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Pollard, Benjamin T., Turner, Anthony N. ORCID: <https://orcid.org/0000-0002-5121-432X>, Eager, Robin, Cunningham, Daniel J., Cook, Christian J., Hogben, Patrick and Kilduff, Liam P. (2018) The ball in play demands of international rugby union. *Journal of Science and Medicine in Sport*, 21 (10) . pp. 1090-1094. ISSN 1440-2440 [Article] (doi:10.1016/j.jsams.2018.02.015)

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1 **The Ball in Play Demands of International Rugby Union**

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16 Word Count: 2916

17 Abstract word count: 272

18 No. of tables: 3

19 No of figures: 0

20

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22 **The Ball in Play Demands of International Rugby Union**

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49 **Abstract**

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51 *Objectives:* Rugby union is a high intensity intermittent sport, typically analysed via set time periods
52 or rolling average methods. This study reports the demands of international rugby union via global
53 positioning system (GPS) metrics expressed as mean ball in play (BiP), maximum BiP (max BiP), and
54 whole match outputs.

55 *Design:* Single cohort cross sectional study involving 22 international players, categorised as forwards
56 and backs.

57 *Methods:* A total of 88 GPS files from eight international test matches were collected during 2016. An
58 Opta sportscodes timeline was integrated into the GPS software to split the data into BiP periods.
59 Metres per min ($\text{m}\cdot\text{min}^{-1}$), high metabolic load per min (HML), accelerations per min (Acc), high
60 speed running per min (HSR), and collisions per min (Coll) were expressed relative to BiP periods and
61 over the whole match (>60min).

62 *Results:* Whole match metrics were significantly lower than all BiP metrics ($p < 0.001$). Mean and
63 max BiP HML, ($p < 0.01$) and HSR ($p < 0.05$) were significantly higher for backs versus forwards,
64 whereas Coll were significantly higher for forwards ($p < 0.001$). In plays lasting 61s or greater, max
65 BiP $\text{m}\cdot\text{min}^{-1}$ were higher for backs. Max BiP $\text{m}\cdot\text{min}^{-1}$, HML, HSR and Coll were all time dependant (p
66 < 0.05) showing that both movement metrics and collision demands differ as length of play continues.

67 *Conclusions:* This study uses a novel method of accurately assessing the BiP demands of rugby union.
68 It also reports typical and maximal demands of international rugby union that can be used by
69 practitioners and scientists to target training of worst-case scenario's equivalent to international
70 intensity. Backs covered greater distances at higher speeds and demonstrated higher HML, in general
71 play as well as 'worst case scenarios'; conversely forwards perform a higher number of collisions.

72

73 **Keywords:** GPS analysis, collisions, movement patterns, worst case scenario

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77 **Introduction**

78 Rugby union is characterised as a high intensity intermittent collision sport, requiring athletes to
79 perform repeated running actions, collisions, and static efforts of differing work to rest periods. ¹ The
80 ability to repeat high intensity efforts is linked to success in rugby union ^{2,3} and higher match running
81 demands have been reported at international level. ⁴ Players must be physically prepared for the
82 demands of international competition ^{4,5}, and further research is warranted at this level. ⁶

83
84 The assessment of in-game demands provides coaches with an understanding of what is required from
85 players ⁷, and helps establish physical standards to work on or towards. ⁸ Only two studies have
86 attempted to quantify the physical demands of international rugby using Global Positioning Systems
87 (GPS). ^{5,8} This method allows the measurement of in game movement patterns and velocities, whilst
88 also monitoring these same metrics during training sessions. This allows the potential to monitor
89 training with the aim of matching or superseding match-play demands, providing a physical and
90 tactical stimulus ⁷ likely to positively transfer to competition.

