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1 **Title:** The physical characteristics of specific phases of play  
2 during rugby union match-play

3  
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5  
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35 **Abstract**

36

37 *Purpose:* This study quantified the frequencies and timings of  
38 rugby union match-play phases (i.e., attacking, defending, ball  
39 in play (BIP) and ball out of play (BOP)) and then compared  
40 the physical characteristics of attacking, defending and BOP  
41 between forwards and backs.

42

43 *Methods:* Data were analysed from 59 male rugby union  
44 academy players (259 observations). Each player wore a micro-  
45 technology device (Optimeye S5, Catapult) with video footage  
46 analysed for phase timings and frequencies. Dependent  
47 variables were analysed using a linear mixed-effects model and  
48 assessed with magnitude-based inferences and Cohen's *d* effect  
49 sizes (ES).

50

51 *Results:* Attack, defence, BIP and BOP times were  $12.7 \pm 3.1$ ,  
52  $14.7 \pm 2.5$ ,  $27.4 \pm 2.9$  and  $47.4 \pm 4.1$  min, respectively. Mean  
53 attack ( $26 \pm 17$  s), defence ( $26 \pm 18$  s) and BIP ( $33 \pm 24$  s)  
54 phases were shorter than BOP phases ( $59 \pm 33$  s). The relative  
55 distance in attacking phases was similar ( $112.2 \pm 48.4$  vs.  $114.6$   
56  $\pm 52.3$  m·min<sup>-1</sup>, ES =  $0.00 \pm 0.23$ ) between forwards and backs,  
57 while greater in forwards ( $114.5 \pm 52.7$  vs.  $109.0 \pm 54.8$  m·min<sup>-1</sup>,  
58 ES =  $0.32 \pm 0.23$ ) during defence and greater in backs during  
59 BOP (ES =  $-0.66 \pm 0.23$ ).

60

61 *Conclusion:* Total time in attack, defence and therefore BIP  
62 was less than BOP. Relative distance was greater in forwards  
63 during defence, while greater in backs during BOP and similar  
64 between positions during attack. Players should be exposed to  
65 training intensities from in play phases (i.e., attack and  
66 defence) rather than whole-match data and practice technical  
67 skills during these intensities.

68

69 *Keywords:* Physical preparation; Player development; GPS;  
70 Skill involvements; Contact sports

71

## 72 Introduction

73  
74 The physical characteristics of match-play (i.e., running and  
75 collisions) in age-grade (e.g., U18) rugby union players is a  
76 growing area of research.<sup>1-3</sup> Studies using global positioning  
77 systems (GPS) have published data from county  
78 representative,<sup>4</sup> school,<sup>5</sup> academy<sup>2</sup> and international  
79 competition.<sup>3</sup> Read and colleagues<sup>2</sup> showed that U18 academy  
80 backs covered more distance ( $5639 \pm 368$  vs.  $5461 \pm 360$  m,  
81 effect size (ES) = 0.67) and achieved greater maximum speeds  
82 ( $8.1 \pm 0.4$  vs.  $7.0 \pm 0.7$  m·s<sup>-1</sup>, ES = 1.08) during match-play  
83 compared to forwards. The differences between positions  
84 corroborate similar findings from senior rugby union.<sup>6</sup> The  
85 lower locomotor activities in forwards are likely because of the  
86 higher collision rates ( $0.56 \pm 0.23$  vs.  $0.36 \pm 0.17$  n·min<sup>-1</sup>, ES =  
87 0.99),<sup>7</sup> differences in player physical characteristics<sup>8,9</sup> and  
88 tactical roles they undertake<sup>10</sup> compared to backs. These  
89 findings collectively lead to the common belief that for backs,  
90 the physical characteristics of rugby union are dominated by  
91 running. However, these data are typically reported as a mean  
92 or total from a whole match and due to the stoppages in team  
93 sports are likely to underestimate the intensity of match-play  
94 when the ball is in play, which could also lead to players being  
95 unprepared for the most intense periods of play.<sup>11</sup>

