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

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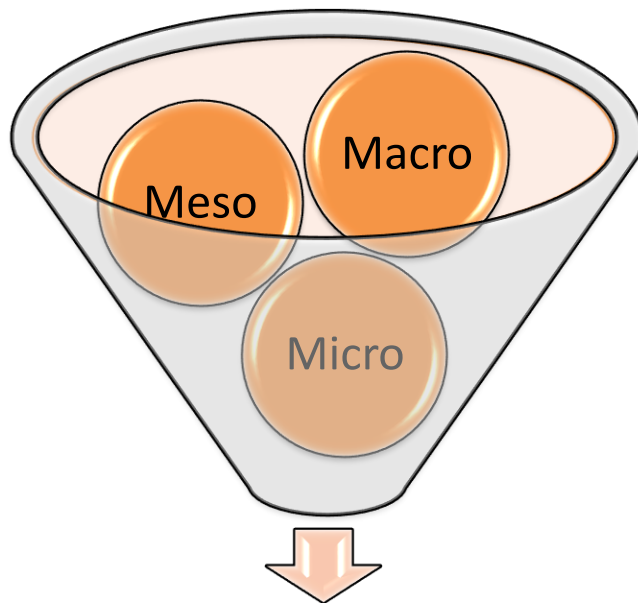


# Fatigue in team sports

**Fatigue = ↓ in total and high-intensity running distance**

(Waldron and Highton, 2014, Sports Med 44:12)

## Distribution of energy resources



## Pacing schema

### 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

Edwards and Noakes, 2009, Sports Med 39:1



# 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 ( $\text{m} \cdot \text{min}^{-1}$ ) in speed zones

Speed bands		
Walking	$0-2\text{m} \cdot \text{s}^{-1}$	Low intensity running $0-4\text{m} \cdot \text{s}^{-1}$
Jogging	$2-4\text{m} \cdot \text{s}^{-1}$	
Striding	$4-6\text{m} \cdot \text{s}^{-1}$	High intensity running $>4\text{m} \cdot \text{s}^{-1}$
Sprinting	$>6\text{m} \cdot \text{s}^{-1}$	

