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RESEARCH ARTICLE

Effect of fatigue on the movement activities of senior male Zimbabwean national rugby sevens players

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ABSTRACT

The objective of the study was to determine the effect of fatigue on the percentage of time sevens rugby players spend on the movement activities during the two different halves of match play and to compare the percentage of time starter and substitute players spend on high and low-intensity movement activities. Sixty-one time-motion analyses data-sets of twelve (12) senior male elite Zimbabwean rugby sevens players with a mean age of 27.8 years were gathered at two International Sevens rugby tournaments. Time-motion analysis data were captured at 10 Hz with a minimaxX GPS device. Results indicated that starter players covered a significantly greater distance ($r = 0.26$) than substitute players. However, substitute players covered a significantly greater relative distance (distance per minute) ($r = 0.33$) than the starter players. Hence, the substitute players had less rest during match play and therefore a higher work-to-rest ratio than the starter players. No large practically significant differences found between the high intensity movement activities of the players during the two halves of match play, suggesting that fatigue did not affect the players' movement activities. The results therefore suggest that the use of substitute players may support the ability of teams to increase the players work rate.

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KEYWORDS
Rugby; tournament level; time-motion analyses; fatigue

1. Introduction

Rugby sevens is played across the globe in tournaments that stretch across 2–3 days, where teams are expected to play 3–6 matches per day (Lopez et al., 2012) with rest periods between matches on the same day. These rest periods may vary from 20 to 180 min. A match lasts 14 min (two 7-min halves with a 2-min break in between), except for the cup final which lasts 20 min (two halves of 10 min each) (Meir, 2012). Each team consists of 12 players with seven starter and five substitute players (Carreras, Kraak, Planas, Martin, & Vaz, 2013). The popularity of rugby sevens, as well as its Olympic status, has increased the need for scientific research which can contribute to the improvement of players' performance (Higham, Hopkins, Payne, & Anson, 2014).

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As rugby teams strive towards performance, the physiological impact of the game/s as depicted by movement activities needs to be determined through time-motion analyses (TMA) of the respective players (Quarrie, Hopkins, Anthony, & Gill, 2013; Smith, 2013). Global positioning system (GPS) units are considered to be the most valid and reliable TMA method to measure the movement activities of rugby players during matches (Coughlan, Green, Pook, Toolan, & O'Connor, 2011; Coutts & Duffield, 2010; Johnston et al., 2013). Movement activities within the game are divided into high-intensity (fast jogging, running and sprinting) and low-intensity (slow jogging, walking and standing) activities.

The knowledge and testing of the movement activities of rugby players during match play are considered to be of great value to coaches and sport scientists for determining work rate and monitoring player performance during a match (Austin, Gabbett, & Jenkins, 2011; Quarrie et al., 2013).

Due to the relatively high intensity of match play during sevens rugby, coaches also regarded it necessary to determine whether a difference occurs in the movement activities between the two halves of matches. Although, no significant differences were found between any movement activities of rugby sevens players during the two halves (Rienzi, Reilly, & Malkin, 1999; Suãrez-Arrones, Portillo, González-Ravé, Muñoz, & Sanchez, 2012), results indicated that the work rate of players decreased slightly, in the second half of match play (Carreras et al., 2013; Higham, Payne, Anson, & Eddy, 2012).

In addition to comparing the effect of fatigue on the movement activities of the players during the two halves, literature suggested that the impact of movement activities of substitute players should also be investigated (Van den Berg, 2013), due to the fact that starter players are replaced throughout the match by substitute players. The reason for the substitutions may be either to replace an injured player, to enhance a tactical concern of the coach or to try and prevent a decrease in the team's work rate. When comparing the movement activities of starter vs. substitute rugby sevens players research found that substitute players travelled longer distances on the various movement activities than was the case with the starter players (Higham et al., 2012).

Higham et al. (2012) focused on an Australasian population and documented the metres travelled per minute to compare their data. Similar comparisons were done by the research team from the current study to determine if the findings from Higham et al. (2012) were also applicable on international players from a different continent and the focus on the current study was rather on percentage time spend on movement activities and work-to-rest ratios than on metres travelled per minute.

The aims of this study were therefore to determine the effect of fatigue on the percentage of time and work-to-rest ratios that sevens rugby players spend on the movement activities during the two different halves of match play and also to compare the percentage of time and work-to-rest ratios that the starter and substitute players spend on high- and low-intensity movement activities.

Results of the present study may provide additional insight into the movement activities of rugby sevens players which may assist coaches, sport scientists and players to better understand the impact of the intensities and durations of the movement activities throughout the different halves of match play. It may also guide coaches with regards to when and how often to use their respective substitute players during the game to minimise the influence of fatigue on the team's and/or individual's performance.

