

Time-motion analysis via Global Positioning Systems that discriminate between successful and less-successful South African, U/18 provincial sevens Rugby teams

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Abstract

Despite the popularity of Sevens Rugby, due to its Olympic status, very limited scientific research exists to date. Such knowledge may shed light on the physical demands that this sport places on the participants during match play. The purpose of this study was to determine if movement velocities discriminated significantly between the successful (top eight teams) and less successful (bottom eight teams) South African, u/18 provincial Sevens Rugby teams. The movement velocities, frequencies, distances and duration of hundred and sixty players who represented sixteen provinces at the 2011 South African Sevens Rugby Tournament were recorded using the Catapult Minimax (Catapult 10Mhz). The movements were categorized according to the velocities as determined by Castagna and D'Ottavio (2001). Finally work to rest ratio's were determined. The effect size results of the differences between the successful and less successful teams indicated that walking efforts, walking time and high intensity running efforts displayed a moderate practical significant difference between teams compared to walking distance which obtained a small practical significance value. The results of the forward stepwise descriptive analysis revealed that the percentage time spent on walking, distance and high intensity running distance together with the number of high intensity running efforts significantly discriminated ($p \leq 0.05$) between successful and less successful Sevens Rugby teams. The classification matrix showed that the discriminant analysis prediction functions were 77.5% accurate in classifying the different teams back into successful and less successful groups. The average work to rest ratio for all the matches, was found to be 1:18. Furthermore, the results showed that the percentage time spent walking, walking distance and high intensity running distance together with the number of high intensity running efforts, discriminated significantly between successful and less successful Sevens Rugby.

Keywords: Time motion analyses, Sevens Rugby, rugby, work rest ratios, GPS sport tracking.

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Introduction

Sevens rugby is a variant of Rugby Union with repeated short duration, high intensity running efforts on multiple occasions (Higham *et al.*, 2011). The game is played on a normal Rugby Union field with only seven players in each team,

which add up to fourteen players in total permitted on the field at any stage in a Sevens match in comparison with the thirty players on the field during a Rugby Union match. The duration of a Sevens rugby match comprise fourteen minutes that is divided into two seven minute halves. Sevens Rugby has increased in popularity due to the Sevens rugby World Cup and International Rugby Board World Sevens Series. Higham *et al.* (2011) believes that the already existing popularity of Sevens Rugby will increase since the International Olympic Committee granted Olympic status to the sport in 2009.

Despite the popularity of Sevens rugby, to date very limited scientific research on Sevens Rugby exists. The importance of such scientific research have been recognized and pleaded for by several researchers (Duthie *et al.*, 2003; Deutsch *et al.*, 2007; Cunniffe *et al.*, 2009) in the belief that light would be shed on the physical demands that the sport place on the corresponding participants.

Duthie *et al.* (2003) suggested time-motion analysis to determine and understand the physical demands that sport codes requires from players to perform. Previous studies have used video notation to analyse time-motion in Rugby Union in order to a) estimate the distance players travelled at certain velocities (Deutsch *et al.*, 1998; Roberts *et al.*, 2008; Austin *et al.*, 2011b), b) determine the time players spend on certain movement activities (Duthie *et al.*, 2005; Deutsch *et al.*, 2007; Kraak *et al.*, 2011 & Austin *et al.*, 2011a), c) determine the work to rest ratios' of successful teams/players (Brewer & Davis 1995; Eaton & George, 2006) d) determine certain fixed movement activities known as performance indicators (Sasaki *et al.*, 2007; Jones *et al.*, 2008; Van den Berg & Malan, 2010) during match-play in rugby union. Objectivity was considered the biggest advantage of time-motion analyses (Randers *et al.*, 2010).

Unfortunately, vigorous debates have originated with regards to the reliability and validity of time-motion analyses done by means of video notation (Duthie *et al.*, 2003). It is therefore understandable that Global Positioning Systems (GPS) are currently preferred when time-motion analysis is done. Studies using GPS-tracking to analyse time-motion have proven valid and reliable by Jennings *et al.* (2010). Gray *et al.* (2010) concurred and advised the use of GPS sport tracking for team based sport codes.

