RUGBY SEVENS MATCH DEMANDS AND MEASUREMENT OF PERFORMANCE: A REVIEW

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Review
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Abstract:

The purpose of this review is to summarize the research that has examined the match demands of elite-level, men's rugby sevens, and provide enhanced understanding of the elements contributing to successful physical and technical performance. Forty-one studies were sourced from the electronic database of PubMed, Google Scholar and SPORTDiscus. From these, twelve original investigations were included in this review. Positive match outcomes are the result of an interplay of successful physical, technical, and tactical performances. The physical performance of players (activity profile measurement from GPS) includes high relative total distance and high-speed distance values in comparison to other team sports. The technical performance of players (skill involvement measurement from match statistics) involves the execution of a range of specific offensive and defensive skills to score points or prevent the opponent from scoring. The factors influencing change in these performance constructs has not been investigated in rugby sevens. There is a paucity in the literature surrounding the situational and individual factors affecting physical and skill performance in elite rugby sevens competition. Future studies should investigate the factors likely to have the strongest influence on player performance in rugby sevens. This should include larger sample sizes and account for repeated measures within players. This will allow coaches and scientists to improve their interpretation of activity and skill profile data, and make more informed decisions on players' athletic preparation program.

Key words: *physical factors, technical factors*

Introduction

Rugby sevens is a field-based team sport and derivative of 15-a-side rugby union requiring a unique interplay of well-developed physical, technical, and tactical capacities of players (Ross, Gill, & Cronin, 2015). Teams of seven players aim to manipulate space to advance the ball across the opponents' try-line to score points. The game is played on the same field dimensions as rugby union (100 × 70 m), but contested over seven-minute halves and is typified by frequent bouts of high-intensity running, rapid accelerations/decelerations, and collisions, varied by playing position.

Since 1999, the World Rugby Sevens Series has been run as an annual competition of elite-level international tournaments featuring national rugby sevens teams from all major rugby playing nations. In this international competition, teams accumulate points based on their finishing ranking in each of the tournaments that comprise the World Series. Following the completion of all tournaments, the team with the highest accumulated points total are crowned the series champions. Rugby sevens is unique to all other rugby codes at the elite level in that each tournament is contested over a 2-3-day period involving 5-6 matches for each team. Teams are required to compete in up to three matches per day with approximately three hours between performances. The multiple daily performances and consecutive days of competition present a novel physical and psychological challenge whereby athletes must manage physiological readiness and psychological arousal throughout the day, peaking for matches. These challenges have not commonly been encountered at the elite-level of the traditional 15-a-side rugby format. In addition to the intra-tournament recovery challenges, tournaments are scheduled on two consecutive weekends, fol-

lowed by an extended break from competition (3-7 weeks). Contextual factors such as competition scheduling (Murray, Gabbett, & Chamari, 2014), and travel demands (Mitchell, Pumpa, & Pyne, 2017) have been suggested to influence performance of elite-level team-sport athletes. This imposes unique challenges for performance staff to consider when periodising training and recovery schedules.

Once viewed as a novelty variation of 15-a-side rugby union, rugby sevens now exists as an Olympic sport, distinct from other rugby codes in the participating nations of the World Rugby Sevens Series. Players at the professional level are more commonly becoming contracted as full-time sevens players and train to the specific demands of rugby sevens. The inclusion of rugby sevens in 2016 Rio Olympics resulted in the sport receiving a significant boost in financial and administrative support from various national governing bodies (Curry, Heptonstall, & Warwick, 2015) and a growth in popularity from spectators and researchers (Tucker, 2016) (Figure 2).

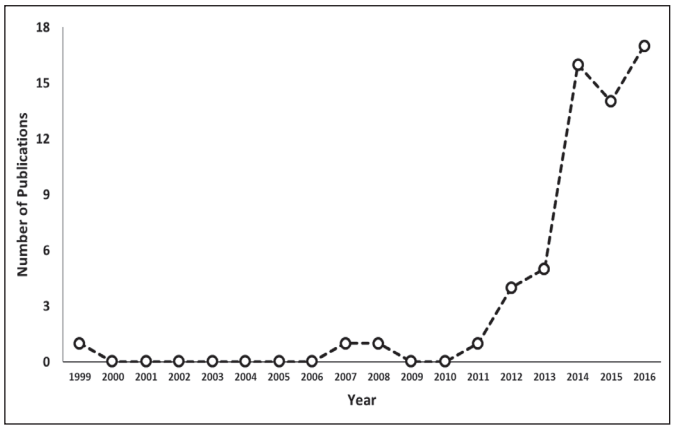

Figure 2. The number of rugby sevens publications from the earliest records (1999) to the last complete year (2016).

Previous rugby sevens research has provided normative values relating to the physical and technical performance of athletes (Higham, Hopkins, Pyne, & Anson, 2014; Higham, Pyne, Anson, & Eddy, 2012; Hughes & Jones, 2005; Ross et al., 2015), but the contextual factors influencing variance of these values is not known. A greater understanding of the influence of situational and individual factors affecting performance will provide coaches a clearer framework to make decisions with the greatest beneficial impact.

Early methods of match analysis in rugby sevens was typically performed by mostly coding match video files to provide information on specific factors (e.g., possession time, ball retention, restart contests won) perceived to be related to successful match performance (Hughes & Jones, 2005; van Rooyen, Lombard, & Noakes, 2008). Video analysis techniques of manually assessing time spent in subjective movement speed categories were also employed in the initial establishment of normative activity profile values for rugby sevens (Rienzi, Reilly, & Malkin, 1999).

