Anthropometric and Physical Positional Differences in International Level Female Sevens Athletes

by

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Supervisory Committee

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Dr. David Docherty
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Abstract

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The purpose of this study was to profile international level female sevens athletes and determine if anthropometric and physical qualities are able to differentiate between backs and forwards.

Twenty-four subjects with a mean (±*SD*) age of 22.75±3.99 years and body weight of 69.36±5.21kg were sampled from the national team training program. Anthropometric measures (height, body mass and sum of 7 skinfolds) and performance measures (power clean, front squat, bench press, neutral grip pull up, 40m sprint and 1600m run) were collected across the 2013-2014 centralized period and compared across playing position.

Thirteen backs (mean age±*SD*= 21.28±3.54 years) and eleven forwards (mean age±*SD*= 24.47±3.95 years) had significant differences in body mass (66.40±3.48kg vs. 72.87±4.79kg) and initial sprint momentum (366.81±19.83kg*m/s vs.399.24±22.42*m/s). However no other measures showed positional differences. It is possible that the lack of positional differences in female rugby sevens is due to the multifarious physical requirements of a sevens player, leading

to a generic player profile or perhaps due to a lack of selective pressure. It is also possible that the anthropometric and physical qualities measured in this study lacked the necessary resolution or failed to capture the unique attributes of each position.

In conclusion, this is the first research profiling international level female sevens athletes. The normative data presented within this paper highlights the physical requirements of female sevens athletes for strength and conditioning practitioners. In addition, the lack of positional differences discovered should impact training program design.

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Acknowledgements

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Chapter 1: Introduction

Identifying the key variables responsible for successful performance is essential when developing elite athletes. It is therefore common practice to quantify physical and anthropometric attributes of elite athletes to determine which factors appear to most readily define success. Anthropometric measures (AM) often monitored are body mass, standing height and sum of seven skinfolds. Physical qualities (PQ) assess the physical capacity and capabilities of the athletes which may define their ability to cope with the demands of their sport. For example, in sevens rugby (sevens) athletes are required to sustain high work rates and recover from repetitive sprints (Suarez-Arrones, Nunez, Portillo, & Mendez-Villanueva, 2012), justifying the measurement of sprinting ability and aerobic power. Furthermore, high levels of strength and power are necessary for accelerating, scrummaging and rucking, justifying measures of lower and upper body strength and power. Therefore, based on the theoretical relationships between sport ability, AM and PQ it is assumed that the development of normative AM and PQ data could assist in player development, guiding athletes' training and assisting coaches in team selections. Differences in AM and PQ have been noted not only between sports (Gabbett, 2007; Khosla & McBroom, 1985), but across levels of performance and position (Gabbett, Kelly, Ralph, & Driscoll, 2009). Therefore, it is important to investigate which AM and PQ are appropriate for each playing position and level of performance in a given sport. In studies of rugby league, AM and PQ have been shown to indicate differences in playing levels such as novice/elite and between team members such as starters/non-starters (Gabbett et al., 2009; Gabbett, Jenkins, & Abernethy, 2011; Till et al., 2011). Furthermore, AM and PQ measures have been shown to impact positional roles (forwards and backs) across varying codes of rugby, such as rugby union and rugby league (Comfort, Graham-Smith, Matthews, & Bamber, 2011; Duthie, Pyne, & Hooper, 2003; Gabbett, 2000; Gabbett, 2005; Gabbett, 2006; Gabbett, 2007). However it is important to note that the majority of these studies were performed on male rugby players.

While rugby league and rugby union have received the greatest attention in the literature, sevens rugby has received minimal focus despite a growing global profile over the last ten years (International Rugby Board, 2012). A popular variant of rugby union, sevens follows the Laws of Rugby Union and is played on a standard sized rugby pitch, however only seven players are allowed on the field at a time compared to fifteen in rugby union. In addition the sevens game consists of two seven minute halves with a one minute break at half-time which is substantially shorter than the two forty-minute halves played in rugby union. An exception to the typical sevens game length is a tournament finals, which consist of two ten minute halves with a two minute break at half-time. Due to the shorter game length and lack of defenders, sevens is a running dominant game consisting of high intensity bouts, such as sprinting and tackling, separated by low intensity activity such as jogging and walking (Suarez-Arrones et al., 2012). These games usually take place in a tournament format with each team playing multiple games in a single day. With its increasing popularity (International Rugby Board, 2012), and competitiveness, sevens was recently included in the 2016 Rio de Janeiro Olympics. This inclusion has led to a “professionalization” of the game with many nations, such as Canada, providing financial stipends and physical training to their top players. However, there has been very little published research on this rapidly growing sport. Furthermore in women's sevens, only one study has investigated AM and critical power (Clarke, Presland, Rattray, & Pyne, 2013). Using the Australian Rugby Sevens National team, Clarke et al. collected a limited number of AM and PQ (refer to Table 1) to "compare field-based critical velocity running tests to routine laboratory and field-based tests of aerobic fitness." Clarke et al. determined that a critical velocity test is an appropriate aerobic fitness test yielding results similar to the Yo-Yo Intermittent recovery test, however they cautioned that the results cannot be used interchangeably.

Table 1. *Select Anthropometric & Performance Measures*

n	Age (y)	Body Weight (kg)	Height (m)	Sum of 7	$vV0_2$ (m/s)
22	25±5	69±7	1.68±0.06	85±15	3.7±0.3

Note. Select results from Critical Velocity as a Measure of Aerobic Fitness in Women's Rugby Sevens (Clarke, Presland, Rattray & Pyne, 2013)

Due to the limited research on the sevens variant of rugby, specifically using female athletes, the purpose of this study is to describe and compare the AM and PQ of international level female sevens players. We hypothesize that the AM and PQ will reflect similar trends noted in men`s rugby. Specifically we believe that AM and PQ will differ between positional groups when divided by backs and forwards. Furthermore, based on pilot data we believe that international level female sevens players will be both faster and leaner than previously reported in elite female rugby league players (T. J. Gabbett, 2007) and rugby union players (Hene, Bassett, & Andrews, 2011).

