THE PHYSICAL METRICS OF WORLD SERIES SEVENS TOURNAMENT MATCHES

Matt Blair, Simon Body and Hayden Croft

INTRODUCTION

Rugby Sevens is a team sport that is characterised by contact and bouts of high-intensity intermittent exercise (HIIE) that is similar to the Fifteens version of the game. While both forms of rugby are played on the same field and essentially under the same rules, Sevens matches are shorter in length (14 minutes as opposed to 80 minutes) and involve fewer players (seven rather than 15). Fifteens also differs from Sevens in terms of the competition format used. Fifteens usually involves a once-weekly match, while Sevens most often uses a tournament format, with five to six games played over two to three days. HIIE involves unique physical requirements that engage a spectrum of aerobic and anaerobic conditioning abilities – for example, aerobic power and anaerobic power (speed–agility). This has been documented in the most recent review of Sevens rugby (Ross, Gill & Cronin, 2014). Unsurprisingly, the physical requirements when playing Sevens are significant, and there is a need for further research in this area (Ross et al.). By comparison, the investigation of Rugby Fifteens in this area is well documented (Ross et al.). Rugby Sevens is emerging as a new global sport, as seen by its inclusion for the first time in the 2016 Olympic Games held in Rio de Janeiro.

Rugby nations preparing for this world event focused their efforts on world-class support to enable optimal team performance. Increasingly, sport science support includes micro-sensor technology such as global positioning systems (GPS). GPS is now used extensively with team sports to provide descriptive detail of key physical metrics (PMs) engaged during competition and training (Ross, Gill & Cronin, 2015; Cahill, Lamb, Worsfold, Headey & Murray, 2013). PMs include physiological responses such as heart rate, and work rate demands such as locomotion speed. GPS PMs are classified as an external (objective) load measure; by comparison, the rate of perceived exertion (RPE) is considered an internal (subjective) load measure (Ritchie, Hopkins, Bucheit, Cordy & Bartlett, 2016). RPE has been well reported as a good indicator of internal training load (physical and psychological stress), for example, with youth soccer players (Rodriguez-Marroyo & Antonan, 2015). Despite this, there are some practical implications for utilising the measure effectively – for example, coach buy-in and human resource (Akenhead & Nassis, 2016). Considering these points, PMs and RPE can contribute to the development of effective training schedules that are specific to Sevens players and, if implemented correctly, can enhance match performance. Importantly, these measures can also highlight the difference between the physical requirements of Sevens and Fifteens matches, taking into account the differing competition formats.

The primary aim of this project was to describe the current PMs of athletes competing in World Series Sevens Tournament matches, as well as to explain the different physical requirements between Rugby Sevens and Fifteens. This information can then be used to enhance an evidence-based approach for the creation of Sevens-specific training schedules.

METHOD

Participants

The project was approved under the auspices of the Otago Polytechnic Research Ethics Committee. Eleven Fifteens players who participated in the 2012 Super Rugby competition and 100 Tier 2 Sevens players who participated in four 2013 World Series Sevens tournaments were included in the sample investigated. The Fifteens player sample included a range of playing positions from front row, second row, loose forward and inside–outside backs. 2012 was the first season that the Super Rugby team involved in this project used GPS; this impacted on the player buy-in and therefore on the sample number of matches recorded. By comparison, the Tier 2 Sevens teams were very enthusiastic about the opportunity to use GPS; as a result, player buy-in was enhanced and more matches were recorded from all playing positions.

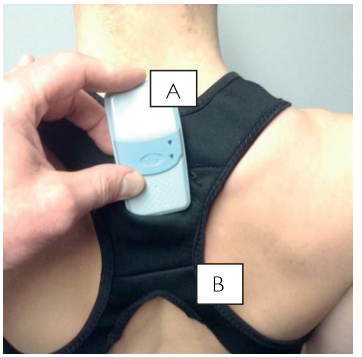

Figure 1: Global Positioning System equipment used to collect physiological responses and work rate demands during a Super Rugby competition and World Series Sevens tournament games, including: (a) GPS unit, (b) black vest, together with a pouch where the transmitter sits. Note. HR strap is built into the vest.

