

**Title of Article:** Match physical performance of elite female soccer players during international competition

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1 **ABSTRACT**

2 The purpose of the present study was to provide a detailed  
3 analysis of the physical demands of competitive international  
4 female soccer match-play. A total of 148 individual match  
5 observations were undertaken on 107 outfield players  
6 competing in competitive international matches during the  
7 2011-2012 and 2012-2013 seasons, using a computerized  
8 tracking system (Prozone Sports Ltd., Leeds, England). Total  
9 distance (TD) and total high-speed running distances (THSR)  
10 were influenced by playing position, with central midfielders  
11 (CM) completing the highest ( $10985\pm706$  m and  $2882\pm500$  m)  
12 and central defenders (CD) the lowest ( $9489\pm562$  m and  
13  $1901\pm268$  m) distances, respectively. Greater total very high-  
14 speed running (TVHSR) distances were completed when a  
15 team was without ( $399\pm143$  m) compared to with ( $313\pm210$  m)  
16 possession of the ball. The majority of sprints were over short  
17 distances with 76 % and 95 % being less than 5 m and 10 m,  
18 respectively. Between half reductions in physical performance  
19 were present for all variables, independent of playing position.  
20 The current study provides novel findings regarding the  
21 physical demands of different playing positions in competitive  
22 international female match-play and provides important  
23 insights for physical coaches preparing elite female players for  
24 competition.

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26 **Key Words:** football; match analysis; tracking system; playing

27 position; high-speed running

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51 **INTRODUCTION**

52 A comprehensive understanding of the physical demands of  
53 match-play is necessary in order to apply a systematic approach  
54 to training and testing protocols.<sup>1</sup> As a consequence, global  
55 positioning system (GPS) technology and semi-automated  
56 camera systems have been extensively used to provide a  
57 detailed analysis of specific elements of a player's physical  
58 performance in men's soccer.<sup>2-4</sup> Despite advancements in the  
59 understanding of the physical demands of match-play in elite  
60 male players, limited research currently exists on elite female  
61 players. This predominantly reflects the fact that female  
62 matches are rarely played in stadiums equipped with semi  
63 automated camera systems. Furthermore, the high financial  
64 costs that are associated with other contemporary technologies,  
65 often prohibit their use in female soccer.<sup>5,6</sup> Consequently, a  
66 large proportion of the research undertaken to date has been  
67 derived from relatively small samples using traditional video-  
68 based technology.<sup>7-10</sup> Collectively, these factors limit the depth  
69 of analysis possible; therefore, it is important that further  
70 information relating to female match-play is derived to better  
71 inform female-specific training prescription and testing  
72 protocols.

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74 Available data on female match-play indicates that the standard  
75 of competition influences physical performance with greater

76 total distances observed in European club football<sup>11</sup> compared  
77 to friendly international competition.<sup>6</sup> Furthermore, greater  
78 high-speed running (HSR) and sprinting have also been  
79 observed during friendly international matches compared to  
80 domestic club matches.<sup>12</sup> However, to date, no information  
81 utilizing contemporary techniques exists on the demands of  
82 competitive international match-play, which represents the  
83 highest standard within the female game. Furthermore, due to  
84 the limited sample sizes available, the majority of studies  
85 examining the influence of playing position on match physical  
86 performance have been restricted to more generic assessments  
87 (e.g. defenders, midfielders and attackers) with only one  
88 study<sup>11</sup> further differentiating between central and wide  
89 positions. Bradley and colleagues<sup>11</sup> presented activity profiles  
90 for female match-play across five playing positions; however,  
91 the primary focus of their research was to compare male and  
92 female match-play and as such detailed female positional  
93 comparisons were lacking. Consequently, a comprehensive  
94 positional analysis of the physical demands of elite female  
95 match-play is necessary in order to provide applied  
96 practitioners working with elite players, pertinent information  
97 to better inform position-specific training prescription.  
98 Therefore, the aim of the current investigation was to provide a  
99 detailed analysis of the physical demands of different playing  
100 positions during competitive international female match-play.

101

102 **METHODS**

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104 **EXPERIMENTAL APPROACH TO THE PROBLEM**

105 To quantify the demands of competitive international female  
106 match-play, physical performance data were collected during  
107 the 2011-2012 and 2012-2013 seasons. Data were derived from  
108 ten matches, featuring thirteen teams playing in different  
109 stadiums across Europe.

110

111 **SUBJECTS**

112 A total of 148 individual match observations were undertaken  
113 on 107 outfield players (goalkeepers were excluded) with a  
114 median of two matches per player (range = 1-4). Data were  
115 only included for those players completing entire matches (i.e.  
116 90 minutes). Data were collected as a condition of employment  
117 in which player performance is routinely measured during  
118 match-play.<sup>13</sup> Therefore, usual appropriate ethics committee  
119 clearance was not required. Nevertheless, to ensure team and  
120 player confidentiality, all physical performance data were  
121 anonymised before analysis. Permission to publish this data  
122 was granted by Prozone (Prozone Sports Ltd., Leeds, UK).