Due to the limited research performed on female sevens rugby, a causal comparative design will be used. In order for this study to proceed a number of assumptions must be made. First players will perform to the best of their ability during the performance testing, and second, the menstrual cycle will not influence performance testing (Rechichi & Dawson, 2009). Furthermore, as this study is using international level athletes, the PQ are limited to non-invasive field tests consisting of movements typically performed as part of their daily training. Lastly due to the lack of research on rugby sevens and specifically female rugby sevens, this study has been delimited to female sevens athletes.

This research study will provide a baseline for further female rugby sevens research to build upon. In addition, this research will provide a greater understanding to what differentiates international level playing positions in women's sevens. Lastly, this research will aid in the development of performance standards for the Canadian Women's Sevens Rugby Team.

Chapter 2: Literature Review

A number of studies have been conducted in rugby league investigating the relationships between AM, PQ, playing level (novice, elite) (Gabbett et al., 2011; Gabbett et al., 2009; Till et al., 2011) and positional role(Comfort, Graham-Smith, Matthews, & Bamber, 2011; Duthie, Pyne, & Hooper, 2003; T. J. Gabbett, 2000, 2005, 2006, 2007). The AM variables most often examined are body mass, skinfolds and height while the PQ include lower body power, speed and strength. It has been postulated that AM and PQ could be used to differentiate elite and sub-elite performers and possibly influence personnel decisions (Gabbett et al., 2011).

Unfortunately the majority of rugby research is often limited to rugby league and male rugby league players. Further, difference in testing equipment, conditions and populations complicate the generalizability of results. The following literature review aims to summarize the most recent research on AM and PQ in rugby, identify conflicts in the findings and identify areas for future research in rugby.

ANTHROPOMETRIC MEASURES

Human body measurements such as height, weight and body fat are considered to be AM. AM allow for the development of comprehensive anthropometric profile of the athlete. Furthermore these measurements can be taken for a variety of purposes such as: “monitoring athletes, tracking growth, development, aging and motor performance” (Society for the Advancement of Kinanthropometry, 2001). The AM discussed here will be Body Mass, Height and skinfold testing (bodyfat).

Body Mass. Rugby is considered a collision sport and therefore many studies have included body mass in their investigations (Baker & Newton, 2008; Duthie et al., 2003; Gabbett, Jenkins, & Abernethy, 2010; Gabbett, Kelly, & Pezet, 2008; Gabbett, 2000, 2002, 2005, 2006, 2007; Gabbett et al., 2009; Till et al., 2011). Quarrie and Wilson (2000) noted a high correlation between body mass and scrummaging force; which is logical as muscle strength is proportional to the muscles cross sectional area (Maughan, Watson & Weir, 1983). Numerous studies performed by Gabbett and colleagues have quantified anthropometric measures of rugby league players (refer to Table 2 for positions).

Table 2. *Rugby League Positions*

Position Number	Position	Positional Category	Gabbett's Positional Groups
1	Full Back	Backs	Adjustables
2	Right Wing Threequarter	Backs	Outside Backs
3	Right Centre Threequarter	Backs	Outside Backs
4	Left Centre Threequarter	Backs	Outside Backs
5	Left Wing Threequarter	Backs	Outside Backs
6	Stand-off Half or Five-eighth	Backs	Adjustables
7	Scrum Half	Backs	Adjustables
8	Prop	Forwards	Hit Up Forwards
9	Hooker	Forwards	Adjustables
10	Front Row Forward	Forwards	Hit Up Forwards
11	Second Row Forward	Forwards	Wide-Running Forwards
12	Second Row Forward	Forwards	Wide-Running Forwards
13	Lock Forward	Forwards	Wide-Running Forwards

Note. Positions taken from *Rugby League Laws of the Game* (2013); Gabbett's positional groups taken from *Physical Demands of Professional Rugby League Training and Competition Using Microtechnology* (2010)

Gabbett’s 2005 study, found that in junior rugby, league props were significantly heavier than half backs and wings (refer to Table 3 for the full results). Similar positional differences in body mass have also been noted in elite junior players, with hit-up forwards weighing significantly more than adjustables and outside backs (T. Gabbett et al., 2009). The differences in the body mass of the players examined in Gabbett’s 2005 study and Gabbett et al.’s 2009 study can partially be explained by the different ages of the players examined. Gabbett’s 2005 study was conducted primarily on 17 year olds, whereas his 2009 study was conducted primarily on 16 year olds. The trend of heavier forwards continues when examining the senior ranks with sub-elite hit-up forwards being heavier than both adjustables and outside backs (T. J. Gabbett et al., 2008). This trend was also observed in Gabbett’s 2006 study on sub-elite rugby

Table 3. *Anthropometric characteristics of specific individual positions in junior rugby league players*

Position	Height (cm)	Body mass (kg)	Sum of skinfolds (mm)
Prop	183.9 (182.1 to 185.7)*	101.1 (97.5 to 104.8)*	72.0 (64.8 to 79.2)*
Hooker	171.9 (171.1 to 172.7)	69.9 (66.5 to 73.2)†	5.9 (31.3 to 40.5)
Second row	176.8 (175.3 to 178.2)	83.6 (80.4 to 86.9)	39.5 (36.1 to 42.9)
Lock	176.7 (174.3 to 179.1)	74.8 (70.1 to 79.5)	33.7 (28.9 to 38.5)
Halfback	170.6 (168.1 to 173.2)†	9.1 (66.3 to 72.0)†	40.9 (38.1 to 43.8)
Five-eighth	176.3 (174.4 to 178.1)	72.0 (65.5 to 78.5)	24.7 (23.7 to 25.8)
Centre	176.7 (175.6 to 177.9)	79.6 (76.1 to 83.0)	34.8 (30.9 to 38.7)
Wing	176.4 (175.0 to 177.7)	72.9 (70.2 to 75.5)†	30.7 (28.3 to 33.1)
Fullback	177.1 (175.5 to 178.7)	78.8 (73.4 to 84.2)	36.2 (32.0 to 40.4)