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

## SPI Pro GPS unit

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



# Methods



## Player characteristics

Age  $25.5 \pm 2.4$  years

Body mass  $101.5 \pm 12.2$  kg

Stature  $1.86 \pm 0.07$  m

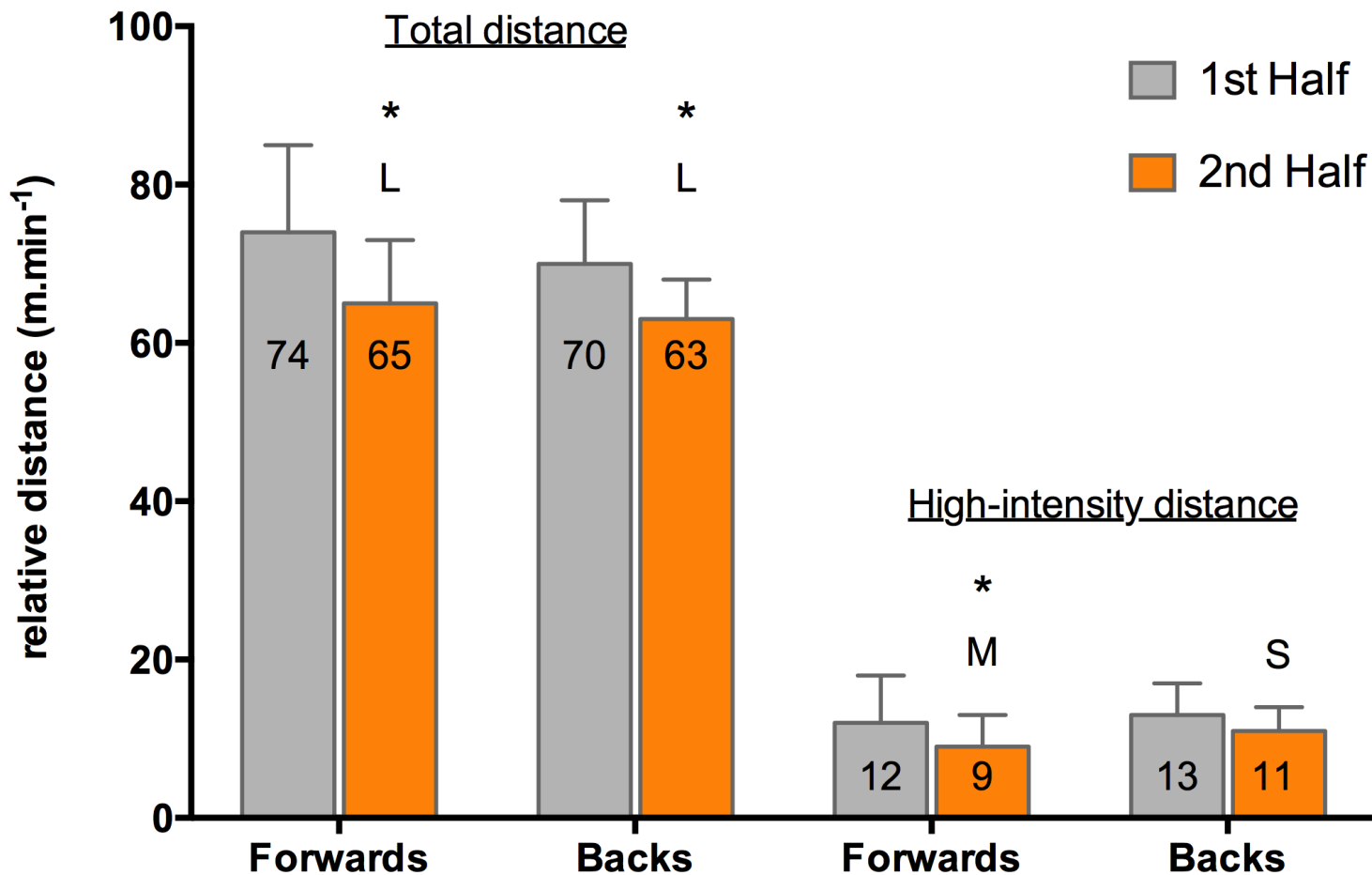
- Whole game players – start game and complete >35 min in 2<sup>nd</sup> half
- Substitute players – 2<sup>nd</sup> half replacements

## Statistics

- Factorial ANOVA
- Paired and independent sample t-tests
- Cohen's effect size



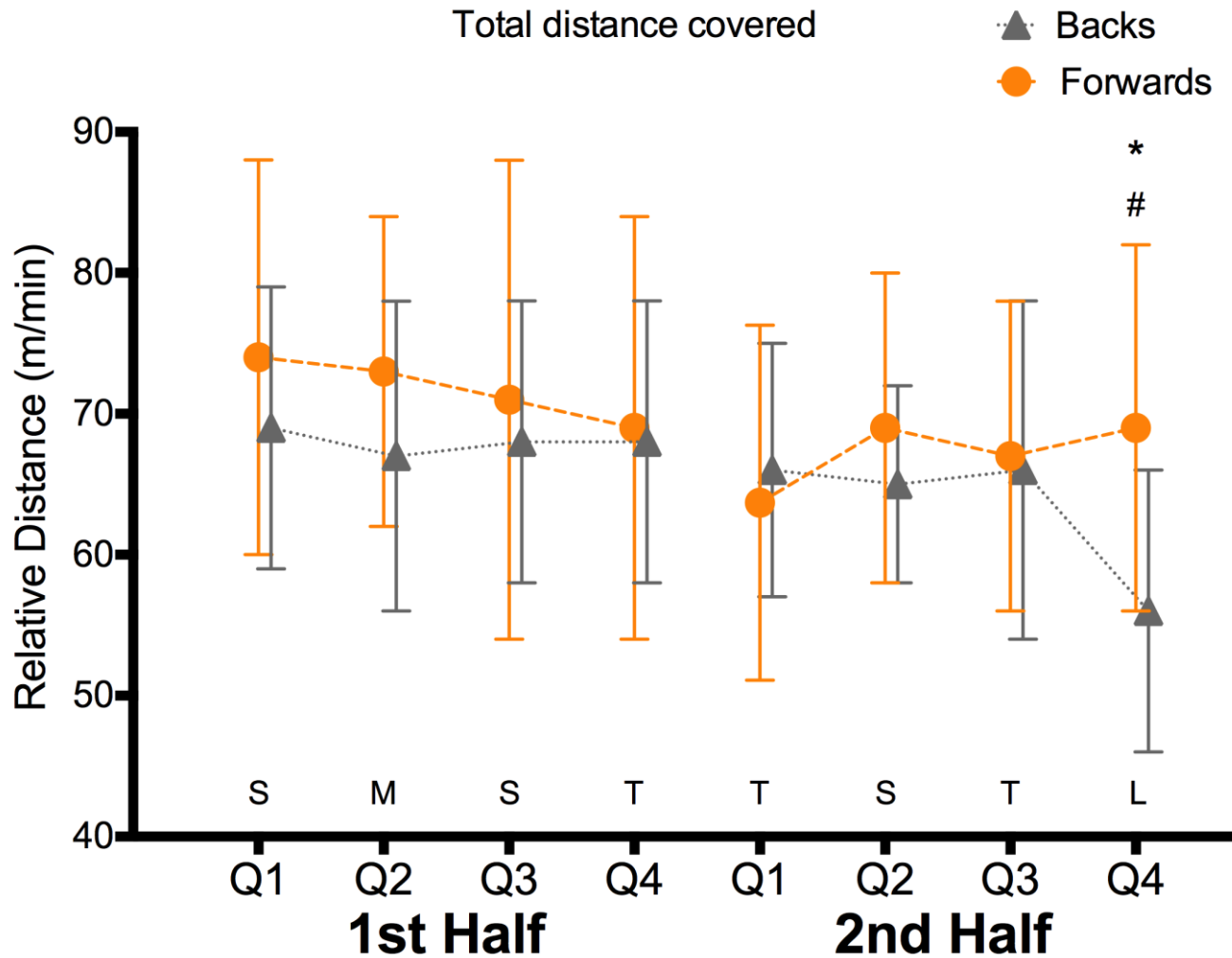
## Results – Effect of half on total and high-intensity distance



