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Match physical performance of elite
female soccer players during international
competition

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 ± 706 m and 2882 ± 500 m)
12 and central defenders (CD) the lowest (9489 ± 562 m and
13 1901 ± 268 m) distances, respectively. Greater total very high-
14 speed running (TVHSR) distances were completed when a
15 team was without (399 ± 143 m) compared to with (313 ± 210 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.

25

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.¹ 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.²⁻⁴ 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.^{5,6} 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.⁷⁻¹⁰ 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.

73

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 football¹¹ compared
77 to friendly international competition.⁶ Furthermore, greater
78 high-speed running (HSR) and sprinting have also been
79 observed during friendly international matches compared to
80 domestic club matches.¹² 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 study¹¹ further differentiating between central and wide
89 positions. Bradley and colleagues¹¹ 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**

103

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.¹³ 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 valid¹⁴ and reliable¹⁵ 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.

140

141 The following activity classifications were used: total distance
142 (TD), walking (0.7-7.1 km.h⁻¹), jogging (7.2-14.3 km.h⁻¹),
143 running (14.4-19.7 km.h⁻¹), HSR (19.8-25.1 km.h⁻¹) and
144 sprinting (>25.1 km.h⁻¹) distance. Total high-speed running
145 (THSR) (>14.4 km.h⁻¹) and total very high-speed running
146 (TVHSR) (>19.8 km.h⁻¹) were also computed.¹⁶ The above
147 velocity thresholds for each activity have been extensively
148 employed to quantify the physical demands of male match-
149 play.²⁻⁴ Recent commentary¹⁷ 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.¹⁷ For example, female specific HSR and
158 sprint thresholds derived from small samples (n = 5-14) of non-
159 elite players (domestic level players).^{9,18} have been proposed
160 without consideration for the key methodological
161 considerations required when determining velocity
162 thresholds.¹⁹ This includes the use of match activity zones that
163 are expressed relative to individual players physical
164 capabilities.²⁰ 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.²¹ Consequently, the authors feel that the
171 suggested velocities¹⁷ 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.¹⁵

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 data²² 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).²³

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

239 ******Table 1 near here******

240

241 There were no significant differences between playing
242 positions for either the percentage of explosive (ES 0.0-0.7) or
243 leading (ES 0.0-0.7) sprints. However, CM generally
244 completed a greater percentage of explosive sprints compared
245 to WD and A (ES 0.6-0.7). Central midfielders completed a
246 greater proportion of sprints that were explosive compared to
247 leading in nature (ES 0.8; $p < 0.05$) (Table 1). The total number
248 of sprints was influenced by playing position ($p < 0.001$) (Figure
249 1). Attackers completed more sprints than defenders (ES 0.8-

250 2.5; $p < 0.05$) but a similar number to WM (ES 0.1). Similar
251 numbers of sprints (ES 0.2) were also observed between WD
252 and CM. Central defenders completed less sprints than all other
253 playing positions (ES 0.9-2.5; $p < 0.05$).

254

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

270

271 ******Figure 1 near here******

272

273 **BETWEEN HALF MATCH PERFORMANCE:**

274 **INFLUENCE OF PLAYING POSITION**

275 There was a reduction in the average 'ball in play time' in the
276 second (59.9 ± 7.8 %) compared to the first (64.1 ± 7.3 %) half
277 (ES 0.6). When considering the sample as a whole there was a
278 reduction in TD (365 ± 270 m (ES 0.8; $p<0.001$)), THSR
279 (141 ± 169 m (ES 0.5; $p<0.001$)) and TVHSR (47 ± 100 m (ES
280 0.4; $p<0.001$)) during the second half compared to first. These
281 differences were mainly attributed to a reduction in jogging
282 (217 ± 188 m (ES 0.8; $p<0.001$)), running (93 ± 108 m (ES 0.5;
283 $p<0.001$)) and HSR (38 ± 71 m (ES 0.4; $p<0.001$)) and to a
284 lesser extent sprinting (10 ± 41 m (ES 0.2; $p<0.05$)). Trivial to
285 small reductions in VHSRP (16 ± 66 m (ES 0.1; $p<0.05$)) and
286 VHSRWP (24 ± 65 (ES 0.3; $p<0.001$)) were also observed
287 during the second half compared to the first half. The
288 magnitude of the reduction in physical performance between
289 the first and second half was independent of playing position.
290 There were no differences in the percentage of explosive or
291 leading sprints between halves for any playing position (ES
292 0.0-0.4).

