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Game movement demands and physical profiles of junior, senior and elite male and female rugby sevens players

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ABSTRACT

To inform recruitment, selection, training and testing of male and female rugby sevens players game running movement patterns and physical characteristics were quantified across junior, senior, and elite playing levels. Anthropometric and physical testing (40 m sprint, vertical jump, Yo-Yo IR1) occurred prior to players' national championships or international tournaments (n = 110 players), while game movements were obtained via GPS (n = 499 game files). The game movements of male players were similar across playing levels except for number of impacts >10 g which were 2 to 4-fold higher in elite (25.0 ± 11.2 impacts · game^{-1}; mean ± SD), than junior (6.3 ± 3.5) and senior (11.8 ± 6.6) players. In men, there were fewer substantial correlations between on- and off-field measures which may reflect similar physical attributes across playing levels, and that other (strength, technical or tactical) factors may better differentiate these players. In females, elite players had more favourable on- and off-field performance measures than juniors and seniors, with moderate to strong correlations between on- and off-field variables. Female players should benefit from additional fitness training, while male players need to balance fitness with other technical and tactical factors.

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KEYWORDS
Match analysis; football; player development; anthropometry; positional differences

Introduction

Studies in rugby league and rugby union have documented the anthropometric, physical and match demands of athletes at various playing levels (Coughlan, Green, Pook, Toolan, & O'Connor, 2011; Gabbett, Jenkins, & Abernethy, 2011; McLellan & Lovell, 2013; Smart, Hopkins, Quarrie, & Gill, 2011). This information is useful for player assessment, recruitment, selection, and prescription of training at higher representative levels. Research in men's rugby sevens has characterised players and the game at elite and provincial levels of competition (Higham, Pyne, Anson, & Eddy, 2012, 2013a; Ross, Gill, & Cronin, 2015a, 2015c; Suarez-Arrones, Nunez, Portillo, & Mendez-Villanueva, 2012b) but there is no data available on junior (under 18) male players. In female rugby sevens, the analysis of on- and off-field performance of players is predominantly in elite-level players (Clarke, Anson, & Pyne, 2015a; Clarke, Presland, Rattray, & Pyne, 2014; Suarez-Arrones, Nunez, Portillo, & Mendez-Villanueva, 2012a) with some research also comparing elite and provincial players (Clarke, Anson, & Pyne, 2015b; Portillo et al., 2014; Vescovi & Goodale, 2015).

Previous research in women's rugby sevens shows that international level players complete greater total and high-speed running distances during games compared to development players (Vescovi & Goodale, 2015), while elite male rugby sevens players have favourable anthropometric and physical qualities compared to provincial-level players (Ross et al., 2015c). Currently though, there is no data available on the game movements or physical profiles of junior male or female rugby sevens players. In rugby league and soccer, substantial game and physical differences are apparent between junior and senior players (McLellan & Lovell, 2013; Mujika, Santisteban, Impellizzeri, & Castagna, 2009), with a more pronounced gap in the women's performances (Mujika et al., 2009). Given the potential influence of playing level, and/or fitness to affect subsequent muscle damage and neuromuscular fatigue in players (Clarke et al., 2015b) understanding the differences between playing levels is worthwhile. Rugby sevens is a relatively new sport to the world stage, and it is possible that a large gap exists between junior and elite playing levels, especially for female players who anecdotally are coming from a wide array of sporting backgrounds, compared to males who would predominately come from rugby union, or possibly rugby league. Comparing differences between genders and the development changes across playing levels can help to direct specific training requirements needed as well as gain a greater understanding of the effect that other aspects of the game, such as playing history and training background can influence the physical progression and game movements of players across playing levels.

Anthropometric and physiological characteristics can influence the on-field performance of players in different codes of football. In men's rugby sevens, faster 10 and 40 m sprint times correspond (r = 0.32–0.51) to a greater number of line breaks, effective tackles made and defenders beaten during games (Ross, Gill, Cronin, & Malcata, 2015b). Similar relationships are evident in men's rugby union (Smart et al., 2011),

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rugby league (Gabbett et al., 2011) and Australian football (Young & Pryor, 2007). However, understanding whether anthropometric and physiological characteristics influence the running movement patterns of players is unclear. Relationships between anthropometric and physical assessments with game running movements (via global positioning systems, GPS) of rugby sevens players have yet to be established. Similarly, whether playing level or gender affect possible relationships between such measures is also uncertain.

