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ABSTRACT

The purpose of the present study was to provide a detailed analysis of the physical demands of competitive international female soccer match-play. A total of 148 individual match observations were undertaken on 107 outfield players competing in competitive international matches during the 2011-2012 and 2012-2013 seasons, using a computerized tracking system (Prozone Sports Ltd., Leeds, England). Total distance (TD) and total high-speed running distances (THSR) were influenced by playing position, with central midfielders (CM) completing the highest (10985±706 m and 2882±500 m) and central defenders (CD) the lowest (9489±562 m and 1901±268 m) distances, respectively. Greater total very high-speed running (TVHSR) distances were completed when a team was without (399±143 m) compared to with (313±210 m) possession of the ball. The majority of sprints were over short distances with 76 % and 95 % being less than 5 m and 10 m, respectively. Between half reductions in physical performance were present for all variables, independent of playing position. The current study provides novel findings regarding the physical demands of different playing positions in competitive international female match-play and provides important insights for physical coaches preparing elite female players for competition.

Key Words: football; match analysis; tracking system; playing position; high-speed running

INTRODUCTION

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

Available data on female match-play indicates that the standard of competition influences physical performance with greater total distances observed in European club football[11] compared to friendly international competition.[6] Furthermore, greater high-speed running (HSR) and sprinting have also been observed during friendly international matches compared to domestic club matches.[12] However, to date, no information utilizing contemporary techniques exists on the demands of competitive international match-play, which represents the highest standard within the female game. Furthermore, due to the limited sample sizes available, the majority of studies examining the influence of playing position on match physical performance have been restricted to more generic assessments (e.g. defenders, midfielders and attackers) with only one study[11] further differentiating between central and wide positions. Bradley and colleagues[11] presented activity profiles for female match-play across five playing positions; however, the primary focus of their research was to compare male and female match-play and as such detailed female positional comparisons were lacking. Consequently, a comprehensive positional analysis of the physical demands of elite female match-play is necessary in order to provide applied practitioners working with elite players, pertinent information to better inform position-specific training prescription. Therefore, the aim of the current investigation was to provide a detailed analysis of the physical demands of different playing positions during competitive international female match-play.

METHODS

EXPERIMENTAL APPROACH TO THE PROBLEM

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

SUBJECTS

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

PROCEDURES

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

The following activity classifications were used: total distance (TD), walking (0.7-7.1 $km.h^{-1}$), jogging (7.2-14.3 $km.h^{-1}$), running (14.4-19.7 $km.h^{-1}$), HSR (19.8-25.1 $km.h^{-1}$) and sprinting (>25.1 $km.h^{-1}$) distance. Total high-speed running (THSR) (>14.4 $km.h^{-1}$) and total very high-speed running (TVHSR) (>19.8 $km.h^{-1}$) were also computed.[16] The above velocity thresholds for each activity have been extensively employed to quantify the physical demands of male match-play.[2-4] Recent commentary[17] has suggested that transposing these thresholds to the performances of female players will underestimate match-play demands by reducing the amount of high-speed activities completed by individuals. While the present authors support this view in general, there has been a reluctance to adopt such thresholds in the current data as a consequence of the confidence that can be associated with current recommendations that exist regarding female specific velocity thresholds.[17] For example, female specific HSR and sprint thresholds derived from small samples (n = 5-14) of non-elite players (domestic level players).[9,18] have been proposed without consideration for the key methodological considerations required when determining velocity thresholds.[19] This includes the use of match activity zones that are expressed relative to individual players physical capabilities.[20] Furthermore, if physiological thresholds are used to demarcate individualized match activity zones they should be ascertained from activity patterns that replicate the movement demands of soccer in order to account for the increased energy cost associated with unorthodox modes of motion (e.g. backwards and sideways running) experienced during match-play.[21] Consequently, the authors feel that the suggested velocities[17] will not be representative of the abilities of either elite female players (as used in the present study) or female soccer players more generally. As such it may be that activity classifications derived from these thresholds may not be any more valid than the arbitrary male thresholds presently used.