\* 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.

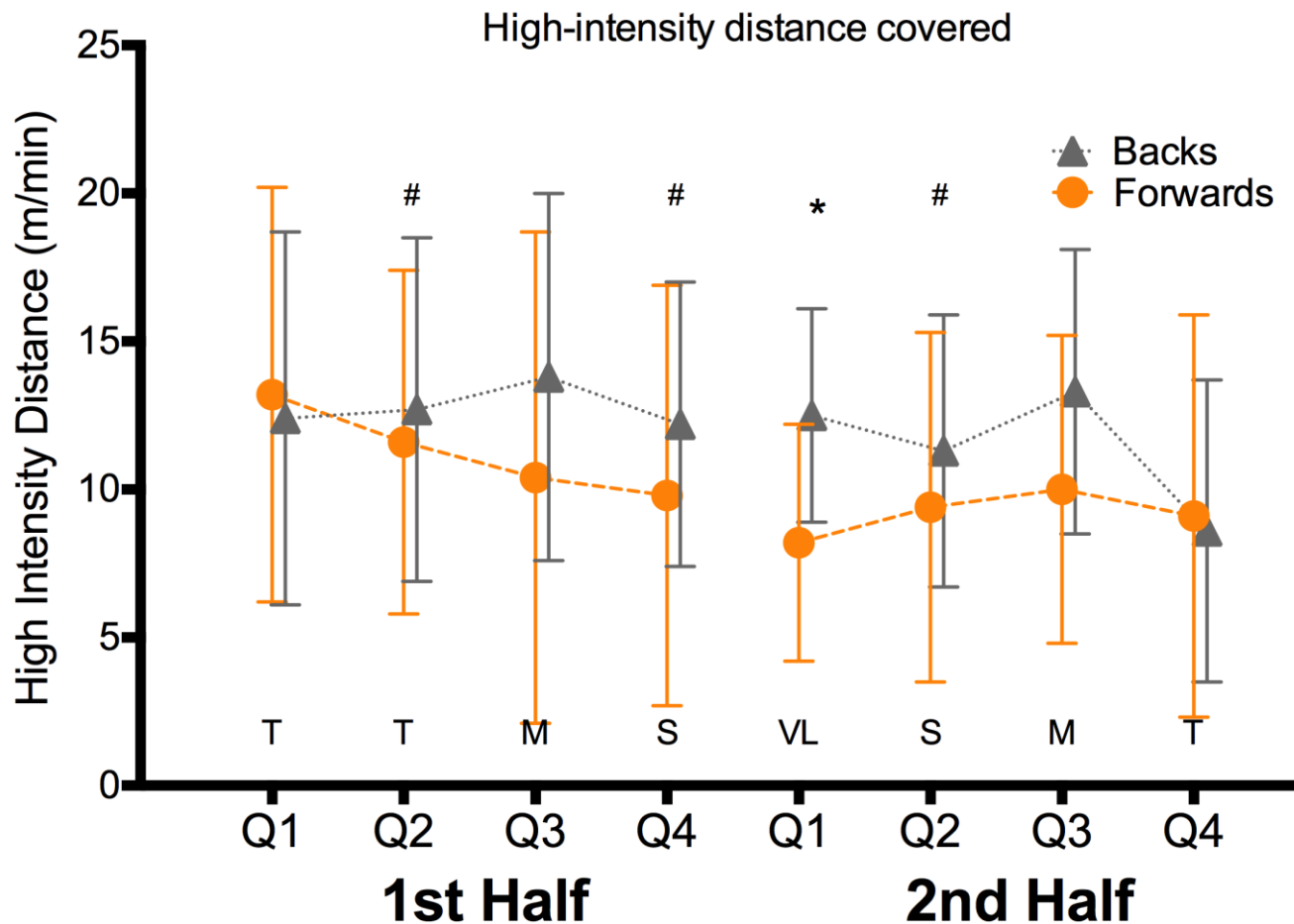


# Results – Total distance per match period



\* 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.