293

294 **WITHIN HALF MATCH PERFORMANCE (15 MINUTE**
295 **INTERVALS)**

296 Total high-speed running distance during the final 15-min
297 period of the match was lower (12-35 %) compared to all other
298 15-min blocks (ES 0.4-1.1; $p<0.001$) (Figure 3). In both halves,
299 THSR was lower in the final 15 minutes compared to the first

300 and second 15-minute interval (1st half, ES 0.2-0.5; $p < 0.05$; 2nd
301 half, ES 0.4-0.7; $p < 0.001$) (Figure 2).

302

303 ******Figure 2 near here******

304

305 **WITHIN HALF MATCH PERFORMANCE (5 MINUTE**
306 **INTERVALS)**

307 The peak THSR distance in a 5-minute period was 223 ± 47 m.
308 In the following 5-minute period, the amount of THSR was 39
309 % lower ($p < 0.001$) (135 ± 47 m, ES 1.9; $p < 0.001$) but was not
310 different to the mean distance covered during all 5-minute
311 intervals not including the peak distance (135 ± 32 m) (ES 0.0).

312

313 **DISCUSSION**

314 The present study represents the largest single analysis of elite
315 female match-play data to date and provides novel insights into
316 the physical demands of different playing positions during
317 competitive international match-play using contemporary
318 techniques. The present data highlights large differences in the
319 physical demands of match-play between playing positions and
320 the number of high-speed efforts is lower across the duration of
321 the match in all positions. Collectively, the current data
322 provides physical coaches with new insights into the position-
323 specific physical demands of competitive international match-

324 play which will inform the design and implementation of
325 training drills for elite female players.

326

327 The TD covered in this current investigation (10321 ± 859 m) is
328 similar to values previously observed in European club football
329 (10754 m)¹¹ and college soccer (9496 - 10297 m)²⁴ but appear
330 greater than the TD reported during a small sample of
331 international friendlies (9292 - 9631 m).⁶ This increase in TD
332 covered during competitive international matches relative to
333 international friendlies⁶ appears consistent across playing
334 positions (defenders = 9864 vs. 8759 m, midfielders = 10864
335 vs. 10150 m, attackers = 10262 vs. 9442 m). Whilst some
336 caution should be exercised when comparing data between
337 studies that have utilized different data capture methods²⁵⁻²⁷
338 and small sample sizes, the moderate to large effect size
339 suggests an increased overall physical demand of competitive
340 versus friendly international match-play. This to some extent
341 may simply reflect the greater importance associated with
342 competitive matches.

343

344 Low-speed activity (walking and jogging) accounts for the
345 majority (~85 %) of total distance covered in elite females,
346 during domestic-level matches.^{7,10,12} However, it is high-speed
347 activity that is widely regarded as an important component of
348 match physical performance as these activities are often critical

349 to the outcome of matches by directly impacting goal scoring
350 opportunities.^{15,28} Interestingly, in the current study a distance
351 of ~2520 m was covered at high-speed, accounting for 24 % of
352 the total distance. These observations suggest that a greater
353 proportion of high-speed activity may be undertaken during
354 competitive international football relative to domestic-level
355 matches.^{7,10,12} As noted previously, there remains no consensus
356 in the literature regarding female specific velocity thresholds.¹⁷
357 The female specific thresholds that have recently been
358 proposed¹⁷ are not representative of this elite population and
359 therefore may not be any more valid than the arbitrary male
360 thresholds that frequent the literature. The findings from the
361 current study indicate similar proportions (23 % in males and
362 24 % in females) of high-speed activity relative to total
363 distance when compared to male players.¹⁶ As a consequence, a
364 focus on high-intensity soccer-specific conditioning^{29,30} should
365 represent an integral component of the training methodology
366 applied to the development of elite female players.

