profiled National-level junior American football players from Australia. 36 subjects (age: 16.6 ± 0.8 years; mass: 81.8 ± 20.6 kg; height: 1.81 ± 0.07 m), comprising: three quarterbacks (QB); three running backs (RB); seven wide receivers (WR); three tight ends (TE); six linebackers (LB); seven defensive backs (DB); and seven linemen (offensive and defensive – LM), were tested. Measurements included height; mass; 40-yard sprint; vertical jump; pro-agility shuttle; standing broad jump; three-cone drill; and backwards overhead medicine ball throw. Means were calculated by position, and positions were grouped as offensive backfield (OBF: QB, RB, WR, TE), defensive backfield (DBF: LB, DB) and LM. A 1-way analysis of variance found significant ($p \leq 0.05$) differences between position groups. Data were also compared to normative values. LM were bigger, and did not perform as well in the tests. OBF and DBF players were superior in speed (40-yard sprint: LM = 5.78 ± 0.55 s; OBF = 5.07 ± 0.27 s; DBF = 5.14 ± 0.23 s), agility (pro-agility shuttle: LM = 5.74 ± 0.41 s; OBF = 4.63 ± 0.29 s; DBF = 4.63 ± 0.17 s), and power (vertical jump: LM = 0.40 ± 0.08 m; OBF = 0.56 ± 0.09 m; DBF = 0.53 ± 0.09 m). Australian players tended to be smaller and scored lower in the tests, when compared to similar-aged American players. Australian RB were comparable to American RB in speed and agility. To prepare for college football, Australian players must increase mass, speed, and power.

Key words: Gridiron, high school athletes, physical testing, speed and agility, power

INTRODUCTION

American football is the dominant form of football in the United States of America (USA). Increasingly, American football is being played in countries outside the USA, evidenced by the number of nations associated with the International Federation of American Football (IFAF). In previous IFAF World Championships, participating countries have included the USA, Mexico, Canada, Austria, Germany, France, Japan, Finland, and Australia [3]. International players from several of these countries, including Australia, have been recruited by major college football programs in the USA. American football has been played in Australia since 1983, with competitions for both senior (all ages) and junior (high school-aged, under the age of 19 years) players.

American football has very specific physiological requirements. Following a review of literature, Hoffman [12] affirmed that the phosphagen energy system provides up to 90% of the energy requirements for American football, with the glycolytic energy system contributing the remaining 10%. This is supported by time-motion analysis of American football, which revealed that typical plays in high school, college and professional games in the USA last for approximately 5 seconds (s), and that the time between plays is approximately 30 s [20]. As a result of these game requirements, most of the physiological testing for American football focuses on high-intensity activities such as sprinting speed, agility and change-of-direction speed, and power. There are certain physiological tests common to American football. These include: the 40-yard sprint, which is a test of linear speed; vertical jump, which serves as an indirect measure of vertical power; standing broad jump, which serves as an indirect measure of horizontal power; and the pro-agility shuttle and three-cone drill, which are tests that measure agility and change-of-direction speed [8, 10, 11, 22]. Other assessments that have been used for American football players include strength tests such as the bench press; shuttle runs over various distances to evaluate conditioning; and medicine ball throws to assess combined upper- and lower-body power [10, 22, 27].

There is limited physiological data available for high school-age football players. Dupler et al [8] analyzed high school players in the 40-yard sprint, pro-agility shuttle, and vertical jump, in an attempt to distinguish differences in performance characteristics across year groups (9^{th}, 10^{th}, 11^{th}, and 12^{th} grades). Ghigiarelli [11] compiled a detailed profile of high school players who were recruited by Division I colleges. Defining the characteristics for Australian players of a similar age would have great value for football coaches, strength and conditioning practitioners, and players alike. Identifying physiological strengths and limitations possessed by young Australian players will assist football coaches in recruitment, and would aid strength and conditioning coaches develop appropriate training programs for these players.

With more than 50 international players playing college football in the USA [13], it is important for football and strength and conditioning coaches to know the characteristics of young international players for both recruitment and conditioning purposes. This study will create a physiological profile of National-level junior, high school-aged American football players in Australia, using common football tests. To assess the relative performance level of Australian junior players, comparative data analysis will be performed against data from USA players. It is hypothesized that Australian offensive and defensive backfield players will be physically smaller, and perform better in tests of speed and power when compared to Australian linemen. It is further hypothesized that collectively, Australian players will be physically smaller, and will not perform as well in the tests, when compared to USA players. Establishing a baseline of physiological assessments for Australian junior football players will assist with identifying future players; provide a basis for tracking performance; and deliver essential recruitment and conditioning information to USA-based coaches.