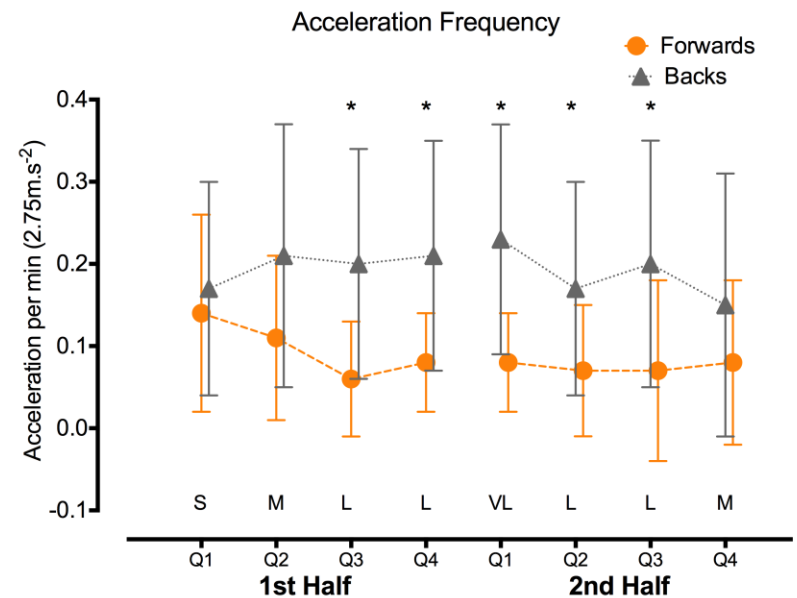
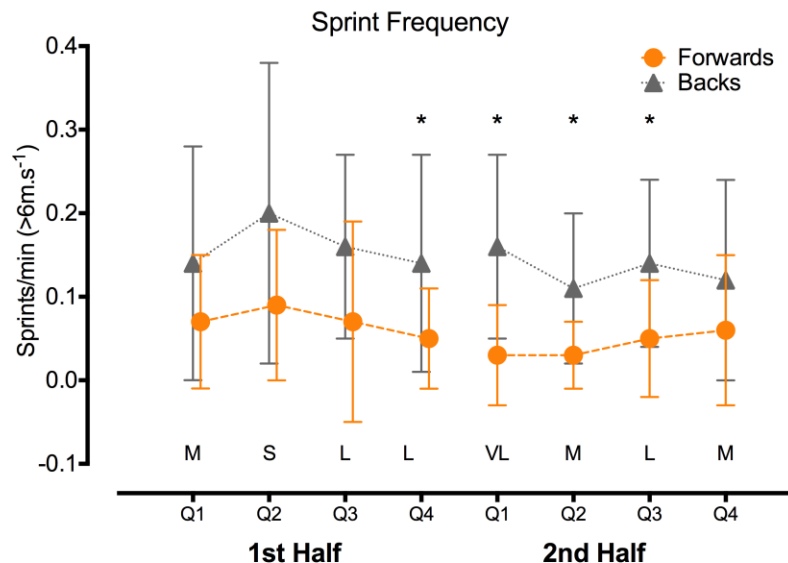
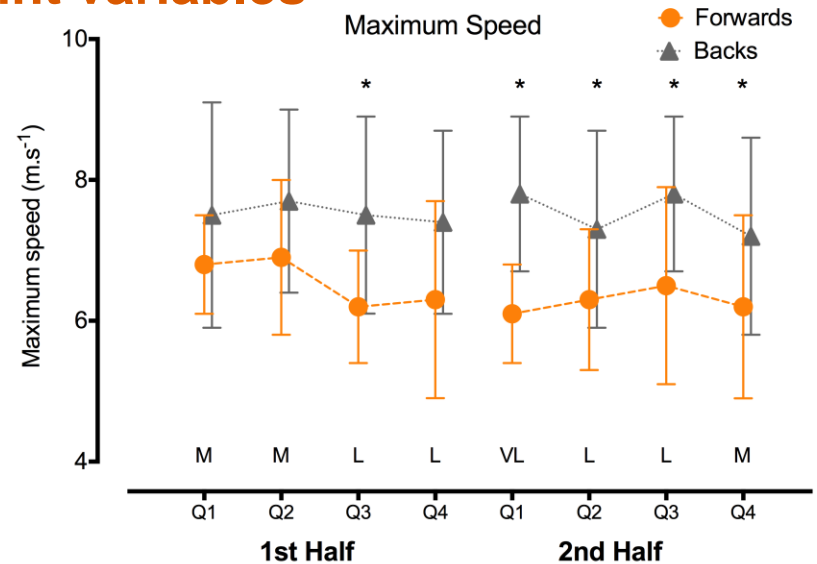
# Results – High-intensity distance per match period