Note: Data is expressed as means (95% CI). *Significantly different ($p<0.05$) from all other positions; †significantly different ($p<0.05$) from second row; ‡significantly different ($p<0.05$) from fullback; [s]significantly different ($p<0.05$) from hooker. (Gabbett, 2005)

league players with props being significantly heavier than all other positions. Unfortunately there has been only one published study on female Rugby League (Gabbett, 2007) players and another on Rugby Union (Hene et al., 2011) but a similar trend emerged with forwards were significantly heavier than backs. The trend noted across the preceding studies of heavier forwards compared to backs makes sense due to the increased role of collisions and scrummaging across the forward positions (Gabbett, Jenkins & Abernethy, 2011)

Increased body mass may also play a role in determining playing level. A number of studies have been conducted comparing starters and non-starters or sub-elite and elite rugby league players (Baker & Newton, 2008; T. J. Gabbett, 2002, 2007; T.J. Gabbett et al., 2009; Till et al., 2011). Typically elite players are heavier than sub-elite players. Baker in his 2008 study noted that National Rugby League players were 8.9% heavier than their State Rugby League counterparts. Duthie, Pyne and Hooper (2003) have also noted a similar trend in Rugby Union. The heavier body mass found in elite players allows them to carry greater momentum into contact if travelling at an equivalent speed as their lighter counterparts. This increase in momentum allows an offensive player to push the defender back or possibly break a defender's tackle. However, Gabbett's 2007 study on female Rugby League players found no significant difference in body mass between playing levels. In addition Gabbett's 2010 study on junior elite and sub-elite Rugby League players also found no significant difference in body mass between playing levels, however there was a moderate effect size difference (ES=0.50). The conflicting findings of Gabbett's 2007/2010 studies could be attributed to the limitations of using only body weight, as it may not reflect fat free mass levels in female and sub-elite Rugby League players.

Skinfold testing. Skinfold testing is an AM performed as an indirect measure of an individual's body fat percentage. Due to the risks of body mass measurements including fat mass that may play a negative role in performance, a number of studies have included skinfold measurements. Though it is hard to compare between studies as both the sum of four (Gabbett, 2000, 2005, 2006; Gabbett et al., 2010, 2008; Till et al., 2011) and sum of seven (Gabbett, 2007; Gabbett et al., 2010; Gabbett et al., 2009) skinfold method have been used. There does appear to be differences between position and skinfolds. Gabbett's 2005 and 2006 studies on junior rugby league players showed that props had significantly higher skinfolds than all other positions. This difference in skinfold thickness and position has also appeared at the junior elite level (Gabbett et al., 2009) with hit-up forwards having a significantly higher sum of seven skinfolds (M=80.2mm) than adjustables (M=59.6mm); and at the junior sub-elite level between hit-up forwards (M=113.6mm) when compared to adjustables (M=60.6mm) and outside backs (M=60.8mm). Finally, Gabbett's 2008 study on senior sub-elite players concluded that hit-up forwards possessed (sum of four M=51.0mm) a greater skinfold measurement than adjustables (sum of four M=34.6). Even in female rugby league and union players the ability of skinfolds to discriminate between playing positions has appeared (T. J. Gabbett, 2007; Hene et al., 2011). Gabbett (2007) determined that forwards (sum of seven M=141.2mm) had significantly higher skinfolds than backs (sum of seven M=114.8mm); and that female rugby league players had higher skinfolds than female rugby union, soccer and field hockey athletes.

In some cases skinfolds can also help discriminate between playing levels in rugby league. Till et al. (2011), using a stepwise discriminant analysis, reported that, "maximum oxygen uptake (VO_2max), chronological age, body mass, 20m sprint, height, sum of 4 skinfolds and sitting height discriminated between selection levels." This analysis accounted for 28.7% of the variance and 63.3% accuracy at predicting if players played at a UK junior regional or national level. In contrast, Gabbett's 2009 study on elite and sub-elite juniors and 2010 study found no significant difference in skinfolds. Furthermore, Gabbett's 2007 study on female rugby league players reported no significant difference between selected and non-selected players. Finally, Duthie, Pyne and Hooper (2003) in their review of rugby union physiology highlight this conflicting information regarding the relationship between body composition and performance levels but proceeds to state that "the general consensus is that fat levels decrease with higher levels of play".

Height. Another AM that has shown have some potential at discriminating between levels of play is height (Gabbett et al., 2009; Till et al., 2011). This could be due to the role height plays in certain maneuvers (contesting restarts and lineouts). In contrast, a number of studies have shown no significant difference (Gabbett, 2007) or only a small effect size (T. J. Gabbett et al.,

2010) in height. However, height has shown more promise at discriminating between playing positions. Gabbett's 2005 study performed on junior rugby league players determined that props (M=183.9cm) were significantly taller than all other playing positions and that halfbacks (M=170.6cm) were significantly shorter than fullbacks (M=177.1cm). This is in line with Gabbett's 2006 study on sub-elite players which determined that props were significantly taller than all other positions and Duthie, Pyne and Hooper's 2003 review which determined that forwards are typically taller than backs. Conversely, Gabbett's 2008 study on sub-elite senior players could not discriminate positions based on height.

PHYSICAL QUALITIES

PQ assess the physical capabilities and capacities of the athletes and their ability to cope with the demands of the sport. Typically these measures assess general physical abilities such as: speed, strength, power and aerobic ability.

Speed. Speed has also shown some potential at discriminating between playing positions. Gabbett's 2005 study found a number of speed differences by individual positions, for example, hookers, centers and backs were faster than props over 40m. In addition centers were also significantly faster than the second row over 40m. Interestingly when examining the 10m sprint times by individual positions there were no significant difference by position. Gabbett's 2008 study investigating skill and fitness among rugby playing positions also found no significant differences in positional abilities to accelerate over 10m but that there was a significant differences between hit-up forwards, adjustables and outside backs over 20m and 40m. This could be interpreted to mean that the majority of the discrepancies in speed are occurring past

10m. Gabbett, in 2006, had similar findings noting that centers, fullbacks and hookers were faster than props over 40m. However, unlike the preceding studies there were significant speed differences over the first 10m with props (M=2.18) slower than hookers/halves (M=2.07), backrows (M=2.17) and the outside back (M=2.12) positional groups. Lastly, Gabbett's 2007 study on female rugby union players determined that backs were significantly faster than forwards over 10m (backs M= 1.96s vs. forwards M= 2.04s), 20m (backs M= 3.44s vs. forwards M= 3.60s) and 40m (backs M 6.33s vs. forwards M= 6.59s).