Total very high-speed running (>19.8 km.h^{-1}) was expressed as both TVHSR distance completed when the respective player's team were in possession (VHSRP) or were without possession (VHSRWP) of the ball. Further analysis of sprinting activity (>25.1 km.h^{-1}) was also considered, with the distance covered and the type of sprint classified. Sprints were classed as either explosive or leading sprints. An explosive sprint was defined as the attainment of sprint speed from standing, walking, jogging or running with time spent in the HSR category less than 0.5 s. Conversely, a leading sprint was defined as the attainment of sprint speed from standing, walking, jogging or running whilst entering the HSR category for a minimum of 0.5 s.[15]

STATISTICAL ANALYSIS

Data are presented as mean±SD, with significance set at $p < 0.05$. Data were analyzed using factorial linear mixed modeling using the Statistical Package for Social Sciences (Version 21). Linear mixed modeling can be applied to repeated measures data from unbalanced designs, which was the case in our study since players differed in terms of the number of repeated matches they participated in. Linear mixed modeling can also cope with the mixture of random and fixed level effects that occur with performance analysis data[22] as well as with missing and 'nested' data (hierarchical models). Significant main effects of each factor were followed up with Bonferroni-corrected multiple contrasts. Effect size (ES), estimated from the ratio of the mean difference to the pooled standard deviation, were also calculated. The ES magnitude was classified as trivial (<0.2), small (>0.2-0.6), moderate (>0.6-1.2), large (>1.2-2.0) and very large (>2.0-4.0).[23]

RESULTS

TOTAL MATCH PERFORMANCE

The average 'ball in play time' was 62.0±7.7 % of the total match duration. The distance covered in all speed classification zones was influenced by playing position ($p<0.001$) (Table 1). Total distance was greater in CM compared to all other playing positions (ES 1.0-2.3; $p<0.05$) except WM (ES 0.5); conversely CD completed less total distance compared to all other positions (ES 1.1-2.3; $p<0.05$). Total high-speed running distance was similar between all positions (ES 0.1-0.6) with the exception of CD who completed the least distance (ES 1.6-2.4; $p<0.001$) and between CM and WD (ES 0.7, $p<0.05$). Positional differences for running, HSR and sprinting were also apparent. Physical performance was generally similar between wide players (WD and WM) and A, with no differences observed in TD, jogging, running, HSR or sprinting distances (Table 1).

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

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

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

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

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

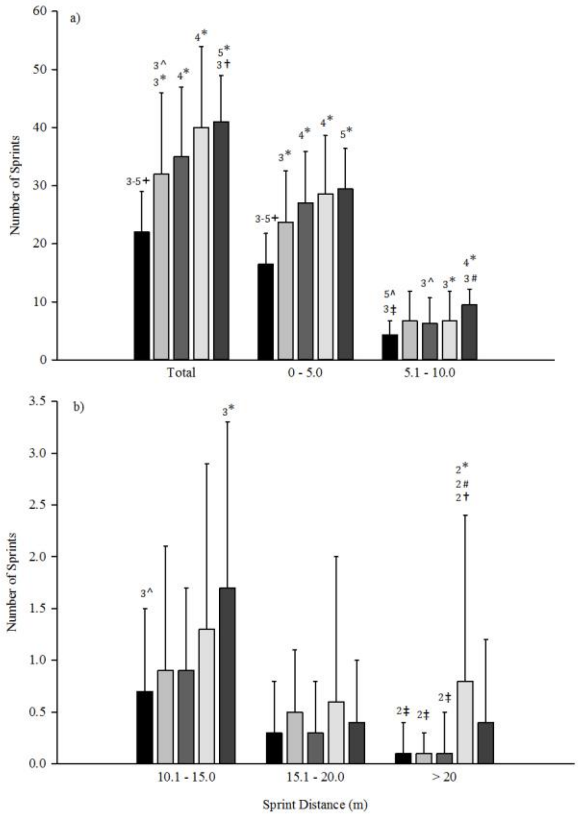

Figure 1. Influence of playing position on the total number of sprints and the number of sprints completed over different distances (mean±SD). Significant difference ($p<0.05$): +different from all other playing positions, *different from CD, ^different from A, #different from CM, †different from WD,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

BETWEEN HALF MATCH PERFORMANCE: INFLUENCE OF PLAYING POSITION

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

WITHIN HALF MATCH PERFORMANCE (15 MINUTE INTERVALS)