96  
97 The demands of match-play have been categorised using  
98 different methods, for example, time when the ball is in play  
99 (BIP) and when the ball is out of play (BOP).<sup>10</sup> Senior rugby  
100 union international matches in 1992 had a mean BIP time of 29  
101 min over an 80 min game, while the mean and maximum BIP  
102 cycle were 19 and 70 s, respectively.<sup>12</sup> Further research has  
103 highlighted a trend for an increase in BIP time between 2000  
104 and 2002 to approximately 31 min<sup>13</sup> and again to  $36.3 \pm 2.7$   
105 min between 2004 and 2010.<sup>10</sup> However, BIP can also be  
106 further split into attacking and defensive phases for rugby  
107 union which often occur in isolation without the transition  
108 between attack and defence and therefore are often trained  
109 separately. Despite this, little is known about the frequencies or  
110 timings of these phases of play, or the overall physical  
111 characteristics of each phase. Previously, a study in rugby  
112 league quantified the locomotor characteristics of attacking and  
113 defending and highlighted that relative distance was greater  
114 while defending ( $109 \pm 16$  vs.  $82 \pm 12$  m·min<sup>-1</sup>, ES = 1.35).<sup>14</sup>  
115 Despite this, the study only reported data from forwards in  
116 senior rugby league and thus the applicability for age-grade  
117 rugby union players is limited.

118  
119 In England, age-grade rugby union players can participate in  
120 several playing standards (e.g., amateur club, school and  
121 representative) concurrently, with academy rugby perceived to

122 be the highest standard besides international competition.<sup>15</sup>  
123 Academy rugby is the final step before age-grade international  
124 and professional rugby and therefore sport scientists and  
125 strength and conditioning coaches require information on the  
126 most demanding phases of play to appropriately prepare  
127 players. Therefore, the aim of the study was to quantify and  
128 compare the physical characteristics of the three phases of play;  
129 attacking, defending and BOP between forwards and backs  
130 during academy rugby union match-play.

131

## 132 **Methods**

133

### 134 *Participants*

135

136 Fifty-nine male rugby union players were recruited from a  
137 regional academy. The participants were split by position;  
138 forwards (age:  $17.5 \pm 0.6$  years; stature:  $185.9 \pm 5.7$  cm; body  
139 mass:  $95.0 \pm 8.9$  kg) and backs (age:  $17.7 \pm 0.6$  years; stature:  
140  $180.3 \pm 5.2$  cm; body mass:  $81.8 \pm 10.5$  kg). There were  
141 repeated measurements of individual participants and therefore  
142 259 observations were collected (mean  $\pm$  standard deviation  
143 (SD);  $4 \pm 3$  observations per player). The repeated  
144 measurement of participants if appropriately accounted for and  
145 outlined in the statistical analysis.<sup>16</sup> Ethics approval was  
146 granted from Leeds Beckett University institutional ethics  
147 committee and adhered to throughout. Written informed  
148 consent was gained from all participants prior to starting the  
149 study, with a parent or guardian providing this for participants  
150 under the age of 18.

151

### 152 *Design*

153

154 The study used an observational research design whereby data  
155 were collected during competitive matches from the regional  
156 academy annual league during the 2014/2015 and 2015/2016  
157 seasons, totalling 12 matches. In England, the 14 regional  
158 academies are split into two groups of seven (north and south  
159 leagues), meaning each academy plays six competitive matches  
160 per year. Therefore, this study consists of two full seasons data.  
161 Of the 12 matches, there were an equal number of home and  
162 away fixtures, with a mean points scored and conceded per  
163 game of  $12 \pm 10$  and  $30 \pm 10$ . Matches at the U18 age-grade are  
164 70 min in length.

165

### 166 *Methodology*

167

168 Video footage from the matches was obtained (AX100 4K  
169 Camcorder, Sony, Tokyo, Japan) and analysed manually for  
170 attacking, defending, BIP and BOP timings. Attacking phases  
171 were defined as when the team under investigation were in

172 possession of the ball, whereas when the opposition were in  
173 possession this was classified as a defensive phase. The referee  
174 blowing the whistle was used to signify the beginning of a BOP  
175 period (e.g., try scored, penalty awarded).<sup>14</sup> When kicks into  
176 touch were made, the raising of the flag from the assistant  
177 referee was used to signify the beginning of a BOP period.  
178 Instances where a team restarted play within 5 seconds or less  
179 after being awarded a penalty were not considered as a BOP  
180 phase.<sup>17</sup> When a scrum occurred, the BOP phase ended with the  
181 call of 'set' from the referee, as this is the point at which the  
182 front rowers of both teams engage in physical contact.<sup>13</sup>

