The use of Global Positioning System (GPS) tracking devices to assess movement demands and impacts in Under-19 Rugby Union match play

RACHEL E. VENTER, EBEN OPPERMAN AND SIMON OPPERMAN

Department of Sport Science, Stellenbosch University, Private Bag X1 Matieland, 7602 South Africa; E-mail: rev@sun.ac.za

(Submitted: 25 October 2010; Revision accepted: 09 November 2010)

Abstract

This study attempted to use Global Positioning System (GPS) devices to obtain information on elite Under-19 rugby union forward and back players with regard to selected movement patterns, as well as impacts from collisions experienced by players. Seventeen Under-19 male rugby players from a provincial rugby institute in Stellenbosch, South Africa, were studied during five games in a Super League A competition. Data revealed that players covered on average 4469.95 ± 292.25 m during a game. Players spent 72.32 ± 4.77% of the total game time either standing or walking. Props and locks spent more time jogging (26.11 ± 3.77%) compared to outside backs (15.6 ± 2.3%). The outside backs spent more time sprinting (1.11 ± 1.18%) than inside backs (0.72 ± 0.30%) or the front and back row forwards (0.48 ± 0.23% and 48 ± 0.13%) respectively. Back row forwards had the highest total amount of impacts (measured in G-force, g) during the games (683.4 ± 295.04). The inside backs experienced the highest amount of severe impacts (>10g) (12.16 ± 3.18) per match. The intermittent nature of Under-19 rugby union match play, as well as the unique roles and requirements of positional groups, were confirmed. The use of GPS technology also offered valuable insight into the severity of impacts experienced by players in different positions, which was not previously available. An understanding of match-play requirements, as well as the number and intensity of collisions experienced by players, can assist coaches with planning specific training programmes, as well as adequate recovery between training sessions and games.

Keywords: Global Positioning System, rugby union, match-play, impact.

Introduction

In order to develop specific conditioning programmes and recovery strategies for rugby players, it is essential to have a thorough understanding of the game and the unique demands of different playing positions. Professionalism in rugby union has led to rapid changes in the movement patterns and physical demands of elite players (Duthie, Pyne & Hooper, 2003; Quarrie & Hopkins, 2007; Bompa & Claro, 2009). The movement patterns of rugby union are classified as highly intermittent. There are bursts of shorter, high-intensity efforts, periods of low-intensity jogging and walking, as well as multiple physical collisions and
tackles. These demands vary depending on the position played (Duthie et al., 2003).

Key information on the game demands of team sports not only focuses on movement patterns, but also relates to differences between players in various positions, effects of tactical changes, effects of rule changes (Wisbey, Montgomery, Pyne & Rattray, 2010), as well as the impacts experienced through collisions (Gabbett, Jenkins & Abernethy, 2010). This information can be used to enhance the specificity of training to better prepare players for competition (Aughey & Falloon, 2010).

Numerous studies have used time-motion analysis to quantify the movement and physical demands of team sports such as hockey (Spencer, Lawrence, Rechichi, Bishop, Dawson, & Goodman, 2004), rugby union (Deutsch, Kearny & Rehrer, 2007; Duthie, Pyne & Hooper, 2005), rugby league (King, Jenkins & Gabbett, 2009), and soccer (Burgess, Naughton & Norton, 2006). Although time-motion analysis is a popularly used method, the process has some limitations such as errors with regard to the categorization of locomotor activities, subjectivity involved when interpreting the data (Cunniffe et al., 2009), measurement error (Duthie et al., 2003), and the time taken to complete the analysis (Aughey & Falloon, 2010).

The use of portable global positioning system (GPS) devices has become a popular and convenient method to quantify movement patterns and physical demands in sport (Wisbey et al., 2010). It has been reported that GPS devices are reliable and valid for assessing the movement patterns of field hockey players (Macleod & Sunderland, 2007), and also have an acceptable level of accuracy and reliability for total distance and peak speeds during high-intensity, intermittent activities in team sports (Coutts & Duffield, 2010). In court-based sports or movements in confined spaces, GPS technology under reported distance covered, and both mean and peak speed of movement (Duffield, Reid, Baker & Spratford, 2010).