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

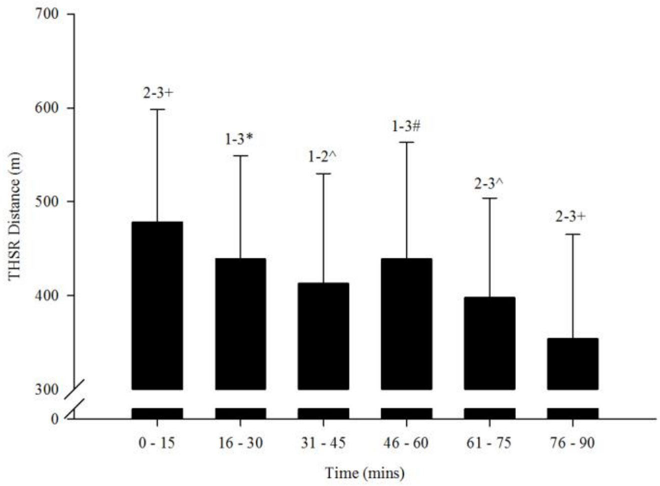

Figure 2 Influence of time (15-minute periods) on total high speed running (THSR) distance (mean±SD). Significant difference ($p<0.05$): $^{+}$different from all other time points, $^{\#}$different from all time points except 16-30 mins, *different from all time points except 46–60 mins, $^{\wedge}$different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

WITHIN HALF MATCH PERFORMANCE (5 MINUTE INTERVALS)

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

DISCUSSION

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

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

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

Previous investigations examining sprint activity in women's soccer are largely limited to the analysis of total sprint distance.[6-8,10,24] The sprint distance covered in the current investigation (168±82 m) was less (ES 1.2-

4.9) than values previously observed (221-380 m) in elite players during domestic level matches.[7,10] Since greater THSR was observed in the present study relative to domestic level matches,[7,10,12] it is possible this increase largely reflects an increase in HSR activity rather than any changes in sprint activity. The present study is the first to provide a comprehensive analysis of both the range of sprint distances and types of sprints undertaken by elite female players. Sprint distances between 0-5 m and 0-10 m accounted for 76 % and 95 % of all sprints, respectively. Whilst female sprint data has not previously been presented in this format, average sprint distances of 15.1±9.4 m have been observed in players from a professional league in the United States.[31] It is likely that this distance is greater than the average sprint distance in the current sample of players since 95 % of all sprints were shorter than 10 m. Alongside a high proportion of shorter sprints, the present data demonstrates an even distribution of explosive and leading sprints (51±10% vs. 49±10%). Interestingly, these findings suggest that women adopt a greater proportion of explosive sprints compared to males (77 % leading vs. 23 % explosive).[32] This observation could reflect differences in how the game is played with females being more reactive to match-play events relative to males, or that males obtain the sprint threshold at a lower proportion of their maximum sprint velocity, however, further work is needed in order to confirm this. Collectively, the present findings indicate that sprint training in elite female players should include a particular focus on sprinting over short distances (<10 m) with a combination of sprinting from a stationary and rolling start. This emphasis on short sprints and accelerations is necessary due to the explosive nature of activity reported in the current findings. However, it should be noted that sprint training drills over longer distances (>20 m) are required in order to condition players for the longer sprint distances that arise in match-play, albeit infrequently, and also to develop maximum sprinting speed.[33] It should be acknowledged that although the present study provides novel data concerning the locomotor demands of elite female match-play it fails to quantify the true physical demands. For example, a limitation of camera based tracking systems, such as the one used in the present study, is their inability to provide a valid assessment of acceleration and deceleration activity. Similarly, camera based systems, unlike GPS that are equipped with triaxial accelerometers, cannot provide information pertaining to mechanical loading. Consequently, it is not possible from the current dataset to gain a full understanding of the physical demands of match-play due to the inability to quantify variables such as the number of tackles, jumps or the instances that a player goes to ground. As the use of GPS monitors in competitive match-play has now been sanctioned, a more comprehensive analysis of the overall physical demands of match-play should be more permissible. This detailed understanding will aid practitioners in developing complete physical training regimes.

