

## Performance Characteristics According to Playing Position in Elite Soccer

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### Abstract

The paper provides a large-scale study into the motion characteristics of top class soccer players, during match play, according to playing position. Three hundred top-class outfield soccer players were monitored during 20 Spanish Premier League and 10 Champions League games using a computerized match analysis system (Amisco Pro<sup>®</sup>, Nice, France). Total distance covered in five selected categories of intensity, and the mean percentage of playing time spent in each activity were analyzed according to playing position. Midfield players covered a significantly greater total distance ( $p < 0.0001$ ) than the groups of defenders and forwards did. Analyzing the different work rates showed significant differences ( $p < 0.5 - 0.0001$ ) between the different playing positions.

There were no significant differences between halves in the total distance covered, or in distances covered at submaximal and maximal intensities. However, significantly more distance was covered in the first half compared to the second in medium intensities (11.1 – 19 km/h). The current findings provide a detailed description of the demands placed on elite soccer players, according to their positional role at different work intensities, which may be helpful in the development of individualized training programs.

### Key words

Association football · time-motion analysis · match analysis · activity profile · training specificity · positional role

### Introduction

Over the last two decades, there has been a growing interest in match-analyses of soccer [1, 4, 6, 11, 12, 15 – 17, 22, 24, 25, 29, 32, 34]. The practical value of such analyses is that well chosen performance indicators can help coaches to identify good and bad performances of individuals or teams. In this respect, match-analysis has been helpful in identifying the physiological demands of the sport, and in examining how a particular player compares to the needs of his event. Understanding the physiological load imposed on top-level soccer players according to their positional

role during competitive matches (activity profile, distance covered, intensity, energy systems and muscles involved) is necessary to develop a sport specific training protocol. Especially in elite athletes, the most important form of training is that which matches energy use and biomechanics of an intended competitive performance. Therefore, match-analyses are helpful to develop a specific training program which mimics the physiological conditions imposed by the game.

Similar to other field based team games, the physiological demands of soccer are of an intermittent nature [2, 9, 10, 22 – 24, 30].

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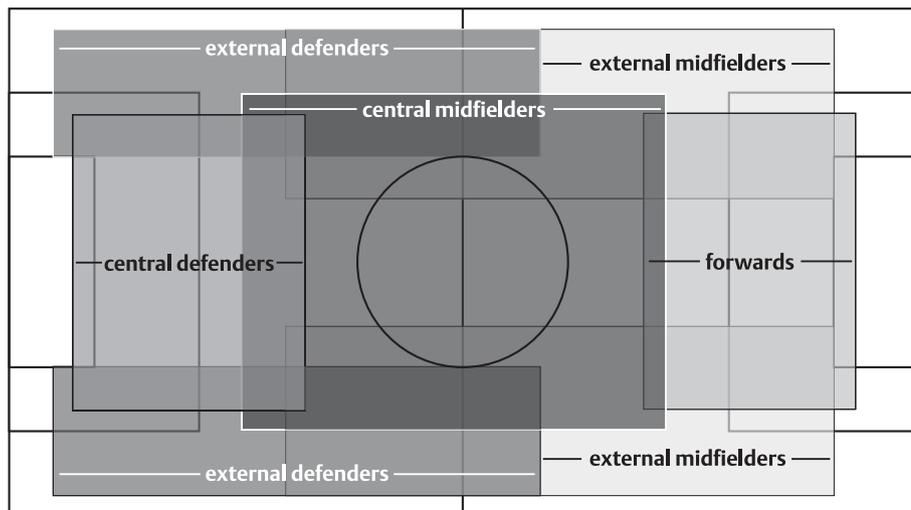


Fig. 1 Techno-tactical assignment to positional roles based on match-analyses.

A major limitation of previous match-analyses is that the number of subjects analyzed was very small. The purpose of this investigation, therefore, was to provide a large-scale study of top class soccer players and examine the work rate profile, and exercise patterns according to positional role during 20 Spanish Premier League matches and 10 Champions League games, using a new developed computerized time-motion analysis system.

## Methods

Twenty Spanish Premier League matches and ten Champions League games were monitored in the 2002/2003 and 2003/2004 seasons, using a multiple-camera match analyses system (Amisco Pro<sup>®</sup>, version 1.0.2, Nice, France). Movements of all 20 outfield players (goalkeepers were excluded) of the two competing teams were observed during the whole game duration by means of 8 stable, synchronized cameras positioned at the top of Bernabeu Stadium (Madrid, Spain) (sampling frequency: 25 measures a second) in those 30 matches. Altogether, 300 players were profiled, including the home players, once only. Signals and angles obtained by the encoders were sequentially converted into digital data and recorded on 6 computers for post-match analyses.