Speed may also play a role in determining the athletes' playing level. Gabbett's (2010) study on correlates of tackling ability found that there was significant differences is junior elite and junior sub-elite rugby league players in their abilities to accelerate (junior elite M=1.81s vs. junior sub-elite M=1.94). The athletes ability to accelerate was also determined to have the highest correlation to tackling ability ($r=0.60$, $p<0.001$). This is in agreement with Green, Blake & Caulfield's 2011 study which determined that academy players were significantly faster than club players over 10m and 30m. Also, Gabbett's 2009 study determined that junior elite players were faster over 10m, 20m and 40m than sub-elite players. In addition Till et al. (2011) noted that 20m sprint speed helped discriminate between national level and regional level players. However, Baker and Newton (2008) found that there was no difference in speed measurements between national rugby league athletes and second division state league players over 10m and 40m. In addition, no significant differences in 10,20,30 and 40m sprint times was found between players selected for a semi-professional rugby league team and those not selected (Gabbett, 2002).

Strength. Another PQ that could be important in rugby is strength. Strength is defined as: the ability to overcome or counteract an external resistance by muscular effort (Zatsiorsky & Kraemer, 2006). However, there is a surprising lack of studies addressing strength levels of elite rugby players. This may be due to the perceived danger of performing maximal lifts with high level athletes or perhaps due to the time required to perform a 1RM test. A study by Baker & Newton (2008) examined lower body strength in rugby league players using a 1RM full squat. It was determined that national rugby league players were 17% stronger than their second division state counterparts. Another study performed on elite English rugby league players noted that there were positional differences in strength levels (Comfort et al., 2011). Comfort et al. found that forwards had higher levels of absolute strength when compared to backs. However when strength levels where adjusted for bodyweight, backs had a higher level relative strength than forwards. Furthermore, Smart, Hopkins & Gill (2013) found significant differences between strength measures (bench press, back squat, box squat and chin-up) and playing level (not selected, Provincial, Super Rugby and International). In addition to isometric squat Comfort et al. (2011) used an isokinetic knee flexion and extension test with an isokinetic dynamometer; however this movement is not sport specific, due to the muscles being used in isolation. Nonetheless, Duthie, Pyne and Hooper (2003), in their review of rugby union, came to similar conclusions noting that forwards have higher levels of absolute strength.

Lower body power. Unlike strength, there is a great amount of research on lower body power movements. Power is defined as the amount of work per unit of time (Zatsiorsky & Kraemer, 2006) or force multiplied by velocity. In field settings the term power has become a colloquialism (Knudson, 2009) as most athletic movements display power, with both an element of force and velocity. Typically lower body 'power' is measured using a movement similar to jumping thus having a higher velocity than typical strength movements such as squatting. This is most likely due to the ease of running large groups of athletes through tests such as the vertical jump test. The importance of lower body power has been shown in Gabbett et al.'s 2010 study on tackling ability, with lower body power being the second highest correlate of tackling ability (r=0.38, p<0.01) behind acceleration (r = 0.60, p<0.001). The majority of the studies on lower body power have used a yardstick device to measure jump height (Gabbett, 2000, 2002, 2005, 2006, 2007; Gabbett et al., 2008, 2009, 2010). However notable exceptions are Till et al. (2011), who used a Takei vertical jump meter; Baker and Newton (2008) who performed a weighted vertical jump profile; and Comfort, Graham-Smith, Mathews and Bamber (2011) who performed both a 40kg jump squat in addition to performing a vertical jump on a contact mat.

Lower body power has also shown some promise in discriminating between playing level. Baker and Newton's study in 2008 found that national rugby league players were 11.5% more powerful than their second division state rugby league counterparts. Junior elite rugby league players have also been found to have better lower body power than sub-elite players (Gabbett et al., 2010). In addition, Gabbett et al. (2009) found that junior elite players had better vertical jumps than their sub-elite counterparts. Comfort, Graham-Smith, Mathews and Bamber (2011) discovered positional differences in peak power output between forwards (M=2106W) and backs (M=1709W) in English elite rugby league players. Interestingly when the absolute power values were converted to relative power backs (M=20.71$W \cdot kg^{-1}$) had a significantly higher output than forwards (M=19.91$W \cdot kg^{-1}$). These positional differences have also been observed at the sub-elite level between the outside backs (M=50.0cm) and hit-up (M=39.7cm) forwards (Gabbett et al., 2009). Furthermore, a study on female rugby league athletes found positional difference in vertical jump height (hit-up forwards M=34.3cm vs. outside backs M=37.0cm) when using minimum clinically important differences (Gabbett, 2007). In contrast to the above studies a number of studies (Gabbett, 2005, 2006; Gabbett et al., 2008; Comfort, Graham-Smith, Mathews & Bamber, 2011) have found no significant difference in vertical jump height between playing positions. In addition, Gabbett's 2007 study on female rugby league players found no difference between selected and non-selected players. Part of the difficulty when interpreting these findings lays in the differing methodologies; for example whether force is measured using a force plate and velocity using a linear position transducer or as in many studies measured using a proxy such as jump height.

Upper body power. Unlike lower body power, only one study has investigated upper body power in rugby players to the author's knowledge. However, similar to measurements of lower body power a proxy measure was used to assess upper body power. Till et al. (2011), used a 2kg medicine ball throw to assess upper body power in 13-16 year old rugby league players. However the researchers did not end up using the 2kg med ball throw in the stepwise discriminant analysis to predict national selection in rugby league.