MATERIALS AND METHODS

SUBJECTS

36 players (age: 16.6 ± 0.8 years; mass: 81.8 ± 20.6 kilograms; height: 1.81 ± 0.07 meters [m]) were tested for this study. By position, there were: three quarterbacks (QB); three running backs (RB); seven wide receivers (WR); three tight ends (TE); six linebackers (LB); seven defensive backs (DB); and seven linemen (offensive and defensive – LM). Due to the relatively small number of LM tested, offensive and defensive LM were grouped together. Subjects were recruited if they were a member of Gridiron Australia's developmental squad for the Under 19's national team, and had permission to participate from their respective state team coaches. The methodology used in this study was approved by the institutional ethics committee. Players and their parents were contacted via email and telephone to have the study procedures explained to them. All subjects received a clear explanation of the study, including the risks and benefits of participation. Informed consent was obtained prior to testing from players and parents (if subjects were less than 18 years of age). Subjects also completed a questionnaire that surveyed any other sports the subjects' regularly played (at least 1 session·week^{-1} during the regular season for the particular sports).

PROCEDURES

Data were collected during the 2011 Junior National Championships held during April in Sydney, Australia, in one 120-minute session. The session included measurements of height and body mass; 40-yard sprint; pro-agility shuttle; three-cone drill; vertical jump; standing broad jump; and backwards overhead medicine ball throw (BOMBT). These tests were selected as they are often used in the assessment of American football players. The 40-yard sprint, vertical jump, standing broad jump, and BOMBT, were conducted on a synthetic athletics track. The pro-agility shuttle and three-cone drill were conducted on a natural grass surface. These surfaces were used at the request of the national team coaching staff. Similar surfaces had been previously used when testing American football players [5, 8, 18, 27]. Subjects wore joggers for the tests on the athletics track, and football cleats on the grass surface. Testing was conducted in the late morning. Subjects did not eat for 2-3 hours before the session. Subjects also refrained from intensive exercise, and abstained from caffeine or stimulants in the 24-hour period before testing. Subjects consumed water *ad libitum* throughout the session.

Prior to data collection, the subjects' age, height, and mass were recorded. Height was measured barefoot using a stadiometer (Seca 213, Ecomed Trading, Australia), recorded to the nearest 0.01 centimeters (cm). Body mass was recorded to the nearest 0.1 kg using digital scales (BF-522, Tanita Corporation, Japan). Height and mass measurements were used to calculate BMI ($BMI = height \cdot (body\ mass^2)^{-1}$). All subjects then completed a standardized warm-up, which consisted of ten minutes of jogging, ten minutes of dynamic stretching of the lower limbs, and linear and lateral runs over 20-40 yards that progressively increased in intensity. Subjects completed testing in the following order, and rotated alphabetically by surname for each test. This ensured sufficient recovery periods of greater than 3 minutes between efforts.

40-YARD SPRINT

10-, 20-, and 40-yard sprint time was recorded by a timing lights system (Smartspeed, Fusion Sports, Australia). Gates were positioned at 0 yards, 10 yards (9.14 m), 20 yards (18.29 m), and 40 yards (36.58 m). Subjects began the sprint from a three-point stance 30 cm behind the start line, so as to trigger the first gate. Subjects were instructed to accelerate from the starting line and sprint through all sets of timing lights. If the subjects moved prior to starting, the trial was disregarded and repeated. Time for each distance was recorded to the nearest 0.001 s. Subjects completed two trials, and the fastest trial was used for analysis.

VERTICAL JUMP

A Vertec apparatus (Yardstick, Swift Performance Equipment, Australia) was used to measure vertical jump performance [9]. The subject initially stood side-on to the Vertec (on the subject's dominant side), and while keeping their heels on the floor, reached upward as high as possible, fully elevating the shoulder to displace as many vanes as possible. The last vane moved became the zero reference. The subject then jumped as high as possible with no preparatory step, and height was recorded from highest vane moved. No restrictions were placed on the knee angle attained during the eccentric phase of the jump. Vertical jump height was calculated by subtracting the standing reach height from the jump height. Each subject completed two trials, and the best trial was used for analysis. Power output was also calculated for the best trial by using the Lewis formula: *Power* $(kg \cdot m \cdot s^{-1}) = \sqrt{4.9} \cdot \text{Body Mass} \cdot \sqrt{\text{Vertical jump height}}$ [25, 26].

PRO-AGILITY SHUTTLE

The pro-agility shuttle course is shown in Figure 1. Subjects were allowed a practice trial prior to the test. One timing gate (Smartspeed, Fusion Sports, Australia) was used. Subjects straddled the middle line in a three-point stance in between the timing gate. An in-beam start was used, whereby once the subject was stable in the light beam, they could begin. To initiate the test, the subject turned and ran five yards (4.57 m) to one side and touched the line with one hand. The subject then turned and ran 10 yards (9.14 m) to the other side and touched the other line**,** before turning and finishing by running back through the start/finish line. Researchers were positioned at either end of the pro-agility shuttle to ensure subjects touched the line. If they did not, the trial was disregarded and re-attempted. Timing started when the subject left the light beam, and stopped recording when subjects returned through the gate for the last time. Two trials were completed – one with movement initiation to the left, and the other with movement initiation to the right [8, 24]. As is typical of combine football testing [8, 10, 11, 22, 24], the fastest time was used for analysis.