More recently, advancements in micro-technology has given rise to the use of Global Positioning System (GPS) and accelerometer devices in team sports to monitor and track each player's physical activity during matches and training (Aughey & Falloon, 2010; Barbero-Álvarez, Coutts, Granda, Barbero-Álvarez, & Castagna, 2010; Coutts & Duffield, 2010; Edgecomb & Norton, 2006; MacLeod, Morris, Nevill, & Sunderland, 2009). These devices provide teams an automated system of measuring movement demands with greater detail and accuracy than previously possible (Aughey & Falloon, 2010). In addition to the activity profile provided by GPS data, modern notational analysis systems (such as customizable video analysis software) provide information on the technical demands of rugby sevens match play. Through combining these physical and technical performance data, coaches and sports scientists are provided with tools to improve understanding of an individual's overall match performance.

The main purpose of this review is to provide a summary of the research that has examined the match demands of elite-level, men's rugby sevens. The first section provides an overview of rugby sevens and the development of match analysis in the sport. The second describes the activity profile and skill demands of elite-level rugby sevens. The third section reviews the current research on the measurement of, and determinants contributing to, successful sporting performance.

Methods

The articles referred to in this review were collected using a combination of keyword search strings (rugby sevens, performance, GPS, team sport, movement demands, skill demands, physical activity profile, match performance and physical performance) in the electronic databases of PubMed, Google Scholar and SPORTDiscus. Additional relevant sources were obtained via a bibliography search of specific articles. A total of 12 articles published between 1999 and 2017 were included in this literature review. The review is delimited to match performance in international men's rugby sevens athletes, thus the exclusion criteria included training studies, studies in sub-elite populations, studies on women's rugby sevens, and injury research.

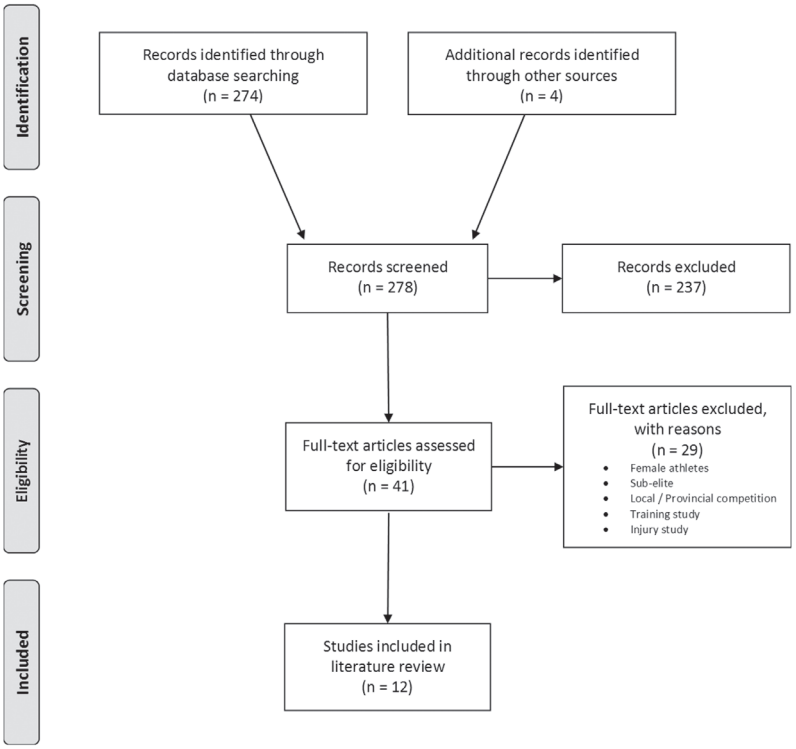

Figure 1. Flow chart schematic of literature selection process.

Results

Rugby sevens match demands

Activity profile

Players' activity profiles during matches provide coaches and scientists quantifiable data relating to their physical match performance. This information may then be used to manipulate physical match intensities in training, and provide a means of load management during a training period or competitive season (Aughey & Falloon, 2010; Malone, Lovell, Varley, & Coutts, 2017). Recent research describing normative activity profile values examined several relevant variables (speed [m·min^{-1}], total distance [TD], and high-speed running [HSR]) using video analysis and GPS data (Table 1). The initial match demands research in rugby sevens was conducted by Rienzi et al. (1999) who used match video analysis to establish a range of normative match values based on time spent in subjective movement speed categories. Methodological differences between rugby sevens activity profile research, such as the subjective movement categories employed by Rienzi et al. (1999) compared to modern GPS systems, make comparisons between studies difficult. Higham et al. (2012) showed that 19 international players covered a mean relative distance of 120±17 m·min^{-1} across 11 matches, with ~19% of the total distance travelled at ≥5 m·s^{-1} and ~11% at ≥6 m·s^{-1}. These values were higher than those found in a later investigation by Ross et al. (2015) who reported a mean total distance for starting players to be 1452±243 m and 1420±332 m covered by forwards and backs, respectively, at ~106 m·min^{-1}.