367

368 Previous investigations examining sprint activity in women's
369 soccer are largely limited to the analysis of total sprint
370 distance.^{6-8,10,24} The sprint distance covered in the current
371 investigation (168±82 m) was less (ES 1.2-4.9) than values
372 previously observed (221-380 m) in elite players during
373 domestic level matches.^{7,10} Since greater THSR was observed

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

399 distances (<10 m) with a combination of sprinting from a
400 stationary and rolling start. This emphasis on short sprints and
401 accelerations is necessary due to the explosive nature of
402 activity reported in the current findings. However, it should be
403 noted that sprint training drills over longer distances (>20 m)
404 are required in order to condition players for the longer sprint
405 distances that arise in match-play, albeit infrequently, and also
406 to develop maximum sprinting speed.³³ It should be
407 acknowledged that although the present study provides novel
408 data concerning the [locomotor](#) demands of elite female match-
409 play it fails to quantify the true physical demands. For example,
410 a limitation of camera based tracking systems, such as the one
411 used in the present study, is their inability to provide a valid
412 assessment of acceleration and deceleration activity. Similarly,
413 camera based systems, unlike GPS that are equipped with
414 triaxial accelerometers, cannot provide information pertaining
415 to mechanical loading. [Consequently, it is not possible from the](#)
416 [current dataset to gain a full understanding of the physical](#)
417 [demands of match-play due to the inability to quantify](#)
418 [variables such as the number of tackles, jumps or the instances](#)
419 [that a player goes to ground.](#) As the use of GPS monitors in
420 competitive match-play has now been sanctioned, a more
421 comprehensive analysis of the overall physical demands of
422 match-play should be more permissible. This detailed

423 understanding will aid practitioners in developing complete
424 physical training regimes.

425

426 Understanding the physical demands of specific playing
427 positions represents an integral component of training
428 prescription. Due to the limited sample sizes employed in
429 previous studies, the examination of playing position has
430 largely been restricted to basic positional comparisons (e.g.
431 defenders, midfielders and attackers) with only one study¹¹
432 further differentiating between central and wide positions. The
433 present findings support previous research which has
434 highlighted that midfielders cover greater TD^{6,7,24} and THSR^{6,7}
435 than defenders. Large differences (ES 1.4) in TD were
436 observed between defenders and midfielders in the present
437 study. These positional differences are similar (ES 1.6) to
438 those previously noted in international match-play⁷ using
439 video-based technology. However, larger differences (ES 2.7)
440 have been noted between defenders and midfielders during
441 domestic match-play,⁷ which may be a consequence of reduced
442 tactical and physical demands of domestic relative to
443 international match-play.

444

445 To the authors knowledge the current study is the first to
446 examine the physical demands of specific defensive and
447 midfield positions in competitive international female match-

448 play. Numerous differences in the physical activity profiles
449 between CD and WD and also CM and WM were noted.
450 Specifically, CM covered more TD and THSR than WD and
451 CD (and A for TD only). Central defenders completed less TD
452 and THSR than all other playing positions. The activity profile
453 of CD is in contrast to WD, as they complete more TD, THSR
454 and TVHSR than their central defensive counterparts. This
455 confirms the need to analyze physical match performance
456 across five playing positions. The findings from the current
457 study which highlight that CM cover the greatest TD and CD
458 the least are in accordance with previous data on European club
459 football.¹¹ The positional differences observed in the current
460 study are similar to those reported in male match-play^{2,15} and
461 are likely to be a direct consequence of the tactical role of each
462 playing position within the team. The high requirement of
463 midfielders to cover distance to support attacking and defensive
464 movements is accepted and thus their greater values of TD and
465 THSR are to be expected.

466

467 It has previously been shown that attackers complete a greater
468 sprint distance during match-play than defenders and
469 midfielders.^{8,10} This finding was in part corroborated in the
470 present study with moderate to large effect sizes shown for
471 differences in sprinting distance between CD and other playing
472 positions (CM (ES 1.0), WM (1.2) and A (ES 2.3)). There was