2. Methods

2.1. Ethical considerations

Before the start of the study, all the players completed an informed consent form after the study protocol had been explained to them. It was also explained to the players that their participation in the study was done on a voluntary basis and that any player may withdraw at any time during the study without reprisal. The team management and federation gave their approval for the study. The study was approved by the Ethics Committee of the North-West University [NWU-00122–11-A1].

2.2. Participants

Twelve (12) senior male elite Zimbabwean rugby sevens players with a mean age of 27.8 years were used in the study. All the players had at least two years' experience of playing International rugby sevens.

2.3. Procedures

Sixty-one (n = 61) TMA data-sets were gathered from the Zimbabwean rugby seven's matches played at two International Sevens tournaments which were held one week apart. TMA elements such as work-to-rest ratios, distance travelled and percentage of time spent by the players in five different velocity categories during each half of match play, were included in the analyses. The data-sets were divided into TMA of players who completed the first and second half. When the TMA data-sets of the two halves were compared, only data-sets that represented a player's TMA of a full half were used.

TMA data were also divided for starter and substitute players with the hypothesis that substitute players are expected to play for shorter durations which might influence their respective TMA. When the data of the substitute and starter players were analysed, only data-sets of substitute players that were introduced in the second half (less than 7 min)were compared with data-sets of starter players who completed the match. Data of players who left the field during match time were discarded. All matches were played on a dry, standard rugby field with a natural grass surface.

Time-motion analysis data were captured with players wearing a safe, stretchable harness under their playing attire with a small pouch between the shoulder blades in which a minimaxX GPS device (Team Sport v 2.5, Catapult Innovation, Melbourne, Australia) was fitted. The devices were activated five minutes before and switched off just after each of the matches to record data at 10 Hz when switched on. Recorded data were downloaded and analysed using Logan Plus 4.4.0 software, developed for this system (Catapult Innovation, Melbourne, Australia). Movement velocities were categorised as suggested by Reid, Cowman, Green, and Goughlan (2013), which was at the time of data retrieving the most recent published guideline, namely: low-intensity activities/standing (0–0.5 m/s), walking (0.6–1.7 m/s), jogging (1.8–3.6 m/s), high-intensity activities/medium-intensity running (3.7–5 m/s), high-intensity running (5.1–6.7 m/s), and sprinting (above 6.7 m/s) indicating velocity zones which represent the range of loco-motor activity profiles typical of intermittent team sports and are routinely used during GPS monitoring of players' movement patterns in Rugby Union and Rugby Sevens.

2.4. Reliability concerns

To ensure inter-device validity, each player was allocated the same GPS device throughout both tournaments (Akenhead, French, Thompson, & Heys, 2014). Another reliability concern as indicated by the literature was addressed by ensuring the horizontal dilution of position values were never above 1, which is an acceptable value for good GPS signal strength throughout the recording (Petersen, Pyne, Portus, & Dawson, 2009). The movement activity data captured from the GPS recordings were expressed as follows: the percentage of time spent in each movement activity as well as the total distance travelled (Suarez-Arrones et al., 2012). Total distance travelled during the match was also calculated as total distance travelled per minute (relative distance) to account for variations in game time (Cunniffe, Practor, Baker, & Davies, 2009; Higham et al., 2012). Work-to-rest ratios were determined by comparing the time players had spent on low-intensity activities with the time players had spent on high-intensity activities. Low-intensity activities included standing, walking and jogging. The rest of the movement activities were considered to be high-intensity activities (McLean, 1992). Finally, the time players were off the playing field and the time for the half-time interval were not included in the analyses.

2.5. Statistical analysis

Statsoft Statistical Data Processing package (StatSoft Inc, 2013) was used to process the data. A hierarchical linear model (mixed models) was used to compare the TMA data of the two halves and that between the substitute and starter players. During the exploration of the data, Q–Q plots were drawn to determine normality by eyeballing the plots. From this, all the variables can be assumed to be normally distributed. Due to the fact that this was not a randomly selected sample, statistical significance alone was not used to determine differences between the groups, but more emphasis was placed on practical significance through Cohen's effect sizes (Ellis & Steyn, 2003). Practical significance was set as follows: small effect ≥ 0.2; moderate effect ≥ 0.5 and a large effect as ≥ 0.8. For the comparison between the starter and substitute data-sets a non-parametric Mann–Whitney test was additionally done to address the discrepancy that exist between the number of data-sets of the two groups. However, this analysis does not take the dependence of repeated measures into consideration as was the case for hierarchical linear models.