91
92 The majority of club and international level studies have reported whole match or per half demands of
93 rugby matches. ^{4,8,9} However, it is noteworthy that whole match averages may not reflect fluctuations
94 in running or playing intensity that occur throughout match-play. ^{6,10,11} It has been suggested that team
95 sport athletes should be exposed to training at ‘worst-case scenario’ (WCS) intensities, which align to
96 the highest recorded intensity recorded within match-play. ^{5,12,13} Previously, studies have analysed
97 small set time periods to view fluctuations in intensity within competition ^{6,14}, however, it may be that
98 the most intense period of play do not fall within these periods, for example, zero to five, or 60 to 70
99 min into the game. ⁵ Varley et al. ¹⁵ showed that pre-determined blocks under-estimate a peak rolling
100 average method by 25%, and peak rolling average method was also found to best quantify intensities
101 in rugby 7’s. ¹¹

102
103 An alternative method is to analyse the actions during the time the ball is in play. ¹⁶ This is an
104 important consideration as rugby union is such an intermittent sport. It typically demonstrates a ball in

105 play (BiP) time less than ball out of play time during Rugby World Cups (approximately 44% of
106 overall match time¹⁷). Recently the longest BiP period in matches (average duration 152-161s)¹⁶, and
107 attacking plays in the opposition 22m zone¹³, from the European Rugby Championship and Guinness
108 Pro12 League matches have been investigated. Both studies reported significantly higher metres per
109 min (m min^{-1}) (117 m min^{-1} and $98.8\text{-}115.6 \text{ m min}^{-1}$) than had been previously reported, 68 m min^{-1}
110 regarding average whole match m min^{-1} .¹⁴ This analysis was the average of the longest play from
111 each game¹⁶, or of a specific action by a team¹³, therefore neither reports typical demands within a
112 match nor maximum physical demands dependant on movement and/or collision activities (ie. WCS).

113

114 The aims of this study were to report both mean and the max BiP demands of international rugby
115 union alongside whole match demands and differing positional groups. It is hypothesised that BiP
116 demands will differ from whole match demands and that outputs may be higher for the forwards
117 compared to those previously reported. This is due to no movement data from ball out of play time
118 included within the BiP data, therefore disregarding the likely higher repositioning movement of the
119 backs. This will give a greater understanding of the typical physical demands and describe the peak
120 demands of duration specific BiP periods, allowing comparison of WCS in relation to international
121 standards, of which there is a lack of research at present.

122 **Methods**

123 GPS data were collected from eight international matches during 2016, data were included if the
124 player had played ≥ 60 min. This was chosen as it has been shown that substitutes have higher outputs
125 than starting players, potentially due to pacing strategies.¹⁸ Given the discrete roles, players were
126 grouped into units of forwards and backs. The average number of files contributed by each player was
127 4.5 ± 2.6 . Every player contributed a minimum of one GPS file, with the maximum collected from any
128 player being eight; there were 35 units used over the course of six months of collection. The GPS data
129 was analysed post game to view locomotor and collision metrics, and data was separated into
130 positional groups and compared. A BiP timeline of all the duration of all plays was generated by Opta

131 (London, UK), this is the duration which play is ongoing prior to the ball exiting the pitch or the
132 referee stopping play. Matches played were at varying international rugby stadiums.

133 A total of 22 male international players took part in the study (Table 1). Prior to giving written
134 consent, all players were provided with an outline of the rationale and procedures of the study.
135 Approval was granted from Swansea University ethics committee. All players were healthy and
136 partaking in full training at the time. The data collection was carried out as part of the players' routine
137 monitoring procedures ensuring all players were familiar with wearing GPS units.

138

139 *******Table 1** about here*****

140

141 Data was collected between January 2016 and July 2016 over two international competitions. The
142 units were placed in bespoke pockets in the players' match shirts, between their shoulder blades close
143 to their thoracic spine minimising movement artefacts.¹⁹ The 10 Hz GPS units (Viper Pod,
144 STATSports, Belfast, UK) collected data using the four best satellites obtainable, with respect to
145 signal strength. 10 Hz units have been shown previously to be more reliable than 5Hz when assessing
146 team sport movement patterns^{20,21}, and the manufacturer of these specific units have been utilised for
147 other elite rugby and soccer studies analysing acceleration profiles.^{8,22, 23, 24}