Recent studies done by means of GPS tracking on international Sevens rugby players include work done by Higham *et al.* (2011) who determined that players reached higher maximum running velocity during international tournament matches than during domestic tournaments and covered a greater distance at higher velocities, respectively. Second half substitute players exhibited a substantially greater work-rate compared with players that played the entire match. A study done by Cunniffe *et al.* (2009) on rugby union, determined that during a game of 83 minutes, 72% of the total time was spent standing still and

walking, 18.6% of the total time was spent jogging, 3.3% of the total time was spent cruising, 3.8% of the total time was spent striding, 1% of the total time was spent high-intensity running and 1.2% of the total time was spent sprinting. A work to rest ratio value of 1:5.7 was reported.

The following research questions emerged from the above literature. What is the work to rest ratio for South African, provincial u/18 Sevens Rugby players during match play? Do movement velocities discriminate between successful and less successful South African, provincial U/18 Sevens Rugby teams?

The results from this study will enable coaches and sport scientists to assess the effect that specific movement velocities have on performance. The results from the time-motion analysis will also provide an objective yet non-invasive method for quantifying the work-rate ratio of the elite Sevens Rugby players. In addition information directly applicable to the design of physical conditioning and testing programmes will be acquired.

Methodology

Research design

This study was an observational, selective, descriptive, ex-post facto study which means that the data were analysed after completion of the match.

Sample population

All the players (n=160) that took part in the South African provincial U/18 Sevens Rugby tournament held at Konca, Rustenburg were included in the study. These included the following provincial teams according to their respective ranking order as determined by the tournament committee after completion of the respective tournament: Blue Bulls, Cheetahs, Western Province, SWD Eagles, Kwazulu Natal, Golden Lions, Boland Cavaliers, Pumas, Limpopo Blue Bulls, Zimbabwe, Griffons, Namibia, Griquas, Leopards, Griquas Country District and Border Bulldogs. The top 8 teams were categorized as successful and the bottom 8 teams as less successful.

Procedures of testing

Movement velocities were assessed by fitting players with a minimaxX GPS device (Team Sport v 2.5, Catapult Innovations, Melbourne, Australia) recording at 10 Hz. The GPS device was positioned between the scapulae of the player using an elasticised harness worn underneath the playing attire throughout the duration of the match on a standard size rugby union field. The device was activated and satellite lock was established for a minimum of 5 minutes before

the commencement of the first match. Data were downloaded and analysed using Logan Plus 4.4.0 software (Catapult Innovations, Melbourne, Australia). Movement velocities were quantified based on distance covered in specific velocity zones as suggested by Castagna and D'Ottavio (2001) [standing, 0–0.5 m s⁻¹, walking, 0.5–1.7 m s⁻¹, jogging, 1.7–3.6 m s⁻¹, medium intensity running, 3.6 – 5 m s⁻¹, high intensity running, 5 – 6.7 m s⁻¹ and maximum speed running \geq 6.7 m s⁻¹], as well as percentage time spent on each movement activity. The different movement velocities were categorized into active -and passive recovery as well as workload. Active recovery is defined by McLean (1992) as low-intensity activities which include walking and jogging. Passive rest on the other hand included activities that signified very little to no movement. The chosen velocity zones represented the range of loco-motor activity profiles typical of intermittent team sport and were routinely used during GPS monitoring in Australian rugby union.

Statistical procedures

The Statistical Consultation Service of the North-West University determined the statistical methods and procedures for the analysis of the research data. The Statistical Data Processing package (StatSoft Inc., 2011) was used to process the data. Firstly, descriptive statistics of the different variables for each of the provincial Sevens Rugby teams were calculated. This was followed by an independent t-test to indicate the statistical significant differences between the movement velocities of the successful (top eight ranked) and less successful (bottom eight) provincial Sevens rugby teams. The level of significance was set at $p \leq 0.05$. Thirdly, standard and forward stepwise discriminant analyses were performed to determine the variables that discriminated the most between the two groups of players as well as to determine the prediction function of these variables by means of a mathematical formula. In conclusion a work to rest ratio was determined.