183

184 The total number of phases and total time spent in attacking,  
185 defending, BIP and BOP phases were recorded. The mean,  
186 mean of the maximum, maximum and minimum cycle time for  
187 the three phases were analysed in addition to a frequency  
188 distribution of each cycle based on the following  
189 classifications: 0-15, 16-30, 31-45, 46-60, >60 s.<sup>17</sup> In order to  
190 assess inter-rater reliability of the video analysis, the time spent  
191 in attack and defence was analysed by a second trained  
192 individual. The coefficient of variation  $\pm 90\%$  confidence  
193 intervals (CI) for attack, defence and BOP was  $1.98 \pm 0.80\%$ ,  
194  $1.17 \pm 0.70\%$  and  $1.52 \pm 0.72\%$ , respectively.

195

196 During the match, each player wore a micro-technology device  
197 (Optimeye S5, Catapult, Melbourne, Australia) that contained a  
198 GPS system sampling at 10 Hz and a tri-axial accelerometer,  
199 gyroscope and magnetometer sampling at 100 Hz. The devices  
200 were fitted in a vest provided by the manufacturer and worn  
201 under the playing shirts. The devices were switched on outside  
202 at the start of the warm up and switched off at the end of the  
203 match. However, each file was trimmed so it only contained  
204 data from actual playing time for each participant. Similar GPS  
205 units have shown acceptable validity and reliability for  
206 measuring movements that are common during team sport  
207 match-play.<sup>18</sup> The accelerometer used in the current study has  
208 also been shown to have an acceptable CV for within (0.9–  
209 1.1%) and between (1.0–1.1%) unit reliability.<sup>19</sup> The mean  $\pm$   
210 SD number of satellites connected during all data collection  
211 was  $14.5 \pm 0.9$ , while the horizontal dilution of precision was  
212  $0.69 \pm 0.13$ .

213

214 The timings of attack, defence and BOP phases were  
215 synchronised and manually entered into the GPS software  
216 (Sprint 5.1.7, Catapult, Melbourne, Australia). Relative  
217 distance ( $\text{m} \cdot \text{min}^{-1}$ ) was downloaded to assess the locomotor  
218 characteristics of match-play. PlayerLoad<sup>TM</sup> per minute  
219 ( $\text{PL} \cdot \text{min}^{-1}$ ) ( $\text{AU} \cdot \text{min}^{-1}$ ) was downloaded to quantify the  
220 additional external load such as accelerations that rugby players  
221 experience. PL is a vector magnitude and sums the frequency

222 and magnitude of accelerations in the three axial planes.<sup>20</sup> A  
223 very large ( $r = 0.79$ ) relationship between PL and collisions in  
224 rugby union has previously been shown, although it is  
225 acknowledged this measure is limited in its ability to  
226 distinguish between actions.<sup>21</sup>

227

## 228 *Statistical Analyses*

229

230 All estimations were made using the *lme4* package with R  
231 (version 3.3.1, R Foundation for Statistical Computing, Vienna,  
232 Austria). A linear mixed-effects model was used to model the  
233 main and interactive effects of phase of play (attacking,  
234 defending, and BOP), positional group (forwards and backs)  
235 and time classification (0-15, 16-30, 31-45, 46-60 and >60 s)  
236 upon match-play physical characteristics (relative distance and  
237 PL·min<sup>-1</sup>). Dependent variables were log transformed before  
238 modelling, and then effects and standard deviations were back-  
239 transformed to percentages. The random-effects in the model  
240 were match identity (differences between mean match demands  
241 not accounted for by the fixed-effects), athlete identity  
242 (differences between athletes' mean locomotor characteristics)  
243 and the residual (within-athlete and match-to-match  
244 variability). Magnitude-based inferences were applied using the  
245 estimates from the linear mixed model (representing percentage  
246 differences between the levels of the fixed effects) and were  
247 compared against a smallest worthwhile effect threshold  
248 equivalent to 0.2 of the between-subject standard deviations  
249 (relative distance = 4.7% and PL·min<sup>-1</sup> = 4.9%) using a  
250 spreadsheet.<sup>22</sup> Effects were classified as *unclear* if the  
251 percentage likelihood that the true effect was positive and  
252 negative were both >5%. Otherwise, the effect was deemed  
253 clear, and was qualified with a probabilistic term using the  
254 following scale: <0.5%, *most unlikely*; 0.5-4.9%, *very unlikely*;  
255 5-24.9%, *unlikely*; 25-74.9%, *possible*; 75-94.9%, *likely*; 95-  
256 99.5%, *very likely*; >99.5%, *almost certainly*.<sup>23</sup> Cohen's *d* ES  
257 are shown ±90% CI.