148 The units were turned on approximately four hours prior to kick-off to gain signal and satellites for 30
149 min in the centre of the pitch. They were turned off to save battery, and switched on again one hour
150 prior to kick off. The data was then downloaded using specific hardware and a consistent version of
151 software (Viper PSA Software, Version 2.6.1.176, STATSports, Belfast, UK); time periods were split
152 manually for the whole match period. GPS data was viewed to identify any files that lost GPS signal
153 for sections of the match, and these files identified were removed from the dataset. An Opta generated
154 timeline of the game (SportsCode, Sportstec, Lower Hutt, New Zealand) was then integrated into the
155 software to automatically split the match data into periods of BiP. Data was then exported into
156 Microsoft Excel (Microsoft Corporation, USA) for further analyses.

157 Plays less than 30s were not included in the analysis, though ~26% of plays are less than 30s in
158 duration (unpublished research), this helps avoid false representation of intensity due to excessively
159 high calculations of each metric per minute. ¹³ This procedure will also reduce the potential for
160 compounding errors that are artefacts of the methodology utilised to collect BiP data.

161 Mean duration of plays in international rugby are 50-55s in duration (unpublished research). Mean and
162 maximum metrics for three periods of 30 to 60s, 61 to 90s and over 90s (~39, 20 and 15% of all plays
163 respectively) were analysed, alongside the mean intensity of all BiP periods over 30s, These periods
164 represent the most frequent BiP time frames occurring in international rugby, whilst also providing
165 information regarding time frames that are pragmatic to technical, tactical, and conditioning drills
166 utilised in game training. ²⁵

167 GPS metrics were displayed per minute as a measure of intensity of match play for either BiP or whole
168 match. These were relative total distance covered ($\text{m}\cdot\text{min}^{-1}$), high metabolic load distance (HML)
169 (defined as distance accelerating over $2.5\text{m}\cdot\text{s}^{-2}$ and sprinting over $5.5\text{m}\cdot\text{s}^{-1}$), high speed running (HSR)
170 (distance ran over $5\text{m}\cdot\text{s}^{-1}$), accelerations (Acc) (over $3\text{m}\cdot\text{s}^{-2}$), and collisions (Coll) per min as detected
171 by the GPS unit, recently shown by Hulin et al. ²⁶ to be able to detect 97.6% of collisions in rugby
172 league. Given the importance of frequency of collisions, as dictated by the coaching staff, a pilot study
173 was performed to validate the use of this metric from Statsports units. Results found that $85.3\pm 3.6\%$ of
174 the collisions detected by the gps units were correct when compared to video analysis. This is a
175 slightly lower percentage than reported by Hulin et al., (2016)²⁶, possibly due to the differing angles
176 of collisions in rugby league compared to other sports ²⁶.

177 Linear mixed models were used to examine each dependent variable (i.e., the GPS metrics) for the
178 interaction with respect to position (i.e., forwards and backs), with Bonferroni correction used for post
179 hoc analysis and with partial η^2 reported as a measure of effect size. Where sphericity was violated,
180 Greenhouse-Geisser correction was used. All statistical analysis was conducted using SPSS (version
181 21) with the level of significance set as $p < 0.05$.

182 **RESULTS**

183 **Mean Whole Match and BiP**

184 There was a significant difference in mean $m \cdot \text{min}^{-1}$ ($F(4, 68) = 432.86, p < 0.001, \text{partial } \eta^2 =$
185 0.962), HML ($F(4,68) = 223.1, p < 0.001, \text{partial } \eta^2 = 0.929$), Acc ($F(4, 68) = 67.41, p < 0.001,$
186 $\text{partial } \eta^2 = 0.799$), HSR ($F(4, 68) = 60.81, p < 0.001, \text{partial } \eta^2 = 0.782$), and Coll ($F(4, 68) = 118.79,$
187 $p < 0.001, \text{partial } \eta^2 = 0.875$) across all periods of play. For mean HML ($F(1,17) = 18.24, p < 0.01$
188 $\text{partial } \eta^2 = 0.518$), HSR ($F(1,17) = 33.04, p < 0.001, \text{partial } \eta^2 = 0.660$), and Coll ($F(1,17) = 54.50, p$
189 $< 0.001, \text{partial } \eta^2 = 0.762$) differences between position were also noted. All
190 differences across position, whole match and BiP duration, as identified by Bonferoni adjusted post
191 hoc analyses, are reported in Table 2.