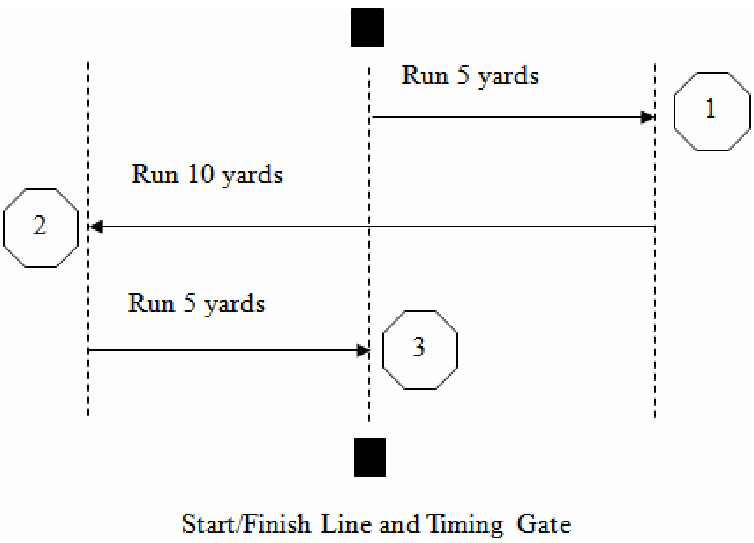

Figure 1. Pro-agility shuttle test with initial movement to the right. The subject straddles the start line in a three-point stance. They then run 5 yards to the right, 10 yards to the left, before sprinting 5 yards back through the finish line

STANDING BROAD JUMP

The standing broad jump involved the athlete placing the toes of both feet on the back of the starting line. With a simultaneous arm swing and crouch, the subject then leaped forward as far forward as possible, ensuring a two-footed landing. Subjects had to 'stick' the landing for the trial to be counted. If the subject did not do this, the trial was disregarded and another trial was completed. No restrictions were placed on body angles attained during the preparatory phase of the jump. The distance was measured using a standard tape measure from the front of the start line to the back of the back heel at the landing [11, 21]. Each subject completed two trials, and the best trial was used.

Three-Cone Drill

The three-cone drill was marked out as shown in Figure 2, and one timing gate (Smartspeed, Fusion Sports, Australia) was used. Subjects were allowed a practice trial prior to the test. Subjects started in a three-point stance 30 cm behind the start line (Marker 1). On the start command, subjects ran to Marker 2, bent down and touched the ground with their right hand, before running back to Marker 1 and touching the ground with their right hand. The subject then ran back to Marker 2 and around the outside of it, weaved inside Marker 3, around the outside of Markers 3 and 2 before finishing at Marker 1. The subject ran forwards throughout the test while changing direction. Researchers were positioned at each marker to ensure subjects completed the drill correctly. If they did not, the trial was disregarded and re-attempted. Time was recorded from when the subject broke the gate the first time, until they returned through the gate from the last section of the test. Two trials were completed. In the first trial, subjects turned to the right from Markers 2 to 3. In the second trial, subjects turned to the left [24]. As for the pro-agility shuttle and for typical football testing [8, 10, 11, 22, 24], the fastest time from the two trials was used for analysis.

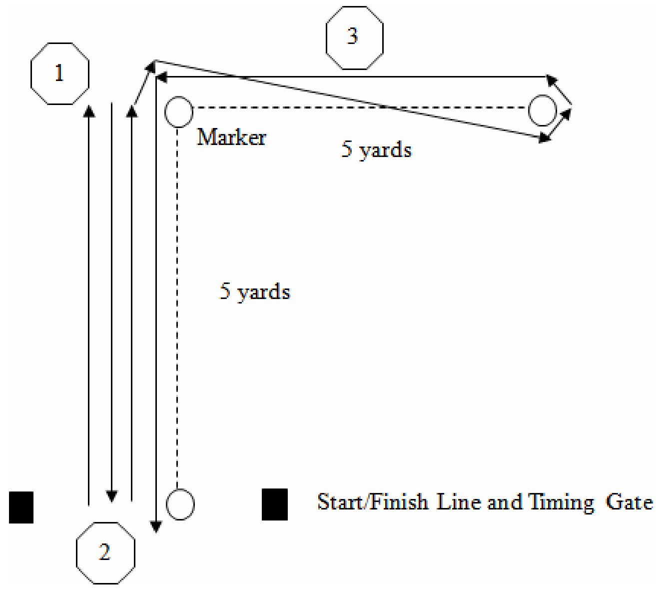

Figure 2. The three-cone drill featuring a right-hand turn. The player runs from the start line to the second marker, returns to the start line, before sprinting forward, turning right, looping around the third marker before returning through the finish line