From the stored data, the distances covered, the time spent in five different intensity categories, and the frequency of occurrence for each activity for players in different positions was obtained by specially developed software (Athletic Mode Amisco Pro<sup>®</sup>, Nice, France).

Match-analyses were carried out distinguishing the following five selected categories of intensity, focusing on intense motions: 0–11 km/h (standing, walking, jogging); 11.1–14 km/h (low speed running); 14.1–19 km/h (moderate-speed running); 19.1–23 km/h (high-speed running); > 23 km/h (sprinting).

The match analyses data on these players of national and international caliber were used to verify differences among playing

positions and quantify demands placed on the players in each of the individual positions.

Based upon video analyses by the same experienced observer, a techno-tactical profile of each player has been defined. This profile is based on the different activity on the pitch, and the primary area in which this activity was carried out (Fig. 1). Outfield players in this investigation were assigned to one of five positional groups: central defenders (CD), external defenders (ED), central midfield players (CM), external midfield players (EM) and forwards (F) resulting in the following numbers of subjects in the different subgroups: CD (n = 63); ED (n = 60); CM (n = 67); EM (n = 58); F (n = 52).

## Statistical analyses

Statistical analyses were performed using the STATISTICA for Windows version 6.0 (StatSoft, Inc., Tulsa, OK, USA) software package for IBM-compatible computers. Data were analyzed using a two-way analysis of variance (ANOVA) with repeated measures to examine the interaction of distance covered at different work intensities and positional role.

Where a significant effect was detected, posthoc comparisons were made using Tukey's "honestly significantly different" test for pair wise comparisons. For all analyses, significance was accepted at  $p < 0.05$ . Data are presented as means  $\pm$  s.

## Results

### Whole match activity – positional differences

Mean total distance ( $\pm$  s) covered over the period of the whole match by all players independent of positional groups was  $11\,393 \pm 1016$  m, ranging from 5696 to 13746 m. The mean total distance ( $\pm$  s) covered over the period of the whole match by the different positional groups is shown in Table 1.

Time-motion analyses of the observed soccer matches demonstrated that CM and EM players covered a significantly greater distance ( $p < 0.0001$ ) than both defender groups, as well as the

**Table 1** Differences in distance (m) covered during the entire match depending on the player's position (mean  $\pm$  s)

Positional role	Mean distance covered	s
Independent of position	11 393 m	1016 m
Central defender (CD)	10 627 m <sup>+</sup>	893 m
External defender (ED)	11 410 m <sup>#</sup>	708 m
Central midfield (CM)	12 027 m <sup>*</sup>	625 m
External midfield (EM)	11 990 m <sup>*</sup>	776 m
Forward (F)	11 254 m <sup>#</sup>	894 m

\* Significantly greater distance covered than CD, ED, F; <sup>+</sup> significantly smaller distance covered than any other subgroup; <sup>#</sup> significant different from CD, CM, EM

group of forwards. The distance covered by the CD, however, was significantly shorter ( $p < 0.0001$ ) than that of any other group, whereas ED did not differ from forwards.

There was no significant difference between players of any position when comparing the distance covered with the lowest intensity (0–11 km/h) (Table 2).

Analyzing the other work rates showed significant differences between the different playing positions (Table 2). Distance covered by CD was significantly shorter ( $p < 0.0001$ ) compared to all other playing positions in all work intensities greater than 11 km/h. The only exception is the highest intensity, where distance covered by CD was not significantly different from CM players. The different subgroups showed significant differences ( $p < 0.05 - 0.0001$ ) at an intensity of 11.1–14 km/h. Only between ED and F, no differences could be ascertained analyzing this intensity. There also was no significant difference between ED and F in all other intensities.

Central midfield players covered the longest distance with intensities between 11.1–19 km/h, whereas EM covered the highest distance at intensities 19.1 km/h and higher. Focusing on the highest intensity (> 23 km/h), no significant differences were ascertained between ED, EM and F, whereas CD and CM covered a significant shorter distance ( $p < 0.0001$ ) in sprinting than the other groups.

#### Distance covered having the ball in possession

The total distance covered by players of different positional roles in a game with the ball ranges between 119–286 meters, which corresponds to 1.2–2.4% of the total distance covered. External midfield players cover a significantly greater distance ( $p < 0.05 - 0.0001$ ) with the ball in the match than players of any other positional role. Central defenders covered a significantly smaller distance than any other subgroups (Table 3).