The aim of this study was to quantify the game running movement patterns and the anthropometric and physical characteristics of male and female rugby sevens players across 3 tiers of playing levels (junior, senior, and elite). Relationships between game movements and anthropometric and physical assessments were also quantified.

Methods

Experimental approach to the problem

A cross-sectional study was conducted on rugby sevens players to quantify differences in game playing movements and physical measures across gender (male and female) and playing level (junior: <18 years, senior: >18 years competing in domestic competitions only, elite: >18 years contracted players competing for Australia in World Series). GPS data were collected during the Australian national rugby sevens championships, a 2-day tournament, for junior and senior players, and at 2 international World Series tournaments for elite players. Physical testing was completed approximately 4 weeks prior to the tournaments.

Subjects

Male and female rugby sevens athletes (n = 110) across 3 playing levels (junior, senior, elite) were involved in this study (Table 1). Ethics approval was obtained from the University of Canberra Committee for Ethics in Human Research and the Australian Institute of Sport Ethics Committee. After explanation of the study purposes, benefits and methods, written informed consent was provided by players or their parent/guardian prior to participating.

Procedures

Each tournament was completed over 2 consecutive days, with 3 games played each day. Junior and senior players finished their respective National Championships in the top 3 places, while elite players finished the 2014–15 Sevens World Series season in 3rd place (women) and 5th place (men). All on-field game movements were captured using GPS units (5 Hz SPI HPU, GPSports Systems, Canberra, Australia). These units are considered acceptable for use in team sports (typical error = <10% for speeds <20 km · h^{-1}, and 19% for speeds >20 km · h^{-1}) (Johnston, Watsford, Kelly, Pine, & Spurrs, 2014). For analysis, the half-time interval was excluded. Game files where players were involved in less than 7 min of game time were excluded to reduce the possible effect of substitutions (Higham et al., 2012). Once a player was substituted they did not return to the field that game. As such, the reported GPS data refers to when a player was on the field and the game was in play, irrespective of stoppages due to penalties or tries.

In total, 499 game files were obtained (junior men n = 88, junior women n = 83, senior men n = 68, senior women n = 90, elite men n = 81, elite women n = 89). Game variables analysed include total distance (m), max speed (m · s^{-1}), max acceleration (m · s^{-2}), number of impacts >10 g (n), relative total distance (m · min^{-1}), total (m) and percent (%) distance covered above 3.5 m · s^{-1}, total (m) and percent (%) distance covered >5 m · s^{-1}, total (m) and percent (%) sprint distance, and mean sprint duration (s). Distance covered above 3.5 m · s^{-1} is potentially a better measure of "high intensity" for women than the commonly used 5 m · s^{-1} threshold (Clarke et al., 2015a). Sprint distance was determined as the distance covered while accelerating >2.0 m · s^{-2} for longer than 1 sec (Higham et al., 2012). The use of GPS-derived impacts >10 g has not yet been validated, however, was included in this study on the basis of manufacturer recommendations and an earlier study (Gabbett, 2013).

Table 1. Anthropometric characteristics and physical testing results of male and female rugby sevens players at different playing levels. Data presented as mean ± SD.