Backwards Overhead Medicine Ball Throw (BOMBT)

The BOMBT was used to assess combined upper and lower body power [26]. Subjects stood with their backs to the throwing area, with their feet shoulder-width apart and heels on the zero-line. To start the throw, the medicine ball was held in front of the body, with the arms extended at shoulder height. In one continuous movement, subjects flexed at the hips, knees and trunk, lowering the ball below the waist. They then extended their legs and thrust the hips forwards, while flexing the shoulders and elevating the ball above shoulder height as they threw it back over their head as far as possible. Following the throw, the subjects' feet were allowed to leave the ground, as would happen with a jump. A 3 kg medicine ball was used [17], and subjects completed 2-3 practice trials for familiarization. The medicine ball was covered in chalk to allow subjects to grip the ball, and to mark the ground when the ball landed after the throw. Horizontal distance was measured by a standard tape measure from the zero-line to the rearmost chalk-marking made by the ball. The BOMBT distance was also made relative to body mass via the formula: *Relative BOMBT = throw distance·body mass*$^{-1}$ [26].

Statistical Analysis

Trial-to-trial reliability of selected variables was assessed by intra-class correlation coefficients (ICC) calculated from a 2-way mixed method consistency model for single measures [16]. An ICC equal to or greater than 0.8 was considered acceptable [28]. Means and standard deviations were calculated by positions (QB, RB, WR, TE, LB, DB, and LM), and the data was compared to normative values. To further investigate positional differences, individual positions were grouped together as offensive and defensive backfield players [27]. QB, RB, WR, and TE encompassed the offensive backfield group (OBF). LB and DB composed the defensive backfield group (DBF). LM were considered as a separate position group. A 1-way analysis of variance (ANOVA) determined if any significant differences existed between position groups in the administered tests [8]. The Levene statistic determined homogeneity of variance of the data. In the event of a significant F-ratio, post hoc analysis was conducted using least significant difference for pairwise comparisons to establish the extent of any significant findings [8]. A power value of 0.8 was set for this study [16], and an alpha level of $p \leq 0.05$ was chosen as the criterion for significance. All statistical analyses were computed using the Statistics Package for Social Sciences (Version 18.0; IBM Corporation, New York, USA).

RESULTS

Figure 3 shows the sporting background of the subjects from this study. Contact sports, such as rugby league, rugby union, and Australian football, predominated. As the testing took place during the 2011 Junior National Championships, the number of LM (offensive and defensive LM combined) tested was relatively low (n = 7). This was due to coaches holding players out of testing. The Levene statistic for the dependent variables (p = 0.124-0.812) indicated that the data were normally distributed, and thus the 1-way ANOVA was used to compare position groups. Anthropometrical measurements for positions and position groups are shown in Table 1. The LM were significantly older than OBF players, and significantly taller, heavier, and had a higher BMI when compared to both OBF and DBF players. The OBF and DBF players were 3% shorter than the LM. OBF players had a 35% lower body mass, and 29% lower BMI when compared to the LM. DBF players had similar results, having a 32% lower body mass, and 27% lower BMI when compared to the LM. There were no significant differences in anthropometry between OBF and DBF players.

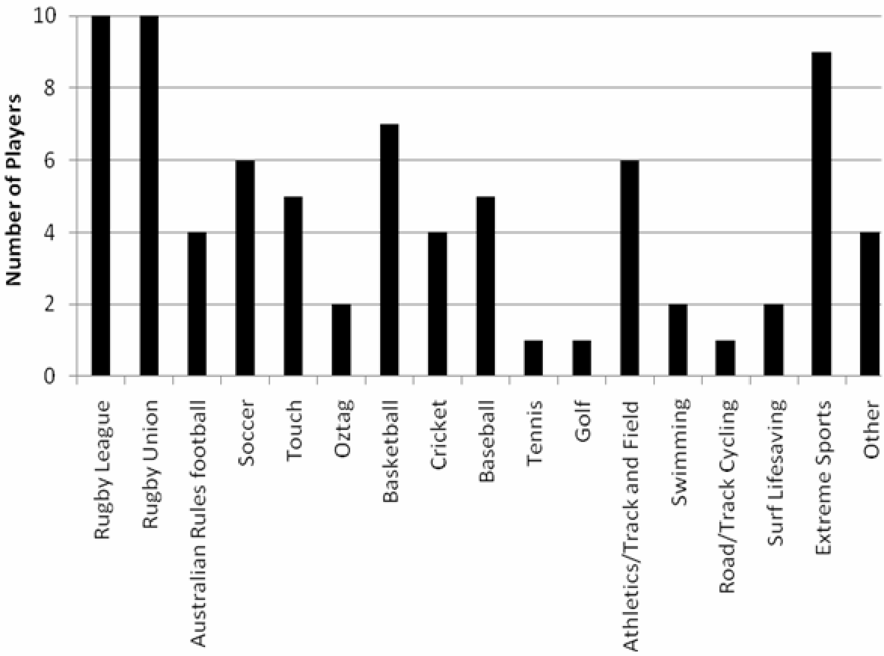

Figure 3. Other sports participated in by National-level Junior Australian Gridiron players. Extreme sports include activities such as skateboarding, inline skating, and surfing