Differences in GPS devices also makes comparisons between studies difficult. Indeed, device sampling rate, positioning and fitting of devices, satellite signal, and data-filtering methods may influence the values recorded by GPS devices (Malone,

Table 1. Normative match activity profile values

Author/s	Year	N	Length	GPS sampling frequency	GPS model & manufacturer	Speed (m·min^{-1})	Match total distance (m)	Match maximum velocity (m·s^{-1})	Distance >5 m·s^{-1} (m)	Distance 0-5 m·s^{-1} (m)
Higham, et al.	2012	19	11 matches	5 Hz	MinimaxX V2.5, Catapault	120±17		8.5±1.1		
Granatelli, et al.	2014	9	15 matches	1 Hz	SPI Elite, GPSports		1221±118			
Ross, et al.	2015	27	54 matches	4 Hz	VX Sport 220, Visuallex	108	1446±299 (Pool), 1423±285 (Cup)	8.11±0.7 (Pool), 8.22±0.8 (Cup)	1193±251	1180±243
Suarez-Arrones, et al.	2016	12	30 matches	5 Hz	SPI Pro X, GPSports	112.1±8.4				
				Mean		113.4	1363.3	8.3	1193	1180

Note. GPS = Global Positioning System

et al., 2017). A limitation of rugby sevens activity profile research is that all studies thus far have only included players from one team in each study, therefore violating the assumption of independence as the tactical or physical characteristics of that team will be prevalent in the findings. Future studies can overcome these limitations by using a multi-centre approach to data collecting.

Changes in activity profile during rugby sevens tournaments have also been described and showed that whilst high inter-match variability exists in running demands and activities performed (CV 9-41% in running demands for pool matches) (Ross, et al., 2015), differences across a tournament were trivial to small (Higham, et al., 2012; Ross, et al., 2015). For example, Higham et al. (2012) reported a small increase in low speed (3.5-5.0 $m \cdot s^{-1}$) activity per minute (Cohen's d effect size [ES] -0.25), and a small decrease in moderate accelerations (ES -0.42) between the first and last matches of a tournament in 19 international players. A reduction in the match activity profile across a tournament was suggested to be related to fatigue accumulation (Granatelli, et al., 2014) and/or adjusted tactical approaches later in tournaments. In contrast to these earlier studies, Ross et al. (2015) recently reported trivial and unclear differences in running demands between pool and cup rounds across 9 international tournaments. Possible reasons for different findings in these studies may include a longer reporting period in the Ross et al. (2015) investigation (54 matches compared to 11), or advancements in athletes' physical capacities between the 2012 and 2015 World Series seasons, allowing maintenance of physical performance throughout tournaments. Limitations of these studies can include small case examples from one team, skewed data from unequal numbers of repeated measures taken from individual players, and different GPS devices and device wearing procedures. Combined, these issues may provide unreliable data, making it difficult to confidently compare findings between studies. Additional research is required to account for these limitations.

Like in other collision-based team sports, reductions in physical activity have been observed between the first and second halves in rugby sevens, irrespective of match score or opposition ranking (Furlan, et al., 2015; Granatelli, et al., 2014; Higham, et al., 2012; Murray, & Varley, 2015; Suarez-Arrones, et al., 2016). Decreases have been reported in: total distance covered, travel speed ($m \cdot min^{-1}$), in number of accelerations, sprints, moderate and high accelerations per minute, and in percentage of distance covered at moderate speed (>3.9 $m \cdot s^{-1}$) and high speed (>5 $m \cdot s^{-1}$) (see Table 2). In general, moderate to large reductions (ES -0.29 to -0.71) in total distance have been reported from the first to the second half (Furlan, et al., 2015; Granatelli, et al., 2014) with speed values displaying a small to large reductions (ES -0.37 to -1.37) (Granatelli, et al., 2014; Higham, et al., 2012). Similar between-half reductions have also been reported in acceleration-based metrics (Furlan, et al., 2015; Higham, et al., 2012; Murray, & Varley, 2015), including metabolic power estimates in the second half compared to the first. In contrast, there is currently conflicting evidence surrounding the changes in HSR distance (i.e., distance travelled >3.9 $m \cdot s^{-1}$) during the second half. For example, whilst Suarez-Arronez et al. (2016) reported a 12.7% decrease (ES -0.36) in the second half values, Granatelli et al. (2014) reported no significant changes in this variable (ES -0.04). This discrepancy can potentially be attributed to the different sampling rates used by the GPS devices; with Granatelli et al. (2014) using 1 Hz units in comparison to the 5 Hz units used by Suarez-Arronez et al. (2016). This may also be the result of low sample sizes (n=12 and n=9, respectively). Nevertheless, Murray and Varley (2015) demonstrated that irrespective of score line or opponent ranking there was a moderate to large reduction in relative distance (ES -1.24) and relative HSR (high speed running; 4.17-10.0 $m \cdot s^{-1}$) (ES -1.17) between match halves. Interestingly, despite the various performance decrements outlined, the maximal sprint velocity attained by players was maintained throughout the match (Higham, et al., 2012).

It has also been reported that substitute players exhibit higher relative total and high-speed distance compared to starting players (Murray, & Varley, 2015; Ross, et al., 2015). This is in accordance with the concept of a speed-duration relationship which suggests that an athlete's speed limits the tolerable duration it can be maintained (Ferguson, Wilson, Birch, & Kemi, 2013). Accordingly, it is logical that as substitutes are exposed to lesser playing time and, consequently, to reduced accumulated fatigue than starting players, they are potentially able to perform at higher relative intensities (Ferguson, et al., 2013). This relationship is likely to affect physical performance data when observing team averages. Whilst this phenomenon may greatly affect data from longer matches such as in rugby union or other field-based team sports, the shorter duration of rugby sevens matches can allow substitutes to play similar durations of the match compared to starting players. Due to this, it is recommended that future studies include substitute players who play a significant portion of the match within the match analysis research.