Maximal aerobic power (VO_{2max}). Maximal aerobic power is the "maximal ability of the individual to take up, transport and utilize oxygen by the working muscle"(Green & Patla, 1992). To measure VO_{2max} all of the studies examined except for Clarke, Presland, Rattray & Pyne (2013) have used a version of a multistage fitness test. Gabbett (2009) noted that VO_{2max} is "common discriminator between starters and non-starters in elite and sub-elite junior rugby league teams." Gabbett found that elite junior players had better aerobic power than sub-elite junior players ($\bar{x}$= 48.2 ml·kg^{-1} ·min^{-1} vs. $\bar{x}$=43. 3ml·kg^{-1} ·min^{-1}); this is in agreement with Till et al. (2011), who determined that VO_{2max} was a predictor of national selection. In contrast a number of studies have also found that aerobic power was not significantly different between selected and non-selected players (Gabbett, 2002, 2007; Gabbett et al., 2009)

VO_{2max} has also shown promise in separating playing positions. Duthie et al. (2003) in a review of rugby union physiology noted that forwards have superior absolute aerobic power than backs but backs had greater relative aerobic power than forwards. The latter has been observed in a number of studies. Gabbett (2005) found that halfbacks exhibited significantly greater relative $V0_2$max than props (M=48.4 ml·kg^{-1} ·min^{-1} vs. M=42.2 ml·kg^{-1} ·min^{-1}). Gabbett also had similar findings in his 2006 study on sub-elite rugby league players. In addition Gabbett's 2007 study, found that hit-up forwards (M=31.2 ml·kg^{-1} ·min^{-1}) had significantly lower MAP than all other positional groups (adjustables M=36.2 ml·kg^{-1} ·min^{-1} and outside backs M= 34.5 ml·kg^{-1} ·min^{-1}). It should be noted that only one study (Clarke et al., 2013) has examined VO_{2max} in female sevens athletes. Clarke et al. using motorized treadmill determined that female sevens athletes had a 46.5 ± 5.2 ml·kg^{-1} ·min^{-1}. This appears to be similar to what has been observed in male rugby union and league players.

In conclusion, despite some variability in the findings, the ability of AM and PQ to determine playing level and positions has shown promise. Typically forwards have been shown to be taller and heavier than backs with higher levels of absolute strength and aerobic power.

Whereas backs have been shown to be leaner, faster and have higher levels of relative strength and aerobic power. Much of the variability in study findings can be attributed to methodological differences such as varying skinfold and sprint measurement techniques and delimitations to specific codes of rugby and genders. This can make the generalizability of these findings difficult to female sevens players. Furthermore there has been limited studies examining lower and upper body strength (Baker & Newton, 2008; Comfort et al., 2011; Smart, Hopkins, & Gill, 2013) in rugby. In addition there have been no studies specifically investigating the anthropometric and performance measures of female sevens athletes. Therefore future research should be directed towards the use of AM and PQ to discriminate between playing level and position in female rugby sevens.

Chapter 3: Anthropometric and Physical Qualities of International Level Female Sevens Athletes Based on Playing Position

INTRODUCTION

Identifying the key variables responsible for successful performance is essential when developing elite athletes. It is therefore common practice to quantify physical and anthropometric attributes to determine which factors appear to most readily define success. Anthropometric measures (AM) often monitored are body mass, standing height and sum of seven skinfolds. Physical qualities (PQ) assess the physical capacity and capabilities of the athletes, which may define their ability to cope with the demands of their sport. For example, in sevens rugby (sevens) athletes are required to sustain high work rates and recover from repetitive sprints (Suarez-Arrones et al., 2012), justifying the measurement of sprinting ability and aerobic power. Based on the relationships between sport ability, AM and PQ it is assumed that the development of normative AM and PQ data could assist in player development, guiding athletes' training and assisting coaches in team selections. Differences in AM and PQ have been noted not only between sports (T. J. Gabbett, 2007; Khosla & McBroom, 1985), but across levels of performance and position (T. Gabbett et al., 2009). Therefore, it is important to investigate which AM and PQ are appropriate for each playing position and level of performance in a given sport.

In the last 10 years rugby sevens has experienced a growing international profile (*International Rugby Board: Rugby Sevens Plan 2011-2020*, 2011). Additionally, with rugby sevens recent inclusion in the 2016 Olympics, many countries have placed an increased emphasis on the development of rugby sevens players. However much of the research on AM and PQ come from male rugby league and fifteens rugby union. Due to the rules of Sevens rugby there are notable physiological differences from other rugby codes. (Suarez-Arrones et al., 2012). The shorter game length and less total players in sevens has resulted in a running dominant game with higher average velocities covered on the female side (100.3m/min) (Suarez-Arrones et al., 2012) and male side (120±17m/min) (Higham, Pyne, Anson, & Eddy, 2012) than male fifteens players (Cunniffe, Proctor, Baker, & Davies, 2009). Male sevens players have been shown to spend a greater proportion of their total running distance at a speed greater than 5m/s (Higham et al., 2012) with increased work to rest ratios (1:0.4) when compared to fifteens (1:1.2-1.4) (Yabar et al., 2014). The high intensities present in rugby sevens results in greater than 75% of the game spent playing with a heart rate greater than 80% of the players' maximum (Suarez-Arrones et al., 2012).

Due to the increased running demands, modified laws and reduced game lengths in sevens, it has been suggested that the positional differences present in fifteens (Durandt et al., 2006; Hene et al., 2011; Holway & Garavaglia, 2009; Smart et al., 2013) may not be as prevalent in sevens (Higham, Pyne, Anson, & Eddy, 2013). With reference to female sevens athletes, drawing conclusions from fifteens and sevens research using male athletes becomes tenuous when considering that the only study comparing female and male sevens players showed that the underlying physical qualities of female sevens athletes are significantly different than their male counterparts (Pyne, Higham, Clarke, Mitchell, & Eddy, 2012). Therefore there is a great need to develop a baseline of data focusing on rugby sevens with gender specific evaluations to assist in player development, guiding athletes' training and assisting coaches in team selections for this increasingly popular rugby variant.

Due to the limited application of fifteens research to rugby sevens (Ross, Gill, & Cronin, 2013) and specifically the lack of research investigating female sevens athletes the purpose of this study is twofold. First we aim to describe the anthropometric and physical qualities of international level female sevens athletes and second to determine what positional differences exist in these variables for international level female sevens athletes.

METHODS

Experimental Approach to the Problem

Due to the paucity of research on female rugby sevens athletes, a causal comparative design (ex post facto design) was used to determine if anthropometric and physical qualities discriminate between playing positions in international level female sevens athletes. Although the results from this quasi-experimental design are limited in terms of generalizability, it will provide insight into the characteristics of international level sevens athletes for future studies. The independent variable assessed was playing position; dividing the athletes into forwards and backs. Due to the limitations of working with international level athletes the dependent variables were limited to anthropometric and physical testing metrics performed as part of the subjects' involvement in the national team training center.