Procedures

All 100 Tier 2 Sevens players had their body composition measured (Kaminsky, 2010; Kaminsky, 2006; Whaley, 2006) at a suitable time during one of the tournament weeks, while all 11 Fifteens players were assessed at regular intervals throughout the competition. Match PMs (see Table 1) were assessed for all players by fitting players with a heart-rate (HR) strap (Polar ElectroTM, Kempele, Finland) and a GPS tracking device (SPI Pro 10, GPSportsTM, Canberra, Australia) 30 minutes prior to kick-off. The GPS device was positioned in the centre of the upper back area (see Figure 1) for the duration of the match. These units recorded movement at a sampling frequency of 10 Hz; the reliability and validity of this procedure has been reported elsewhere (Aughey, 2011). One hundred full-game Sevens GPS files and 47 Fifteens files were collected from 40 and 11 players respectively.

Measure	Definition
Total Distance (m)	Total distance travelled in metres
HIA Sp Distance (m)	HIA distance in metres travelled above 51% of maximal game speed (High speed running)
HIA Sp time (secs)	HIA time in minutes spent above 51% of maximal game speed
% Max Sp	Percentage of maximum speed reached
Freq Accel Hi Speed	Accelerations ≥2.5 – 3.6 ms^2 (High speed accelerations)
Freq Accel Lo Speed	Frequency of accelerations 1.5 - <2.5ms^2 (Low speed accelerations)
Freq Decel Hi Speed	Decelerations ≥2.5 – 3.6 ms^2 (High speed decelerations)
Freq Decel Lo Speed	Frequency of decelerations 1.5 - <2.5ms^2 (Low speed decelerations)
Surge (Sprint) max (m)	Largest distance covered in meters in a surge (sprint)
Surge (Sprint) min (m)	Smallest distance covered in meters in a surge (sprint)
Surge (Sprint) #	Frequency of surges (sprints)
Met Power	Metabolic Power: Force (W/kg) on the body from High speed accelerations, decelerations and HIA running; excluding collisions, kicking, jumps, up and down
%HIA HR time	Percentage of HIA time spent above 80% of maximal heart rate (%High intensity heart rate)
HIA HR time (secs)	HIA time in secs spent above 80% of maximal heart rate (High intensity heart rate time.

Table 1. Match Physical metrics (PMs)
Key: HIA, high intensity activity; Accel, Acceleration; Decel, Deceleration; Sp, Speed; %, Percentage; min, minimum; max, maximum; HR, Heart Rate

ANALYSIS

External Loading

External loading PMs were divided into two categories: physiological response and work-rate demands. Further, an RPE score was used to measure player internal loading. This allowed for comparison both between the PMs collected and between Sevens and Fifteens players using relative and cumulative loading.

Physiological response. Use of the percentage of time spent above 80% of maximal heart rate (% HIA HR time, hereafter referred to as % high-intensity heart rate) and time in seconds above 80% of maximal heart rate (HIA HR secs, hereafter referred to as high-intensity heart rate time) have both been described by a previous investigation into team sport athletes (Martin, Tolfrey, Smith & Jones, 2005).

Work-rate demands. Total distance covered in metres and high-speed running distance in metres travelled above 51% of maximal game speed (HIA Sp Distance (m), hereafter referred to as high-speed running) was used instead of defined locomotor categories, as these have been reported to limit individualised feedback on match movement behaviour (Weston, et al., 2012), illustrated in a previous investigation into team sports (Van Den Berg, 2013; Krustrup et al., 2009). The measurement of surges (sprints) and use of accelerometers to measure acceleration–

deceleration, which all contribute to metabolic power, has been highlighted in a recent review of GPS (Cummins, Orr, O'Connor & West, 2013).

Perceived Exertion

Players' physical intensity during games was recorded by using a ratings of perceived exertion (RPE) scale from 1-10+, with 0 being nothing and 10+ being supramaximal. Where possible, these ratings were obtained within five minutes of the game concluding and have been applied in another study with team sport athletes (Gabbett, 2010).

Relative and Cumulative Loads

Super 14 games in 2012 were typically longer than the Sevens games in 2013 by a factor of 5.5. For the purpose of this article, relative Sevens GPS game variables are determined by absolute values multiplied by a factor of 5.5 to allow a comparison to be made with a Fifteens game. Cumulative tournament load is determined when a player participates in a maximum of six games over a maximum of three days and remains on the field to within the two-minute period before full-time during each game. This method was devised to provide simple and effective comparisons between the PMs of the Sevens and Fifteens game. It is accepted that the comparison here is between a Super Rugby team from a Tier 1 rugby nation and Tier 2 Sevens teams, and that this will have some influence on the metrics recorded.