The influence of playing positions on match activity profile in rugby sevens matches is currently unclear with mixed findings emerging from three investigations (Granatelli, et al., 2014; Higham, Pyne, Anson, Hopkins, & Eddy, 2016; Ross, et al., 2015). Previous research has reported that elite rugby sevens athletes are more homogenous

Table 2. The second half effect size changes in activity profile value

Author/s	Year	N	GPS sampling frequency	Half	m·min^{-1}	Total distance (m)	Accelerations	Relative distance >3.9 m·s^{-1}	No. of sprints (1 s or more >5.6 m·s^{-1})	Metabolic power
Higham, et al.	2012	19	5 Hz	1st	120±19		1.0±0.4 moderate (2-4 m·s²) accelerations/min			
				2nd	113±16		0.9±0.5 moderate (2-4 m·s²) accelerations/min			
				ES	-0.4		-0.28 moderate (2-4 m·s²) accelerations/min			
Granatelli, et al.	2014	9	1 Hz	1st	91.4±13.6	643±70				
				2nd	78.5±18.3	578±77				
				ES	-1.13	-0.29				
Furlan, et al.	2015	12	5 Hz	1st	98±11		-3.6±0.8 moderate (2-3 m·s²) -0.4±0.2 high (3.1-4 m·s²) -0.8±0.3 very high (>4 m·s²)			9.8±0.9
				2nd	90±10		-3.3±0.7 moderate (2-3 m·s²) -0.3±0.2 high (3.1-4 m·s²) -0.7±0.3 very high (>4 m·s²)			9.2±0.8
				ES	-0.71		-0.40 moderate (2-3 m·s²) -0.45 high (3.1-4 m·s²) -0.39 very high (>4 m·s²)			-0.64
Murray & Varley	2015	17	10 Hz	1st	103±15		1.3±0.6 accelerations/min (≥2.78 m·s²)			
				2nd	86±19		1.1±0.6 accelerations/min (≥2.78 m·s²)			
				ES	-1.24		-0.33 accelerations/min (≥2.78 m·s²)			
Suarez-Arrones, et al.	2016	12	5 Hz	1st	112.1±10.4		-7.8±2.0 moderate (>2.78 m·s²) -0.5±0.6 high (>4 m·s²)	41.7±12.6	5.2±2.3	
				2nd	112.1±9.3		-5.3±3.0 moderate (>2.78 m·s²) -0.2±0.4 high (>4 m·s²)	36.4±7.6	3.8±1.8	
				ES	-0.05		-1.22 moderate (>2.78 m·s²) -0.41 high (>4 m·s²)	-0.36	-0.88	

Note. GPS: Global Positioning System; ES: effect size

in physical profile than their 15-a-side rugby union counterparts (Ross, et al., 2015), but despite this, positional groups are commonly described as forwards and backs (as a result of their technical-tactical roles). Forwards are generally taller and heavier than backs, and are involved in more contact situations; whereas backs generally perform more high-speed movements, passes and handle the ball more frequently (Ross, et al., 2015). There have been conflicting findings on the physical activity profiles reported between these positions, with recent research revealing trivial differences (ES<0.2) between backs and forwards in both the total distance and distance covered at ≥5 m·s^{-1} (Ross, et al., 2015). Earlier investigators reported an increased relative total distance (ES 0.54), distance covered at 5-6 m·s^{-1} (ES 0.23) and >6 m·s^{-1} (ES 0.52) in backs compared to forwards (Higham, et al., 2016). Despite these mixed results, a common finding from all studies was that backs achieved higher maximal speed compared to forwards (ES=0.40; Ross, et al., 2015; ES 0.50; Higham, et al., 2016). This is likely due to a range of factors such as backs being positioned wider from the ruck where more space is often available for backs to accelerate into (i.e., a line break). Indeed, backs have been shown to complete more line breaks than forwards, further supporting this suggestion (Higham, et al., 2016). In contrast to these high-speed activities, forwards have been shown to cover a greater total distance (ES 0.45) and low speed distance (≤5 m·s^{-1}) across a full tournament (ES 0.50) compared to backs (Ross, et al., 2015). This may be a result of forwards' more frequent involvement in breakdown situations requiring repeated low speed efforts travelling between rucks to ensure possession of the ball is maintained.

It has been suggested that a range of situational factors such as travel demands can affect physical and mental capacity, and resulting rugby performance (Lee & Galvez, 2012; West, Cook, Beaven, & Kilduff, 2014). Indeed, international travel is frequent for athletes competing on the World Rugby Sevens Series and travel time can range from up to

one hour to over 24 hours. Long-haul travel, commonly encountered in international rugby sevens, often leads to travel fatigue and jet lag, inducing transient changes impairing neuromuscular and cognitive capacity (Lee & Galvez, 2012; West, et al., 2014). Mitchell et al. (2017) recently examined the effects of long-haul travel (>5 h) on match running performance and reported an extra 960±520 m were covered by players across the tournament in comparison to short haul travel (<5 h). Similar findings were reported in match distance covered at >5 $m \cdot s^{-1}$, with a 12±13 m increase observed with long haul travel (Mitchell, et al., 2017). Unfortunately, however, the strength of the findings of this study are limited due to several issues including a small sample size (12) being taken from one national team, as well as a statistical analysis method involving repeated measures within subjects, not accounting for pseudoreplication within the data. Future research is needed to ascertain the effect of a range of travel times (e.g. <5 hours, <10 hours, <15 hours, >15 hours) on physical and technical performance of rugby sevens using a larger sample size.