	Men			Women		
	Junior (n = 22)	Senior (n = 18)	Elite (n = 13)	Junior (n = 24)	Senior (n = 22)	Elite (n = 11)
Anthropometry						
Height (m)	1.82 ± 0.08	1.81 ± 0.05	1.84 ± 0.07†	1.64 ± 0.07	1.70 ± 0.07‡	1.69 ± 0.02
Mass (kg)	81.9 ± 7.1	88.5 ± 10.2‡	92.0 ± 6.9†	63.6 ± 11.8	70.4 ± 9.3‡	68.6 ± 4.4
Sum7 (mm)	65 ± 20	56 ± 13$^{-†}$	48 ± 6$^{-†}$	115 ± 28	89 ± 20$^{-‡}$	67 ± 14$^{-§}$
LMI (mm · kg^{-14})	46.1 ± 3.7	51.2 ± 6.2§	53.8 ± 4.1†	28.4 ± 4.3	32.9 ± 3.8‡	33.7 ± 2.4
Physical testing						
10 m split (s)	1.67 ± 0.06	1.72 ± 0.07‡	1.76 ± 0.06†	1.88 ± 0.09	1.82 ± 0.06$^{-‡}$	1.76 ± 0.05$^{-‡}$
40 m split (s)	5.18 ± 0.20	5.21 ± 0.17	5.14 ± 0.16$^{-†}$	6.00 ± 0.28	5.79 ± 0.17$^{-‡}$	5.50 ± 0.16$^{-§}$
30–40 m split (s)	1.13 ± 0.06	1.11 ± 0.02$^{-†}$	1.10 ± 0.04	1.36 ± 0.08	1.29 ± 0.04$^{-‡}$	1.22 ± 0.05$^{-§}$
Final velocity (m · s^{-1})	8.88 ± 0.48	9.03 ± 0.17†	9.13 ± 0.32	7.39 ± 0.41	7.77 ± 0.26‡	8.23 ± 0.34§
Initial momentum (kg m · s^{-1})	492 ± 49	512 ± 62	523 ± 46	341 ± 52	393 ± 47‡	390 ± 27
Final momentum (kg m · s^{-1})	730 ± 67	800 ± 97‡	840 ± 62	474 ± 71	556 ± 75‡	565 ± 42
Vertical jump (cm)	62.2 ± 9.7	60.3 ± 6.1	65.8 ± 9.3‡	43.3 ± 5.0	47.4 ± 5.5‡	49.6 ± 3.8†
Yo-Yo IR1 (m)	1645 ± 362	1895 ± 423‡	2351 ± 371‡	836 ± 323	1058 ± 249‡	1702 ± 329§

†small effect size; ‡moderate effect size; §large effect size; Substantial differences between junior and senior players shown in senior column, differences between senior and elite players shown in elite column. Negative sign present when junior > senior, or senior > elite players. Sum7, sum of seven skinfold sites; LMI, lean mass index; Yo-Yo IR1, Yo-Yo intermittent recovery test level 1.

Physical measures of height, body mass, and sum of 7 skinfold sites were collected by the same ISAK-accredited anthropometrist (coefficient of variation (CV) = 3%). Lean mass was calculated as body mass/sum of 7 skinfolds^x, where x = 0.17 for women and 0.14 for men (Duthie, Pyne, Hopkins, Livingstone, & Hooper, 2006). Players' sprinting ability was measured over 40-m, with splits at 10- and 30-m, starting 30 cm behind the start line, using infra-red lightgates (CV = 8%, Fusion Sport, Brisbane, Australia). Players were given three attempts and the best time (and associated splits) reported. The 30–40 m split time was used to calculate max velocity ($m \cdot s^{-1}$), which was then multiplied by players' body mass to obtain a measure of momentum ($kg\ m \cdot s^{-1}$). Lower body power was measured via a vertical jump test (CV = 2%, Vertec, Swift Performance Equipment, Queensland, Australia). Players were given 3 attempts to reach maximal height (best attempt reported). The Yo-Yo IR1 (m) was used as a measure of aerobic fitness (CV = 4.9%) (Krustrup et al., 2003), and was completed following all other tests. Some individuals did not complete 1 or more of the physical tests due to injury or unavailability. Given the large variation in ability across groups, a common strength test was not deemed appropriate for this study.

Statistical analysis

Descriptive data are presented as mean ± SD. Raw data were log-transformed prior to analysis using inferential statistics. Data were analysed across playing levels (within gender), between gender (within playing levels), and between playing positions (within playing levels and gender). Standardised mean changes (Cohen's effect size, ES) were used to characterise the magnitude of difference using the following criteria: ES < 0.2 trivial; 0.2–0.6 small; 0.6–1.2 moderate; 1.2–2.0 large; 2.0–4.0 very large; >4.0 extremely large (Hopkins, Marshall, Batterham, & Hanin, 2009). Confidence limits (CL) were set with 90% precision of estimation. Differences were deemed unclear if the ES simultaneously crossed the threshold of ±0.2. Pearson's product–moment correlations were used to assess the relationship between game movement patterns and anthropometric and physical assessments of male and female players across all playing levels combined. Correlations (r-values) were interpreted against the following criteria: r < 0.1 trivial; 0.1–0.3 small; 0.3–0.5 moderate; 0.5–0.7 large; 0.7–0.9 very large; >0.9 almost certain (Hopkins et al., 2009). Confidence intervals (CI) were set with 99% precision of estimation. When the CI of effects simultaneously crossed the threshold of ±0.1 the association was deemed unclear.