192 **Max BiP**

193 There was a significant difference for max $m \cdot \text{min}^{-1}$ ($F(2,40) = 56.96, p < 0.001, \text{partial } \eta^2 = 0.740$),
194 max HML ($F(2,40) = 106.0, p < 0.001, \text{partial } \eta^2 = 0.840$), max Acc ($F(2,40) = 30.18, p < 0.001,$
195 $\text{partial } \eta^2 = 0.601$), max HSR, $F(2, 40) = 79.64, p < 0.001, \text{partial } \eta^2 = 0.799$), and max Coll ($F(2,40)$
196 $= 79.64, p < 0.001, \text{partial } \eta^2 = 0.799$) across all periods of BiP. For max $m \cdot \text{min}^{-1}$ ($F(1,20) = 10.06, p <$
197 $0.01, \text{partial } \eta^2 = 0.335$), max HML ($F(1,20) = 24.3, p < 0.001, \text{partial } \eta^2 = 0.549$), max HSR ($F(1,20)$
198 $= 17.69, p < 0.001, \text{partial } \eta^2 = 0.469$), and max Coll ($F(1,20) = 17.69, p < 0.001, \text{partial } \eta^2 = 0.469$),
199 differences between position were also noted. All differences, as identified by Bonferoni adjusted post
200 hoc analyses, regarding position and max BiP duration, are reported in Table 3

201

202 ******Table 2 and 3 about here******

203

204 **DISCUSSION**

205 This study reports, for the first time, the mean and maximum demands of BiP periods of international
206 rugby compared to whole match demands. As hypothesised, BiP metrics were significantly higher
207 than whole match averages. Mean BiP metrics significantly differed between forwards and backs,

208 primarily between HML, HSR, and Coll (Table 2). Max BiP metrics mirrored this finding but also
209 included $\text{m}\cdot\text{min}^{-1}$. Max BiP $\text{m}\cdot\text{min}^{-1}$, HML, HSR and Coll were all time dependant showing that WCS
210 movement metrics and collision demands decrease in intensity as length of play continues (Table 3).
211 All the above findings offer a novel insight into typical and WCS demands in international rugby
212 match play.

213 Metres per min did not differ between forwards and backs over whole match or BiP periods. This
214 differs to Reardon et al. ¹⁶ who investigated the running demands of the longest play (average duration
215 152-161s), reporting that both tight five ($109 \text{ m}\cdot\text{min}^{-1}$ CI 104-114 $\text{m}\cdot\text{min}^{-1}$) and back row ($111 \text{ m}\cdot\text{min}^{-1}$
216 CI 105-117 $\text{m}\cdot\text{min}^{-1}$) forwards differed from inside backs ($123 \text{ m}\cdot\text{min}^{-1}$ CI 117-129 $\text{m}\cdot\text{min}^{-1}$) and
217 outside backs ($124 \text{ m}\cdot\text{min}^{-1}$ CI 117-131 $\text{m}\cdot\text{min}^{-1}$). These reported $\text{m}\cdot\text{min}^{-1}$ are slightly higher than our
218 papers mean BiP periods over 90s ($105.0 \text{ m}\cdot\text{min}^{-1}$ and $110.9 \text{ m}\cdot\text{min}^{-1}$ for forwards and backs
219 respectively), however they are much lower than the max BiP data of this study over 90s, $141.9 \text{ m}\cdot\text{min}^{-1}$
220 ¹ and $155.5 \text{ m}\cdot\text{min}^{-1}$ for forwards and backs respectively. This is likely because, although Reardon et al.
221 ¹⁷ reports 'WCS' plays, they analysed the average of the longest plays, rather than plays that involved
222 the highest running demands.