Whilst previous research has described the influence of playing positions, match halves, and travel demands on the activity profile in elite rugby sevens, there are some methodological limitations common to quasi-experimental studies that reduce strength of these findings. These include small sample sizes, research conducted within single teams, and unequal numbers of repeated measures taken from individual players. Additionally, it is clear that these studies are also limited as they have failed to control for contextual factors that may influence physical activity profile. The impact of contextual factors on physical performance has been

Table 3. Methodology descriptors for activity profile research in international men's rugby sevens

Author/s	Year	N	Level of competition	Length	Method of data collection	Statistical analysis	Variables measured
Rienzi, et al.	1999	30	International	30 matches	Video analysis	t-test	Normative activity profile values
Higham, et al.	2012	19	International	11 matches	GPS (5 Hz)	Magnitude-based inferences	Maximum velocity Total distance Distance in velocity zones Number of moderate and high accelerations and decelerations
Higham, et al.	2014	42	International	22 matches	GPS (15 Hz)	Magnitude-based inferences	Positional differences in GPS variables
Granatelli, et al.	2014	9	5 international, 4 national players	2 tournaments	GPS (1 Hz) HR BLa	Paired t-test Analysis of variance	Between half changes in distance, HR & BLa Positional differences in distance, HR & BLa
Furlan, et al.	2015	12	International	21 matches	GPS (5 Hz)	Pair-samples t-test Cohen's effect size (ES)	Relative distance Metabolic power
Murray & Varley	2015	17	International	24 matches	GPS (10 Hz)	Generalised linear mixed modelling magnitude-based inferences	Effect of scoreline, opponent, and substitutes on activity profile
Ross, et al.	2015	27	International	54 matches	GPS (4 Hz) Video analysis	Generalised linear mixed modelling Magnitude-based inferences	Match activities Movement demands Positional differences in MA & MD
Suarez-Arrones, et al.	2016	12	International	2 tournaments	GPS (5 Hz)	Magnitude-based inferences	Running performance between halves Repeated high-intensity activities between halves Exercise intensity and internal training load between halves
Mitchell, et al.	2017	12	International	Minimum 8 tournaments	GPS (5 Hz)	t-test	Travel length influence on total distance Travel length influence on relative distance

Note. GPS = Global Positioning System; HR = heart rate; BLa = blood lactate; MA = match activities; MD = movement demands

observed in other field-based team sports such as rugby league (Kempton & Coutts, 2016) and Australian Football (Ryan, Coutts, Hocking, & Kempton, 2017). At present, the influence of both situational factors (such as the opposition rank and weather conditions), and individual factors (such as playing position and fitness) on physical performance is unknown using appropriate statistical modelling procedures. This will benefit staff and athletes through a more efficient and effective framework for the use of time and resources contributing to success. Future research is required on the impact of key contextual factors on rugby sevens physical performance for coaches, scientists, and practitioners to better prepare their athletes and teams for optimal performance.

The current literature shows rugby sevens to be an intermittent sport characterized by frequent high-intensity running bouts interspersed with low-intensity activity. Future studies should investigate the between-team variation in activity profile with standardized GPS devices across a season to provide more context to the presented values for coaches and scientists. The following section will outline the specific skill demands involved in elite rugby sevens match play.

Skill demands

Rugby sevens requires players to possess a large and diverse skill set to achieve a successful match outcome. According to the laws of rugby sevens (World Rugby, 2017), players can run, catch, pass, and kick to advance the ball up the field aiming to ground the ball in the oppositions in-goal area to score a try (5 points). Following a try, a conversion attempt is taken by attempting to drop kick the ball, in line with where the try was scored, over the posts (2 points). In defence, players attempt to tackle the opposition player with the ball by forcibly bringing them to the ground using their body, without tripping the opponent or tackling them above the shoulders. Defensive skill involvements such as tackling, rucking, and mauling are all primarily aimed at either denying the opposition from advancing the ball towards the in-goal area, or attempting to regain possession of the ball for the defensive team.

There has been limited research into the skill demands of rugby sevens, with currently only three studies describing the technical match requirements at the elite level (Higham, et al., 2014; Hughes & Jones, 2005; Ross, et al., 2015). Hughes and Jones (2005) used a novel hand notation system from video recordings of the 2001 IRB World Sevens Series to identify the playing patterns of successful (>70% matches won) and unsuccessful (<70% matches won) teams. Successful teams were shown to perform 33% fewer rucks, missed 50% fewer tackles, and produced 21% more line-breaks than unsuccessful teams (Hughes & Jones, 2005).

More recently, others have shown that successful teams adopt a patient, evasive style of play characterised by fewer rucks and mauls, as opposed to the unsuccessful teams' play characterised by a more direct style with frequent rucks and mauls, regardless of ball retention (Higham, et al., 2014). Indeed, the researchers reported that an increase in rucks and mauls per minute of possession had the largest negative relationship with point scoring and likelihood of winning, whereas percentage of rucks and mauls retained displayed the highest positive relationship. Moreover, when standardised relative to possession time, passing shows a negative association with points scored and kicking shows an unclear relationship. Other aspects of play that were shown to positively influence the scoring of points and likelihood of winning are fewer kicks, more cut-out and dummy passes (fewer normal and loop passes), and increased ball retention (Higham, et al., 2014).