123

124 **PROCEDURES**

125 Match physical performance data were collected using a  
126 computerized semi-automated multi-camera image recognition  
127 system (Prozone Sports Ltd., Leeds, UK). This system  
128 provides valid<sup>14</sup> and reliable<sup>15</sup> estimations of a variety of match  
129 performance indices. Players were categorized by playing  
130 position; central defenders (CD) (n = 25; 35 match  
131 observations), wide defenders (WD) (n = 28; 34 match  
132 observations), central midfielders (CM) (n = 31; 40 match  
133 observations), wide midfielders (WM) (n = 17; 20 match  
134 observations) and attackers (A) (n = 16; 19 match observations)  
135 to determine the influence of playing position on match  
136 physical performance. The influence of playing position on the  
137 difference in activity between the first and second half periods  
138 was undertaken. Within half changes in physical performance  
139 were also assessed by examining 15 and 5-minute time periods.

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141 The following activity classifications were used: total distance  
142 (TD), walking (0.7-7.1 km.h<sup>-1</sup>), jogging (7.2-14.3 km.h<sup>-1</sup>),  
143 running (14.4-19.7 km.h<sup>-1</sup>), HSR (19.8-25.1 km.h<sup>-1</sup>) and  
144 sprinting (>25.1 km.h<sup>-1</sup>) distance. Total high-speed running  
145 (THSR) (>14.4 km.h<sup>-1</sup>) and total very high-speed running  
146 (TVHSR) (>19.8 km.h<sup>-1</sup>) were also computed.<sup>16</sup> The above  
147 velocity thresholds for each activity have been extensively  
148 employed to quantify the physical demands of male match-  
149 play.<sup>2-4</sup> Recent commentary<sup>17</sup> has suggested that transposing

150 these thresholds to the performances of female players will  
151 underestimate match-play demands by reducing the amount of  
152 high-speed activities completed by individuals. While the  
153 present authors support this view in general, there has been a  
154 reluctance to adopt such thresholds in the current data as a  
155 consequence of the confidence that can be associated with  
156 current recommendations that exist regarding female specific  
157 velocity thresholds.<sup>17</sup> For example, female specific HSR and  
158 sprint thresholds derived from small samples (n = 5-14) of non-  
159 elite players (domestic level players).<sup>9,18</sup> have been proposed  
160 without consideration for the key methodological  
161 considerations required when determining velocity  
162 thresholds.<sup>19</sup> This includes the use of match activity zones that  
163 are expressed relative to individual players physical  
164 capabilities.<sup>20</sup> Furthermore, if physiological thresholds are used  
165 to demarcate individualized match activity zones they should  
166 be ascertained from activity patterns that replicate the  
167 movement demands of soccer in order to account for the  
168 increased energy cost associated with unorthodox modes of  
169 motion (e.g. backwards and sideways running) experienced  
170 during match-play.<sup>21</sup> Consequently, the authors feel that the  
171 suggested velocities<sup>17</sup> will not be representative of the abilities  
172 of either elite female players (as used in the present study) or  
173 female soccer players more generally. As such it may be that  
174 activity classifications derived from these thresholds may not



175 be any more valid than the arbitrary male thresholds presently  
176 used.

177

178 Total very high-speed running ( $>19.8 \text{ km}\cdot\text{h}^{-1}$ ) was expressed as  
179 both TVHSR distance completed when the respective player's  
180 team were in possession (VHSRP) or were without possession  
181 (VHSRWP) of the ball. Further analysis of sprinting activity  
182 ( $>25.1 \text{ km}\cdot\text{h}^{-1}$ ) was also considered, with the distance covered  
183 and the type of sprint classified. Sprints were classed as either  
184 explosive or leading sprints. An explosive sprint was defined as  
185 the attainment of sprint speed from standing, walking, jogging  
186 or running with time spent in the HSR category less than 0.5 s.  
187 Conversely, a leading sprint was defined as the attainment of  
188 sprint speed from standing, walking, jogging or running whilst  
189 entering the HSR category for a minimum of 0.5 s.<sup>15</sup>

190

## 191 **STATISTICAL ANALYSIS**

192 Data are presented as mean $\pm$ SD, with significance set at  $p <$   
193 0.05. Data were analyzed using factorial linear mixed modeling  
194 using the Statistical Package for Social Sciences (Version 21).  
195 Linear mixed modeling can be applied to repeated measures  
196 data from unbalanced designs, which was the case in our study  
197 since players differed in terms of the number of repeated  
198 matches they participated in. Linear mixed modeling can also  
199 cope with the mixture of random and fixed level effects that

200 occur with performance analysis data<sup>22</sup> as well as with missing  
201 and ‘nested’ data (hierarchical models). Significant main  
202 effects of each factor were followed up with Bonferroni-  
203 corrected multiple contrasts. Effect size (ES), estimated from  
204 the ratio of the mean difference to the pooled standard  
205 deviation, were also calculated. The ES magnitude was  
206 classified as trivial (<0.2), small (>0.2-0.6), moderate (>0.6-  
207 1.2), large (>1.2-2.0) and very large (>2.0-4.0).<sup>23</sup>

208

## 209 **RESULTS**

210

### 211 **TOTAL MATCH PERFORMANCE**

212 The average ‘ball in play time’ was 62.0±7.7 % of the total  
213 match duration. The distance covered in all speed classification  
214 zones was influenced by playing position (p<0.001) (Table 1).  
215 Total distance was greater in CM compared to all other playing  
216 positions (ES 1.0-2.3; p<0.05) except WM (ES 0.5); conversely  
217 CD completed less total distance compared to all other  
218 positions (ES 1.1-2.3; p<0.05). Total high-speed running  
219 distance was similar between all positions (ES 0.1-0.6) with the  
220 exception of CD who completed the least distance (ES 1.6-2.4;  
221 p<0.001) and between CM and WD (ES 0.7, p<0.05).  
222 Positional differences for running, HSR and sprinting were also  
223 apparent. Physical performance was generally similar between  
224 wide players (WD and WM) and A, with no differences

225 observed in TD, jogging, running, HSR or sprinting distances  
226 (Table 1).