Results

Anthropometric characteristics

The anthropometric characteristics of players are presented in Table 1. Across all playing levels male forwards were taller (3–6%, ~0.88, ±0.66; range, ES, ±90% confidence limits), heavier (7–21%, ~1.34, ±0.85), and had greater lean mass (8–20%, ~1.40, ±0.95) than backs. Skinfold thickness was similar between positions at each playing level. Female forwards (junior and senior) were moderately taller (4–5%, ~1.00, ±0.64), heavier (20–25%, ~1.88, ±0.86), had higher skinfolds (20–40%, ~1.28, ±0.65) and greater lean mass (16–18%, ~1.71, ±0.92). At the elite level, only mass was largely greater in forwards (9%, 1.48, ±1.38).

Physical testing results

Table 1 shows the physical testing results of male and female rugby sevens players. Males had better anthropometric and physical testing scores than females within each playing level (ES = 1.83–5.10), except for 10-m sprint time at an elite level (−0.07, ±0.58). Only 2 senior male players who completed physical testing were identified as a back, and so comparison between playing positions at the senior level was not possible. Junior and elite male backs were moderately faster (40-m) than forwards (3%, 0.80, ±0.83), while elite forwards also had better Yo-Yo IR1 performance (forwards, 2504 ± 241 m; backs, 2255 ± 419 m). Vertical jump, 10 m sprint and player momentum did not differentiate playing position at either level for men. Junior female backs were substantially fitter, faster and more powerful (ES = 0.89–1.78) but with lower running momentum (2.06, ±1.10) than forwards. No substantial differences between playing positions were apparent for senior women, while in elite women, backs were ~4% faster in 10-m and 40-m sprint times (1.30, ±0.77).

Game movement patterns

Mean game movement patterns of male and female players are presented in Table 2 and Table 3, respectively. Within each playing level, game movements of male players were substantially higher than females (~13–60%, ES = 0.43–2.99, small to very large), except for total distance (senior and elite level) and relative total distance (senior level). The greatest differences in each playing level between genders were distance covered >5 $m \cdot s^{-1}$, sprint distance and impacts >10 g.

Positional differences in game movement patterns were most apparent in junior women compared to any other group. Junior female backs covered greater movements

Table 2. Mean game movement patterns of male rugby sevens players across playing levels. Data presented as mean ± SD.

	Junior (n = 22)	Senior (n = 18)	Elite (n = 14)
Total distance (m)	1213 ± 221	1176 ± 259	1249 ± 348
Relative total distance ($m \cdot min^{-1}$)	103 ± 8	101 ± 9	103 ± 9
Max speed ($m \cdot s^{-1}$)	8.51 ± 0.76	8.68 ± 0.56	8.70 ± 0.99
Max acceleration ($m \cdot s^{-2}$)	3.64 ± 0.36	3.85 ± 0.47†	4.02 ± 0.50
Impacts >10 g (n)	6.3 ± 3.5	11.8 ± 6.6‡	25.0 ± 11.2*
Distance >3.5 $m \cdot s^{-1}$ (m)	440 ± 102	439 ± 93	483 ± 172
Distance >3.5 $m \cdot s^{-1}$ (%)	36.0 ± 5.2	37.6 ± 6.0	37.7 ± 5.8
Distance >5 $m \cdot s^{-1}$ (m)	182 ± 53	189 ± 41	201 ± 79
Distance >5 $m \cdot s^{-1}$ (%)	14.9 ± 3.4	16.3 ± 4.6†	15.6 ± 4.2
Sprint distance (m)	184.3 ± 52.4	224.3 ± 46.1‡	223.2 ± 104.7
Sprint distance (%)	15.2 ± 3.0	19.3 ± 4.2‡	16.9 ± 4.3‖
Mean sprint duration (s)	3.9 ± 0.6	3.9 ± 0.9	4.2 ± 1.6

†small effect size, junior < senior players.
‡moderate effect size, junior < senior players.
‖moderate effect size, senior >elite players.
*large effect size, senior < elite players.