The effect of conceding more or fewer penalties and free kicks remains unclear with conflicting research findings (Higham, et al., 2014; Hughes & Jones, 2005). A study from the 2001 World Series showed successful teams conceding more penalties than less successful teams (Hughes & Jones, 2005). It has been suggested that successful teams may be more likely to play through an advantage ruling by the referee (where the team in possession can choose to accept a penalty or continue playing), whereas less successful teams may more commonly opt to accept the penalty (Higham, et al., 2014). This will lead to the more successful team presenting a higher number of penalties conceded. Whilst Higham et al. (2014) found that conceding more penalties and free kicks was associated with fewer points scored, the effect on the likelihood of winning was unclear between teams and trivial within teams.

Differences in technical demands between playing positions have been shown with authors reporting only small differences between backs and forwards (Ross, et al., 2015). Backs typically performed a greater number of ball carries, threw more passes, and scored more tries than forwards, whereas forwards were involved in more defensive ruck activities, restart contests, and more frequently carried the ball into contact (Ross, et al., 2015). The lack of a large distinction in technical performance parameters between positions suggests that players are likely to require a more generalist skillset, and can be trained more homogenously than athletes competing in 15-a-side rugby union (Lacome, Piscione, Hager, & Carling, 2017).

Collectively, these studies show that technical skills account for a large component of successful rugby sevens match and tournament outcomes. It is also clear that players in more successful teams have increased ball retention, fewer rucks and mauls, and fewer missed tackles. These find-

ings provide a framework for coaches to develop technical and tactical approaches. However, similar to previous studies that examined physical activity profiles, these studies also are limited by relatively low sample sizes and failure to adjust for repeated measures from individual players. Further studies with larger sample sizes, controlling for repeated measures within subjects and the confounding effects of contextual factors on performance are required to strengthen these findings.

Measuring performance

Measurement of an individual's performance in team sports is a difficult task that must encompass a range of sport-specific factors contributing to the match outcome. In team sports, winning or losing is a function of scoring more or fewer points than your opposition during a match (points differential). Scoring points and preventing the opposition from scoring is dependent on the success of the offensive and defensive performance of the players and team. Assessing an individual's contribution to his team's offensive and defensive systems is problematic due to the complex interplay between its determinants, and as a result there is presently no single metric to accurately measure an individual's holistic match performance in rugby sevens. In other team sports, researchers have constructed conceptual models of performance encompassing the constructs purported to impact the overall performance measure (i.e., wins) (Impellizzeri & Marcora, 2009). This model provides context to the factors affecting performance in team sport and the constructs associated with those factors. Figure 3 presents a conceptual model of performance for rugby sevens incorporating its relevant constructs. The measurement of a player's performance can be quantified subjectively (coaches/expert perceived ratings) or objectively (i.e., econometric measures based purely on match statistical performance). Subjective measures of performance can be limited due to the inter-individual or inter-coach variation in perceived performance, or conscious or subconscious biases influencing the metric. In contrast however, objective measures are limited by only being able to derive the value of the metric from player match statistics, where it is a wide held belief that many aspects of successful player performance cannot be accurately quantified solely from match statistics (Sullivan, et al., 2014). Greater information on a player's individual contribution to the team's offensive and defensive system will allow coaches to make more informed tactical decisions surrounding team selection and playing style. If successfully employed, this may lead to an improved points differential during matches, and therefore more matches won.

Previous studies have attempted to assess individual performance in other field-based team sports through examining the relationship between physical activity profile and skill involvements in matches won and lost, either within-team or between more and less successful teams (Bauer, Young, Fahrner, & Harvey, 2015; Kempton, Sirotic, & Coutts, 2017; Mangan, et al., 2017; Robertson, Back, & Bartlett, 2016; Sullivan, et al., 2014). Research from Australian football has shown that a combination of skill measures largely predicted coaches' perception of player performance, with only a small contribution of the rating derived from measures of physical output (Sullivan, et al., 2014). In this investigation, increased match physical activity was negatively associated with the player's perceived performance from coaches. A limitation of the ecological validity of this type of measure is that it only incorporates two of the three relevant constructs to overall team performance, with tactical performance not being accounted for. It is possible that a similar association between skill involvements, activity profile, and player performance (as seen in Australian football) may exist in rugby sevens; currently this is

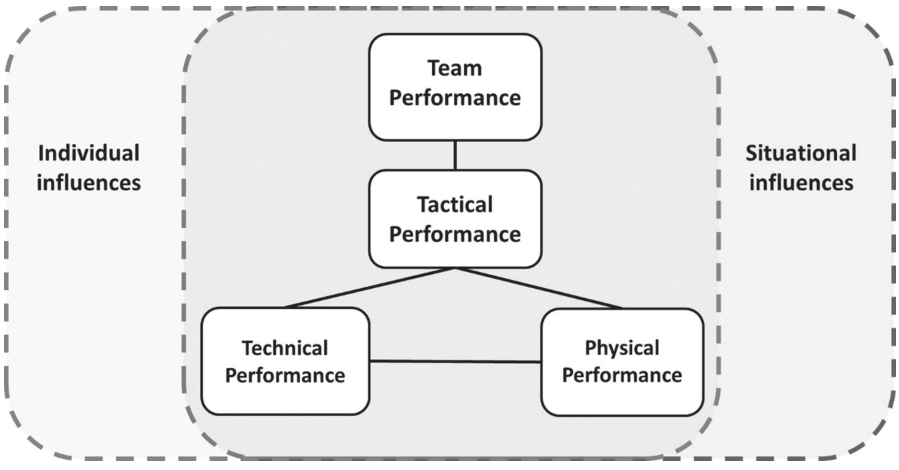

Figure 3: Theoretical model of rugby sevens performance (modified from Impellizerri & Marcora 2009).

unknown. To assist in the conceptual understanding of rugby sevens performance, research is required to determine and value the primary influences impacting the performance constructs in rugby sevens. To date, no research exists in rugby sevens analysing the influence of physical and technical constructs on match performance.