Although GPS technology has been used to analyse game demands of various sports, there is a dearth of published data on the use of GPS technology in rugby union. The aim of the study was to use GPS technology to obtain information on elite Under-19 rugby union forward and back players with regard to movement patterns, as well as impacts from collisions experienced by players. Data collected could provide some insight into the game demands associated with Under-19 rugby union players. Such quantitative data can provide deeper understanding of rugby game demands, with which coaches could design and implement appropriate training programmes and recovery regimes according to specific positional requirements.
Materials and Methods

Subjects

Seventeen Under-19 semi-professional male rugby players (body mass: 89.8 ± 10.8 kg, height: 183 ± 6 cm, age: 18.5 ± 0.5 years) from a provincial rugby institute in Stellenbosch were studied during the games in a Super League A competition. Data were collected on five players per game from five games played at the same venue during a competitive season. The researchers had no information on which players the coach would select to play in a specific position and players were selected randomly based on the number on their jerseys. In total, 23 sets of data were analysed, because some players were selected twice. All the players provided written informed consent for participation in the study.

The players were divided into four groups based on the assumption that they have the same on-field requirements (Duthie et al., 2003). The four groups were: front row forwards (props and locks) (body mass: 99.4 ± 4.9 kg, height: 187 ± 6 cm), back row forwards (hooker, flanks, and eighth man) (body mass: 97.1 ± 7.6 kg, height: 187 ± 7 cm), inside backs (fly halves and centres) (body mass: 81.9 ± 5.0 kg, height: 174 ± 3 cm) and outside backs (wings and full backs) (body mass: 76.1 ± 3.1 kg, height: 177 ± 5 cm). Similar to Deutsch et al. (1998), the scrum halves were not included in the study, as a result of their mix responsibilities during a game.

Procedures

Players were randomly selected for assessment before the warm-up for the game. The selected players wore an individual GPS unit (mass: 76 g; dimensions: 48 x 20 x 87 mm) encased within a vest with a small protective pocket below the neck, between the shoulder blades. The tracking devices (SPI Pro; GPSports Systems, Canberra, Australia) were switched on just before going onto the field for the game, worn for the duration of the entire game, and switched off directly after the game. GPS data were recorded with a 5 GHz processor. Data stored included position, distance, velocity, direction, and intensity of player impacts as measured in "g" force. After the game, the vest and GPS devices were collected and the data were downloaded onto a computer. Analysis was carried out with the use of the system software provided by the manufacturer (Team AMS; GPSports, Canberra, Australia), which was also used in other research on the use of GPS devices (Coutts & Duffield, 2010). The duration of the games was supposed to be 70 minutes each, with 35 minutes per half. Data from the first 30 minutes of the first half, as well as the first 30 minutes of the second half were analysed, because none of the halves lasted for a full 35 minutes. The Under-19 matches were often stopped before full-time, because they were played as
curtain-raisers to the main games and the main games had to start on time. Players were asked to subjectively report any inconvenience while wearing the GPS units. No negative reports were received from any player and the assumption was made that wearing the units did not negatively affect their performance during the game.

Measures

Distances covered by the players, as well as the speed at which they were moving, were recorded. The readings for the speed zones were recorded in 0.2 seconds intervals. The speed of the players was divided in six different speed zones similar to the study by Duthie, Pyne, Marsh, & Hooper (2006), namely: standing (0-1 km.h⁻¹), walking (<20% Vmax), jogging (20%-50% Vmax), striding (51%-80% Vmax), sprinting (81%-95% Vmax) and maximum sprint (96%-100% Vmax). The maximum speed (Vmax) was the maximum speed players reached during the game.

Data on player impacts were gathered from accelerometer data provided in "g" force. An impact is counted by the system if the force applied is more than five G-force units (5g). The software displays the total impact count from collisions, the intensity, as well as the time in the game where the impact occurred. A scaling system between 5-10+g for grading the impacts is used: 5-6g: light impact, hard acceleration/deceleration/ change of direction; 6-6.5g: light to moderate impact (player collision, contact with the ground); 6.5-7g: moderate to heavy impact; 7-8g: heavy impact; 8-10g: very heavy impact (scrum engagement); and 10+g: severe impact/ tackle/ collision (Carling, Reilly & Williams, 2009). Impacts above 10g were used to report on the number of severe impacts that the players received during games.

Data were presented as the mean±standard deviation and were analysed using Statistica v9.0 (StatSoft, Inc., Tulsa, Oklahoma). Analysis of variance (ANOVA) was used to test any significant differences in the mean data and disparity between the groups, with Bonferroni post-hoc method. Statistical significance was set at p<0.05.