227

228 Both VHSRP and VHSRWP also differed between positions  
229 ( $p < 0.001$ ) (Table 1). The VHSRP was greater in A and WM  
230 compared to defenders (CD and WD) and CM (ES 0.9-4.4;  
231  $p < 0.05$ ). The VHSRP was similar in WD and CM (ES 0.0),  
232 however, CD completed less VHSRP than all other playing  
233 positions (ES 1.5-4.4;  $p < 0.001$ ). The VHSRWP was greater in  
234 CM (ES 0.8-1.5;  $p < 0.05$ ) compared to all other playing positions  
235 except WD (ES 0.5). Attackers completed less VHSRWP than  
236 all other playing positions with moderate to large differences  
237 observed (ES 0.8-1.5) (Table 1).

238

Table 1. Influence of playing position on match physical activity profile.

	CD	WD	CM	WM	A	All Positions	p value
TD (m)	9489 ± 562 <sup>+3-5</sup>	10250 ± 661 <sup>*3 #3</sup>	10985 ± 706 <sup>*5 ^3 †3</sup>	10623 ± 665 <sup>*4</sup>	10262 ± 798 <sup>*3 #3</sup>	10321 ± 859	p<0.001
Walking (m)	3401 ± 142 <sup>#3</sup>	3301 ± 190 <sup>^3</sup>	3224 ± 183 <sup>^3 *3</sup>	3328 ± 182	3449 ± 214 <sup>#3 †3</sup>	3326 ± 194	p<0.001
Jogging (m)	4158 ± 457 <sup>#4</sup>	4382 ± 426 <sup>#3</sup>	4857 ± 451 <sup>+3-4</sup>	4488 ± 445 <sup>#3</sup>	4202 ± 606 <sup>#3</sup>	4448 ± 537	p<0.001
Running (m)	1367 ± 193 <sup>+4-5</sup>	1743 ± 293 <sup>*4 #3</sup>	2029 ± 310 <sup>^3 *5 †3</sup>	1865 ± 324 <sup>*4</sup>	1714 ± 338 <sup>*4 #3</sup>	1744 ± 373	p<0.001
HSR (m)	423 ± 79 <sup>+4-5</sup>	634 ± 168 <sup>*4</sup>	683 ± 170 <sup>*5</sup>	700 ± 167 <sup>*5</sup>	651 ± 135 <sup>*5</sup>	608 ± 181	p<0.001
Sprinting (m)	111 ± 42 <sup>+3-5</sup>	163 ± 79 <sup>*3</sup>	170 ± 69 <sup>*3</sup>	220 ± 116 <sup>*3</sup>	221 ± 53 <sup>*5</sup>	168 ± 82	p<0.001
THSR (m)	1901 ± 268 <sup>+4-5</sup>	2540 ± 500 <sup>*4 #3</sup>	2882 ± 500 <sup>*5 †4</sup>	2785 ± 510 <sup>*5</sup>	2586 ± 463 <sup>*4</sup>	2520 ± 580	p<0.001
TVHSR (m)	534 ± 113 <sup>+4-5</sup>	796 ± 237 <sup>*4</sup>	853 ± 229 <sup>*4</sup>	920 ± 260 <sup>*4</sup>	872 ± 161 <sup>*5</sup>	776 ± 247	p<0.001
VHSRP (m)	103 ± 48 <sup>+4-5</sup>	309 ± 161 <sup>^4 *4 †3</sup>	311 ± 197 <sup>^4 *4 †3</sup>	485 ± 195 <sup>*5 #3 †3</sup>	530 ± 127 <sup>*5 #4 †4</sup>	313 ± 210	p<0.001
VHSRWP (m)	371 ± 100 <sup>#3</sup>	418 ± 120 <sup>^3</sup>	485 ± 163 <sup>^4 *3 †3</sup>	366 ± 116 <sup>#3</sup>	274 ± 114 <sup>#4 †3</sup>	399 ± 143	p<0.001
Explosive Sprints (%)	53 ± 10	48 ± 9	54 ± 10 <sup>\$3</sup>	50 ± 14	48 ± 8	51 ± 10	p=0.090
Leading Sprints (%)	47 ± 10	52 ± 9	46 ± 10 <sup>\$3</sup>	50 ± 14	52 ± 8	49 ± 10	p=0.088