Understanding the physical demands of specific playing positions represents an integral component of training prescription. Due to the limited sample sizes employed in previous studies, the examination of playing position has largely been restricted to basic positional comparisons (e.g. defenders, midfielders and attackers) with only one study[11] further differentiating between central and wide positions. The present findings support previous research which has highlighted that midfielders cover greater TD[6,7,24] and THSR[6,7] than defenders. Large differences (ES 1.4) in TD were observed between defenders and midfielders in the present study. These positional differences are similar (ES 1.6) to those previously noted in international match-play[7] using video-based technology. However, larger differences (ES 2.7) have been noted between defenders and midfielders during domestic match-play,[7] which may be a consequence of reduced tactical and physical demands of domestic relative to international match-play.

To the authors knowledge the current study is the first to examine the physical demands of specific defensive and midfield positions in competitive international female match-play. Numerous differences in the physical activity profiles between CD and WD and also CM and WM were noted. Specifically, CM covered more TD and THSR than WD and CD (and A for TD only). Central defenders completed less TD and THSR than all other playing positions. The activity profile of CD is in contrast to WD, as they complete more TD, THSR and TVHSR than their central defensive counterparts. This confirms the need to analyze physical match performance across five playing positions. The findings from the current study which highlight that CM cover the greatest TD and CD the least are in accordance with previous data on European club football.[11] The positional differences observed in the current study are similar to those reported in male match-play[2,15] and are likely to be a direct consequence of the tactical role of each playing position within the team. The high requirement of midfielders to cover distance to support attacking and defensive movements is accepted and thus their greater values of TD and THSR are to be expected.

It has previously been shown that attackers complete a greater sprint distance during match-play than defenders and midfielders.[8,10] This finding was in part corroborated in the present study with moderate to large effect sizes shown for differences in sprinting distance between CD and other playing positions (CM (ES 1.0), WM (1.2) and A (ES 2.3)). There was a trend for WM and A to complete a greater number of short sprints (<15 m) than other positions with WM undertaking a greater number of longer sprints (>15 m). Differences in the percentage of sprint type were only highlighted in CM who completed a higher proportion of explosive relative to leading sprints. The differences in sprinting profile between playing positions is again likely to be related to positional requirements in match-play. The tendency for a higher percentage of CM sprints to be explosive and shorter in nature may reflect the tighter spaces within which they operate and the tactical role of these individuals as they attempt to counteract the movement of the opposition.[15] Conversely, the fact that attacking players (WM and A) complete more longer sprints may be a function of their need to complete fast movements away from defending players to generate space or to capitalize on goal scoring opportunities.[15] The majority of differences between positions were related to CD completing less actions and distances than other playing positions across a number of the measured indices, which is most likely due to their predominant involvement being limited to defensive actions. This finding highlights the importance of analyzing positional subsets, i.e. CD versus WD not only for an understanding of match-play but also for the direct impact on training regimes.

A unique element of the current investigation was to differentiate high-speed activity with and without the ball, which enabled the effectiveness of high-speed efforts in relation to crucial match actions to be evaluated.[15] A small increase in the amount of TVHSR completed when a team was without possession of the ball was observed (399±143 m vs. 313±210 m, ES 0.5) as previously reported in male match-play.[2,15] A link between TVHSR when out of possession and team success has been demonstrated in male match-play with less successful teams completing more VHSRWP,[15] this analysis was beyond the scope of our study but is a recommendation for future work. Despite, an overall increase in TVHSR by the team when out of possession, the amount of TVHSR undertaken with or without possession was dependent upon playing position. Attacking positions (A, WM and CM) completed more TVHSR when the team was in possession with defensive players (CD and WD) completing more TVHSR when the team was without possession. These trends are similar to those previously reported in male match-play.[2,15] The observed differences in high-speed activity when a team is with and without possession, particularly between different playing positions, provides important insights for both technical and physical coaches regarding the influence of styles of play and tactical formations on the physical demands of match-play. Practitioners should consider the implementation of position-specific training drills that reflect the nature of TVHSR, for example, attacking players may benefit from undertaking a greater proportion of their high-speed training with the ball compared to more defensive players, as activity that incorporates the ball has an increased energetic cost, rating of perceived exertion and blood lactate response.[34] However, it should be noted that the analysis of team metrics, as in the current study, limit the level of specificity that can be applied to individual players.