Table 3. Mean game movement patterns of female rugby sevens players across playing levels. Data presented as mean ± SD.

	Junior (n = 22)	Senior (n = 21)	Elite (n = 11)
Total distance (m)	1060 ± 318	1099 ± 228	1078 ± 197
Relative total distance ($m \cdot min^{-1}$)	90.9 ± 8.1	98.2 ± 12.4‡	85.8 ± 3.9‖−
Max speed ($m \cdot s^{-1}$)	7.08 ± 0.83	7.40 ± 0.52†	8.05 ± 0.55‖+
Max acceleration ($m \cdot s^{-2}$)	3.18 ± 0.43	3.31 ± 0.41†	3.49 ± 0.38§
Impacts >10 g (n)	4.9 ± 2.6	10.2 ± 7.1‡	12.6 ± 4.7§
Distance >3.5 $m \cdot s^{-1}$ (m)	289 ± 117	330 ± 97†	323 ± 87
Distance >3.5 $m \cdot s^{-1}$ (%)	27.0 ± 6.7	29.8 ± 5.2†	29.7 ± 3.4
Distance >5 $m \cdot s^{-1}$ (m)	89 ± 52	102 ± 44†	120 ± 41§
Distance >5 $m \cdot s^{-1}$ (%)	8.3 ± 4.2	9.2 ± 2.9†	11.0 ± 2.7§
Sprint distance (m)	93.8 ± 47.4	126.9 ± 42.9†	148.6 ± 39.1§
Sprint distance (%)	8.9 ± 4.1	11.6 ± 3.3†	14.2 ± 2.8§
Mean sprint duration (s)	3.5 ± 1.0	4.2 ± 1.7†	4.1 ± 0.44

†small effect size, junior < senior players.
‡moderate effect size, junior < senior players.
§small effect size, senior < elite players.
‖moderate effect size; − senior > elite, + senior < elite players.

compared to forwards for all GPS measures (7–56%, ES = 0.81–3.06, moderate to very large). Total distance, distance >3.5 $m \cdot s^{-1}$ and distance >5 $m \cdot s^{-1}$ were also small to moderately greater in senior female backs (0.56–1.09), while at an elite level there were no positional differences. For male players, junior backs had small to moderately greater max speed, distance >5 $m \cdot s^{-1}$, sprint distance, and number of impacts >10 g (10–20%). Senior male backs obtained a moderately greater number of impacts >10 g per game (1.05 ± 0.88), while elite backs had greater max acceleration (1.38, ±1.44). No other differences were apparent in male players.

Correlation between on- and off-field measures

Correlations between game running movements and Yo-Yo IR1, 10 m sprint and skinfold thickness are presented in Figure 1. Relative total distance did not correlate substantially with any measure, except for age in women (r = 0.32, −0.04 to 0.60, 99% confidence interval). Overall, there were a greater number of positive correlations between on- and off-field measures for females. Age positively correlated with number of impacts >10 g, relative and absolute total distance, sprint distance and max acceleration (r = 0.27–0.53) in females. Player mass had negative correlations with max speed, max acceleration, total distance and distance >3.5 $m \cdot s^{-1}$ (r = ~0.33 ± 0.30). Sprint time (40 m) negatively correlated with all on-field movements (r = −0.42 to −0.71) except was unclear for absolute and relative total distance covered. Vertical jump correlated positively with max speed, sprint distance, distance >5 $m \cdot s^{-1}$ and impacts >10 g (r = 0.39–0.50). In male players, 40-m sprint time negatively correlated with max speed, max acceleration and distance >5 $m \cdot s^{-1}$ (r = −0.35 to −0.61) while vertical jump performance correlated positively with max speed and acceleration only (r = ~0.39, −0.03 to 0.70). Age and LMI moderately correlated with impacts >10 g and sprint distance (r = ~0.40, 0.09 to 0.72), while player mass and momentum correlated positively with sprint distance