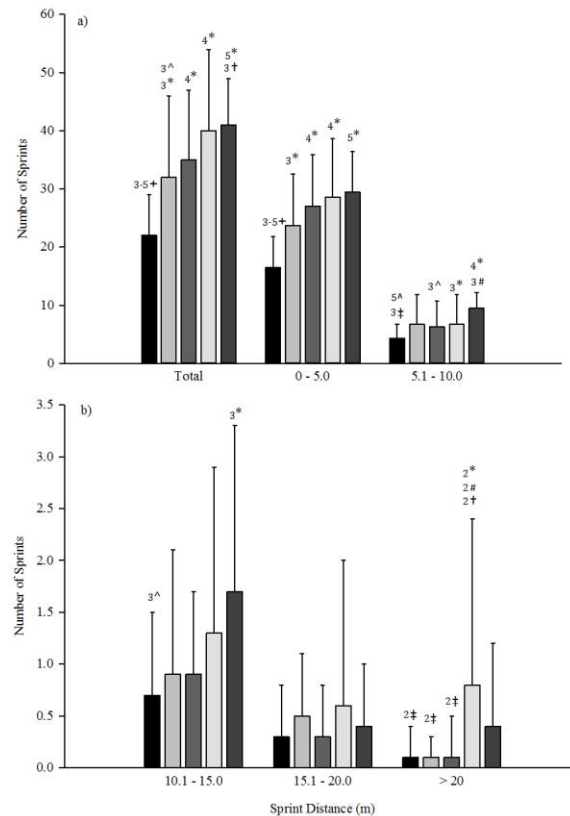
TD = total distance; HSR = high-speed running; THSR = total high-speed running; TVHSR = total very high-speed running; VHSRP = total very high-speed running with team in possession of the ball; VHSRWP = total very high-speed running without team in possession of the ball (mean ± SD). Significant difference (p<0.05): +different from all other playing positions, \*different from CD, ^different from A, #different from CM, †different from WD, ‡different from WM, \$different from percentage of leading sprints, §different from percentage of explosive sprints. Numbers denote magnitude of Effect Size for significant differences: 3 = moderate ES (>0.6-1.2), 4 = large ES (>1.2 - 2.0) and 5 = very large ES (> 2.0).

248 There were no significant differences between playing positions for either  
249 the percentage of explosive (ES 0.0-0.7) or leading (ES 0.0-0.7) sprints.  
250 However, CM generally completed a greater percentage of explosive sprints  
251 compared to WD and A (ES 0.6-0.7). Central midfielders completed a  
252 greater proportion of sprints that were explosive compared to leading in  
253 nature (ES 0.8;  $p<0.05$ ) (Table 1). The total number of sprints was  
254 influenced by playing position ( $p<0.001$ ) (Figure 1). Attackers completed  
255 more sprints than defenders (ES 0.8-2.5;  $p<0.05$ ) but a similar number to  
256 WM (ES 0.1). Similar numbers of sprints (ES 0.2) were also observed  
257 between WD and CM. Central defenders completed less sprints than all  
258 other playing positions (ES 0.9-2.5;  $p<0.05$ ).

259

260 A similar number of very short sprints ( $<5$  m) were completed by A, WM  
261 and CM (ES 0.1-0.3), with trends for WD to complete less than A (ES 0.7).  
262 Central defenders completed fewer very short sprints (ES 1.0-2.1;  $p<0.05$ )  
263 compared to all positions. Wide midfielders completed more 5.1-10.0 m  
264 sprints than CD (ES 1.2;  $p<0.05$ ) and A completed more than both CD and  
265 CM (ES 0.9-2.0;  $p<0.05$ ). Attackers also completed more 10.1-15.0 m  
266 sprints than CD (ES 0.8;  $p<0.05$ ), with no other significant positional  
267 differences found between 5.1-10.0 m (ES 0.1-0.7) and 10.1-15.0 m sprints  
268 (ES 0.0-0.6). There was a trend (ES 0.6-0.7) for A to complete more mid-  
269 range sprints (5.1-15.0 m) than WD. All players completed a similar  
270 number of 15.1-20.0 m sprints (ES 0.0-0.4), but WM produced marginally  
271 more  $>20$  m sprints than defenders and CM (ES 0.6;  $p<0.05$ ) (Figure 1).

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273

274 **Figure 1.** Influence of playing position on the total number of sprints  
 275 and the number of sprints completed over different distances (mean±SD).  
 276 Significant difference ( $p < 0.05$ ): +different from all other playing positions,  
 277 \*different from CD, ^different from A, #different from CM, †different from  
 278 WD, ‡different from WM. Numbers denote magnitude of Effect Size for  
 279 significant differences: 2 = small ( $ES > 0.2-0.6$ ), 3 = moderate  $ES (> 0.6-1.2)$ ,  
 280 4 = large  $ES (> 1.2-2.0)$  and 5 = very large  $ES (> 2.0)$ .

281

282

283 **BETWEEN HALF MATCH PERFORMANCE: INFLUENCE OF**  
 284 **PLAYING POSITION**

285 There was a reduction in the average 'ball in play time' in the second  
 286 ( $59.9 \pm 7.8$  %) compared to the first ( $64.1 \pm 7.3$  %) half ( $ES 0.6$ ). When