Results

With regard to the time spent walking, the outside backs spent on average 36 min 12 s ± 2 min 21s (60.34 ± 3.92%) of the time walking, which is significantly more (p<0.05) than the 25 min 15 s ± 5 min 59s (42.1 ± 9.99%) of the front row forwards. Time spent jogging also showed a significant difference (p<0.05). Props and locks spent on average more time jogging (15 min 40 s ± 2 min 16 s or 26.11 ± 3.77%), compared to outside backs (9 min 22 s ± 1 min 23 s or 15.6 ± 2.3%). The outside backs spent more time sprinting (39.96 ± 4.48 s or 1.11 ± 1.18%) than inside backs (25.92 ± 10.8 s or 0.72 ± 0.30%), the front row
forwards (17.28 ± 8.28 s or 0.48 ± 0.23%), and back row forwards (17.28 ± 4.68 s or 0.48 ± 0.13%), although the differences were not significant (Table 1).

**Table 1**: Percentage time spent in the six speed sones by front row forwards, back row forwards, inside backs, and outside backs

<table>
<thead>
<tr>
<th></th>
<th>Front row forwards</th>
<th>Back row forwards</th>
<th>Inside backs</th>
<th>Outside backs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speed sone 1: Standing</strong></td>
<td>21.66</td>
<td>23.01</td>
<td>20.95</td>
<td>20.70</td>
</tr>
<tr>
<td>(&lt;1 km.h⁻¹)</td>
<td>2.09</td>
<td>4.88</td>
<td>3.50</td>
<td>1.41</td>
</tr>
<tr>
<td><strong>Speed sone 2: Walking</strong></td>
<td>42.17</td>
<td>46.88</td>
<td>53.57</td>
<td>60.34</td>
</tr>
<tr>
<td>(&lt;20% Vmax)</td>
<td>9.99*</td>
<td>6.53</td>
<td>5.80</td>
<td>3.92*</td>
</tr>
<tr>
<td><strong>Speed sone 3: Jogging</strong></td>
<td>26.11</td>
<td>23.58</td>
<td>19.99</td>
<td>15.63</td>
</tr>
<tr>
<td>(20-49% Vmax)</td>
<td>3.77*</td>
<td>5.88</td>
<td>3.03</td>
<td>2.30*</td>
</tr>
<tr>
<td><strong>Speed sone 4: Striding</strong></td>
<td>9.58</td>
<td>6.04</td>
<td>6.22</td>
<td>2.84</td>
</tr>
<tr>
<td>(50-79% Vmax)</td>
<td>4.59</td>
<td>1.83</td>
<td>3.67</td>
<td>0.45</td>
</tr>
<tr>
<td><strong>Speed sone 5: Sprinting</strong></td>
<td>0.42</td>
<td>0.42</td>
<td>0.66</td>
<td>0.26</td>
</tr>
<tr>
<td>(&gt;80-95% Vmax)</td>
<td>0.02</td>
<td>0.12</td>
<td>0.26</td>
<td>1.05</td>
</tr>
<tr>
<td><strong>Maximum sprint</strong></td>
<td>0.06</td>
<td>0.05</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>(&gt;95% Vmax)</td>
<td>0.01</td>
<td>0.02</td>
<td>0.04</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*<p<0.05; Vmax = maximum speed players reached during the match.

Players covered on average a total distance of 4469.95 ± 292.25 m during a game. The front row forwards covered the greatest total distance (4672.00 ± 215 m), followed by outside backs (4597.93 ± 210.18 m), inside backs (4307.78 ± 214 m), and then back row forwards (4302.1 ± 529.82 m). Maximum speeds reached did not differ significantly between the groups of players. Outside backs reached speeds of 33.10 ± 0.79 km.h⁻¹, followed by inside backs (27.97 ± 1.42 km.h⁻¹), back row forwards (26.01 ± 2.32 km.h⁻¹), and then the front row forwards (23.01 ± 2.03 km.h⁻¹). The highest average player running speeds over the games were 4.69 ± 0.38 km.h⁻¹ (outside backs) and the lowest were 4.30 ± 0.47 km.h⁻¹ (back row forwards).