223 Mean BiP $\text{m}\cdot\text{min}^{-1}$ data did not differ between forwards and backs, however, max BiP $\text{m}\cdot\text{min}^{-1}$ was
224 significantly higher for backs ($p < 0.05$) for plays 61s or over. Delaney et al. ⁵ reported similar WCS
225 $\text{m}\cdot\text{min}^{-1}$ to our paper, with 154-184 $\text{m}\cdot\text{min}^{-1}$ and 122-147 $\text{m}\cdot\text{min}^{-1}$ for 1 and 2 min peak rolling averages
226 respectively, and also reported that backs ran significantly further versus tight five. This suggests that
227 typical relative distance may be similar between positions, however, WCS plays demand greater
228 running from the backs due to positional requirements and/or players running capacities.

229 Both HML and HSR were significantly higher for backs versus forwards across mean whole match (as
230 similarly reported by Cunningham et al. ⁸) and mean and max BiP periods. Though there is no
231 significant difference between mean BiP $\text{m}\cdot\text{min}^{-1}$, the positional difference for both HML and HSR
232 min^{-1} suggests that the backs cover these similar distances at higher speeds than forwards. As Quarrie
233 et al. ⁴ explains, the role of the backs is typically to utilise the space, whereas the forwards contest for
234 the ball. The average distance for a high intensity running effort is 6-14m ^{27,28}, therefore perhaps the

235 forwards' acceleration capability and capacity is more important than high speed running in respect of
236 their roles.⁵ The above point might also explain why the current study found no difference between
237 forwards and backs regarding mean or max BiP Acc. Previous research has shown accelerations to be
238 similar in frequency between forwards and backs⁸, and a higher mean acceleration for the forwards
239 (2.46 m/s^2) vs backs (2.36 m/s^2).⁶ This is a very relevant metric to report as acceleration qualities are
240 fundamental¹ and relate to success in rugby.^{2,3}

241
242 This study supports the notion that collision capability and capacity are also very important for
243 forwards^{10,16}, as they are involved in higher Coll than backs over a whole match as well as mean and
244 max BiP periods ($p < 0.01$). This study reports similar Coll over the whole match (0.51 and 0.27
245 coll/min^{-1} for forwards and backs respectively) using GPS detected collisions, compared to TMA
246 analysis by Lindsay et al.⁹ (0.56 and 0.36 coll/min^{-1}). Forwards are involved in ~89 static or collision
247 actions throughout a game³, equating to ~30% of actions⁶ and in international rugby there is a ruck
248 every ~12 seconds¹⁷ suggesting multiple players are involved in a collision effort at a high frequency.
249 It is known that collisions and static efforts in rugby are similarly fatiguing to running efforts for
250 players²⁹, and higher heart rate %, higher rating of perceived exertion, and decrement in sprinting
251 performance has been shown when simulated collisions are added into a running drill.³⁰ Collisions are
252 therefore an essential metric when reporting holistic physical demands of positional groups alongside
253 movement metrics.¹⁷ This study is the first to report GPS detected collisions within BiP, recently
254 validated by Hulins et al.²⁶

255
256 Throughout all max BiP periods, GPS metrics decreased over time ($p < 0.05$), with the highest outputs
257 observed in periods lasting 30-60s and the lowest over 90s, a similar trend to movement metrics
258 demonstrated using a peak rolling average by Delaney et al.⁵. This shows the importance of reporting
259 intensity metrics over duration specified periods. If the aim of a rugby or conditioning drill is to align
260 to WCS demands, then there are specific GPS metrics to achieve, dependant on the duration of the
261 drill. The decrease in intensity that occurs as the play duration increases are possibly due to positional
262 or tactical requirements where a player is not involved in a high intensity activity. Conversely, during

263 longer periods of plays, for example >90s, it may not be possible for all players to maintain the
264 intensity of work seen in shorter periods (30-60s) due to limits of their physical capacities.

265
266 It is also worth noting that this analysis was performed using commercially available software that can
267 output any GPS metric available. Other analysis of peak demands of play such as peak rolling average,
268 is appropriate for only certain metrics, and is not as yet readily commercially available or usable.

