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

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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)
Diversity of Physical Requirements

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

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

SPI Pro GPS unit
(GPSports, Canberra)
- mass = 76g;
- size = 87 x 48 x 20 mm
- 5Hz GPS Tracking
- 100Hz 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 ± 0.07 m

- 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

- Forwards: 1st Half 74, 2nd Half 65
- Backs: 1st Half 70, 2nd Half 63

High-intensity distance

- Forwards: M 12, S 13
- Backs: M 9, S 11

* 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

Total distance covered

- Backs
- Forwards

Relative Distance (m/min)

1st Half

2nd Half

S M S T T S T L

Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4

* 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

High-intensity distance covered

* 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 increased sprint and acceleration frequency, but \( n = 3 \).
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 2nd half.

Similar results in soccer¹, rugby league² and rugby sevens³.

**BUT**

Rugby union work rates are much lower than other sports (~70 vs. ~100m.min⁻¹)¹,²,³

3. Higham et al., 2011, J Sci Med Sport 15
Backs and forwards demonstrate differing fatigue profiles.

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