Back row forwards had the highest total amount of impacts (measured in during the games (683.4 ± 295.04), while the outside backs had the least amount of impacts (474.33 ± 81.92). More severe impacts (>10g) were experienced by the inside backs (12.16 ± 3.18), while the front row forwards had the least amount of severe impacts (8 ± 4.58).
Discussion

It should be taken into consideration that there are little or no studies to our knowledge which assessed the game demands of Under-19 players using GPS technology over a number games, which makes it difficult for us to make comparisons. In the present study, players covered an average total distance of 4469.95 m ± 292.25 m during the games. This is less than the average total distance of 6 953 m reported by Cuniffe et al. (2009), who also used GPS technology with two participants (mean age 25 ± 3.6 years) from an elite rugby union club team during one game. It should, however, be noted that Cuniffe et al. (2009) analysed 83 minutes from the game, while we analysed 60 minutes each from five games. Match running data showed that players in professional rugby league covered between 5908 ± 158 m and 6265 ± 318 m in a match (King, Jenkins & Gabbett, 2009), while players in elite Australians Rules Football covered 12 939 ± 1145 m on average during a match (Coutts et al., 2010). Similar to a study by Deutsch et al. (1998) who used time-motion analysis to monitor six under-19 players during four games, our data also showed that the back row forwards (hooker, flanks, and eight man) covered the shortest distance. Previous studies found that the backs travelled greater total distances than their forward counterparts (Deutsch et al., 1998; Roberts, Trewartha, Higgitt, El-Abd & Stokes, 2008), while we found that the front row forwards (props and locks) covered the greatest distances, followed by the outside backs. Quarrie and Hopkins (2007) stated that factors such as ground conditions, weather, and the tactics employed by the teams could play a role in the variability of game activities. This study was also conducted on only one team and results could reflect the playing style of the team. The technology used (GPS versus time-motion analysis) could also have made a difference in the data captured.

In the present study, players spent on average 72.32 ± 4.77% of the total time of a game either standing or walking, which is similar to findings reported in the study by Cuniffe et al. (2009) that the players were standing or walking 72% of the total time. Similar to our study, Cuniffe et al. (2009) also found that forwards spent less time standing and walking than backs (66.5 vs. 77.8%, respectively). Props and locks spent more time jogging than the outside backs. This might be as a result of the nature of the game where forwards are continuously moving to get into position for non-running intense activity (Bompa & Claro, 2009), while the backs are typically walking, standing or waiting for the ball to be delivered from the contest (Duthie et. al, 2003).

Our study supports the findings of Cuniffe et al. (2009), in that the outside backs reached higher maximum speeds than the front row forwards. The higher average maximum speed and average player running speed for the outside backs might be attributed to their position on the field and specific requirements of their playing position. The average player running speeds reported for rugby union
players are less than the measured speeds of $7.5 ± 0.6$ km.h$^{-1}$ for Australian Football League players (Wisbury et al., 2010).

Back row forwards (hooker, flanks and eighth man) had the highest total amount of impacts during the games. The inside backs (fly halves and centres) were exposed to the most severe impacts (>10g), while the front row forwards (props and locks) had the least amount of severe impacts. Bompa and Claro (2009: 65) wrote that the centres and fly halves must use their speed and power to run onto the ball and straight at defenders, and also compete for the ball in the air. These specific roles expected of the players exposes them to severe impacts during games.

Results from this study confirm the intermittent nature of Under-19 rugby union match play, as well as the unique roles and requirements of positional groups. The use of GPS technology offers valuable insight into the severity of impacts experienced by players in different positions, which was hardly available previously. An understanding of the number and intensity of collisions can assist coaches in planning for adequate recovery between training sessions and games. Current GPS technology registers activities such as pushing in scrums and pulling in rucks and mauls as low-intensity collisions, although it might be intense static efforts. Therefore, with current GPS technology, it could be useful to combine the GPS data with video recordings for more detail on non-running intense efforts by players. Future research could also focus on the severity of collisions and the incidence of injury. Further studies on the use of GPS technology in rugby union are warranted.

Acknowledgement

The authors would like to thank Steph Nel and the players and coaching staff of the Western Province Rugby Institute, Stellenbosch, South Africa, for their participation. We also thank Peter Schnetler, Carel du Plessis and Marius van der Westhuizen at Fika Sport Management Systems for the use of the GPS technology.

References