258

## 259 **Results**

260

261 A breakdown of the attacking, defending, BIP and BOP phases  
262 are shown in Table 1.

263

264 \*\*\* INSERT TABLE ONE NEAR HERE \*\*\*

265

266 The distributions for all time classifications in attack (A),  
267 defence (B), BIP (C) and BOP (D) are shown in Figure 1. The  
268 frequency distribution was the greatest in the 0-15 and 16-30 s  
269 classifications for both attacking ( $31.9 \pm 6.2$  and  $39.2 \pm 7.1\%$ )  
270 and defending ( $30.0 \pm 8.3$  and  $40.0 \pm 7.0\%$ ). While 16-30 s

271 (31.7 ± 5.8%) and >60 s (39.7 ± 9.5%) had the greatest  
272 distribution during BIP and BOP phases, respectively.

273

274 \*\*\* INSERT FIGURE ONE NEAR HERE \*\*\*

275

276 Figure 2 presents the relative distance (A) and PL·min<sup>-1</sup> (B) for  
277 the three phases of play and two positions. The difference in  
278 relative distance in attacking phases of play was *unclear* (ES =  
279 0.00 ±0.23) between forwards (112.2 ± 48.4 m·min<sup>-1</sup>) and  
280 backs (114.6 ± 52.3 m·min<sup>-1</sup>), while measures during defending  
281 were *likely* (ES = 0.32 ±0.23) greater in forwards (114.5 ± 52.7  
282 m·min<sup>-1</sup>) compared to backs (109.0 ± 54.8 m·min<sup>-1</sup>). During  
283 BOP time backs (54.3 ± 29.2 m·min<sup>-1</sup>) were *almost certain* (ES  
284 = -0.66 ±0.23) to have a greater relative distance than forwards  
285 (47.7 ± 27.5 m·min<sup>-1</sup>). The difference in PL·min<sup>-1</sup> was *almost*  
286 *certainly* greater in forwards during both attacking (12.6 ± 5.0  
287 vs. 12.0 ± 6.7 AU·min<sup>-1</sup>, ES = 0.76 ±0.33) and defending (12.8  
288 ± 5.2 vs. 11.0 ± 6.3 AU·min<sup>-1</sup>, ES = 1.19 ±0.33) phases than  
289 backs. The difference in PL·min<sup>-1</sup> was *unclear* during BOP (4.2  
290 ± 2.4 vs. 4.3 ± 3.0 AU·min<sup>-1</sup>, ES = 0.12 ±0.33) time between  
291 the two positions.

292

293 Within the forwards group, the difference in attacking and  
294 defending was *likely trivial* for relative distance (ES = 0.07  
295 ±0.19) and PL·min<sup>-1</sup> (ES = 0.02 ±0.18). Within the backs  
296 group, the difference in attack phases were *likely* greater  
297 compared to defence phases for relative distance (ES = 0.39  
298 ±0.22) and PL·min<sup>-1</sup> (ES = 0.41 ±0.22).

299

300 \*\*\* INSERT FIGURE TWO NEAR HERE \*\*\*

301

302 The relative distance for each time classification, position and  
303 phase of play is presented in Table 2. Differences between  
304 positions are analysed for each time classification and phase of  
305 play. In attack, the difference in relative distance during 31-45  
306 s phases was *possibly* lower (ES = -0.23 ±0.37) in forwards  
307 (118.3 ± 35.6 m·min<sup>-1</sup>) than backs (124.2 ± 39.2 m·min<sup>-1</sup>). All  
308 other attack comparisons were *unclear*. In defence, forwards  
309 were *possibly* (ES = 0.24 ±0.34) to *very likely* (ES = 0.53  
310 ±0.33) greater than backs at all time classifications. During  
311 BOP, forwards were *possibly* (ES = -0.32 ±0.34) to *very likely*  
312 (ES = -0.36 ±0.11) lower than backs at all time classifications.