Table 2 displays the results for the tests of speed (10-yard, 20-yard and 40-yard times) and agility (pro-agility shuttle and three-cone drill times) by position and group. The ICCs for the 10-yard, 20-yard, and 40-yard sprint times were 0.88, 0.91, and 0.98, respectively. The ICCs for the pro-agility shuttle and three-cone drill times were 0.93 and 0.95, respectively. There were no significant differences in these tests between the OBF and DBF players. OBF and DBF players were significantly faster in all 40-yard sprint intervals and the agility tests when compared to LM. Over 10 yards, OBF and DBF players had 8% and 7% faster sprint times, respectively; over 20 yards, 11% and 10%; and over 40 yards, 12% and 11%. In the pro-agility shuttle, both the OBF and DBF players had a 19% faster time when compared to the LM. In the three-cone drill, OBF players had an 11%, and DBF players had a 10% faster time.

Table 1. Characteristics (mean ± standard deviation) by position (QB: Quarterbacks; RB: Running backs; WR: Wide Receivers; TE: Tight Ends; LB: Linebackers; DB: Defensive Backs; LM: Linemen) and position groupings (LM: Linemen; Offensive Backfield: OBF; Defensive Backfield; DBF) in age, height, mass, and body mass index (BMI)

	Age (years)	Height (m)	Mass (kg)	BMI (m·[kg^2]$^{-1}$)
All (n = 36)	16.53 ± 0.77	1.81 ± 0.06	81.20 ± 19.97	24.70 ± 4.75
QB (n = 3)	17.00 ± 1.00	1.83 ± 0.08	83.87 ± 13.10	24.84 ± 1.84
RB (n = 3)	15.67 ± 0.58	1.74 ± 0.03	66.00 ± 10.01	21.73 ± 2.55
WR (n = 7)	16.00 ± 0.82	1.79 ± 0.07	69.07 ± 3.62	21.69 ± 1.76
TE (n = 3)	16.33 ± 0.58	1.79 ± 0.07	74.70 ± 7.73	23.18 ± 0.68
LB (n = 6)	16.67 ± 0.52	1.82 ± 0.05	82.35 ± 10.01	24.84 ± 2.95
DB (n = 7)	16.43 ± 0.53	1.77 ± 0.03	70.50 ± 9.79	22.26 ± 2.47
LM (n = 7)	17.29 ± 0.49	1.85 ± 0.05	111.20 ± 22.93	31.91 ± 5.29
OBF (n = 16)	16.19 ± 0.83*	1.79 ± 0.07*	72.33 ± 9.50*	22.57 ± 2.05*
DBF (n = 13)	16.54 ± 0.52	1.80 ± 0.05*	75.97 ± 11.29*	23.45 ± 2.91*

* Significant ($p \leq 0.05$) difference between Offensive (OBF) or Defensive (DBF) Backfield group and Linemen (LM)

Table 2. Characteristics (mean ± standard deviation) by position (QB: Quarterbacks; RB: Running backs; WR: Wide Receivers; TE: Tight Ends; LB: Linebackers; DB: Defensive Backs; LM: Linemen) and position groupings (LM: Linemen; Offensive Backfield: OBF; Defensive Backfield; DBF) in 10-yard, 20-yard, 40-yard, pro-agility shuttle, and three-cone drill times

	10-yard (s)	20-yard (s)	40-yard (s)	Pro-Agility Shuttle (s)	Three-cone Drill (s)
All (n = 36)	1.66 ± 0.11	2.90 ± 0.22	5.22 ± 0.41	4.85 ± 0.53	7.88 ± 0.66
QB (n = 3)	1.68 ± 0.08	2.91 ± 0.12	5.14 ± 0.16	4.72 ± 0.48	7.71 ± 1.01
RB (n = 3)	1.55 ± 0.04	2.72 ± 0.01	4.84 ± 0.06	4.39 ± 0.32	7.02 ± 0.60
WR (n = 7)	1.61 ± 0.08	2.74 ± 0.16	4.98 ± 0.16	4.64 ± 0.25	7.66 ± 0.57
TE (n = 3)	1.79 ± 0.03	3.12 ± 0.05	5.60 ± 0.21	4.64 ± 0.48	7.86 ± 0.49
LB (n = 6)	1.64 ± 0.09	2.88 ± 0.15	5.17 ± 0.25	4.59 ± 0.09	7.63 ± 0.44
DB (n = 7)	1.64 ± 0.07	2.86 ± 0.12	5.11 ± 0.23	4.68 ± 0.23	7.82 ± 0.34
LM (n = 7)	1.77 ± 0.12	3.18 ± 0.25	5.78 ± 0.55	5.74 ± 0.41	8.59 ± 0.75
OBF (n = 16)	1.63 ± 0.10*	2.82 ± 0.18*	5.07 ± 0.27*	4.63 ± 0.29*	7.65 ± 0.58*
DBF (n = 13)	1.64 ± 0.08*	2.87 ± 0.13*	5.14 ± 0.23*	4.63 ± 0.17*	7.72 ± 0.38*