Results and Discussion

Firstly the descriptive statistics of all the rugby teams including the top 8 teams (successful) and the bottom 8 teams (less-successful) that took part in the 2011 u/18 Sevens Rugby Tournament as determined by an independent t-test are presented in Table 1. Table 1(a) displays the data describing the variables concerning active and passive rest movement velocities, while Table 1(b) displays the data describing the variables of workload movement velocities. Table 1(a): Descriptive statistics of the different movement velocities of all the participants in the South African provincial u/18 Sevens players.

Table 1 (a): Active and passive rest movement velocities

Variables	All teams		Top 8 teams		Bottom 8 teams	
	Mean	SD	Mean	SD	Mean	SD
Standing Time (s)	383.6762	330.5093	430.0625	435.8286	337.29	159.8474
Standing Time (%)	58.5	13.5377	58.15	14.6703	58.85	12.3853
Walking Distance (m)	428.6**	137.6172	396.975	115.2180	460.225	151.0494
Walking Distance (%)	35.1437	8.3875	34.6	7.3719	35.6875	9.3085
Walking Time (s)	279.777**	92.5513	257.4	77.7662	302.1538	100.887
Walking Time (%)	23.9812	7.8704	23.775	8.0567	24.1875	7.7248
Walking Efforts	52.8250**	19.2166	48.1750	16.4777	57.4750	20.6863
Jogging Distance (m)	412.0625	158.3046	398.0875	156.0505	426.0375	160.2830
Jogging Distance (%)	35.4562	39.8494	33.0625	7.2012	23.85	55.9695
Jogging Time (s)	142.7450	57.1133	138.7475	58.2866	146.7425	55.9953
Jogging Time (%)	12.1125	4.8603	12.4125	5.3408	11.8125	4.3403

*Significant walking effort and walking time.

A medium, statistical significant difference ($p=0.0036$) was found for walking distance with the less successful teams walking 63.5 meters more on average than the successful teams. These results are supported by the significant statistical values that emerged from walking efforts ($p=0.001983$) and walking time ($p=0.002001$).

Table 1(b): Descriptive statistics of the different workload orientated movement velocities during match play of the participating subjects in the South African provincial u/18 Sevens players.

Variables	All teams		Bottom 8 teams		Top 8 teams	
	Mean	SD	Mean	Variables	Mean	SD
Running Distance (m)	178.2912	86.9045	170.3325	76.2568	186.25	96.2133
Running Distance (%)	13.8250	4.5881	14.15	4.5759	13.5	4.6060
Running Time (s)	41.6475	29.7295	39.0925	23.6399	44.2025	34.7391
Running Time (%)	3.3813	1.9259	3.4875	2.0745	3.275	1.7716
Running Efforts	13.8125	22.2468	14.8250	30.9805	12.8000	5.8513
Sprinting Distance (m)	99.4125	56.9226	92.65	52.6772	106.175	60.4472
Sprinting Distance (%)	7.7625	3.4064	7.6750	3.5606	7.85	3.2651
Sprinting Time (s)	18.7694	17.3553	17.9763	18.9950	19.5625	15.6250
Sprinting Time (%)	1.4625	1.2229	1.3750	0.9329	1.55	1.4574
Sprinting Efforts	5.7188*	3.1184	5.0250	2.8947	6.4125	3.3326
Maximal Sprint Distance (m)	41.0437	40.0219	36.2375	33.7422	45.85	45.1493
Maximal Sprint Distance (%)	3.1937	2.9937	2.9750	2.6954	3.4125	3.2674
Maximal Sprint Time (s)	6.0799	7.8469	5.5838	6.7881	6.5761	8.7950
Maximal Sprint Time (%)	0.4125	0.5307	0.3875	0.4903	0.4375	0.5702
Maximal Sprint Efforts	1.7438	1.5016	1.5250	1.2219	1.9625	1.7170