269

270 **Conclusion**

271 This study is the first to report whole match, mean and max BiP demands of international rugby union.
272 BiP analysis allows an accurate portrayal of the movement and collision demands to further the
273 understanding of international rugby union. BiP metrics were higher than whole match averages.
274 During both mean and max BiP, backs perform greater HML and HSR, and forwards perform a higher
275 number of collisions.

276

277 **Practical Implications**

- 278 • The challenge within rugby union is to attempt to improve various aspects of technical,
279 tactical and physical qualities of performance simultaneously. With knowledge of typical, but
280 perhaps more so, the maximum demands of duration specific movement and collision outputs
281 in international rugby, training can be aimed to match or supersede these metrics whilst
282 monitored by GPS for feedback.
- 283 • WCS training drills or conditioning drills should align to positional differences encompassing
284 that backs cover greater HML and HSR, and forwards must have the capacity to repeat
285 accelerations and collisions.
- 286 • By aligning WCS playing demands to training drills there is likely greater transfer to
287 performance in match play via executing skills and decision making, alongside stimulating
288 physical capabilities and capacities.

289

290 **Acknowledgements**

291 No funding was provided.

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369 **Table 1.** Anthropometric data for each positional group and presented as an average for the team.

Positional Group	BW (kg)	Age (years)	Height (cm)
Forwards (F) n = 12	116.8 ± 7.7	27.4 ± 3.0	191 ± 6
Back (B) n = 10	91.9 ± 5.7	26.6 ± 2.8	182 ± 5
Team n = 22	106.1 ± 14.1	27.0 ± 2.9	187 ± 7

370 Data is presented as means ± standard deviation

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388 **Table 2.** Average outputs for GPS metrics across a whole match (>60min), and various passages of
 389 BiP, separated by position (Forwards vs. Backs).

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		Mean Whole Match	Mean BiP	Mean for Plays 30-60s	Mean for Plays 61-90s	Mean for Plays >90s
M Min ⁻¹ per Position	Forwards	65.7 ± 3.8 ^a	106.0 ± 5.6	106.9 ± 5.6	104.6 ± 6.1	105.0 ± 8.5
	Backs	69.7 ± 5.0 ^a	111.4 ± 10.5	109.6 ± 11.4	115.1 ± 11.4 ^{*b}	110.9 ± 9.5
	Average	67.6 ± 4.8 ^a	108.6 ± 8.5	108.2 ± 8.7	109.6 ± 10.2	107.8 ± 9.2
HML per min per Position	Forwards	7.9 ± 1.5 ^a	21.8 ± 4.3	23.7 ± 4.2 ^e	19.8 ± 4.8	19.2 ± 4.7 ^c
	Backs	11.2 ± 1.6 ^{*a}	29.5 ± 4.4 [*]	29.8 ± 5.4 ^{e*}	30.3 ± 4.8 [*]	27.5 ± 2.9 ^{c*}
	Average	9.5 ± 2.3 ^a	25.4 ± 5.8	26.6 ± 5.6 ^e	24.8 ± 7.1	23.1 ± 5.7 ^c
Acc >3m s ⁻³ per min per Position	Forwards	0.3 ± 0.1 ^a	0.8 ± 0.2 ^e	0.8 ± 0.2	0.8 ± 0.2	0.7 ± 0.2 ^b
	Backs	0.4 ± 0.1 ^a	0.9 ± 0.1 ^e	0.9 ± 0.2 ^e	0.8 ± 0.2	0.7 ± 0.1 ^{bc}
	Average	0.3 ± 0.1 ^a	0.8 ± 0.2 ^e	0.8 ± 0.2	0.8 ± 0.2	0.7 ± 0.2 ^b
Coll per min per Position	Forwards	0.5 ± 0.1 ^{^a}	1.1 ± 0.2 [^]	1.1 ± 0.2 [^]	1.2 ± 0.2 [^]	1.1 ± 0.2 [^]
	Backs	0.3 ± 0.1 ^a	0.5 ± 0.1	0.5 ± 0.1	0.7 ± 0.2	0.6 ± 0.1
	Average	0.4 ± 0.2 ^a	0.8 ± 0.3 ^{cd}	0.8 ± 0.3 ^{bd}	0.9 ± 0.3 ^{bc}	0.8 ± 0.3
HSR per min per Position	Forwards	3.3 ± 1.5 ^a	8.9 ± 4.0 ^{ce}	10.9 ± 4.7	7.0 ± 4.1 ^b	5.8 ± 2.7 ^b
	Backs	7.8 ± 1.9 ^{*a}	19.0 ± 4.5 ^{*ce}	20.3 ± 5.7 [*]	18.9 ± 5.1 ^{*b}	15.6 ± 3.4 ^{*b}
	Average	5.5 ± 2.8 ^a	13.7 ± 6.6 ^{ce}	15.4 ± 7.0 ^e	12.6 ± 7.6 ^b	10.4 ± 5.8 ^{bc}