Previous research has used changes in physical performance both between halves and within each half as possible indicators of fatigue.[35] Reductions in physical performance in the second half have frequently been observed with specific reference to TD, THSR[7,10] and sprint distance.[10] In the present study, TD, THSR and sprint distances were reduced during the second half. The moderate reduction in TD (361 m; ES 0.8) between halves was greater than those reported in other studies, however, the small reduction in THSR (ES 0.5) and sprinting (ES 0.2) respectively were similar to previous reports.[6,7,10] Within half decreases in THSR were also currently observed, with less THSR completed during the final 15-minutes of each half compared to the previous 15-minutes. There was also a 35 % reduction in THSR in the last 15-minutes of match-play compared to the first 15-minute interval. This finding was similar to the 26 % reduction shown by Hewitt et al.[6] but less than the 57 % reduction demonstrated by Mohr et al.[10] These findings suggest that in some instances elite female players may be unable to perform at the required speed for the duration of the match. A second half reduction in physical performance by females has previously been attributed in part to fatigue development and an insufficient training capacity of players.[7,9,10] However, due to a lack of data on the match outcome, tactics, fitness status of players or biochemical markers of fatigue it is difficult to provide a clear explanation for the transient changes in high-speed activity presently observed. Furthermore, little information is currently available regarding the variability of within-game physical performance, measures. However, it is likely that differences in activity may be mediated to some extent by the inherent variation in a player's match physical performance that is associated with changes in the tactical and technical requirements of the game as opposed to fatigue.[36]

The current investigation reported a 39 % reduction in THSR from the most intense 5-minute period to the next 5-minutes, which was in agreement but less substantial than previous studies (48-58 %).[7,10] In contrast to earlier reports, the current study failed to demonstrate transient fatigue immediately after the most intense period of the match which is in agreement with other more recent findings.[11] In the current study the reductions in THSR both toward the end of the match and following intense activity, were not as pronounced as studies that were conducted over 5 years ago. This smaller decrease in THSR may be a consequence of increased levels of professionalism and training status of female players in recent years; however, the issues of methodological differences and within game variability must also be considered. There were very few differences between positions for the changes in physical performance shown between halves, which is consistent with previous findings in females.[10]

PRACTICAL APPLICATIONS

The present study provides an overview of the position-specific locomotor demands of competitive international female match-play. These findings are of relevance to applied practitioners responsible for the physical development of elite female players. In order to elicit a comprehensive analysis of the overall physical demands of match-play, practitioners should combine the current dataset with information derived from GPS technology, which provide data on acceleration and deceleration profiles as well as mechanical loading. As the use of GPS monitors has now been sanctioned for use in match-play, such data will become readily available in the future. A number of differences were highlighted in the current study between wide and central defensive playing positions which suggest that it may be necessary for WD to complete more high-intensity soccer-specific conditioning, relative to CD, in order to cope with the increased locomotor of their playing position. During match-play the majority of sprints are less than 10 m in distance and are both explosive and leading in nature. Consequently, soccer-specific sprint drills should focus on short acceleration based activities from both a stationary and rolling start. Sprint training over longer distances (>20 m) is also required in order to condition players for longer sprint distances that may be required during match-play and to develop maximum sprinting speed. The finding that attacking-based players complete more high-speed activity when a team is in possession whilst defensive players complete more high-speed activity when a team is out of possession provides an important link between tactical and physical decision-making. Specifically, this information may be used by the coach to affect decision-making on substitutions or by the physical trainer to direct post-match training and recovery routines. Reductions in physical performance are apparent between and within halves and although these may not be entirely attributed to fatigue it emphasizes the importance of appropriate conditioning levels in order to maintain work rate.

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TABLE AND FIGURE CAPTIONS

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

Figure 1. Influence of playing position on the total number of sprints and the number of sprints completed over different distances (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. Numbers denote magnitude of Effect Size for significant differences: 2 = small (ES>0.2-0.6), 3 = moderate ES (>0.6-1.2), 4 = large ES (>1.2–2.0) and 5 = very large ES (>2.0).

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

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