313

314 \*\*\* INSERT TABLE TWO NEAR HERE \*\*\*

315

## 316 Discussion

317

318 The aim of the study was to quantify and compare the physical  
319 characteristics of the three phases of play (i.e., attacking,  
320 defending and BOP) between forwards and backs during



321 academy rugby union match-play. The results highlight that  
322 less than half of the match is spent with the BIP (37%), while  
323 the mean time for phases in attack ( $26 \pm 17$  s), defence ( $26 \pm 18$   
324 s) and BIP ( $33 \pm 24$  s) are lower than BOP ( $59 \pm 33$  s). This is  
325 the first study to show that relative distance during attacking  
326 phases was similar between forwards and backs, while  
327 forwards had a greater relative distance during defensive  
328 phases. In contrast, during BOP phases relative distance was  
329 greater in backs than forwards. Based on whole match data,  
330 previous studies<sup>2,6,10</sup> have reported backs to cover greater  
331 distances during a match, whereas this study shows that  
332 forwards cover more distance per minute in defence and were  
333 similar to backs in attack. These data provide new information  
334 for applied practitioners working in rugby union and can be  
335 used to prepare players for the specific phases of play.

336  
337 Senior international rugby union match-play has a greater BIP  
338 ( $36.3 \pm 2.7$  vs.  $27.4 \pm 2.9$  min) and BOP ( $53.5 \pm 5.5$  vs.  $47.4 \pm$   
339  $4.1$  min) time than the current study, as U18 matches in  
340 England last 70 min in comparison to 80 min at the senior  
341 level.<sup>10</sup> However little information exists on the attack and  
342 defence timings in rugby union. Differences between rugby  
343 league and union are evident in the mean length of attacking  
344 ( $40 \pm 6$  vs.  $26 \pm 17$  s) and defending ( $40 \pm 6$  vs.  $26 \pm 18$  s)  
345 phases, while the BOP ( $48 \pm 4$  vs.  $59 \pm 33$  s) phases were  
346 longer in the current study.<sup>24</sup> Differences between rugby codes  
347 are likely because of the additional stoppages in rugby union  
348 for events such as lineouts and scrums, but could also be  
349 attributed to the participants used by Sykes et al.<sup>24</sup>, as  
350 differences between standards (e.g., U18 vs. professional) are  
351 unknown. Based on the mean BIP, attack and defence cycles, it  
352 may be questioned whether academy matches are demanding  
353 enough to challenge players with the most potential to progress  
354 toward the senior professional pathway. Match-play represents  
355 the greatest opportunity for players to develop skills under  
356 pressure against opposition and therefore BIP time should be  
357 maximised for age-grade players. Caution is advised when  
358 extrapolating these data to an entire league as it is taken from  
359 one team and previous research has highlighted that top 4  
360 teams in the NRL have longer BIP cycles than the bottom 4  
361 teams in the same league.<sup>25</sup> Future studies should look to  
362 incorporate data from multiple teams to negate this issue.

363  
364 In the current study, the frequency distributions of attacking  
365 and defensive phases were weighted towards the shorter  
366 classifications (0-15 and 16-30 s), while BOP phases were  
367 concentrated towards the longer classifications (31-45 and >60  
368 s). It should be noted that several attack and defence phases  
369 could occur in between BOP phases, and therefore on  
370 occasions might be longer than the BOP phase. However, the

371 BIP time was still relatively low ( $27.4 \pm 2.9$  min; 37%) in the  
372 context of a whole match, with each BIP cycle lasting an mean  
373 of 33 s, only 7 s longer than the mean attack and defence phase  
374 highlighting the need for this type of analysis. Previous  
375 research has reported that BIP cycles were longer during  
376 international sevens competition compared to provincial  
377 matches and this was related to skill execution (e.g., fewer  
378 handling errors).<sup>17</sup> The impact of skill execution on BIP time is  
379 currently unknown within this cohort but future research should  
380 investigate this, as it would provide further insight into rugby  
381 union match-play and has potential implications for player  
382 development.