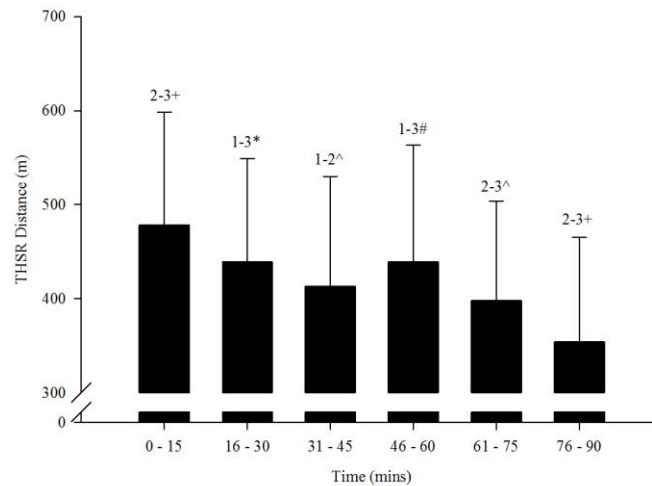
287 considering the sample as a whole there was a reduction in TD ( $365\pm 270$  m  
288 (ES 0.8;  $p<0.001$ )), THSR ( $141\pm 169$  m (ES 0.5;  $p<0.001$ )) and TVHSR  
289 ( $47\pm 100$  m (ES 0.4;  $p<0.001$ )) during the second half compared to first.  
290 These differences were mainly attributed to a reduction in jogging  
291 ( $217\pm 188$  m (ES 0.8;  $p<0.001$ )), running ( $93\pm 108$  m (ES 0.5;  $p<0.001$ )) and  
292 HSR ( $38\pm 71$  m (ES 0.4;  $p<0.001$ )) and to a lesser extent sprinting ( $10\pm 41$  m  
293 (ES 0.2;  $p<0.05$ )). Trivial to small reductions in VHSRP ( $16\pm 66$  m (ES 0.1;  
294  $p<0.05$ )) and VHSRWP ( $24\pm 65$  (ES 0.3;  $p<0.001$ )) were also observed  
295 during the second half compared to the first half. The magnitude of the  
296 reduction in physical performance between the first and second half was  
297 independent of playing position. There were no differences in the  
298 percentage of explosive or leading sprints between halves for any playing  
299 position (ES 0.0-0.4).

300

### 301 **WITHIN HALF MATCH PERFORMANCE (15 MINUTE** 302 **INTERVALS)**

303 Total high-speed running distance during the final 15-min period of the  
304 match was lower (12-35 %) compared to all other 15-min blocks (ES 0.4-  
305 1.1;  $p<0.001$ ) (Figure 3). In both halves, THSR was lower in the final 15  
306 minutes compared to the first and second 15-minute interval (1<sup>st</sup> half, ES  
307 0.2-0.5;  $p<0.05$ ; 2<sup>nd</sup> half, ES 0.4-0.7;  $p<0.001$ ) (Figure 2).

308



309

310 **Figure 2** Influence of time (15-minute periods) on total high speed  
 311 running (THSR) distance (mean±SD). Significant difference (p<0.05):  
 312 +different from all other time points, #different from all time points except  
 313 16-30 mins, \* different from all time points except 46–60 mins, ^different  
 314 from all time points except 61-75 mins. Numbers denote magnitude of  
 315 Effect Size for significant differences: 1 = trivial (ES<0.2), 2 = small  
 316 (ES>0.2-0.6), 3 = moderate ES (>0.6-1.2).

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318

319 **WITHIN HALF MATCH PERFORMANCE (5 MINUTE**  
 320 **INTERVALS)**

321 The peak THSR distance in a 5-minute period was 223±47 m. In the  
 322 following 5-minute period, the amount of THSR was 39 % lower (p<0.001)  
 323 (135±47 m, ES 1.9; p<0.001) but was not different to the mean distance  
 324 covered during all 5-minute intervals not including the peak distance  
 325 (135±32 m) (ES 0.0).

326

327



328 **DISCUSSION**

329 The present study represents the largest single analysis of elite female  
330 match-play data to date and provides novel insights into the physical  
331 demands of different playing positions during competitive international  
332 match-play using contemporary techniques. The present data highlights  
333 large differences in the physical demands of match-play between playing  
334 positions and the number of high-speed efforts is lower across the duration  
335 of the match in all positions. Collectively, the current data provides  
336 physical coaches with new insights into the position-specific physical  
337 demands of competitive international match-play which will inform the  
338 design and implementation of training drills for elite female players.

339

340 The TD covered in this current investigation ( $10321 \pm 859$  m) is similar to  
341 values previously observed in European club football ( $10754$  m)<sup>11</sup> and  
342 college soccer ( $9496$ - $10297$  m)<sup>24</sup> but appear greater than the TD reported  
343 during a small sample of international friendlies ( $9292$ - $9631$  m).<sup>6</sup> This  
344 increase in TD covered during competitive international matches relative to  
345 international friendlies<sup>6</sup> appears consistent across playing positions  
346 (defenders =  $9864$  vs.  $8759$  m, midfielders =  $10864$  vs.  $10150$  m, attackers  
347 =  $10262$  vs.  $9442$  m). Whilst some caution should be exercised when  
348 comparing data between studies that have utilized different data capture  
349 methods<sup>25-27</sup> and small sample sizes, the moderate to large effect size  
350 suggests an increased overall physical demand of competitive versus  
351 friendly international match-play. This to some extent may simply reflect  
352 the greater importance associated with competitive matches.