* Significant ($p \leq 0.05$) difference between Offensive (OBF) or Defensive (DBF) Backfield group and Linemen (LM)

Table 3. Characteristics (mean ± standard deviation) by position (QB: Quarterbacks; RB: Running backs; WR: Wide Receivers; TE: Tight Ends; LB: Linebackers; DB: Defensive Backs; LM: Linemen) and position groupings (LM: Linemen; Offensive Backfield: OBF; Defensive Backfield; DBF) in vertical jump, vertical jump power (VJP), standing broad jump, backwards overhead medicine ball throw (BOMBT), and relative backwards overhead medicine ball throw (RBOMBT)

	Vertical Jump (m)	VJP (kg·m·s^{-1})	Standing Broad Jump (m)	BOMBT (m)	RBOMBT (m·kg^{-1})
All (n = 36)	0.52 ± 0.10	127.27 ± 22.68	2.17 ± 0.31	12.04 ± 1.80	0.150 ± 0.029
QB (n = 3)	0.56 ± 0.05	138.94 ± 24.02	2.16 ± 0.20	14.35 ± 3.18	0.161 ± 0.010
RB (n = 3)	0.67 ± 0.06	119.66 ± 20.93	2.53 ± 0.25	11.20 ± 1.87	0.171 ± 0.014
WR (n = 7)	0.57 ± 0.06	115.05 ± 6.37	2.28 ± 0.21	11.84 ± 0.73	0.173 ± 0.016
TE (n = 3)	0.43 ± 0.01	107.97 ± 17.58	2.08 ± 0.25	11.35 ± 1.77	0.153 ± 0.001
LB (n = 6)	0.50 ± 0.09	127.68 ± 15.77	2.32 ± 0.25	12.55 ± 1.58	0.148 ± 0.020
DB (n = 7)	0.56 ± 0.08	116.50 ± 18.01	2.24 ± 0.25	11.35 ± 1.36	0.163 ± 0.028
LM (n = 7)	0.40 ± 0.08	153.54 ± 24.81	1.73 ± 0.16	11.92 ± 2.60	0.108 ± 0.011
OBF (n = 16)	0.56 ± 0.09*	121.27 ± 17.16*	2.26 ± 0.24*	12.18 ± 1.75	0.167 ± 0.014*
DBF (n = 13)	0.53 ± 0.09*	121.74 ± 17.34*	2.28 ± 0.24*	11.95 ± 1.51	0.155 ± 0.024*

* Significant ($p \leq 0.05$) difference between Offensive (OBF) or Defensive (DBF) Backfield group and Linemen (LM)

Table 3 presents vertical jump, vertical jump power, standing broad jump, BOMBT and relative BOMBT data by position and group. For the vertical jump (ICC = 0.99), LM had a 29% lower jump height when compared to OBF players, and 25% lower height when compared to DBF players. When considering vertical jump power, LM generated 27% greater power than OBF players, and 26% greater power than DBF players. LM had a 23% lower standing broad jump distance (ICC = 0.98) than OBF players, and 24% lower jump distance when compared to DBF players. There were no significant differences between the groups for the BOMBT (ICC = 0.91). When the BOMBT was made relative to body mass, both OBF and DBF players had a significantly greater score when compared to the LM (55% and 44%, respectively).

DISCUSSION

This study profiled National-level junior American football players in Australia. As the mean age of players from the current study was approximately 16-17 years, this is equivalent to North American players from 10th or 11th grade [8]. Ghigiarelli [11] has also compiled comprehensive information about high school players, providing further comparative data. Regarding the performance tests used in this study, it was hypothesized that OBF and DBF players would perform better when compared to LM. Generally, this hypothesis was confirmed (Tables 2 and 3). It was further hypothesized that when compared to equivalent-aged players from the USA, Australian players would not fare as well in the performance tests. For the most part, this was confirmed as well. The findings from this study provide practical applications for not only football coaches and strength and conditioning practitioners in Australia, but also for any country where American football is a developing sport.

