Rugby union movement patterns: The impact of fatigue and substitute players

Jason C. Tee\textsuperscript{a}, Mike I. Lambert\textsuperscript{b} and Yoga Coopoo\textsuperscript{a}

\textsuperscript{a} Department of Sport and Movement Studies, University of Johannesburg
\textsuperscript{b} Division of Exercise Science and Sports Medicine, University of Cape Town

Email: jasonctee@gmail.com
Fatigue in team sports

Fatigue = ↓ in total and high-intensity running distance
(Waldron and Highton, 2014, Sports Med 44:12)

Distribution of energy resources

**Macro-pacing** (pre-match)
- hydration, fuel availability, motivation, temperature, opposition, whole-game/substitute

**Meso-pacing** (half time)
- homeostatic disturbance, opposition, scoreline

**Micro-pacing** (continuous)
- homeostatic disturbance, opposition, scoreline

Pacing schema

Professional Rugby Union

Rugby union is characterised by short-duration, high-intensity efforts during which players collide, often while running at full speed; interspersed by longer low-intensity periods of standing, walking and jogging.

(Austin et al., 2011, J Sci Med Sport 14:3)
The game demands differ for players in different positions. (Deutsch et al., 2007, J Sport Sci 25:4)

Research Aim

Understand the nature of fatigue in professional rugby union

- What is the influence of match period and position on movement patterns?
- What is the influence of substitutes on movement patterns?
Methods – Global Positioning System (GPS)

Variables measured

- Playing time
- Relative distance (m.min\(^{-1}\)) in speed zones

<table>
<thead>
<tr>
<th>Speed bands</th>
<th>Speed (m.s(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>0-2 m.s(^{-1})</td>
</tr>
<tr>
<td>Jogging</td>
<td>2-4 m.s(^{-1})</td>
</tr>
<tr>
<td>Striding</td>
<td>4-6 m.s(^{-1})</td>
</tr>
<tr>
<td>Sprinting</td>
<td>&gt;6 m.s(^{-1})</td>
</tr>
</tbody>
</table>

- Sprint (>6 m.s\(^{-1}\)) frequency
- Acceleration (>2.75 m.s\(^{-2}\)) frequency
- Accelerometer
  - Total impacts >5 G.min\(^{-1}\)
  - High-intensity impacts >8 G.min\(^{-1}\)

SPI Pro GPS unit
(GPSports, Canberra)
mass = 76 g;
size = 87 x 48 x 20 mm
5 Hz GPS Tracking
100 Hz Tri-axial Accelerometer
Methods

19 professional players

Whole game players (n = 46)
- 1st half (27 backs, 19 forwards)
- 2nd half (27 backs, 19 forwards)
  - 4 quartiles

Substitute players (n = 20)
- 2nd half (3 backs, 17 forwards)
  - 4 quartiles

Player characteristics
- Age 25.5 ± 2.4 years
- Body mass 101.5 ± 12.2 kg
- Stature 1.86 ± 0.07m

- Whole game players – start game and complete >35 min in 2nd half
- Substitute players – 2nd half replacements

Statistics
- Factorial ANOVA
- Paired and independent sample t-tests
- Cohen’s effect size
Results – Effect of half on total and high-intensity distance

**Total distance**

<table>
<thead>
<tr>
<th></th>
<th>1st Half</th>
<th>2nd Half</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forwards</td>
<td>74</td>
<td>65</td>
</tr>
<tr>
<td>Backs</td>
<td>70</td>
<td>63</td>
</tr>
</tbody>
</table>

**High-intensity distance**

<table>
<thead>
<tr>
<th></th>
<th>1st Half</th>
<th>2nd Half</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forwards</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Backs</td>
<td>13</td>
<td>11</td>
</tr>
</tbody>
</table>

* indicates significant difference from 1st half. S, M, L and VL indicate effect sizes small (0.2-0.5), medium (0.5-0.8), large (0.8-1.2) and very large (>1.2) respectively.
Results – Total distance per match period

* indicates significant difference between backs and forwards, # indicated significant different from all other match periods. T, S, M, L and VL indicate effect sizes trivial (<0.2), small (0.2-0.5), medium (0.5-0.8), large (0.8-1.2) and very large (>1.2) respectively.
Results – High-intensity distance per match period

* indicates significant difference between backs and forwards, # indicates significant different from match period 2nd half Q4. T, S, M, L and VL indicate effect sizes trivial (<0.2), small (0.2-0.5), medium (0.5-0.8), large (0.8-1.2) and very large (>1.2) respectively.
Results – Match period effects sprint variables

Sprint and acceleration frequency are reduced in the 2nd half for forwards, but not for backs.

* indicates significant difference between backs and forwards. T, S, M, L and VL indicate effect sizes trivial (<0.2), small (0.2-0.5), medium (0.5-0.8), large (0.8-1.2) and very large (>1.2) respectively.
The effect of physical contact

↑ physical contact = ↓ total and high-intensity running distance (Johnston et al., 2014, Int J Sports Physiol Perform, Epub)

Forwards experience ↑ contact involvements than backs (Deutsch et al., 2007, J Sport Sci 25:4)

Accelerometer data – backs experience ↑ total (>5G) and high-intensity (>8G) “impacts” than forwards

Data doesn’t fit fatigue model
Results – Effect of substitutes

Forward substitutes increased sprint and acceleration frequency and high-intensity impacts.

Back substitutes showed increased sprint and acceleration frequency, but $n = 3$. 

* indicates significant difference between whole game and substitutes. T, S, M, L and VL indicate effect sizes trivial (<0.2), small (0.2-0.5), medium (0.5-0.8), large (0.8-1.2) and very large (>1.2) respectively.
Results – effect of forward substitutes

* indicates significant difference between whole game players and substitutes. T, S, M, L and VL indicate effect sizes trivial (<0.2), small (0.2-0.5), medium (0.5-0.8), large (0.8-1.2) and very large (>1.2) respectively.
Conclusions – running distance

Rugby union players total (10%) and high-intensity (18%) running in 2\textsuperscript{nd} half.

Similar results in soccer\textsuperscript{1}, rugby league\textsuperscript{2} and rugby sevens\textsuperscript{3}.

\textbf{BUT}

Rugby union work rates are much lower than other sports (~70 vs. ~100 m\textsuperscript{-1} min\textsuperscript{-1})\textsuperscript{1,2,3}

3. Higham et al., 2011, J Sci Med Sport 15
Pacing profile

Backs and forwards demonstrate differing fatigue profiles.

<table>
<thead>
<tr>
<th>Pacing profile</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forwards</strong></td>
</tr>
<tr>
<td>“Slow positive”</td>
</tr>
</tbody>
</table>

Forwards progressively total and high-intensity distance, maximum speed, sprint and acceleration frequency

Backs maintain total and high-intensity distance, maximum speed, sprint and acceleration frequency for majority of match
Conclusions – Impact of substitutes

Substitutes match intensity by high-intensity distance, acceleration frequency and high-intensity impacts.

Substitutes set a higher pacing strategy in the early part of their exercise bout – a “one bout, all out” strategy.
For the coach - Take home message

• Fatigue is evidenced by reductions in total and high intensity running distance and sprint and acceleration frequencies.

• Fatigue profile of forwards and backs is different

• Monitor high-intensity running distance to determine onset of fatigue

• Replacing fatigued players with substitutes is an effective method of maintaining playing intensity
Goodbye and thank you for listening!

Acknowledgements
Thank you to the players and staff of the Golden Lions Rugby Union for their support of the project.

This research was partially funded by the National Research Foundation.

Email: jasonctee@gmail.com