353

354 Low-speed activity (walking and jogging) accounts for the majority (~85  
355 %) of total distance covered in elite females, during domestic-level  
356 matches.<sup>7,10,12</sup> However, it is high-speed activity that is widely regarded as  
357 an important component of match physical performance as these activities  
358 are often critical to the outcome of matches by directly impacting goal  
359 scoring opportunities.<sup>15,28</sup> Interestingly, in the current study a distance of  
360 ~2520 m was covered at high-speed, accounting for 24 % of the total  
361 distance. These observations suggest that a greater proportion of high-speed  
362 activity may be undertaken during competitive international football  
363 relative to domestic-level matches.<sup>7,10,12</sup> As noted previously, there remains  
364 no consensus in the literature regarding female specific velocity  
365 thresholds.<sup>17</sup> The female specific thresholds that have recently been  
366 proposed<sup>17</sup> are not representative of this elite population and therefore may  
367 not be any more valid than the arbitrary male thresholds that frequent the  
368 literature. The findings from the current study indicate similar proportions  
369 (23 % in males and 24 % in females) of high-speed activity relative to total  
370 distance when compared to male players.<sup>16</sup> As a consequence, a focus on  
371 high-intensity soccer-specific conditioning<sup>29,30</sup> should represent an integral  
372 component of the training methodology applied to the development of elite  
373 female players.

374

375 Previous investigations examining sprint activity in women's soccer are  
376 largely limited to the analysis of total sprint distance.<sup>6-8,10,24</sup> The sprint  
377 distance covered in the current investigation ( $168 \pm 82$  m) was less (ES 1.2-

378 4.9) than values previously observed (221-380 m) in elite players during  
379 domestic level matches.<sup>7,10</sup> Since greater THSR was observed in the present  
380 study relative to domestic level matches,<sup>7,10,12</sup> it is possible this increase  
381 largely reflects an increase in HSR activity rather than any changes in sprint  
382 activity. The present study is the first to provide a comprehensive analysis  
383 of both the range of sprint distances and types of sprints undertaken by elite  
384 female players. Sprint distances between 0-5 m and 0-10 m accounted for  
385 76 % and 95 % of all sprints, respectively. Whilst female sprint data has  
386 not previously been presented in this format, average sprint distances of  
387 15.1±9.4 m have been observed in players from a professional league in the  
388 United States.<sup>31</sup> It is likely that this distance is greater than the average  
389 sprint distance in the current sample of players since 95 % of all sprints  
390 were shorter than 10 m. Alongside a high proportion of shorter sprints, the  
391 present data demonstrates an even distribution of explosive and leading  
392 sprints (51±10% vs. 49±10%). Interestingly, these findings suggest that  
393 women adopt a greater proportion of explosive sprints compared to males  
394 (77 % leading vs. 23 % explosive).<sup>32</sup> This observation could reflect  
395 differences in how the game is played with females being more reactive to  
396 match-play events relative to males, or that males obtain the sprint  
397 threshold at a lower proportion of their maximum sprint velocity, however,  
398 further work is needed in order to confirm this. Collectively, the present  
399 findings indicate that sprint training in elite female players should include a  
400 particular focus on sprinting over short distances (<10 m) with a  
401 combination of sprinting from a stationary and rolling start. This emphasis  
402 on short sprints and accelerations is necessary due to the explosive nature of

403 activity reported in the current findings. However, it should be noted that  
404 sprint training drills over longer distances (>20 m) are required in order to  
405 condition players for the longer sprint distances that arise in match-play,  
406 albeit infrequently, and also to develop maximum sprinting speed.<sup>33</sup> It  
407 should be acknowledged that although the present study provides novel data  
408 concerning the locomotor demands of elite female match-play it fails to  
409 quantify the true physical demands. For example, a limitation of camera  
410 based tracking systems, such as the one used in the present study, is their  
411 inability to provide a valid assessment of acceleration and deceleration  
412 activity. Similarly, camera based systems, unlike GPS that are equipped  
413 with triaxial accelerometers, cannot provide information pertaining to  
414 mechanical loading. Consequently, it is not possible from the current  
415 dataset to gain a full understanding of the physical demands of match-play  
416 due to the inability to quantify variables such as the number of tackles,  
417 jumps or the instances that a player goes to ground. As the use of GPS  
418 monitors in competitive match-play has now been sanctioned, a more  
419 comprehensive analysis of the overall physical demands of match-play  
420 should be more permissible. This detailed understanding will aid  
421 practitioners in developing complete physical training regimes.

422

423 Understanding the physical demands of specific playing positions  
424 represents an integral component of training prescription. Due to the limited  
425 sample sizes employed in previous studies, the examination of playing  
426 position has largely been restricted to basic positional comparisons (e.g.  
427 defenders, midfielders and attackers) with only one study<sup>11</sup> further

428 differentiating between central and wide positions. The present findings  
429 support previous research which has highlighted that midfielders cover  
430 greater TD<sup>6,7,24</sup> and THSR<sup>6,7</sup> than defenders. Large differences (ES 1.4) in  
431 TD were observed between defenders and midfielders in the present study.  
432 These positional differences are similar (ES 1.6) to those previously noted  
433 in international match-play<sup>7</sup> using video-based technology. However,  
434 larger differences (ES 2.7) have been noted between defenders and  
435 midfielders during domestic match-play,<sup>7</sup> which may be a consequence of  
436 reduced tactical and physical demands of domestic relative to international  
437 match-play.