Subjects

Twenty-three subjects with a mean age of 22.75±3.99 years and body mass of 69.36±5.21kg were purposefully sampled from the same national team training program. All subjects undertook individualized training plans of which twenty of the subjects trained in a centralized environment for the ten months that the study was conducted, two of the subjects trained in the centralized environment for between six and eight months and one subject trained in a decentralized environment. The three athletes who did not fully partake in the centralized program flew in for training camps and testing. All subjects gave their informed consent to partake in this study and ethical approval for the study was obtained from the University of Victoria's Human Research Ethics Board and complied with the principles outlined in the Declaration of Helsinki.

Procedures

All measurements with the exception of the anthropometric measurements were taken by a professional sport scientist with six to ten years' experience in elite sport. These measurements consisted of field tests standard to the teams' testing regiment and covered the areas of: anthropometry, running speed, horizontal jumping ability, strength and aerobic ability. All measurements were taken multiple times throughout the pre-season and season and presented as the athletes average result over the 2013-2014 training period.

Anthropometric Measures. The anthropometric measures were conducted prior to performance testing and training. All measurements followed the International Society for the Advancement of Kinanthropometry (ISAK) protocols and were taken by a ISAK Certified Anthropometrist (skinfolds TEM=5.1%). The anthropometric measures consisted of body mass measured to 0.01kg using a HL120 calibrated scale (Avery Berkel, England) on a hard surface and zeroed prior to testing. The participants were measured barefoot and wearing minimal clothing (as comfort allowed). Standing height was measured to the nearest 0.5cm on stadiometer (Tanita, Japan) using the ISAK stretch stature method. The sum of 7 skinfolds included the triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, front thigh and medial calf sites. A single set of Harpenden skinfold calipers (Baty International, England) was used for all measurements and taken to the nearest millimeter.

Speed & Momentum. Speed was assessed on turf field (Field Turf, Georgia) in cleats, using a Brower Timing TC-System (Utah). The assessment consisted of a 40m sprint with splits taken at 10m and 30m. In order to minimize the risk of false signals, a problem identified by Earp and Newton (2012), the first set of gates was lowered to 50cm and the subjects started with the middle of their front foot positioned 0.75m behind the first set of timing gates. The remainders of the gates were set to a height of 1.00m. Each subject was given three attempts and allowed to see their previous attempt's time between sprints. The best 40m time along with the 0-10m split (ISS) and the 30-40m split (MSS) were measured to 0.01 of a second and converted to velocity. The measurements of ISS and MSS have previously been shown to be reliable with an intra-class correlations of r= 0.91 and r= 0.94 respectively (Matt Barr, Sheppard, Gabbett, & Newton, 2014).

Momentum was calculated by multiplying the subjects' body mass by their average velocity (Baker & Newton, 2008; Matt Barr et al., 2014) over the 0-10m segment termed initial sprint momentum (ISM). This calculation was extended to the 30-40m zone as sevens players are required to sprint distances over 30m (Suarez-Arrones et al., 2012) and termed maximal sprint momentum (MSM). Momentum was calculated to the nearest 0.01 kg·m/s.

Horizontal Jump Ability. Horizontal jump ability was assessed using a standing long jump (SLJ) and a standing triple jump (STJ) preformed in a bilateral manner. The test was conducted on a turf field (Field Turf, Georgia) in cleats for all but one session (grass field at an Olympic training center) The subjects started with their toes behind the starting line and distance was measured from the heel of the athletes' closest foot to the starting line and rounded down to the nearest centimeter. The subjects were given three attempts for both jumps and required to stick the landings. If the athlete fell backwards or moved their feet upon landing they were given a zero. While performing the standing triple jump the participants were required to minimize the time on the ground between jumps (no reset allowed). The best jump for each test was taken for analysis. Previous research using the same protocol showed a Typical Error of Measure TEM and CV of 0.04m and 7% for the SLJ and 0.12m and 7% for the TBJ (M Barr, Sheppard, Agar-Newman, & Newton, 2014).

Strength. Strength testing consisted of power clean, front squat, bench press and neutral grip pull up conducted in that order. All of the strength movements were performed using Eleiko (Sweden) plates & bars and measured to the nearest 0.5kg. In addition, a standardized warm up and testing protocol was used for the 1 repetition maximum (1RM) testing. Concisely, this consisted of starting at 60% of the subjects predicted 1RM and increasing by 10% until 90% of the subjects predicted 1RM was reached. Reps were then conducted at 95% and 100% of the subjects predicted 1RM before increasing by approximately 2% thereafter.

The power clean commenced with the bar and plates resting on the floor. The participants moved the bar in one motion from the floor to the shoulders. The participants were required to receive the bar on the shoulders with the top surface of the leg at the hip joint above the knees for a successful lift. If a participant caught the bar with the top surface of the leg at the hip joint below the knees or dumped the bar a miss was recorded.

The 1 RM bench press began with the spotter providing assistance unracking the bar to a position over the subject's chest. The bar was then lowered to the participant's chest, lightly touching before being pressed to a locked out position and re-racked. The spotter was instructed to assist the participant if the bar stalls for over three seconds or reverses direction during the concentric pressing motion. If the spotter touched the bar at any point besides the initial unracking a miss was recorded.

The 1RM front squat started with the bar placed in a squat cage. The subject unracked the bar, stepped back, squatted to a depth placing the top surface of the leg at the hip joint below the knees and then return to standing. If a participant failed to make the proper depth or dumped the bar a miss was recorded.

The 1RM neutral grip pull up began with the athlete hanging motionless for three seconds using a neutral grip (palms facing towards each other). A signal was given by the tester for the subject began the motion, pulling themselves up and finishing with their chin above the hands. A miss was recorded if the subject assisted the upward movement with their legs or failed to achieve the final position. The weight recorded was the subjects' body mass plus additional weight which was hung from a belt.

Aerobic. The athletes' aerobic fitness was assessed using a 1600m run conducted on a 400m gravel track. All athletes had previous experience with this test. The total time ran was converted into average speed over 1600m (m/s).