This review has demonstrated that rugby sevens requires the synergy of physical, technical, and tactical proficiencies. In other team sports, studies have examined the relationships between physical activity profile and skill involvements on performance. The association between these parameters, and the factors influencing them, has not been investigated in rugby sevens.

Summary and conclusions

This review summarized the literature relating to the demands of international rugby sevens match play, including players' physical activity profiles and technical skill demands. Further, the literature highlights a dearth of research on the measurement of international rugby sevens match performance incorporating its physical activity and skill involvement constructs. This has been identified as an area for future research, as well as the influence of a range of contextual factors associated with international rugby sevens programs.

The findings from this review include:

- Successful performance in rugby sevens requires the synergy of physical, technical, and tactical proficiencies.
- The activity profile of rugby sevens involves large relative distance ($m \cdot min^{-1}$) values compared to other field-based team sports, incorporating intermittent high-intensity running bouts.
- The skill profile of rugby sevens involves players offensively catching, running, passing, and kicking the ball, and defensively tackling, rucking and mauling.
- Aspects of the game such as increased ball retention and decreased rucks and mauls per minute have been shown to correlate strongly with increased point scoring and likelihood of winning.
- Many of the studies conducted in rugby sevens are limited by small sample sizes, research within one team, and repeated measures of players.
- There is a poor understanding of how situational and individual contextual factors influencing elite rugby sevens programs are affecting physical and technical performance.

Further research is required to investigate the relationship between physical and technical performance on match outcome, and the factors affecting the physical and technical constructs of performance.

References

Aughey, R.J., & Falloon, C. (2010). Real-time versus post-game GPS data in team sports. *Journal of Science and Medicine in Sport, 13*(3), 348-349. doi:10.1016/j.jsams.2009.01.006

Barbero-Álvarez, J. C., Coutts, A.J., Granda, J., Barbero-Álvarez, V., & Castagna, C. (2010). The validity and reliability of a global positioning satellite system device to assess speed and repeated sprint ability (RSA) in athletes. *Journal of Science and Medicine in Sport, 13*(2), 232-235. doi:10.1016/j.jsams.2009.02.005

Bauer, A.M., Young, W., Fahrner, B., & Harvey, J. (2015). GPS variables most related to match performance in an elite Australian football team. *International Journal of Sports Performance Analysis in Sport, 15*(1), 187-202. doi:10.1080/24748668.2015.11868786

Coutts, A.J., & Duffield, R. (2010). Validity and reliability of GPS devices for measuring movement demands of team sports. *Journal of Science and Medicine in Sport, 13*(1), 133-135. doi:10.1016/j.jsams.2008.09.015

Curry, A., Heptonstall, V., & Warwick, C. (2015). The future of rugby: An HSBC report. *HSBC World Rugby Sevens Series 2015/16*.

Edgecomb, S.J., & Norton, K.I. (2006). Comparison of global positioning and computer-based tracking systems for measuring player movement distance during Australian football. *Journal of Science and Medicine in Sport, 9*(1-2), 25-32. doi:10.1016/j.jsams.2006.01.003

Ferguson, C., Wilson, J., Birch, K.M., & Kemi, O.J. (2013). Application of the speed-duration relationship to normalize the intensity of high-intensity interval training. *PLoS ONE, 8*(11), e76420. doi:10.1371/journal.pone.0076420

Furlan, N., Waldron, M., Shorter, K., Gabbett, T.J., Mitchell, J., Fitzgerald, E., Osborne, M. A., & Gray, A.J. (2015). Running-intensity fluctuations in elite rugby sevens performance. *International Journal of Sports Physiology and Performance, 10*(6). doi:10.1123/ijspp.2014-0315

Granatelli, G., Gabbett, T.J., Briotti, G., Padulo, J., Buglione, A., D'Ottavio, S., & Ruscello, B.M. (2014). Match analysis and temporal patterns of fatigue in rugby sevens. *Journal of Strength and Conditioning Research, 28*(3), 728-734. doi:10.1519/JSC.0b013e31829d23c3

Higham, D.G., Hopkins, W.G., Pyne, D.B., & Anson, J.M. (2014). Performance indicators related to points scoring and winning in international rugby sevens. *Journal of Sports Science and Medicine, 13*(2), 358-364.

Higham, D.G., Pyne, D.B., Anson, J.M., & Eddy, A. (2012). Movement patterns in rugby sevens: Effects of tournament level, fatigue and substitute players. *Journal of Science and Medicine in Sport, 15*(3), 277-282. doi:10.1016/j.jsams.2011.11.256

Higham, D.G., Pyne, D.B., Anson, J.M., Hopkins, W.G., & Eddy, A. (2016). Comparison of activity profiles and physiological demands between international rugby sevens matches and training. *Journal of Strength and Conditioning Research, 30*(5), 1287-1294. doi:10.1097/jsc.0000000000000212

Hughes, M.D., & Jones, R. (2005). Patterns of play of successful and unsuccessful teams in men's 7-a-side rugby union. In *Science and Football V*, The Proceedings of the Fifth World Congress on Sports Science and Football (pp. 252-258). London: Routledge.