RESULTS

Body composition and dimension measures revealed understandable differences between Sevens and Fifteens players. Absolute Sevens PMs demonstrate the HIIE physical requirements, and there were clear differences between the two variations of rugby with regard to relative and cumulative match loading.

Body Composition and Dimension

The mean bodyweight values for 100 Sevens players was 92.3kg, which was less than the 105kg recorded for 11 Fifteens players (see Table 2). While measures for height were similar (1.8m), the Fifteens players' mean waist circumferences (Wc) of 90cm was greater than the 84.2cm for the Sevens players, as shown in Table 2.

Bodyweight (Kg)	92.3 (105)
Height (m)	1.8 (1.84)
BMI (Kg/m^2)	27.7 (31)
Sum 7 skinfolds (mm)	64.3
Waist circumference (cm)	84.2 (90)

Figure 3: Body composition and dimension values for 100 Sevens players participating in four 2013 World Series Sevens tournaments. Data in bold and brackets {} are mean values for eleven Fifteens players participating in the 2013 Super Rugby competition

Key: Kg, Kilograms; m, meter; BMI, body mass index

Absolute PMs and RPE

The absolute measures of both physiological response and work-rate demands for a Fifteens player are much higher than those of a Sevens player in a single game, as shown in Table 3. For work rate, the mean high-speed running distance during a Sevens game was 344m, which was less than the 459m measured for Fifteens. Relative distance reported here reveals that Sevens players commit to much larger running metres when expressed as metres per minute, compared to Fifteens players; 112 and 82 m/min respectively. Total distance travelled in metres (1574) was also less than the 6553m recorded for the Fifteens players. Sevens players undertook surges, with a range from 6m to 39m, with some players getting up to a distance of 111m. The mean number of high-speed accelerations during a Sevens game was 14, which was less than the mean number of high-speed decelerations (18). This was not observed for the Fifteens players. Metabolic power was the only exception, where a value of 10 was recorded for Sevens players, greater than the 6.4 W/kg recorded with the Fifteens players.

Physiological response. As measured by total high-intensity heart-rate time, was much higher for a Fifteens player (1hr 10mins 30secs) when compared with a single Sevens game (13mins 18secs). When this is expressed as a percentage of actual game time, then the stress for Sevens players was 73.4%, which was similar to the 75.0% recorded for Fifteens players. The rate of perceived exertion showed that the Sevens players usually rated the physical requirement at 7/10+ (very hard), which was not dissimilar to the Fifteens players at 8/10+ (very hard).

					Surges (Sprints)						
GPS variables	Total Distance (m)	HIA Sp Distance (m)	Freq Accel Hi Speed (ms^2)	Freq Decel Hi Speed (ms^2)	Range (m) (min – max)		#	Metabolic Power (W/kg)	%HIA HR time	HIA HR time (hrs/mins/secs)	RPE /10+
Mean	1574.4	343.8									
	(112 m/min)	(22%)	14.3	18.6	5.7	38.8	7.5	10.1	73.4	13:18	7.0
	(6553)	(459)						(6.4)	(75)	(1:10:30)	(8.0)
	(82 m/min)	(7%)									
SD	267.4	115.2	5.2	6.1	3.3	19.5	4.6	2.6	21.2	4:06	1.5
Range	355.2	49.3	1	3.0	0.0	8	0.0	7.2	9.7	1:49	2.0
	2043.9	597.6	31.0	35.0	15.0	111.0	39.0	13.4	100	19:59	10.0

Table 3: Mean absolute Global Positioning System (GPS) Physical Metrics (PMs) for 40 Sevens players participating in 105 2013 World Series Sevens tournament games. Data in bold and brackets () are mean values for eleven Fifteens players participating in forty seven 2012 Super Rugby competition games

Key: HIA, High intensity activity; Accel, Acceleration; Decel, Deceleration; W/kg, Watts per kilogram; Sp, Speed; %, Percentage; ms2, metres per second squared; min, minimum; max, maximum; HR, Heart Rate; RPE, rate of perceived exertion; ~22 and ~7% represents % of Total Distance travelled using HIA Sp for sevens and fifteens respectively; ~112 and ~82 m/min represents the relative distance travelled in meters per minute for sevens and fifteens players' respectively

Relative PMs

The relative amounts of both physiological response and work-rate demands for a player are much higher for a Sevens player when compared with a Fifteens player, especially when the Sevens game is projected out to an equivalent Fifteens game length played in a typical weekend (see Table 4). Most notably, there would be over four times the amount of high-speed running metres (1891 vs. 459).