* $p \leq 0.05$ (small); ** $p \leq 0.005$ (medium); *** $p \leq 0.001$ (large)

These results correlate with a study done by Higham *et al.* (2011) on Sevens Rugby players during domestic and international tournaments, and found a small statistically significant difference between the international and domestic

movement velocities. The international tournament data reflected a mean walking distance of 30.6 meters per minute, and the domestic tournaments' mean walking distance of 33.3 meters per minute was obtained. This could be due to the fact that the international players' higher level of experience and knowledge of the game together with the physical demands that this level required them to do less walking than the players in the domestic tournaments. It is our belief that with the successful teams in this study and the international players in the study of Higham *et al.* (2011) both understand the importance of energy preservation and therefore refrained from migrating unnecessarily.

Sprinting distance as seen in Table 1(b) displays a small statistical significant difference, where the successful teams with a mean value of 5.0250 efforts per match, had less sprinting efforts compared to the mean of 6.4125 efforts per match, by the less successful teams. No data regarding sprinting efforts could be found in other studies. The differences in sprinting efforts in this study could be the result of the fact that the less successful teams had to do more defensive than attacking plays. The increasing defensive efforts could have resulted in them having to commit more than one defender to one attacking player which led to a higher sprinting effort count than the successful teams.

Table 2: The results of the forward stepwise discriminant analyses of u/18 Sevens Rugby teams during the Provincial tournament

	F-remove	p-value
Walking time	2.87991	0.091779
Walking time %	38.00372***	0.0000000
Walking distance	10.55095**	0.001435
Jogging distance	1.34451	0.248095
Sprinting time %	2.40974	0.122704
Sprinting distance	3.93223*	0.049207

*p<0.05 (small); **p<0.005 (medium); ***p<0.001(large)

The results from the forward stepwise discriminant analysis also gave some insight in compiling a classification matrix that would enable participants to accurately predict if their team will be classified as successful or less-successful. Furthermore a small statistically significant difference was obtained from the forward stepwise discriminant analysis regarding sprinting distance, which can be attributed to the above sprinting efforts in table 1(b) previously mentioned.

The following formulas were used to determine the prediction function:

$$\text{Successful rugby teams (G1)} = (0.233 \times \text{walking efforts}) + (2.375 \times \% \text{ walking time}) + (0.155 \times \text{walking distance}) + (0.873 \times \text{running fast efforts}) + (0.268 \times \text{Running time}) + (-0.006 \times \text{running efforts}) + (-0.002 \times \text{walking time}) + (-0.33 \times \text{running fast \% distance}) + (4.164 \times \text{running fast \% time}) + (0.066 \times \% \text{ jogging distance}) - 125.677$$

Less successful teams (G2) = (0.202 x walking efforts) + (2.204 x % walking time) + (0.146 x walking distance) + (0.561 x running fast efforts) + (0.254 x Running time) + (0.013 x running efforts) + (-0.001 x walking time) + (0.143 x running fast % distance) + (3.803 x running fast % time) + (0.060 x % jogging distance) -109.045. The prediction function led to the following classification matrix as presented in Table 3.

Table 3: The results from the classification matrix

	Percentage correct	Group 1	Group 2
G1: Successful teams	75.00	60	20
G2: Less successful team	80.00	16	64
Total	77.50	76	84

The classification matrix clearly predicts a 77.5% accuracy in whether a team would be placed in the successful (top 8) or less successful (bottom 8) groups. After the classification of the teams, a work:rest ratio was determined according to the percentage time spent on the different movement velocities.