\* 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 2<sup>nd</sup> 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.

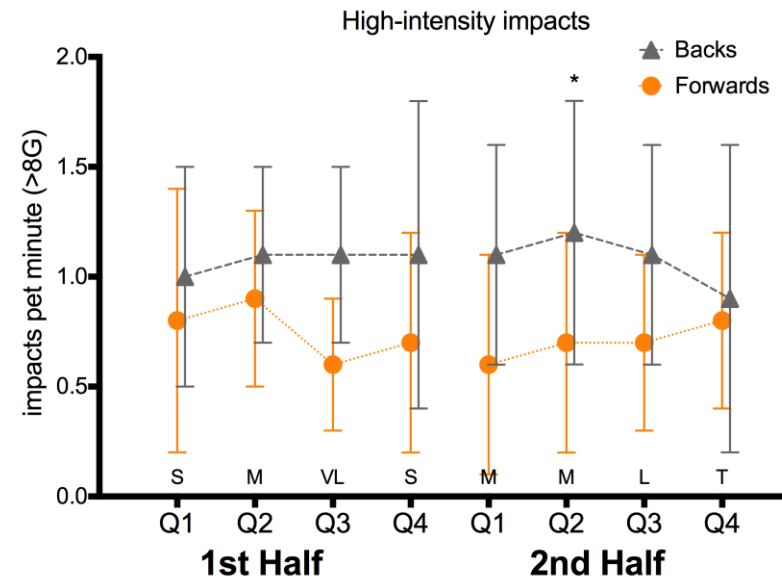
# The effect of physical contact

↑ physical contact = ↓ total  
↓ 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)