Statistical Analyses

The subjects mean testing scores over the course of the 2013-2014 training period, including the 2013-2014 WSWS season was analyzed. To determine the ability of physical and anthropometric measures to discriminate between positional groups the data was separated into backs (n=13) and forwards (n=11). The anthropometric and physical tests were analyzed using a series of independent t-tests using the pooled variance as $n<30$. Alpha was set to $p<0.05$ and a Dunn–Šidák correction was applied. Due to the small n in conjunction with the Dunn–Šidák correction, it was unlikely that statistical significance would be achieved. Therefore, Cohen's d was calculated and presented using Hopkins' scale of effect magnitudes (Hopkins, 2002) in addition to the adjusted p-value. All data was analyzed using SYSTAT version 13 (San Jose).

RESULTS

Backs (n=13) and forwards (n=11) were of similar age, 21.29±3.54 years and 24.47±3.95 years respectively (p=0.65, effect magnitude=moderate). When examining the anthropometric values (refer to Table 1) only body mass was significantly different between the two positions. There was a moderate effect magnitude (d=0.79) with forwards being taller than backs (mean difference= 4.14cm; 95% CI=-0.38 to 8.66) however this was non-significant (p=0.78). In addition the backs had a larger CV when comparing sum of 7 skinfolds and height skinfold ration.

Examining running measures (refer to table 2); ISM was the only measure significantly different between positions. Forwards carried increased momentum over the first 10m (mean difference= 32.43kg*m/s; 95% CI= 14.19 to 50.67). In addition MSM had a large effect magnitude (*d*=1.33) however this was non-significant (*p*=0.09).

Lastly, none of the strength measures (refer to Table 3) or horizontal jumping measures (refer to Table 4) were significantly different between positions. Although there was a large effect magnitude (*d*=1.37) when examining the absolute weight lifted in the neutral grip pull up (mean difference 8.24kg; 95% CI= 2.60 to 13.88), this was not significant (*p*=0.13)

Table 4. *Anthropometric Measures*

	Backs				Forwards						
Test	*n*	Mean	*SD*	CV	*n*	Mean	*SD*	CV	*p*	*d*	Magnitude
Height (cm)	13	166.32	6.03	4%	11	170.46	4.31	3%	0.78	0.79	Moderate
Body Mass (kg)	13	66.40	3.48	5%	11	72.87	4.79	7%	0.02	1.55	Large
Sum of 7 (mm)	13	84.35	26.14	31%	11	94.97	12.26	13%	0.97	0.52	Small
Weight Skinfold Ratio (mm/kg)	13	0.84	0.18	21%	11	0.78	0.08	10%	1.00	0.43	Small

Note: p-value reported as a Dunn–Šidák adjusted *p*-value

Table 5. *Running Speed Measures*

	Backs				Forwards						
Test	*n*	Mean	*SD*	CV	*n*	Mean	*SD*	CV	*p*	*d*	Magnitude
0-10m Speed (m/s)	12	5.54	0.10	2%	11	5.43	0.12	2%	0.47	1.00	Moderate
30-40m Speed (m/s)	12	8.21	0.26	3%	11	8.02	0.25	3%	0.84	0.74	Moderate
40m Speed (m/s)	12	7.14	0.18	3%	11	7.00	0.14	2%	0.61	0.87	Moderate
Initial Sprint Momentum (kg*m/s)	12	366.81	19.83	5%	11	399.24	22.42	6%	0.03	1.53	Large
Maximal Sprint Momentum (kg*m/s)	12	545.30	31.99	6%	11	589.43	34.42	6%	0.09	1.33	Large
1600m Speed (m/s)	13	4.12	0.28	7%	10	4.26	0.28	7%	1.00	0.50	Small

Note: p-value reported as a Dunn–Šidák adjusted *p*-value

Table 6. *Strength Measures*

	Backs				Forwards						
Test	*N*	Mean	*SD*	CV	*n*	Mean	*SD*	CV	*p*	*d*	Magnitude
Power Clean (kg)	8	68.24	6.20	9%	7	73.52	4.46	6%	0.84	0.98	Moderate
Front Squat (kg)	8	82.50	11.30	14%	9	84.50	5.84	7%	1.00	0.22	Small
Bench Press (kg)	11	61.85	7.15	12%	10	68.79	7.13	10%	0.56	0.97	Moderate
Neutral Grip Pull Up (kg)	12	78.11	6.71	9%	9	86.35	5.19	6%	0.13	1.37	Large
Relative Power Clean (kg/kg)	8	1.03	0.10	10%	7	1.00	0.04	4%	1.00	0.39	Small
Relative Front Squat (kg/kg)	8	1.25	0.17	14%	9	1.15	0.11	10%	0.97	0.70	Moderate
Relative Bench Press (kg/kg)	11	0.94	0.12	13%	10	0.94	0.11	12%	1.00	0.00	Trivial
Relative Neutral Grip Pull Up (kg/kg)	12	1.18	0.11	9%	9	1.19	0.10	8%	1.00	0.10	Trivial

Note: *p*-value reported as a Dunn–Šidák adjusted *p*-value

Table 7. *Horizontal Jumping Measures*

	Backs				Forwards						
Test	*n*	Mean	*SD*	CV	*n*	Mean	*SD*	CV	*p*	*d*	Magnitude
SLJ (cm)	12	229.42	10.85	5%	11	228.03	9.13	4%	1.00	0.14	Trivial
STJ (cm)	12	704.60	31.96	5%	11	690.86	28.03	4%	1.00	0.46	Small

Note: *p*-value reported is a Dunn–Šidák adjusted *p*-value

DISCUSSION

To the author's knowledge this is the first paper to profile international level female sevens athletes' AM and PQ as well as demonstrate positional differences. Overall, we found that there are very few differences between backs and forwards in female sevens. This is a unique result that is not evident in other variants of rugby across genders. The only anthropometric and physical qualities that appear to discriminate between playing positions in female sevens rugby are body mass and ISM. This result is unlike male (Smart et al., 2013) and female (Hene et al., 2011) fifteens and male (T. J. Gabbett et al., 2008) and female (T. J. Gabbett, 2007) rugby league where positional differences can be clearly delineated using multiple AM and PQ. This research demonstrates that while it is beneficial to collect data on AM and PQ for women's seven rugby the specific metrics used here may not be able to distinguish between positional roles and novel standards of differentiation may be required. Further, it is possible that the lack of positional differences in female rugby sevens is due to lack of selective pressure in this relatively new rugby variant or to the multifarious physical requirements of a sevens player, leading to a generic player profile.