383

384 A previous conception of rugby union is that for backs the  
385 game is dominated physically by running, however the current  
386 study questions this. In attack, the difference in relative  
387 distance was *unclear* between the two positional groups, but  
388 *likely* greater in forwards during defence. It is unknown if the  
389 preparation of this specific team impacted this. It is  
390 acknowledged the use of relative distance is a limitation and  
391 the inclusion of high-speed running would have provided  
392 further insight. However, it is also generally accepted that as  
393 players get older more position specific skills are practiced,  
394 physical characteristics develop<sup>8,26</sup> and therefore the physical  
395 characteristics of age-grade matches might not always reflect  
396 the same pattern as the senior game.<sup>4,5</sup>

397

398 The mean relative distance ranged from  $109.0 - 114.6$  m·min<sup>-1</sup>  
399 in attack and defence for the current study, which is  
400 substantially higher than mean match data ( $71.7 - 74.0$  m·min<sup>-1</sup>)  
401 from regional academy players.<sup>2</sup> The mean values for attack  
402 and defence are within the range presented by Tierney et al.<sup>27</sup>  
403 during entries into the attacking 22 m area for front row props  
404 ( $97.5$  m·min<sup>-1</sup>) and scrum halves ( $121.0$  m·min<sup>-1</sup>). However,  
405 research from Delaney et al.<sup>28</sup> has shown the peak running  
406 intensities of international rugby union match-play to be as  
407 high as  $175 \pm 22$  m·min<sup>-1</sup> for a 1 min rolling mean.  
408 Furthermore, previous research has indicated that there is a  
409 drop in distance covered and skill involvements from less  
410 experienced, younger players following an intense period of  
411 play compared to more experienced, older players.<sup>29</sup> Therefore,  
412 coaches should expose age-grade players to peak running  
413 intensities during training to increase their ability to sustain  
414 physical and technical output following intense periods of play  
415 in preparation for senior rugby. In addition, the difference in  
416 PL·min<sup>-1</sup> was *almost certainly* greater in forwards during  
417 attacking and defending, which is likely representative of the  
418 greater amount of running, carries, tackles and rucks entered  
419 and should be considered when designing training practices.<sup>10</sup>

420

421 A novel finding of this study was that backs covered an *almost*  
422 *certainly* greater relative distance than forwards during BOP  
423 time. It is hypothesised this is because backs reposition around  
424 the pitch while forwards are waiting for the match to restart  
425 (e.g., lineouts, scrums, etc). Future research should investigate  
426 if the current findings are replicated in senior players or if this  
427 is specific to age-grade players, as this would potentially  
428 change the current understanding of the locomotor  
429 characteristics for forwards and backs and inform the physical  
430 preparation of players.

431  
432 It is also important to understand how the phases of play  
433 compare within the same position as this has potential  
434 implications for the way coaches prepare specific positional  
435 groups. For forwards, the difference between attacking and  
436 defending for both relative distance and  $PL \cdot \text{min}^{-1}$  was *likely*  
437 *trivial* and therefore preparation for these two phases of play  
438 can be similar in physical characteristics. In contrast, backs had  
439 a *likely* greater difference in relative distance and  $PL \cdot \text{min}^{-1}$  in  
440 attack compared to defence, which indicates attacking play is  
441 the most demanding phase of play for backs. This suggests  
442 backs are involved in more of the play in attacking situations  
443 than defensive, which has previously been shown in junior  
444 rugby league<sup>30</sup>. The use of data from specific phases of play  
445 provides context to the preparation of rugby players, in that  
446 training is often focussed on these phases. Despite that, this  
447 type of analysis could underestimate the true worse case  
448 scenario, as this could come from BIP action that involves both  
449 attacking and defending and is acknowledged as a limitation to  
450 the study. The quantification of the peak running intensities  
451 using a rolling mean of the instantaneous velocity would  
452 encapsulate these periods.

### 453 454 **Practical Applications**

455  
456 Players should be exposed to training that uses intensities from  
457 in play phases (i.e., attack and defence) rather than means from  
458 whole match data. Coaches should incorporate this into rugby  
459 training to ensure that executions of technical skills are  
460 practiced during these intensities. Age-grade rugby coaches  
461 should use the timings provided in Table 1 to appropriately  
462 manipulate training and where possible place conditions on  
463 match-play to increase BIP time in preparation for players  
464 progressing to professional rugby.