Game type	HIA Sp Dist. (m)	Accel. Hi Sp (ms^2)	Decel. Hi Sp (ms^2)	Total Distance (m)	Metabolic Power (W/kg)	HIA HR (hrs/mins/secs)
Fifteens	459	NA	NA	6553	10.1	1:13:03
Sevens	1891	79	102	8659	6.4	1:13:09

Table 4: Comparison of relative estimated Global Positioning System (GPS) Physical Metrics (PMs) for 40 players participating in 105 2013 World Series Sevens tournament games and eleven Fifteens players participating in fourty seven 2012 Super Rugby competition games

Key: HIA, High intensity activity; Accel, Acceleration; Decel, Deceleration; W/kg, Watts per kilogram; ms2, metres per second squared; HR, Heart Rate

Game type	HIA Sp Dist. (m)	Accel. Hi Sp (ms^2)	Decel. Hi Sp (ms^2)	Total Dist.(m)	HIA HR (hrs/mins/secs)
Fifteens	459	NA	NA	6553	1:13:03
Sevens	2063	86	112	9446	1:19:48

Table 5: Comparison of cumulative estimated Global Positioning System (GPS) Physical Metrics (PMs) for 40 players participating in 105 2013 World Series Sevens tournament games and eleven Fifteens players participating in fourty seven 2012 Super Rugby competition games

Key: HIA, High intensity activity; Accel, Acceleration; Decel, Deceleration; W/kg, Watts per kilogram; ms2, metres per second squared; HR, Heart Rate

Cumulative PMs

The cumulative amounts of both physiological response and work-rate demands for a player are much higher for Sevens when compared with a Fifteens player, especially when participation in a three-day Sevens tournament is compared with a single Fifteens game played in a typical match weekend (see Table 5). Sevens players would travel over four times the amount of high-speed running metres (459 vs. 2063), and be subjected to an extra six minutes of high-intensity heart rate.

DISCUSSION

Body composition and dimension values clearly show that Sevens players typically have a lower body weight than their Fifteens counterparts. While it is accepted that there is a range of weight for both Sevens and Fifteens players due to their varied playing positions, the Fifteens game has more specialist positional requirements and, hence, a bigger range in body types (Ross, Gill & Cronin, 2014). It is likely that this reduced body weight is reflective of the nature of Sevens rugby. By comparison, Sevens players are required to run larger relative and cumulative total distances and, within this, achieve much higher levels of high-speed running. As a result, all Sevens players must be very mobile (Ross, Gill & Cronin, 2015).

The physical demands of a one-off Sevens game are, in absolute terms, lower than those a player may experience within a full game of Fifteens. This is not surprising, but there are some complexities to be aware of. For example, relative distance (m/minute) is greater for Sevens players, which is consistent with measures reported from domestic (sub-elite) Sevens (Suarez-Arrones, Nunez, Portillo & Mendez-Villanueva, 2012). Interestingly, % high-intensity heart rate and RPE tell a different story. Sevens players typically play with a heart in the high-intensity zone for 73% of match time, which is similar to the Fifteens players at 75%. We would expect Sevens players to have greater HR responses as they achieve much higher levels of relative high-speed running, but it is accepted that physiological response – as measured by heart rate – has its limitations. For example, HR response is delayed and doesn't synchronise well with changes in movement activities (Martin, Smith, Tolfrey & Jones, 2001). Further to this, Fifteens players, while working less in relative terms, engage in activities such as scrums and breakdown play (rucks and mauls), which involve large amounts of isometric contractions that increase HR response (Deutsch, Kearney & Rehrer, 2007).

In addition, the reported RPEs for Sevens and Fifteens players are similar (very hard), and this reveals limitations with the applied use of RPE. Sevens players, in this investigation, had no trial period to become familiar with the use of RPE, whereas the Fifteens players had ten weeks to get accustomed to it. This represents a previously acknowledged human resource limitation (Akenhead & Nassis, 2016). Formerly (Weston, Bird, Helsen, Nevill & Castagna, 2006), where a significant relationship has been reported between HR and RPE, the athletes investigated underwent a trial period. These types of HR and RPE findings could explain why strength and conditioning coaches have tended to focus more on GPS metrics such as high-speed running meters and accelerations–decelerations.