Impellizzeri, F.M., & Marcora, S.M. (2009). Test validation in sport physiology: Lessons learned from clinimetrics. *International Journal of Sports Physiology and Performance, 4*(2), 269-277.

Kempton, T., & Coutts, A.J. (2016). Factors affecting exercise intensity in professional rugby league match-play. *Journal of Science and Medicine in Sport, 19*(6), 504-508. doi:10.1016/j.jsams.2015.06.008

Kempton, T., Sirotic, A.C., & Coutts, A.J. (2017). A comparison of physical and technical performance profiles between successful and less-successful professional rugby league teams. *International Journal of Sports Physiology and Performance*, 12(4), 520-526. doi:10.1123/ijspp.2016-0003

Lacome, M., Piscione, J., Hager, J.P., & Carling, C. (2017). Fluctuations in running and skill-related performance in elite rugby union match-play. *European Journal of Sport Science, 17*(2), 132-143. doi:10.1080/17461391.2016.1220986

Lee, A., & Galvez, J. C. (2012). Jet lag in athletes. *Sports Health, 4*(3), 211-216. doi:10.1177/1941738112442340

MacLeod, H., Morris, J., Nevill, A., & Sunderland, C. (2009). The validity of a non-differential global positioning system for assessing player movement patterns in field hockey. *Journal of Sports Sciences, 27*(2), 121-128. doi:10.1080/02640410802422181

Malone, J.J., Lovell, R., Varley, M.C., & Coutts, A.J. (2017). Unpacking the black box: Applications and considerations for using GPS devices in sport. *International Journal of Sports Physiology and Performance, 12*, S2-18-S2-26. doi:10.1123/ijspp.2016-0236

Mangan, S., Malone, S., Ryan, M., McGahan, J., O'neill, C., Burns, C., Warne, J., Martin, D., & Collins, K. (2017). The influence of match outcome on running performance in elite Gaelic football. *Science and Medicine in Football*, 1(3), 272-279. doi:10.1080/24733938.2017.1363907

Mitchell, J.A., Pumpa, K.L., & Pyne, D.B. (2017). Responses of lower-body power and match running demands following long-haul travel in international rugby sevens players. *Journal of Strength and Conditioning Research, 31*(3), 686-695. doi:10.1519/JSC.0000000000001526.

Murray, A.M., & Varley, M.C. (2015). Activity profile of international rugby sevens: Effect of score line, opponent, and substitutes. *International Journal of Sports Physiology and Performance, 10*(6), 791-801. doi:10.1123/ijspp.2014-0004

Murray, N.B., Gabbett, T.J., & Chamari, K. (2014). Effect of different between-match recovery times on the activity profiles and injury rates of national rugby league players. *Journal of Strength and Conditioning Research, 28*(12), 3476-3483. doi:10.1519/jsc.0000000000000603

Rienzi, E., Reilly, T., & Malkin, C. (1999). Investigation of anthropometric and work-rate profiles of Rugby Sevens players. *Journal of Sports Medicine and Physical Fitness, 39*(2), 160.

Robertson, S., Back, N., & Bartlett, J. D. (2016). Explaining match outcome in elite Australian Rules football using team performance indicators. *Journal of Sports Sciences, 34*(7), 637-644. doi:10.1080/02640414.2015.1066026

Ross, A., Gill, N., & Cronin, J. (2015). The match demands of international rugby sevens. *Journal of Sports Sciences, 33*(10), 1035-1041. doi:10.1080/02640414.2014.979858

Ryan, S., Coutts, A.J., Hocking, J., & Kempton, T. (2017). Factors affecting match running performance in professional Australian Football. *International Journal of Sports Physiology and Performance*, 1-19. doi:10.1123/ijspp.2016-0586

Suarez-Arrones, L., Núñez, J., Sáez de Villareal, E., Gálvez, J., Suarez-Sanchez, G., & Munguía-Izquierdo, D. (2016). Repeated high-intensity running activity and internal training load of elite rugby sevens players during international matches: A comparison between halves. *International Journal of Sports Physiology and Performance, 11*(4). doi:10.1123/ijspp.2014-0523

Sullivan, C., Bilsborough, J.C., Cianciosi, M., Hocking, J., Cordy, J.T., & Coutts, A.J. (2014). Factors affecting match performance in professional Australian football. *International Journal of Sports Physiology and Performance, 9*(3), 561-566. doi:10.1123/ijspp.2013-0183

Tucker, R. (2016). Rugby Sevens: Olympic debutante and research catalyst. *British Journal of Sports Medicine, 50*(11), 638. doi: 10.1136/bjsports-2016-096306.

van Rooyen, M.K., Lombard, C., & Noakes, T.D. (2008). Playing demands of sevens rugby during the 2005 Rugby World Cup sevens tournament. *International Journal of Performance Analysis in Sport, 8*(2), 114-123. doi:10.1080/24748668.2008.11868441

West, D.J., Cook, C.J., Beaven, M.C., & Kilduff, L.P. (2014). The influence of the time of day on core temperature and lower body power output in elite rugby union sevens players. *Journal of Strength and Conditioning Research, 28*(6), 1524-1528. doi:10.1519/jsc.0000000000000301

World Rugby. (2017). Laws of the Game. Retrieved from http://laws.worldrugby.org/?variation=2 on 20th June, 2017.

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