There were no significant differences between OBF and DBF players in height, mass, or BMI (Table 1). LM were significantly heavier than OBF and DBF players (Table 1). This translated to a significantly greater BMI when compared to the two position groups, and is typical of LM [27]. This would likely be due to a combination of greater lean body and fat mass. Although it was outside the scope of this study to assess the fat mass of players through skinfold assessment or a similar measure, it would be of benefit for future research to assess the fat mass of junior American football players from Australia. When compared to players from the USA, Australian junior players tended to be physically shorter and lighter. The mean age of subjects from the current study is approximately 1-2 years younger than most USA high school players entering their first year of college, and the lower mass of the subjects may be attributable to this. Nonetheless, to highlight some examples, Australian LB were more than 14 kg lighter than college-recruited high school players (82.35 $\pm$ 10.01 kg vs. 97.2 $\pm$ 7.65 kg); RB were over 20 kg lighter (66.00 $\pm$ 10.01 kg vs. 89.8 $\pm$ 9.37 kg) [11]. Even allowing for further physical development, this mass difference is substantial. Greater height and mass have considerable benefits for American football, and this is evidenced by taller and heavier high school players being more heavily recruited by colleges [11]. Junior Australian players wishing to specialize in American football should attempt to increase their body mass.

The lower body mass displayed by subjects in the current study may have been affected by the sports historically played by the participants, including rugby union, rugby league, and Australian football (Figure 3). American football players tend to have a higher body mass when compared to athletes from other football codes. Kraemer et al. [15] found the mass for professional American football players to range from approximately 86-140 kg when considering all positions. The upper limit of this range was appreciably greater when compared with the mass of elite players from rugby union (backs = 90.9 $\pm$ 6.5 kg; forwards = 110.9 $\pm$ 9.1 kg) [4], rugby league (97.6 $\pm$ 9.7 kg) [2], and Australian football (90.6 $\pm$ 8.8 kg) [1]. These differences in body mass are related to the demands each of these codes place on their respective athletes. Players in rugby league [14] and rugby union [6] can cover over 6000 m during a game, whilst players in Australian football over 10000 m [1]. This highlights the level of aerobic conditioning needed for these sports. American football, with work-to-rest ratios (~5 s for a play, with ~30 s between plays) that allow for a greater emphasis on speed and power [20], afford larger players the opportunity to successfully meet playing demands.

Another impact of the variety of sports played by the subjects from this study is that it will affect their ability to train specifically for American football. Indeed, the training history of Australian players when compared to their counterparts from the USA would likely be vastly different. This would impact not only the body mass of football players from Australia, but also their performance in the tests completed in this study. When compared to players from the USA, who would have undergone much more specific conditioning for American football, the impact of this training history will be further underlined. For football coaches who are scouting Australian players, it is important to understand the athletic background of these athletes. As will be discussed, players from Australia may require specific physical conditioning in the various physical traits important for American football before entering the USA college system. This was especially true for the assessments of speed (Table 2) and power (Table 3).

The 40-yard sprint is considered one of the gold-standard tests when considering the physical requirements for American football [18]. 10-yard and 20-yard times were included in the current study to provide information about acceleration. The RB and WR had the lowest sprint times over each distance interval (Table 2), which is typical of players from these positions [8, 11]. Furthermore, when considering 40-yard sprint time, the RB from the current study (4.84 ± 0.06 s) were similar to the 10th (4.98 ± 0.23 s) and 11th (4.80 ± 0.24) grade players analyzed by Dupler et al [8]. All other position groups from the current study tended to be slower when compared to USA players of a similar standard [8]. Importantly, the Australian LM were over 0.5 s slower than 10th and 11th grade offensive and defensive LM from the USA [8]. Given the importance of mobility in LM, this is a major difference. There are particular players within the Australian system who possess the requisite speed to successfully compete in the USA. Nonetheless, as a group, Australian players should attempt to improve linear speed.

The pro-agility shuttle measures change-of-direction speed, and is a staple for American football combine testing [8, 11, 24]. Using the data collected by previous research, a pro-agility shuttle time under 5 s is adequate for high school players, with faster times being under 4.6 s [8, 11]. Within the current study, RB were fastest in the pro-agility shuttle, with a time of 4.39 ± 0.32 s (Table 2). WR, TE, and LB recorded pro-agility shuttle times close to 4.6 s (Table 2). When considering position groups, OBF and DBF players had an average of approximately 4.63 s. The LM were significantly slower than both the OBF and DBF players, with a time in excess of 5 s. Considering that high school LM who are recruited by colleges will record pro-agility shuttle times below 5 s [11], this illustrates a major mobility issue for Australian junior LM. This is further demonstrated by the three-cone drill data.