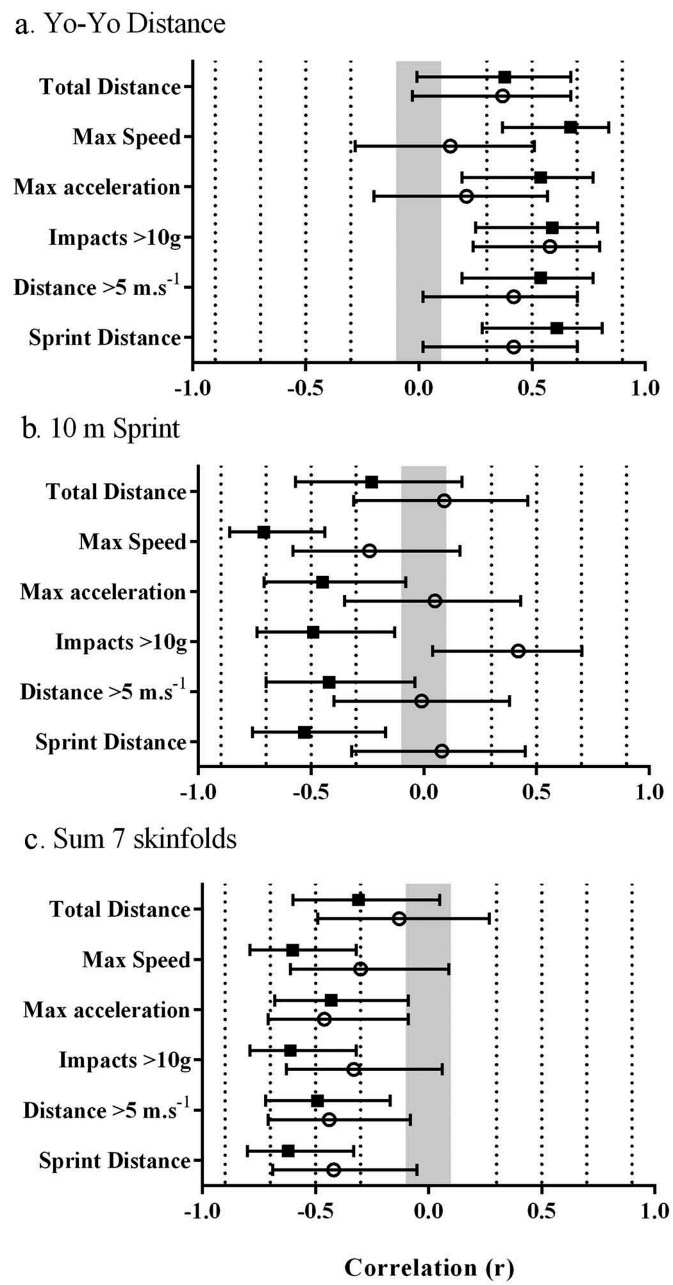

Figure 1. Correlation between on-field running measures and (A) Yo-Yo distance, (B) 10 m sprint time, and (C) Sum of seven skinfold thickness, in women (squares) and men (circles). Data presented with 99% confidence interval. Correlations are unclear when they cross over the grey area at ±0.1. Dotted lines represent the thresholds for small (0.1–0.3), moderate (0.3–0.5), large (0.5–0.7), very large (0.7–0.9) and almost certain (>0.9).

(r = ~0.32, −0.10 to 0.67). No other substantial correlations were observed in male players.

Discussion

This is the first study to characterise the game movements and anthropometric and physical attributes of male and female rugby sevens players across different playing levels. The number of impacts >10 g per game was the main difference in male players across playing groups, likely related to their larger size and more physical style of play. For females, there were moderate to large on- and off-field differences from junior to senior and elite level. Correlational analysis showed that, for females, superior physical fitness is beneficial for on-field performance, while in men it is harder to discriminate playing levels using fitness tests, possibly as a result of greater emphasis on aspects not covered in this study such as strength, power, technical or tactical ability.