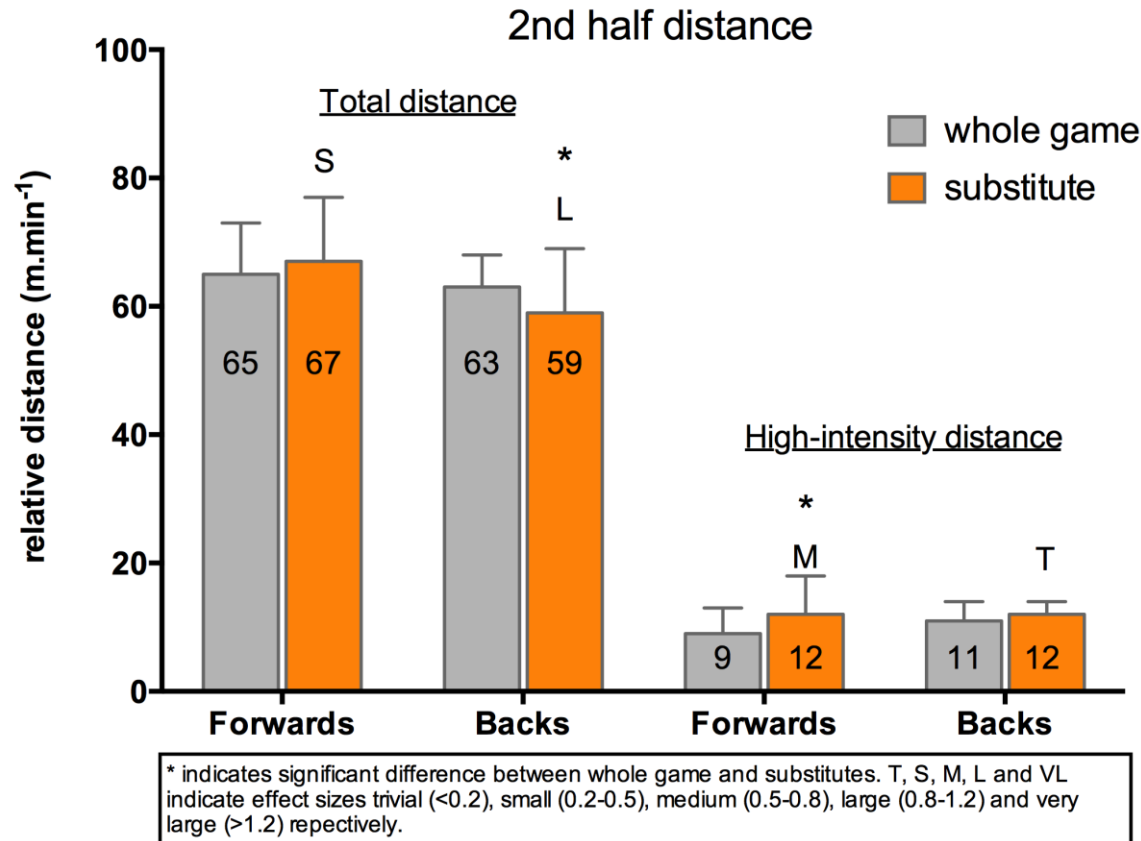
Accelerometer data – backs  
experience ↑ total (>5G) and  
high-intensity (>8G) “impacts”  
than forwards