3. Results

The TMA data of the national senior Zimbabwean rugby sevens players between the two different halves during match play are displayed in Table 1.

Table 1 indicates that players travel an average of 548.1 m a half and a significant ($d = 0.53$) bigger distance in the second half compared to distance travelled in the first half. Players spend a moderate practically significant percentage of time standing less ($d = 0.47$) in the second half than in the first half. The players did, however, spend a significantly (moderate size) percentage time more on slow jogging ($d = 0.58$) and medium-intensity running ($d = 0.45$) in the second half than what the case was during the first half. No practically significant differences were found between the percentage of time players had spent on high-intensity running and sprinting between the two halves of rugby sevens match play. In

Table 1. Comparative movement activities of Zimbabwean national senior rugby sevens players between the two different halves during match play.

		1st Half (n = 57)	2nd Half (n = 44)			
Variables	Mean for total group	Mean for first half	Mean for second half	MSE	p-value	ES
Total distance (m)	548.1	596.8	504	30,724	0.043	0.53*
Relative distance (m min^{-1})	78.8	78	79.7	28,255.9	0.780	0.07
% time standing^{LI}	56.92	59.77	54.07	131.5	0.061	0.47*
% time walking^{LI}	13.75	13.15	14.35	30.1	0.395	0.22
% time jogging^{LI}	13.18	11.73	14.63	20.0	0.016	0.58*
% time medium-intensity running^{HI}	8.07	7.35	8.79	8.9	0.069	0.45*
% time high-intensity running^{HI}	5.91	5.74	6.08	9.6	0.670	0.11
% time sprinting^{HI}	1.48	1.24	1.71	2.5	0.260	0.25
Work-to-rest ratio	1:6.86	1:7.33	1:6.38	18.4	0.399	0.20

Notes: ES – Effect sizes; ES large ≥ 0.8**; Moderate ≥ 0.5*; Small ≥ 0.2; MSE – Mean square error; LI = Low intensity activity; HI = High intensity activity.

Table 2. Comparison of movement activities in Zimbabwean national senior starter and substitute rugby sevens players during match play.

	Team	Starter (n=54)	Substitute (n= 7)				Mann-Whitney	
Variables	Mean	Mean	Mean	MSE	p–value	ES = d	p-value	ES = r
Total distance (m)	550.8	564.2	424	30878	0.052	0.80**	0.041	0.26*
Relative distance (m min^{-1})	91.2.	74.89	107.39	23238.7	0.001	1.33**	0.000	0.33*
% time standing^{LI}	53.92	57.80	50.04	141.2	0.121	0.64*	0.643	0.04
% time walking^{LI}	12.38	14.20	10.56	29.1	0.098	0.67*	0.001	0.33*
% time jogging^{LI}	14.17	12.90	15.44	22.0	0.220	0.50*	0.686	0.04
% time medium-intensity running ^{HI}	9.10	7.79	10.32	9.1	0.053	0.8**	0.222	0.12
% time high-intensity running^{HI}	6.78	5.66	7.90	9.1	0.070	0.74*	0.080	0.17
% time sprinting^{HI}	1.72	1.39	2.04	2.6	0.374	0.34*	0.024	0.21
Work-to-rest ratio	1:5.71	1:5.30	1:3.86	18.4	0.117	0.81**	0.000	0.35*

Notes: Guidelines for d – ES: Large = 0.8**; Moderate ≥ 0.5*; Small ≥0.2; Guidelines for r – ES: Large ≥ 0.5**; Moderate ≥ 0.2*; Small ≥ 0.1; ES – Effect sizes; MSE – Mean square error; LI = Low-intensity activity; HI = High-intensity activity.

addition to comparing the TMA data of the sevens rugby players between the two different halves, the current study also aimed at investigating the possible differences that may exist between the TMA data of the starter and substitute rugby sevens players. The results for this comparison are presented in Table 2.

All TMA variables discriminated practically significant (d value) between starter and substitute players. Substitute players had spent a higher percentage of time on all high-intensity activities as well as on medium-intensity running. The starter players also spent significantly more percentage time on the lower intensity activities. However, only four variables indicated a practical significant difference between starter and substitute rugby sevens players which was confirmed by a moderate practical effect size of the Mann–Whitney test. Starter players covered a significantly greater distance (d = 0.8) (r = 0.26) than substitute players but substitute players covered a significantly greater relative distance (distance per minute) (d = 1.33) (r = 0.33) than the starter players. The starter players had spent significantly percentage more time (d = 0.67) (r = 0.33) walking than substitute players and lastly, the starter players recorded significantly (d = 0.81) (r = 0.35) lower work-to-rest ratios than the substitute players. When the work-to-rest ratios are considered, one needs to understand that the second value in the ratio expresses the seconds during which the player or group

rested. Hence, the substitute players had less rest during match play and therefore a higher work-to-rest ratio than the starter players.