### 465 466 **Conclusions**

467  
468 This study quantifies and compares the physical characteristics  
469 of attacking, defending, BIP and BOP phases during academy  
470 rugby union match-play. The current study is the first to

471 provide reference values for specific phases of match-play in  
472 academy rugby union, with values for attacking and defending  
473 substantially greater than previously reported whole match  
474 data. While the game of rugby union requires all positions to  
475 undertake many roles and responsibilities, backs roles are  
476 predominately described as locomotor based (i.e., high speed  
477 running, greater total distance). However, novel findings in the  
478 current study show that forwards covered more distance per  
479 minute when in defence while the backs covered more during  
480 BOP time. The greater PL·min<sup>-1</sup> in forwards likely represents  
481 the more actions they undertake which have been shown in  
482 notational analysis studies. As noted in previous studies, the  
483 ball is in play for a low percentage of time with the mean  
484 attacking and defending phase as low as 26 s. Therefore,  
485 policy-makers should consider the impact of competition  
486 demands at an age-grade (academy) level upon player  
487 development, and consider opportunities to modify laws or  
488 game formats to allow greater development opportunities.

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495 **References**

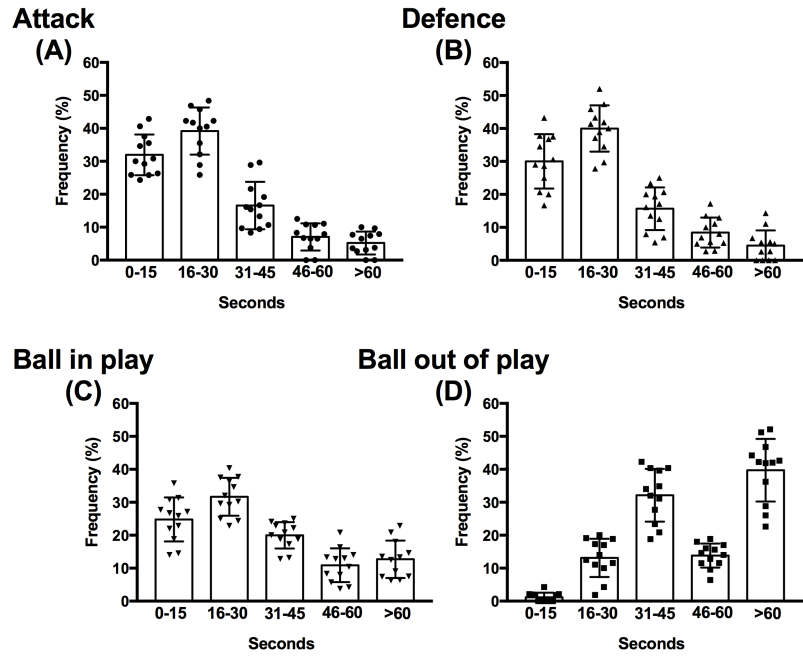
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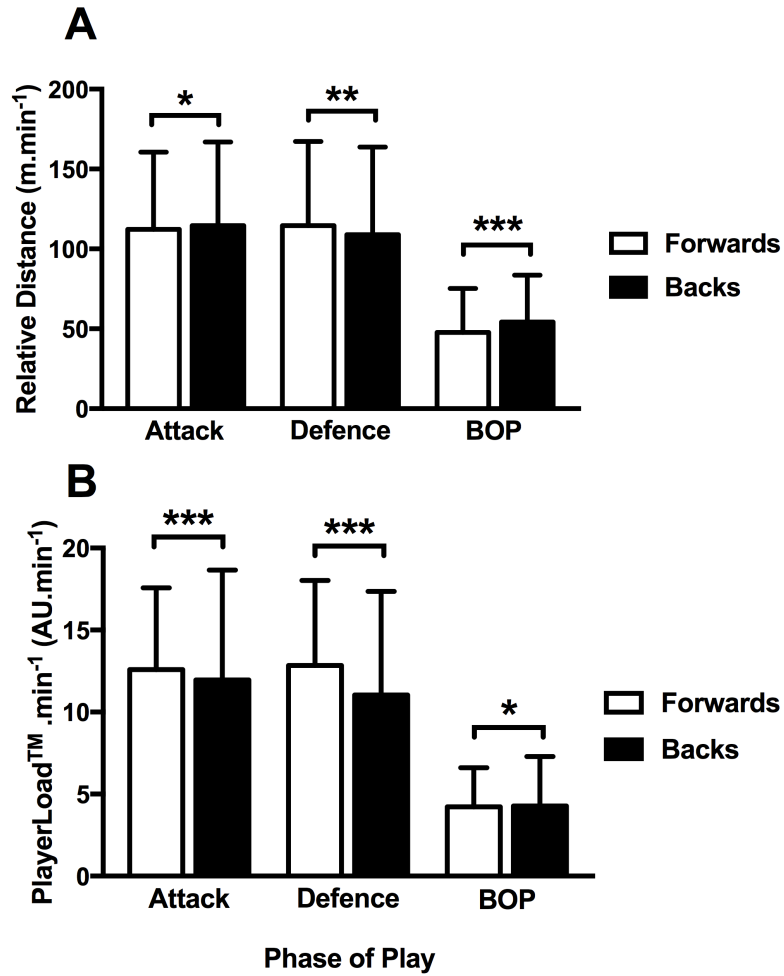
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**Figure 1.** The distribution times of attack (A), defence (B), ball in play (C) and ball out of play (D) phases during academy rugby union match-play