438

439 To the authors knowledge the current study is the first to examine the  
440 physical demands of specific defensive and midfield positions in  
441 competitive international female match-play. Numerous differences in the  
442 physical activity profiles between CD and WD and also CM and WM were  
443 noted. Specifically, CM covered more TD and THSR than WD and CD  
444 (and A for TD only). Central defenders completed less TD and THSR than  
445 all other playing positions. The activity profile of CD is in contrast to WD,  
446 as they complete more TD, THSR and TVHSR than their central defensive  
447 counterparts. This confirms the need to analyze physical match  
448 performance across five playing positions. The findings from the current  
449 study which highlight that CM cover the greatest TD and CD the least are  
450 in accordance with previous data on European club football.<sup>11</sup> The  
451 positional differences observed in the current study are similar to those  
452 reported in male match-play<sup>2,15</sup> and are likely to be a direct consequence of

453 the tactical role of each playing position within the team. The high  
454 requirement of midfielders to cover distance to support attacking and  
455 defensive movements is accepted and thus their greater values of TD and  
456 THSR are to be expected.

457

458 It has previously been shown that attackers complete a greater sprint  
459 distance during match-play than defenders and midfielders.<sup>8,10</sup> This finding  
460 was in part corroborated in the present study with moderate to large effect  
461 sizes shown for differences in sprinting distance between CD and other  
462 playing positions (CM (ES 1.0), WM (1.2) and A (ES 2.3)). There was a  
463 trend for WM and A to complete a greater number of short sprints (<15 m)  
464 than other positions with WM undertaking a greater number of longer  
465 sprints (>15 m). Differences in the percentage of sprint type were only  
466 highlighted in CM who completed a higher proportion of explosive relative  
467 to leading sprints. The differences in sprinting profile between playing  
468 positions is again likely to be related to positional requirements in match-  
469 play. The tendency for a higher percentage of CM sprints to be explosive  
470 and shorter in nature may reflect the tighter spaces within which they  
471 operate and the tactical role of these individuals as they attempt to  
472 counteract the movement of the opposition.<sup>15</sup> Conversely, the fact that  
473 attacking players (WM and A) complete more longer sprints may be a  
474 function of their need to complete fast movements away from defending  
475 players to generate space or to capitalize on goal scoring opportunities.<sup>15</sup>  
476 The majority of differences between positions were related to CD  
477 completing less actions and distances than other playing positions across a

478 number of the measured indices, which is most likely due to their  
479 predominant involvement being limited to defensive actions. This finding  
480 highlights the importance of analyzing positional subsets, i.e. CD versus  
481 WD not only for an understanding of match-play but also for the direct  
482 impact on training regimes.

483

484 A unique element of the current investigation was to differentiate high-  
485 speed activity with and without the ball, which enabled the effectiveness of  
486 high-speed efforts in relation to crucial match actions to be evaluated.<sup>15</sup> A  
487 small increase in the amount of TVHSR completed when a team was  
488 without possession of the ball was observed ( $399\pm 143$  m vs.  $313\pm 210$  m,  
489 ES 0.5) as previously reported in male match-play.<sup>2,15</sup> A link between  
490 TVHSR when out of possession and team success has been demonstrated in  
491 male match-play with less successful teams completing more VHSRWP,<sup>15</sup>  
492 this analysis was beyond the scope of our study but is a recommendation  
493 for future work. Despite, an overall increase in TVHSR by the team when  
494 out of possession, the amount of TVHSR undertaken with or without  
495 possession was dependent upon playing position. Attacking positions (A,  
496 WM and CM) completed more TVHSR when the team was in possession  
497 with defensive players (CD and WD) completing more TVHSR when the  
498 team was without possession. These trends are similar to those previously  
499 reported in male match-play.<sup>2,15</sup> The observed differences in high-speed  
500 activity when a team is with and without possession, particularly between  
501 different playing positions, provides important insights for both technical  
502 and physical coaches regarding the influence of styles of play and tactical

503 formations on the physical demands of match-play. Practitioners should  
504 consider the implementation of position-specific training drills that reflect  
505 the nature of TVHSR, for example, attacking players may benefit from  
506 undertaking a greater proportion of their high-speed training with the ball  
507 compared to more defensive players, as activity that incorporates the ball  
508 has an increased energetic cost, rating of perceived exertion and blood  
509 lactate response.<sup>34</sup> However, it should be noted that the analysis of team  
510 metrics, as in the current study, limit the level of specificity that can be  
511 applied to individual players.

512

513 Previous research has used changes in physical performance both between  
514 halves and within each half as possible indicators of fatigue.<sup>35</sup> Reductions  
515 in physical performance in the second half have frequently been observed  
516 with specific reference to TD, THSR<sup>7,10</sup> and sprint distance.<sup>10</sup> In the present  
517 study, TD, THSR and sprint distances were reduced during the second half.  
518 The moderate reduction in TD (361 m; ES 0.8) between halves was greater  
519 than those reported in other studies, however, the small reduction in THSR  
520 (ES 0.5) and sprinting (ES 0.2) respectively were similar to previous  
521 reports.<sup>6,7,10</sup> Within half decreases in THSR were also currently observed,  
522 with less THSR completed during the final 15-minutes of each half  
523 compared to the previous 15-minutes. There was also a 35 % reduction in  
524 THSR in the last 15-minutes of match-play compared to the first 15-minute  
525 interval. This finding was similar to the 26 % reduction shown by Hewitt et  
526 al.<sup>6</sup> but less than the 57 % reduction demonstrated by Mohr et al.<sup>10</sup> These  
527 findings suggest that in some instances elite female players may be unable