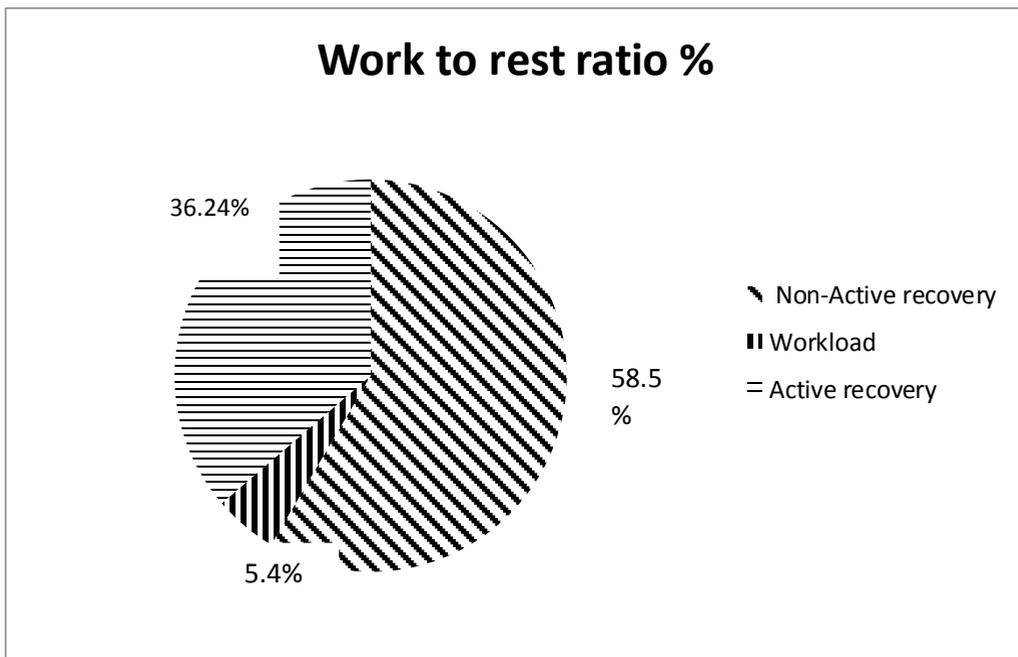


Figure 1: Workload ratio of the U/18 Rugby provincial tournament

The different movement velocities were categorized into active –recovery and passive recovery as well as workload. Active recovery as defined by McLean (1992) includes low-intensity activities which include walking and jogging. Passive recovery on the other side refers to activities with very little to no movement such as walking. A work rest ratio of 1:17.6 was found in this study. The work:rest ratio obtained in this study greatly differs from the 1:5.7 work:rest

ratio Cunniffe *et al.* (2009) found in a study done on rugby union. The large difference between these two ratios could be attributed to the different natures of the sports. Rugby union has a longer duration as well as 15 players on each side, and Sevens Rugby being a sport of short duration with a high speed pace. The figure clearly shows that 5.4% of total time spent is on workload activities, while 36.24% total time spent on active recovery movement patterns and 58.5% of the total time spent on passive recovery activities. Both of these two types of recovery activities make up 94.6% of the total time spent on the field, with only 5.4% of the movement velocities spent on workload.

Conclusion and Recommendations

This study revealed that walking distance $p \leq 0.003360$, walking efforts $p \leq 0.001983$, walking time $p \leq 0.002001$ as well as sprinting efforts $p \leq 0.005558$ discriminated statistically significant between successful and less successful provincial South African u/18 Sevens Rugby teams. The prediction matrix produced a 77.5% accuracy in correctly predicting teams into the successful and less-successful groups. The statistical data enabled the researchers to obtain a work:rest ratio of 1:17.6 which can be further divided into non-active recovery at 58.5%, active recovery at 36.24% and workload at 5.4% of the total time spent on match play.

The results of this study could shed some light on the way coaches and sport scientists should construct their preparation and conditioning of the sport, especially when populations similar to the South African u/18 provincial Sevens Rugby players are present.

It is recommended that further research should be conducted where the player position specificity is taken into account. A comparison of the movement velocities and work:rest ratios of substitute players and players playing the entire match might also be insightful.

Although this technology is considered the golden standard, due to the fact that it has only been on the market for a short while, issues could arise concerning the application of this technology in the future.

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