**Figure 2.** Relative distance (A) and PL·min<sup>-1</sup> (B) of attacking, defending and ball out of play phases during academy rugby union match-play for forwards and backs. \* = *Trivial* effect size (<0.20), \*\* = *Small* effect size (0.20-0.59), \*\*\* = *Moderate* effect size (0.60-1.20)

**Table 1.** Attacking, defending, BIP and BOP phases during academy rugby union match-play

	Attacking	Defending	Ball in play	Ball out of play
Time (min, %)	12.7 ± 3.1 (17%)	14.7 ± 2.5 (20%)	27.4 ± 2.9 (37%)	47.4 ± 4.1 (63%)
Phases ( <i>n</i> )	27 ± 9	31 ± 10	49 ± 4	48 ± 3
Mean Phase Time (s)	26 ± 17	26 ± 18	33 ± 24	59 ± 33
Mean Maximum Phase Time (s)	73 ± 14	79 ± 18	103 ± 35	142 ± 60
Maximum Phase Time (s)	96	113	149	259
Minimum Phase Time (s)	7	7	7	9

Data are presented as mean ± standard deviation. BIP = Ball in play. BOP = Ball out of play.

**Table 2.** Relative distance for forwards and backs in 0-15, 16-30, 31-45, 46-60 and >60 s classification times during academy rugby union match-play

Time Classification	Position	Attack		Defence		Ball out of play	
		(m·min <sup>-1</sup> )	MBI; ES ±CI	(m·min <sup>-1</sup> )	MBI; ES ±CI	(m·min <sup>-1</sup> )	MBI; ES ±CI
0-15 s	Forwards	103.3 ± 62.2	<i>Unclear</i>	109.4 ± 67.1	<i>Possibly</i> ↑	72.0 ± 29.3	<i>Possibly</i> ↓
	Backs	102.0 ± 64.2	0.08 ±0.41	106.5 ± 68.6	0.24 ±0.34	86.4 ± 37.2	-0.32 ±0.34
16-30 s	Forwards	115.9 ± 44.8	<i>Unclear</i>	118.4 ± 52.5	<i>Very Likely</i> ↑	65.0 ± 36.6	<i>Likely</i> ↓
	Backs	118.3 ± 50.4	-0.02 ±0.25	110.5 ± 54.5	0.53 ±0.33	73.0 ± 39.3	-0.25 ±0.13
31-45 s	Forwards	118.3 ± 35.6	<i>Possibly</i> ↓	117.4 ± 35.5	<i>Likely</i> ↑	48.2 ± 27.8	<i>Very Likely</i> ↓
	Backs	124.2 ± 39.2	-0.23 ±0.37	113.2 ± 41.1	0.37 ±0.40	56.6 ± 28.7	-0.36 ±0.11
46-60 s	Forwards	116.9 ± 28.6	<i>Unclear</i>	112.6 ± 30.9	<i>Likely</i> ↑	47.4 ± 24.3	<i>Likely</i> ↓
	Backs	121.9 ± 33.4	-0.19 ±0.52	106.7 ± 34.3	0.40 ±0.49	55.0 ± 26.5	-0.32 ±0.13
>60 s	Forwards	112.7 ± 23.3	<i>Unclear</i>	108.4 ± 20.9	<i>Possibly</i> ↑	40.7 ± 20.6	<i>Likely</i> ↓
	Backs	118.7 ± 29.8	-0.21 ±0.56	102.0 ± 28.2	0.44 ±0.59	45.0 ± 21.1	-0.20 ±0.10

Data are presented as mean ± standard deviation. MBI = Magnitude-based inferences. ES = Effect size. CI = Confidence interval (90%).

↑ = Forwards are greater than backs. ↓ = Forwards are lower than backs.