Elite female players in this study completed on-field movements slightly below (~30% less total distance, ~14% lower relative total distance, but equivalent % distance >5 $m \cdot s^{-1}$) previous reports (Portillo et al., 2014; Suarez-Arrones et al., 2012a). These differences likely reflect match-to-match variation, team tactics, and potential differences in the standard of competition. While considered of national level standard (Portillo et al., 2014; Suarez-Arrones et al., 2012a) the games reported were not part of the current Women's Sevens World Series, and may not represent the top level competition available to female players. Differences in what is termed an elite-level are likely related to the emerging stage of women's rugby sevens. With time, the evolution of women's rugby sevens will likely see distinct competition standards emerge, making it easier to delineate and differentiate playing levels. Senior female players covered similar game movements compared to another study on senior players (Portillo et al., 2014). No data is currently available on male and female junior level rugby sevens game movements or physical and anthropometric characteristics. No data exists for the physical and anthropometric characteristics of senior (non-elite) female players either. In elite females, similar anthropometric and physical results have been reported previously (Agar-Newman, Goodale, & Klimstra, 2015; Clarke et al., 2015a, 2014; Goodale, Gabbett, Stellingwerff, Tsai, & Sheppard, 2015). The game movement patterns of male rugby sevens players reported here are similar to data on elite (Granatelli et al., 2014; Higham et al., 2012; Ross et al., 2015a) and senior (provincial) level players (Suarez-Arrones et al., 2014, 2012b). The physical attributes of elite male players has been well characterised (Higham, Pyne, Anson, Dziedzic, & Slater, 2014; Higham et al., 2013a; Rienzi, Reilly, & Malkin, 1999; Ross et al., 2015c, 2015b), with some studies incorporating players at provincial/national level (Ross et al., 2015b, 2015c) and report similar outcomes to the current study.

At higher levels of male rugby sevens, the major difference is the greater number of severe impacts (>10 g) that players experience. This difference is likely related to the higher total and lean mass of players at the higher playing levels. However, when comparing positions within each playing level, junior and senior backs, who are shorter, lighter and have less lean mass, actually experienced a greater number of impacts >10 g. At an elite level, while backs were lighter and leaner than their forward counterparts, a similar number of severe impacts were observed between positions. Backs run at higher speeds before contact and therefore may exhibit higher collision impact ratings (Coughlan et al., 2011), however, positional differences in the number of impacts are unclear at elite (Higham, Pyne, Anson, Hopkins, & Eddy, 2013b) and provincial (Suarez-Arrones et al., 2014) men's rugby sevens. In saying this, however, GPS-derived impact ratings are yet to be validated and their reliability in different game and training settings is unclear. Tackle technique, body position running into contact, and team tactics may all play a role in differences observed between teams and individuals. Potentially, at sub-elite levels backs may be more proficient ball players than forwards and simply have more game involvements.

Unexpectedly, total distance, relative total distance and max speed did not differ substantially across playing levels for males despite differences in players' aerobic fitness and sprinting ability. Studies in men's rugby league (McLellan & Lovell, 2013) and Australian Football (Veale, Pearce, & Carlson, 2007) have successfully differentiated playing level by players' max speed, and total and relative distances covered during games. Although game movements were similar, the senior and elite players had moderately greater aerobic fitness (Yo-Yo IR1) and a slower 10-m sprint time. Likely, the greater aerobic fitness of players has a larger effect on maintaining performance following peak work periods within a game, across halves, or between games within a tournament. However, these scenarios were not addressed directly in this study and warrant investigation. Slower 10-m sprint performance, but similar or faster 40-m sprint time at higher playing levels, shows sprinting ability over longer distances likely dominates over short sprint ability in men's rugby sevens given the large amount of space available to players with typical sprint distances of 20–40 m (Suarez-Arrones et al., 2014, 2012b). The off-field anthropometric and physical qualities of players reported in this study do not seem to substantially influence the on-field movements of players. However, other measures (not reported) may be of greater importance (e.g., upper and lower body strength and power). Where male players have been involved in rugby-specific training, including strength and conditioning programmes, for a number of years, the physical qualities of players are similarly developed and other factors such as technical or tactical proficiency may better discriminate players across playing levels. Understanding the nature and contribution of these other qualities will promote the development of male rugby sevens players for representative opportunities.