473 a trend for WM and A to complete a greater number of short
474 sprints (<15 m) than other positions with WM undertaking a
475 greater number of longer sprints (>15 m). Differences in the
476 percentage of sprint type were only highlighted in CM who
477 completed a higher proportion of explosive relative to leading
478 sprints. The differences in sprinting profile between playing
479 positions is again likely to be related to positional requirements
480 in match-play. The tendency for a higher percentage of CM
481 sprints to be explosive and shorter in nature may reflect the
482 tighter spaces within which they operate and the tactical role of
483 these individuals as they attempt to counteract the movement of
484 the opposition.¹⁵ Conversely, the fact that attacking players
485 (WM and A) complete more longer sprints may be a function
486 of their need to complete fast movements away from defending
487 players to generate space or to capitalize on goal scoring
488 opportunities.¹⁵ The majority of differences between positions
489 were related to CD completing less actions and distances than
490 other playing positions across a number of the measured
491 indices, which is most likely due to their predominant
492 involvement being limited to defensive actions. This finding
493 highlights the importance of analyzing positional subsets, i.e.
494 CD versus WD not only for an understanding of match-play but
495 also for the direct impact on training regimes.
496

497 A unique element of the current investigation was to
498 differentiate high-speed activity with and without the ball,
499 which enabled the effectiveness of high-speed efforts in
500 relation to crucial match actions to be evaluated.¹⁵ A small
501 increase in the amount of TVHSR completed when a team was
502 without possession of the ball was observed (399±143 m vs.
503 313±210 m, ES 0.5) as previously reported in male match-
504 play.^{2,15} A link between TVHSR when out of possession and
505 team success has been demonstrated in male match-play with
506 less successful teams completing more VHSRWP,¹⁵ this
507 analysis was beyond the scope of our study but is a
508 recommendation for future work. Despite, an overall increase
509 in TVHSR by the team when out of possession, the amount of
510 TVHSR undertaken with or without possession was dependent
511 upon playing position. Attacking positions (A, WM and CM)
512 completed more TVHSR when the team was in possession with
513 defensive players (CD and WD) completing more TVHSR
514 when the team was without possession. These trends are
515 similar to those previously reported in male match-play.^{2,15} The
516 observed differences in high-speed activity when a team is with
517 and without possession, particularly between different playing
518 positions, provides important insights for both technical and
519 physical coaches regarding the influence of styles of play and
520 tactical formations on the physical demands of match-play.
521 Practitioners should consider the implementation of position-

522 specific training drills that reflect the nature of TVHSR, for
523 example, attacking players may benefit from undertaking a
524 greater proportion of their high-speed training with the ball
525 compared to more defensive players, as activity that
526 incorporates the ball has an increased energetic cost, rating of
527 perceived exertion and blood lactate response.³⁴ However, it
528 should be noted that the analysis of team metrics, as in the
529 current study, limit the level of specificity that can be applied
530 to individual players.

531

532 Previous research has used changes in physical performance
533 both between halves and within each half as possible indicators
534 of fatigue.³⁵ Reductions in physical performance in the second
535 half have frequently been observed with specific reference to
536 TD, THSR^{7,10} and sprint distance.¹⁰ In the present study, TD,
537 THSR and sprint distances were reduced during the second
538 half. The moderate reduction in TD (361 m; ES 0.8) between
539 halves was greater than those reported in other studies,
540 however, the small reduction in THSR (ES 0.5) and sprinting
541 (ES 0.2) respectively were similar to previous reports.^{6,7,10}
542 Within half decreases in THSR were also currently observed,
543 with less THSR completed during the final 15-minutes of each
544 half compared to the previous 15-minutes. There was also a 35
545 % reduction in THSR in the last 15-minutes of match-play
546 compared to the first 15-minute interval. This finding was

547 similar to the 26 % reduction shown by Hewitt et al.⁶ but less
548 than the 57 % reduction demonstrated by Mohr et al.¹⁰ These
549 findings suggest that in some instances elite female players
550 may be unable to perform at the required speed for the duration
551 of the match. A second half reduction in physical performance
552 by females has previously been attributed in part to fatigue
553 development and an insufficient training capacity of
554 players.^{7,9,10} However, due to a lack of data on the match
555 outcome, tactics, fitness status of players or biochemical
556 markers of fatigue it is difficult to provide a clear explanation
557 for the transient changes in high-speed activity presently
558 observed. Furthermore, little information is currently available
559 regarding the variability of within-game physical performance,
560 measures. However, it is likely that differences in activity may
561 be mediated to some extent by the inherent variation in a
562 player's match physical performance that is associated with
563 changes in the tactical and technical requirements of the game
564 as opposed to fatigue.³⁶