Data doesn't fit fatigue model






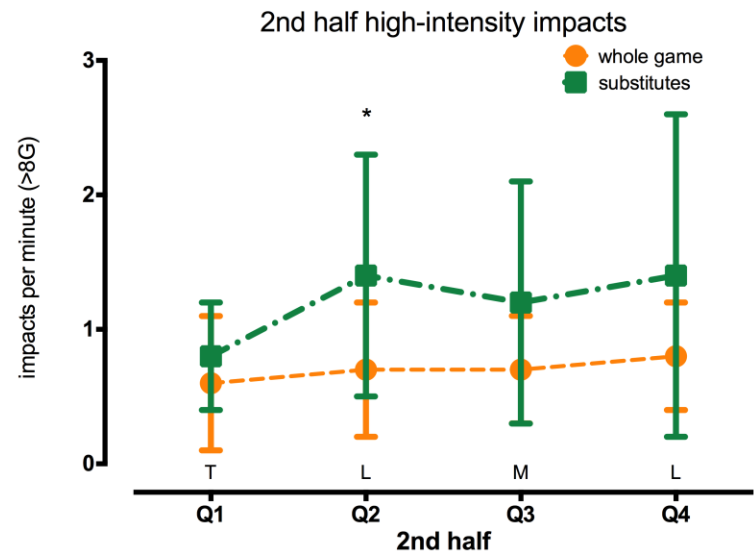
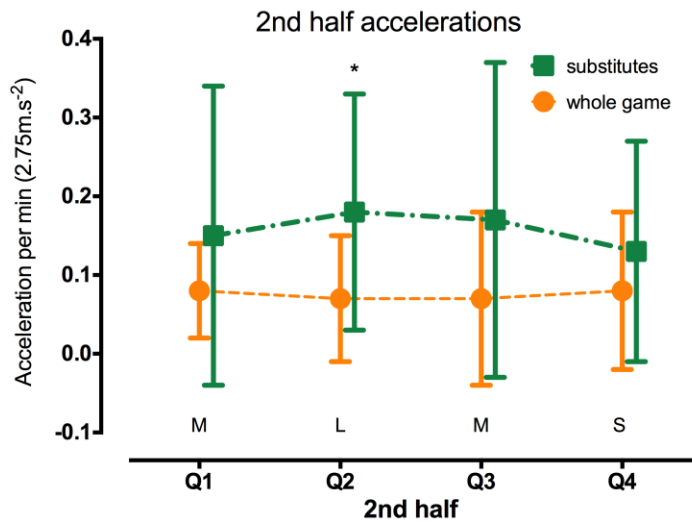
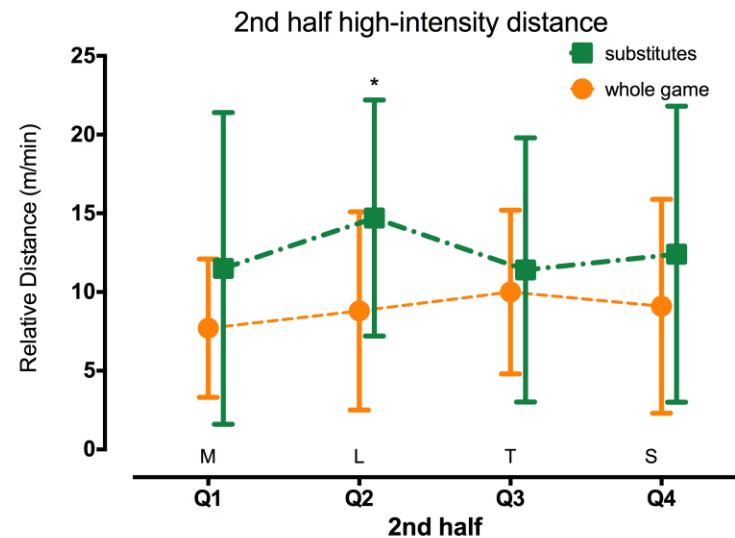
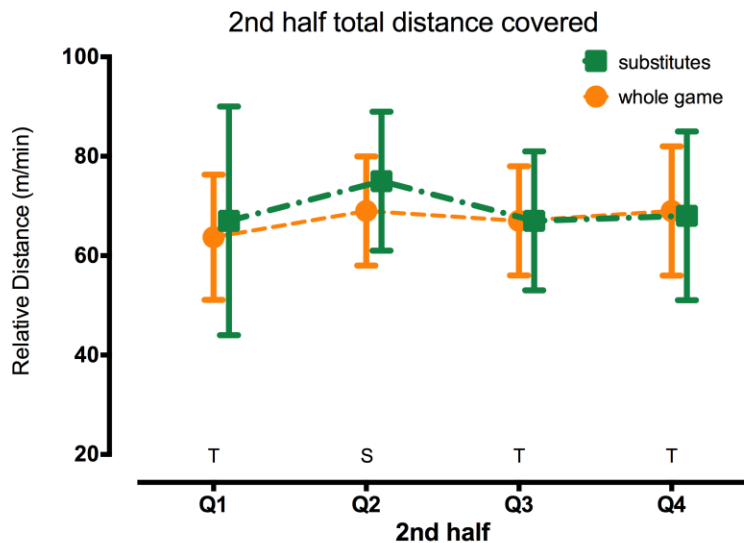
# Results – Effect of substitutes



Forward substitutes  sprint and acceleration frequency and high-intensity impacts


Back substitutes  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 2<sup>nd</sup>  
half.

Similar results in soccer<sup>1</sup>, rugby league<sup>2</sup>  
and rugby sevens<sup>3</sup>.