528 to perform at the required speed for the duration of the match. A second  
529 half reduction in physical performance by females has previously been  
530 attributed in part to fatigue development and an insufficient training  
531 capacity of players.<sup>7,9,10</sup> However, due to a lack of data on the match  
532 outcome, tactics, fitness status of players or biochemical markers of fatigue  
533 it is difficult to provide a clear explanation for the transient changes in  
534 high-speed activity presently observed. Furthermore, little information is  
535 currently available regarding the variability of within-game physical  
536 performance, measures. However, it is likely that differences in activity  
537 may be mediated to some extent by the inherent variation in a player's  
538 match physical performance that is associated with changes in the tactical  
539 and technical requirements of the game as opposed to fatigue.<sup>36</sup>

540

541 The current investigation reported a 39 % reduction in THSR from the most  
542 intense 5-minute period to the next 5-minutes, which was in agreement but  
543 less substantial than previous studies (48-58 %).<sup>7,10</sup> In contrast to earlier  
544 reports, the current study failed to demonstrate transient fatigue  
545 immediately after the most intense period of the match which is in  
546 agreement with other more recent findings.<sup>11</sup> In the current study the  
547 reductions in THSR both toward the end of the match and following intense  
548 activity, were not as pronounced as studies that were conducted over 5  
549 years ago. This smaller decrease in THSR may be a consequence of  
550 increased levels of professionalism and training status of female players in  
551 recent years; however, the issues of methodological differences and within  
552 game variability must also be considered. There were very few differences

553 between positions for the changes in physical performance shown between  
554 halves, which is consistent with previous findings in females.<sup>10</sup>

555

## 556 **PRACTICAL APPLICATIONS**

557 The present study provides an overview of the position-specific locomotor  
558 demands of competitive international female match-play. These findings  
559 are of relevance to applied practitioners responsible for the physical  
560 development of elite female players. In order to elicit a comprehensive  
561 analysis of the overall physical demands of match-play, practitioners should  
562 combine the current dataset with information derived from GPS technology,  
563 which provide data on acceleration and deceleration profiles as well as  
564 mechanical loading. As the use of GPS monitors has now been sanctioned  
565 for use in match-play, such data will become readily available in the future.  
566 A number of differences were highlighted in the current study between  
567 wide and central defensive playing positions which suggest that it may be  
568 necessary for WD to complete more high-intensity soccer-specific  
569 conditioning, relative to CD, in order to cope with the increased locomotor  
570 of their playing position. During match-play the majority of sprints are less  
571 than 10 m in distance and are both explosive and leading in nature.  
572 Consequently, soccer-specific sprint drills should focus on short  
573 acceleration based activities from both a stationary and rolling start. Sprint  
574 training over longer distances (>20 m) is also required in order to condition  
575 players for longer sprint distances that may be required during match-play  
576 and to develop maximum sprinting speed. The finding that attacking-based  
577 players complete more high-speed activity when a team is in possession

578 whilst defensive players complete more high-speed activity when a team is  
579 out of possession provides an important link between tactical and physical  
580 decision-making. Specifically, this information may be used by the coach to  
581 affect decision-making on substitutions or by the physical trainer to direct  
582 post-match training and recovery routines. Reductions in physical  
583 performance are apparent between and within halves and although these  
584 may not be entirely attributed to fatigue it emphasizes the importance of  
585 appropriate conditioning levels in order to maintain work rate.

586

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701

702

703 **TABLE AND FIGURE CAPTIONS**

704 **Table 1** Influence of playing position on match physical  
705 activity profile. TD = total distance; HSR = high-speed running; THSR =  
706 total high-speed running; TVHSR = total very high-speed running; VHSRP  
707 = total very high-speed running with team in possession of the ball;  
708 VHSRWP = total very high-speed running without team in possession of  
709 the ball (mean±SD). Significant difference (p<0.05): +different from all  
710 other playing positions, \*different from CD, ^different from A, #different  
711 from CM, †different from WD, ‡different from WM, \$different from  
712 percentage of leading sprints, §different from percentage of explosive  
713 sprints. Numbers denote magnitude of Effect Size for significant  
714 differences: 3 = moderate ES (>0.6-1.2), 4 = large ES (>1.2–2.0) and 5 =  
715 very large ES (>2.0).

716

717

718 **Figure 1.** Influence of playing position on the total number of sprints  
719 and the number of sprints completed over different distances (mean±SD).  
720 Significant difference (p<0.05): +different from all other playing positions,  
721 \*different from CD, ^different from A, #different from CM, †different from  
722 WD, ‡different from WM. Numbers denote magnitude of Effect Size for  
723 significant differences: 2 = small (ES>0.2-0.6), 3 = moderate ES (>0.6-1.2),  
724 4 = large ES (>1.2–2.0) and 5 = very large ES (>2.0).

725

726 **Figure 2** Influence of time (15-minute periods) on total high speed  
727 running (THSR) distance (mean±SD). Significant difference (p<0.05):



728 <sup>+</sup>different from all other time points, <sup>#</sup>different from all time points except  
729 16-30 mins, <sup>\*</sup>different from all time points except 46–60 mins, <sup>^</sup>different  
730 from all time points except 61-75 mins. Numbers denote magnitude of  
731 Effect Size for significant differences: 1 = trivial (ES<0.2), 2 = small  
732 (ES>0.2-0.6), 3 = moderate ES (>0.6-1.2).