When PMs such as high-speed running are considered for Sevens and Fifteens players in relative terms, the differences are large. For example, a player in a game of Fifteens typically travels 459m of high-speed running; however, if a Sevens player kept going at the pace achieved in one game for the length of a Fifteens game, then over four times this distance would be travelled (1891m). Appreciating that it is very unlikely that a player could achieve this, it shows that the relative physical requirement of a Sevens game is higher than Fifteens. This is illustrated by the metabolic power measure, which was much greater for Sevens players (10.1 vs. 6.4 W/kg) and provides a clear indication that high-intensity work (high-speed accelerations and decelerations, surges (sprints) and high-speed running) was engaged more frequently in Sevens tournament matches. Again, this would be anticipated as there is far more space to run into in Sevens when compared with a Fifteens game, given the fewer players on the field; this leads to more emphasis on one-vs.-one combat and competition for possession (Ross, Gill & Cronin, 2014). These relative PMs clearly demonstrate that the physical preparation of rugby players for Sevens tournaments needs to be very different from Fifteens matches, which are usually played once a week only.

Further insight is gained into the level of physical requirement for Sevens when the cumulative physical values are considered. While these have been calculated to demonstrate what a player who participates in all six games through a three-day tournament would endure, it is accepted that this is a top-end requirement; but, when compared to the relative values, they have a more practical meaning. Put simply, a Sevens player would travel over four times the

amount of high-speed running metres (459 vs. 2063). This would reflect the smaller amount of stoppage time, larger distance covered and higher speed requirements. Combined with a greater demand for 360 degrees of movement (180 degrees is the norm for Fifteens), it is not surprising that Sevens has more running-related injuries (higher speed – higher forces – higher risk of contact injuries) (Ross, Gill & Cronin, 2014).

With this ever-present risk of injury, skill levels must be maintained under extreme levels of physical exhaustion and subsequent muscle fatigue. This emphasises the need for the development of Sevens-specific training schedules, which need to accommodate the unique physical requirements of a tournament format, as opposed to weekly matches. This raises further questions – for example:

1. How can GPS PMs provide some detail on Sevens technical tactical match requirements?

(Note. This study was not developed to investigate this important question, which is a worthy candidate for future research.)

2. While the use of GPS to measure a range of athlete variables has become widespread in recent years, the challenge remains: what can be done further with this data to enhance athlete performance?

SUMMARY

In summary, World Series Sevens Tournament matches involve significant physical work. These demands become more pronounced when cumulative loads over the matches in a three-day tournament are considered and become more practically meaningful. Compared to Fifteens, Sevens players are lighter and complete more work as represented by the metabolic power measure. These findings are reflective of the larger amount of high-speed running that is required in Sevens rugby, when compared with Fifteens.

Mathew Blair completed his undergraduate and postgraduate qualifications at Otago University and Otago Polytechnic, completing degrees in physical education and nutrition, a graduate diploma in tourism and a graduate certificate in teaching. Throughout this period of study (1988-2010), he has held professional roles as a coach, teacher and activity coordinator in the health and wellbeing sectors, and also with professional rugby. This has included 20 years as a personal trainer; strength and conditioning coaching in elite-level rugby; athletic performance coordinator; five years as a tutor at the Otago University School of Physical Education; and 15 years lecturing at the Otago Polytechnic Institute of Sport.

Simon Body holds a Bachelor of Physical Education from the University of Otago (1997) and completed the Graduate Diploma in Physical Conditioning at Otago Polytechnic in 2011. He has been involved as a Physical Conditioning Practitioner with three international rugby teams, the latest being Fiji from 2014-16. He lectures at the Institute of Sport and Adventure at Otago Polytechnic and is currently completing his Masters in Professional Practice.

Hayden Croft is a senior lecturer at Otago Polytechnic and a performance analyst with Otago Rugby and Southern

Steel Netball. His research interests include sports analysis, biomechanics and video technology. Croft has a Master of Physical Education (Biomechanics) from the University of Otago and is currently working toward his PhD at AUT in New Zealand.

Correspondence to: Matt Blair, Institute of Sport and Adventure, Sargood Centre, Otago Polytechnic, 40 Logan Park Drive, Dunedin 9016, New Zealand. Email: Mat.blair@op.ac.nz.

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