**BUT**

Rugby union work rates are much lower  
than other sports ( $\sim 70$  vs.  $\sim 100 \text{ m} \cdot \text{min}^{-1}$ )<sup>1,2,3</sup>

1. Bradley and Noakes, 2013, J Sport Sci 31:15

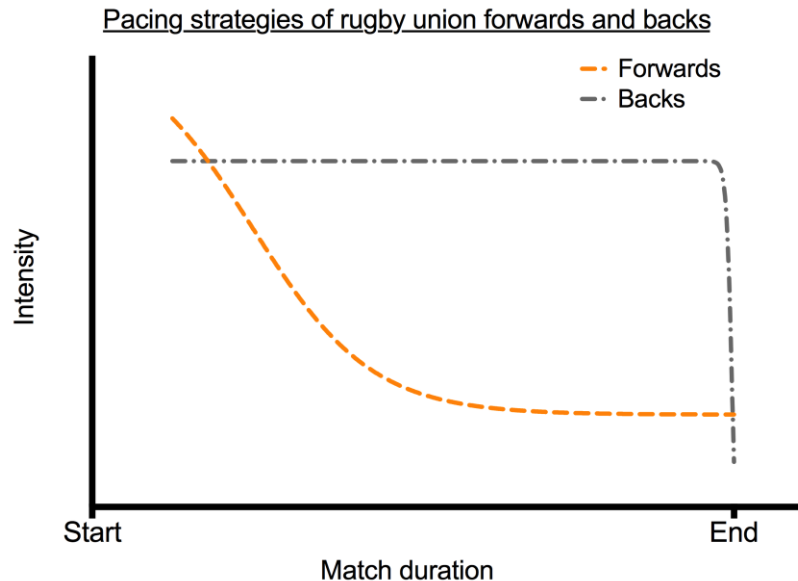
2. Waldron et al., 2013, Int J Sports Physiol Perform 8:2

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




# Conclusions – fatigue profile

Backs and forwards demonstrate differing fatigue profiles.



Pacing profile	
Forwards	Backs
“Slow positive”	“Flat”

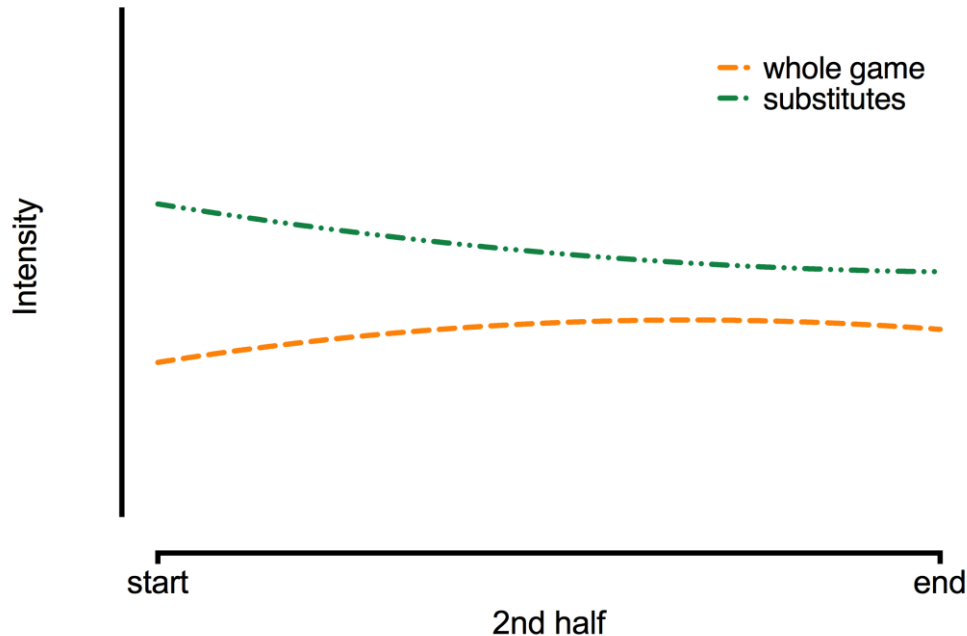
Forwards progressively  total and high-intensity distance, maximum speed, sprint and acceleration frequency

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



# Conclusions – Impact of substitutes

substitute pacing strategy



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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