On- and off-field performance measures in female rugby sevens players improve at higher playing levels, while the magnitude of positional differences declines. Presumably, at a young age players are characterised as either a forward or back based on their physical size and speed qualities, however, with elite training, this difference is minimised and other factors such as ball skills, tackling ability and tactical awareness may become the differentiating factors between positions. This scenario is somewhat different to the men where some positional differences remain substantial right up to the elite level, albeit less apparent than at the junior level. These variations may be related to gender differences in game play, as a result of individual team variation in game and training methods, or from the influence of the coach on team selection. Unclear or small differences have been observed between playing positions in women's (Agar-Newman et al., 2015) and men's (Granatelli et al., 2014; Higham et al., 2013b; Suarez-Arrones et al., 2014) rugby sevens. Consequently, the need for individualising training based on rugby sevens position remains debateable. Despite the lack of positional differences, the game demands and fitness characteristics documented here for each playing level in women's rugby sevens informs player development for upcoming tournaments and future representative aspirations. Likely, there are other subtleties that discriminate positions in rugby sevens and warrant further assessment to enhance the specialisation of players.

Correlations between fitness tests and game movements in female players show that general athletic ability is beneficial for game performance. In men, however, fewer relationships between on- and off-field measures were apparent. Similar to our study, Mujika et al. (2009) reported large correlations between physical tests for female, but not male, soccer players and deemed some tests more appropriate to discriminate female players (e.g., vertical jump) but not males. Given the moderate to large correlations for the majority of on- and off-field measures in female players, those who are generally more athletic will likely perform well in rugby sevens at all levels of competition. For example, female squad players chosen for international representation (and greater game time) had 5–10% better aerobic capacity and strength characteristics than those not selected (Goodale et al., 2015). However, given women's rugby sevens is still a relatively new sport there is likely to be substantial growth and development in this game over the coming years. With the recent inclusion of the Women's World Series, already there has been an increase in the professionalisation of women's rugby sevens in a number of countries. While it is desirable for players to have well-developed physical attributes, as the game evolves more rugby-specific elements will likely be required for players to progress to higher levels of competition. Differences between the genders may be a result of the non-specialisation of upcoming female players (or the early specialisation of male players to rugby union/sevens). Other variables which are more rugby-specific (strength/power, tackling ability, tactical awareness) may have a better relationship with game movement patterns and other on-field measures such as line breaks, tackles made and defenders beaten. As women's rugby sevens continues to develop, the requirements of female players to perform successfully will most likely evolve to a combination of fitness and specific rugby-related attributes.

While most game running movements were substantially correlated with at least one anthropometric or physical characteristic, relative running distance ($m \cdot min^{-1}$) did not correlate with any measure, nor could it differentiate playing levels for men or women. Provincial and elite-level male rugby sevens players have similar results (Higham et al., 2012). In rugby sevens, with so much field space available per player, relative running distance may not be sensitive enough to differentiate standards of play. Instead of observing relative running distance over a whole game, peak relative running distance over shorter game intervals (e.g., a 2 min period) or metabolic power may be used as more discriminating measures (Furlan et al., 2015).

Throughout this study it is assumed that greater game movements result in a more positive outcome for a game. While specific events (e.g., scrum, line out, turnovers) and their effect on point scoring has been quantified in men's rugby sevens (Higham, Hopkins, Pyne, & Anson, 2014), understanding whether greater total or high-speed running distances covered is beneficial to a team is yet to be addressed. More successful teams in Australian football actually perform less high intensity running during games (Wisbey, Rattray, & Pyne, 2009). Similarly, female rugby sevens players having comparable game movements to male players is not necessarily desirable either. Given absolute strength and power differences between genders, a successful performance for one gender may require a different set of skills, techniques and tactics. This has previously been shown in the differences between successful penalty shots in international level men's and women's hockey (Mosquera, Molinuevo, & Román, 2007). Coaching staff also have a major influence over the type of player recruited and selected for tournaments, specific skills and physical qualities trained, and the type of game played within all playing levels. Future studies should address measures of upper and lower body strength as well as objective ratings of tackle technique and tactical decision-making, and observe their influence on the on-field performance both through running movements (GPS) and performance metrics (i.e., line breaks, tackles made etc.) in male and female players.

Conclusion

This study provides comprehensive analysis of the match demands of rugby sevens for different playing levels and genders. These data can be used to prescribe training specific to the demands of competition and develop players for higher representative levels. General physical testing of athletic ability seems appropriate for female players at all playing levels. For male players, physical testing outside of those performed in this study, particularly around strength and power characteristics, as well as measuring technical and tactical ability, may better differentiate players for improving rugby sevens performance.

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