565

566 The current investigation reported a 39 % reduction in THSR
567 from the most intense 5-minute period to the next 5-minutes,
568 which was in agreement but less substantial than previous
569 studies (48-58 %).^{7,10} In contrast to earlier reports, the current
570 study failed to demonstrate transient fatigue immediately after
571 the most intense period of the match which is in agreement

572 with other more recent findings.¹¹ In the current study the
573 reductions in THSR both toward the end of the match and
574 following intense activity, were not as pronounced as studies
575 that were conducted over 5 years ago. This smaller decrease in
576 THSR may be a consequence of increased levels of
577 professionalism and training status of female players in recent
578 years; however, the issues of methodological differences and
579 within game variability must also be considered. There were
580 very few differences between positions for the changes in
581 physical performance shown between halves, which is
582 consistent with previous findings in females.¹⁰

583

584 **PRACTICAL APPLICATIONS**

585 The present study provides an overview of the position-specific
586 [locomotor](#) demands of competitive international female match-
587 play. These findings are of relevance to applied practitioners
588 responsible for the physical development of elite female
589 players. [In order to elicit a comprehensive analysis of the](#)
590 [overall physical demands of match-play, practitioners should](#)
591 [combine the current dataset with information derived from GPS](#)
592 [technology, which provide data on acceleration and](#)
593 [deceleration profiles as well as mechanical loading. As the use](#)
594 [of GPS monitors has now been sanctioned for use in match-](#)
595 [play, such data will become readily available in the future.](#) A
596 number of differences were highlighted [in the current study](#)

597 between wide and central defensive playing positions which
598 suggest that it may be necessary for WD to complete more
599 high-intensity soccer-specific conditioning, relative to CD, in
600 order to cope with the increased [locomotor](#) of their playing
601 position. During match-play the majority of sprints are less
602 than 10 m in distance and are both explosive and leading in
603 nature. Consequently, soccer-specific sprint drills should focus
604 on short acceleration based activities from both a stationary and
605 rolling start. Sprint training over longer distances (>20 m) is
606 also required in order to condition players for longer sprint
607 distances that may be required during match-play and to
608 develop maximum sprinting speed. The finding that attacking-
609 based players complete more high-speed activity when a team
610 is in possession whilst defensive players complete more high-
611 speed activity when a team is out of possession provides an
612 important link between tactical and physical decision-making.
613 Specifically, this information may be used by the coach to
614 affect decision-making on substitutions or by the physical
615 trainer to direct post-match training and recovery routines.
616 Reductions in physical performance are apparent between and
617 within halves and although these may not be entirely attributed
618 to fatigue it emphasizes the importance of appropriate
619 conditioning levels in order to maintain work rate.

620

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760 TABLE AND FIGURE CAPTIONS

761 **Table 1** Influence of playing position on match
 762 physical activity profile. TD = total distance; HSR = high-
 763 speed running; THSR = total high-speed running; TVHSR =
 764 total very high-speed running; VHSRP = total very high-speed
 765 running with team in possession of the ball; VHSRWP = total
 766 very high-speed running without team in possession of the ball
 767 (mean±SD). Significant difference (p<0.05): +different from all
 768 other playing positions, *different from CD, ^different from A,
 769 #different from CM, †different from WD, ‡different from WM,
 770 \$different from percentage of leading sprints, §different from
 771 percentage of explosive sprints. Numbers denote magnitude of

772 Effect Size for significant differences: 3 = moderate ES (>0.6-
773 1.2), 4 = large ES (>1.2–2.0) and 5 = very large ES (>2.0).

774

775

776 **Figure 1.** Influence of playing position on the total
777 number of sprints and the number of sprints completed over
778 different distances (mean±SD). Significant difference
779 (p<0.05): +different from all other playing positions, *different
780 from CD, ^different from A, #different from CM, †different
781 from WD, ‡different from WM. Numbers denote magnitude of
782 Effect Size for significant differences: 2 = small (ES>0.2-0.6),
783 3 = moderate ES (>0.6-1.2), 4 = large ES (>1.2–2.0) and 5 =
784 very large ES (>2.0).

785

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