The three-cone drill also assesses change-of-direction speed, in a test that features five sharp changes of direction. When considering Sierer et al.'s [24] data from collegiate football players who were drafted into professional football, skill positions (WR, RB, DB) had a three-cone drill time of approximately 7.02 s; big skill positions (TE, LB) a time of 7.27 s; and LM a time of 7.78 s. As these players are at the end of their collegiate careers, they are much more physically developed than the players from the current study. Nonetheless, the RB from the current study attained at three-cone drill time similar to drafted skill players (7.02 ± 0.60 s). All other positions were in excess of 7 s, with LM over 8 s (Table 2). With the importance of change-of-direction speed for football players, this is an area that requires improvement for many Australian junior players. However, as per the sprint performance, there are individual Australian players who possess the requisite agility to be recruited for college football.

A greater vertical jump has been related to superior performance during acceleration in field sports [16], and is a characteristic of more highly recruited USA high school football players [11]. When considering vertical jump height in collegiate football players, RB, WR, and DB tend to perform best [9]. This was also true in the current study (Table 3). OBF and DBF players were both significantly superior in vertical jump height when compared to the LM. Nonetheless, the vertical jump performance by college-recruited USA high school players was superior to junior Australian players [11]. Indeed, the lowest mean vertical jump found by Ghigiarelli [11] across the different positions, which was for offensive LM, was greater than 0.6 m. In the current study, only the RB had a mean vertical jump greater than 0.6 m (Table 3).

Vertical jump performance can be investigated further by estimating the power generated during the jump. Heavier players, such as LM, tend to generate more power as they need to overcome the inertia of their greater body mass [22]. This was the case in the current study, with LM generating significantly greater vertical jump power when compared to OBF and DBF players (Table 3). The mean power generated by all subjects (127.27 ± 22.68 $kg \cdot m \cdot s^{-1}$) was greater than competitive volleyball players (120.56 ± 31.72 $kg \cdot m \cdot s^{-1}$) [25], but less than Division I (211.9 ± 31.3 $kg \cdot m \cdot s^{-1}$) and Division II (193.5 ± 37.8 $kg \cdot m \cdot s^{-1}$) college football players [10]. Vertical jump performance, and by extension vertical power, requires improvement in Australian players. The standard set by collegiate football players is the level junior Australian players should strive for.

The standing broad jump has been related to maximum strength as measured by a one-repetition maximum squat and sprint acceleration over 20 yards in collegiate athletes [19]. Similar to the vertical jump, the best-performed positions in the standing broad jump were the RB, WR, LB, and DB (Table 3). There were no significant differences in the standing broad jump between the OBF and DBF players, and both groups were superior to the LM. RB were superior to, and LB were similar to, male collegiate athletes in the standing broad jump (2.53 ± 0.25 m and 2.32 ± 0.25 vs. 2.34 ± 0.59 m, respectively) [19]. When compared to college-recruited high school football players [11], the standing broad jump distance achieved by Australian players was lower across all positions. As per vertical power, horizontal power requires improvement in junior Australian players. Lower-limb power may be an area that requires specific conditioning in junior American football players from Australia.

The BOMBT was used to provide an assessment that incorporated upper body power [26]. When considering position groups (OBF, DBF and LM), the distance for the BOMBT was approximately 12 m (Table 3). The distances thrown were similar to those of male international volleyball players [17], and superior to those of teenage rugby union players [7]. To further investigate the BOMBT, distance was expressed relative to body mass [26]. The LM had a significantly lower relative BOMBT when compared to

OBF and DBF players (Table 3). This further illustrates that the power capacity of Australian LM needs development. Even though previous research has established that LM tend to score lower in tests of power [8, 11, 24], if relative power is too low this will adversely affect the ability to perform explosive movements. Seiler et al. [23] advocated that LM should attempt to bring their BMI closer to that of other players to improve their ability to execute explosive movements. However, lowering BMI too greatly may not be an option for LM, with research highlighting the body mass increases that have occurred for these players over the years [22]. Regardless, LM must ensure that their relative strength and power remain high.

CONCLUSION AND PRACTICAL APPLICATION

With the increase of international players within the USA college football system, it is imperative for football and strength and conditioning coaches to understand the physical conditioning of players recruited from international countries. This study should assist with the scouting and conditioning of any players recruited from Australia. Coaches of American football teams from Australian should aim to improve the speed, agility, and power capacities of their players. Increasing player size, especially through increases in lean body mass, is important for junior Australian players so that they may compete physically at a collegiate level. This is of particular importance for junior Australian LM. Part of what would contribute to the size differences are the sporting backgrounds of players from Australia, in that traditional forms of football played in Australia demand greater aerobic conditioning and reduced body mass to allow for greater movement capabilities. College football coaches and recruiters from the USA should be aware that a period of sport-specific conditioning may be required to prepare Australian players for the rigors of college football. Nonetheless, there were individual Australian players who attained tests scores similar to highly-ranked high school players by the college system. This indicates that there are Australian players who would be viable prospects for college football.

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