The only AM differences noted between women's sevens rugby playing position was that of body mass. It is possible that the positional differences in body mass are due to the specific task of scrummaging that forwards undertake. As muscle strength is proportional to the muscles cross sectional area (Maughan, Watson, & Weir, 1983) and body mass is highly correlated to force in the scrum (Quarrie & Wilson, 2000) it is likely that larger players are placed into the forward positions during their development or that specific interventions have led to the forwards becoming larger than backs. Our findings regarding positional differences in body mass is consistent with previous research investigating male rugby sevens (Fuller, Taylor, & Molloy, 2010), female rugby league (T. J. Gabbett, 2007) and female rugby union (Hene et al., 2011). However unlike other studies none of the other AM achieved statistical significance. This could be due to the limited number of participants in the present study or perhaps a generic player profile is an adaptation to the multiple responsibilities a sevens player must undertake.

Another finding of this study was the positional differences in ISM. As ISS was similar between positions (backs= 5.54±0.10 m/s vs. forwards= 5.42±0.12 m/s) it is probable that the difference in ISM relates back to the differences in body mass. It can also be inferred that forwards produce higher levels of absolute power compared to backs as they are able to move larger masses at similar velocities. The finding of ISM being a discriminator of playing position is in agreement with previous research (Matt Barr et al., 2014). It is likely that future research with a larger *n* would show MSM being a discriminator, as the effect magnitude was large between positions (mean difference= 44.13kg*m/s; 95% CI= 15.35 to 72.93) although not statistically significant. Future research examining momentum in sevens should examine its ability to discriminate between levels of players (national vs. international) similar to studies in other rugby codes (Baker & Newton, 2008; Matt Barr et al., 2014).

Although there was no statistically significant differences between positions in any of the strength measures neutral grip pull up strength showed a large magnitude of effect (d=1.37, p= 0.13). It is therefore likely that with a larger *n* statistical significance would have been shown. However, this effect magnitude became trivial when neutral grip pull up strength was expressed relative to bodyweight. Previous research examining the relationship between chin ups and playing position has used varying methods and therefore has achieved varying results. For example, the average number of pull ups per minute did not differentiate positions in women's rugby union (Hene et al., 2011), conversely the number of chin ups performed to exhaustion has shown the potential to discriminate between positions in elite male junior rugby union players (Durandt et al., 2006). It is possible that that absolute pull up strength may play a positional specific role perhaps impacting tackling or contesting rucks, however this is speculation due to the lack of research on sevens' technical and tactical aspects.

It is possible that the scarcity of positional differences is due to field tests utilized lacking the necessary resolution to determine positional differences in female sevens players. Future research should combine lab tests with a finer resolution such as metabolic cart based VO_2max testing and jump/mid-thigh pulls on a force plate in conjunction with field based testing. It is also possible that AM and PQ do not measure the unique attributes of backs and forwards in sevens. Therefore, specific tests designed off positional technical/tactical demands may be necessary to elucidate these differences. For example, tests involving a cognitive component such as measuring an athlete's ability to attack and defend under varying spatial constraints could be useful in future research. However as previous research in rugby has demonstrated the ability of similar tests to expose positional differences, it is more likely that the reduced number of players leads to multiple common responsibilities per player and thus a generic player profile as suggested by Higham et al. (Higham et al., 2013). It is also possible that female sevens is still in its infancy and yet to experience significant competition for roster positions and thus selection pressure, making it unnecessary for morphological optimization of specialist role players (Norton & Olds, 1996).

Compared to previous research examining anthropometric and physical qualities in female sevens athletes the squad examined had similar ages (22.75±3.99 years vs. 25±5 years), body weights (69.36±5.21kg vs. 69±7kg) and skinfolds (89.22±21.24 mm vs. 85±15 mm) as a 2013 study investigating critical power in international level female sevens athletes (Clarke et al., 2013). When comparing the current cohort of athletes to females fifteens rugby union athletes selected to play for a high performance squad prepping for the 2010 Women's Rugby World Cup the sevens athletes were taller across the forwards and backs position, heavier across the backs position, had lower sum of 7 skinfolds, faster velocities over the 10m and 40m distances across both positions and larger bench presses across the forwards and backs positions (Hene et al., 2011). Taken in conjunction these comparisons present a compelling case that there are similar anthropometric measures among sevens athletes and that the current cohort of sevens athletes are physically superior to the most recent profiles presented on female fifteens athletes.

In this study we were able to establish normative data on female sevens athletes and determine that field based tests delineate few differences in AM and PQ between playing positions. It appears that this cohort is physically superior to the most recent data published on international level female fifteens athletes (Hene et al., 2011), likely due to the professional training environment and increased emphasis placed on sevens in the lead up to the 2016 Olympics. Furthermore, as all of the athletes taking part in this study were undertaking individualized training plans it is likely that this generic profile is a result of the on field demands of rugby sevens. This uniform profile could suggest that a more generic training plan could be applied across playing positions or perhaps an increased emphasis should be placed on teasing out and training positional differences perhaps using lab based or sports specific tests. In addition, although some research has profiled the physical demands of the female game (Suarez-Arrones et al., 2012; Yabar et al., 2014) and the current study profiles the anthropometric and physical qualities of female sevens athletes, it is essential that future research combines the game demands with the physical profiles of the athletes and look to develop position specific measures of fitness.

PRACTICAL APPLICATIONS

This research is the first of its kind to profile the anthropometric and physical qualities of international level female sevens athletes. The normative data presented within this paper should aid strength and conditioning practitioners directing the development of female rugby sevens players' general physical abilities. Furthermore, future research should look at developing position specific measures of fitness based on the game demands of rugby sevens and utilizing a balance of sensitive lab based measures of fitness.

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