4. Discussion

The important effect of fatigue on players and teams' ability to perform has been proven (Higham et al., 2012). Understanding the effect of fatigue on the movement activities of elite senior Zimbabwean rugby sevens players led the current study to collect valid and reliable TMA data via GPS technology to compare the movement activities of rugby sevens players between the two halves as well as between starter and substitute players during match play.

The findings by the current study indicated rugby sevens players travel an average of 548.1 metres a half at 78.8 m min^{-1} which are less than the 745 m travelled in the first half at 97.7 m min^{-1} for forwards and 895.5 m travelled in the first half for backs at 112.2 m min^{-1} as determined by Suarez-Arrones et al. (2014). However, the findings from the current study seem in line with research which found that players travelled a total distance of 643 m in the first half and 578 m in the second half (Granatelli et al., 2014) are more similar to findings of the current study. "A tendency of some rugby sevens teams to play more direct with less continuity while other teams try to prevent contact and keep continuity" might be the reason why different observations with regards to total distance travelled by rugby sevens players during a match occur in literature (M. Van der Watt, *Rugby sevens tendencies* [personal interview], Johannesburg, May 24, 2014).

Although rugby sevens players covered a significant (d = 0.53) bigger distance in the first half compared to distance travelled in the second half, one can see that no difference existed amongst the relative total distance (m min^{-1}) travelled between the two halves. The reason for the significant longer distances travelled in the first half might have been due to the fact that the second halves were all shorter in duration when compared to the first half. The second halves were presumably cut short by match officials who were under pressure to get the next match started on time as scheduled for television.

The findings which stated that rugby sevens players had spent a significant percentage of time more on slow and medium-intensity running movement activities in the second half of match play and a higher percentage of time standing still in the first half are in line with previous literature who found rugby sevens players, although not significantly, to be more stationary in the first half (Rienzi et al., 1999). These findings may be explained by the fact that rugby sevens players try to preserve as much energy as possible (Higham et al., 2012) by trying to remain stationary when they have the opportunity to do so in the first half. As the match progresses and time of match play becomes less, players may venture more towards jogging and medium-intensity running activities instead of being stationary, especially if they are behind on the score board. Similar to previous research, no practically significant differences were found between the percentage of time players had spent on high-intensity running and sprinting movement categories between the two halves of rugby sevens match play (Rienzi et al., 1999; Suãrez-Arrones et al., 2012). In addition to the lack of practically significant differences between the movement activities of the two different halves during match play, comparisons were also drawn between the TMA data of the starter and substitute players.

The practically significant greater relevant distance travelled by the substitute players in a specific allocated game time is similar to that reported by previous literature (Higham

et al., 2012). It therefore seems that the substitute players travel at greater velocities as they travelled greater distances over the same time period as starter players. The starter players spend a significant greater percentage of time walking, when compared to the substitute players. The current study also found that substitute rugby sevens players displayed a significantly better work-to-rest ratio than the starter players. These results are in line with previous research who stated that substitute rugby sevens players presented a better work rate than the starter players (Higham et al., 2012). The reason for the lower work rate by the starter players may be due to them trying to preserve some energy for later in the match to try and counter the effect of fatigue. However, the substitute players have a reduced known period of competing and therefore less need to pace themselves; thus enabling them to work at a higher rate (Higham et al., 2012).

5. Conclusion

The current study showed no large practically significant differences between the movement activities of the Zimbabwean national rugby sevens players during the two halves of match play, suggesting that fatigue did not affect the players' movement activities. However, a decrease in percentage time spent on walking as well as an increase in work-to-rest ratios were found for substitute players compared to the starter players. The results therefore suggest that the use of substitute players may support the ability of teams to counter the stagnation of the work rate put on a display by the teams towards the end of a match by introducing substitute players which should increase the teams work rate. Good communication to players if they were going to be substituted may also encourage them to increase their work rate as they would not need to reserve energy for alter stage in the game.

6. Practical implications

- The data of the study may assist sport scientists in preparing their training sessions more sport specifically, taking into consideration that players should try, during training sessions, to adhere to work-to-rest ratios that occur throughout both halves of match play.
- No significant differences between the work-to-rest ratios of the two halves, but an increase between the work-to-rest ratios of the starter and substitute players suggest that the latter could be arrayed to counter the lack of significant increased high-intensity movement activities during match play and coaches should be encouraged to do so.

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Disclosure statement

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