391 Data is presented as means ± standard deviation

392 [^] = significantly different to backs, * = significantly different to forwards, a = significantly different to all BiP periods, b = significantly
 393 different than mean BiP, c = significantly different than mean BiP periods 30-60s, d = significantly different than mean BiP periods 61-90s,
 394 e = significantly different than mean BiP periods over 90s.

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397 **Table 3.** Maximum outputs for GPS metrics across a whole match (>60min), and various passages of
 398 BiP, separated by position (Forwards vs. Backs).

		Max for Plays 30-60s	Max for Plays 61-90s	Max for Plays >90s
Metres per Min per Position	Forwards	184.1 ± 16.9 ^{gh}	143.3 ± 14.0 ^f	141.9 ± 13.9 ^f
	Backs	196.8 ± 18.2 ^{gh}	164.8 ± 19.9 ^{*f}	155.5 ± 15.6 ^{*f}
	Average	189.9 ± 18.3 ^{gh}	153.0 ± 19.8 ^f	148.1 ± 15.9 ^f
HML per min per Position	Forwards	80.8 ± 10.5 ^{gh}	44.3 ± 12.2 ^{fh}	36.4 ± 10.1 ^{fg}
	Backs	95.4 ± 14.9 ^{*gh}	66.0 ± 16.2 ^{*fh}	56.9 ± 7.1 ^{*fg}
	Average	87.5 ± 14.5 ^{gh}	54.1 ± 17.7 ^{fh}	45.7 ± 13.7 ^{fg}
Accels >3m s ⁻³ per min per Position	Forwards	4.7 ± 1.2 ^{gh}	3.2 ± 0.9 ^{fh}	2.2 ± 0.6 ^{fg}
	Backs	4.7 ± 2.2 ^{gh}	2.9 ± 1.1 ^{fh}	2.2 ± 0.6 ^{fg}
	Average	4.7 ± 1.7 ^{gh}	3.1 ± 1.0 ^{fh}	2.2 ± 0.5 ^{fg}
Collisions per min per Position	Forwards	3.8 ± 1.1 ^{gh}	2.9 ± 0.7 ^f	2.6 ± 0.7 ^f
	Backs	3.5 ± 1.0 ^{gh}	1.9 ± 0.5 ^{fh}	1.5 ± 0.4 ^{fg}
	Average	3.7 ± 1.0 ^{gh}	2.4 ± 0.8 ^{fh}	2.1 ± 0.8 ^{fg}
HSR per Min per Position	Forwards	85.5 ± 25.7 ^h	35.0 ± 17.9 ^h	24.2 ± 7.9 ^{fg}
	Backs	106.0 ± 19.3 ^{gh}	62.8 ± 22.9 ^{*fh}	45.3 ± 10.3 ^{*fg}
	Average	94.6 ± 25.5 ^{gh}	47.6 ± 24.4 ^{fh}	33.7 ± 13.9 ^{fg}

399 Data is presented as means ± standard deviation

400 [^] = significantly different to backs, * = significantly different to forwards, ^f = significantly different than max BiP periods 30-60s, ^g =

401 significantly different than max BiP periods 61-90s, ^h = significantly different than max BiP periods over 90s.

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