#### First versus second half variations

Although a longer distance was covered during the first half of the match compared to the second half (5709  $\pm$  485 m vs. 5684  $\pm$  663 m), this difference was not significant (Table 4). Significantly more distance ( $p < 0.05$ ) was covered in the second half

than in the first at the lowest work intensity (0–11 km/h). However, significantly ( $p < 0.05 - 0.0001$ ) greater distances were covered in the first half compared to the second half at medium intensities (11.1–19 km/h). At submaximal (19.1–23 km/h) and maximal (> 23 km/h) intensities, however, no significant differences could be detected between the first and the second half of the game (Table 4).

#### Comparisons between halves according to the players' different positions

During the second half, midfield players covered significantly greater distance (CM  $p < 0.001$  and EM  $p < 0.05$ , respectively) by walking and jogging (0–11 km/h), whereas there was no significant difference in other positions at this intensity (Table 5). However, low-intensity running coverage (11.1–14 km/h) decreased significantly during the second half in all positions but ED. Only in CM players, medium-intensity (14.1–19 km/h) coverage decreased significantly ( $p < 0.01$ ) during the second half. High-intensity and maximal speed running distance did not show significant half to half variations in any positional group. Comparisons between halves showed that F covered a significantly greater ( $p < 0.5$ ) distance with the ball during the second half.

#### Quantitative and qualitative game performance variables concerning bursts of high intensity activity (> 23 km/h)

The time-motion analyses revealed that during a 90-minute match the players performed 17.3  $\pm$  7.7 (range 3–40) bursts of high intensity activity (> 23 km/h). These bursts of high intensity activity were 19.3  $\pm$  3.2 meters (in distance range: 9.9–32.5 m). Comparing players according to their positional role showed that ED (20.0  $\pm$  7.0), EM (22.0  $\pm$  6.7) and F (20.7  $\pm$  6.9) performed significantly more ( $p < 0.0001$ ) bursts of high intensity activity than CD (11.2  $\pm$  5.2) and CM (13.7  $\pm$  6.2). However, the distance covered in these bursts of high activity was comparable for all subgroups ranging from 17.9  $\pm$  3.7 m (CM) to 20.2  $\pm$  3.1 m (EM), respectively.

#### Discussion

Elite sporting performance in soccer represents a composite of elite physical performance characteristics that, in turn, depend upon a variety of anthropometrical and physiological properties, as well as on the training and health status of the individual athlete [13,19]. It also appears that genetic characteristics affect the orientation of individuals towards particular playing positions [21]. Stroyer et al. (2004) [25] demonstrated that even young elite soccer players in their late puberty, probably because of their genetic characteristics, are highly specialized both according to playing level and position on the field. Comparing elite soccer players from 4 European leagues, Bloomfield et al. (2005) [7] found differences between the age, stature, body mass and BMI of players in different positions.

The current study aimed to quantify the work-rate profiles of elite soccer players according to their positional role. The results of the present study show that the average total match distance for 300 elite players, independent of positional groups throughout the 90-min play, amounted to 11 393  $\pm$  1016 m, ranging from 5696 to 13 746 m. Although large discrepancies exist in published

Table 2 Assessment of positional differences in distance covered at different work intensities

	<i>Distance covered in different work Intensities</i>				
	<i>0–11 km/h</i>	<i>11.1–14 km/h</i>	<i>14.1–19 km/h</i>	<i>19.1–23 km/h</i>	<i>&gt;23 km/h</i>
CD	7080 ± 420 m	1380 ± 232 m*	1257 ± 244 m*	397 ± 114 m*	215 ± 100 m*
ED	7012 ± 377 m	1590 ± 257 m*	1730 ± 262 m*	652 ± 179 m*	402 ± 165 m†
CM	7061 ± 272 m	1965 ± 288 m#	2116 ± 369 m†	627 ± 184 m*	248 ± 116 m*
EM	6960 ± 601 m	1743 ± 309 m°	1987 ± 412 m†	738 ± 174 m#	446 ± 161 m†
F	6958 ± 438 m	1562 ± 295 m*	1683 ± 413 m*	621 ± 161 m*	404 ± 140 m†

11.1–19 km/h: \* significantly smaller than any other subgroup; † significantly different from CD, CM, EM; # significantly greater than any other subgroup; ° significantly different from CD, ED, CM, F; † significantly different from CD, ED, F. 19.1–23 km/h: \* significantly smaller than any other subgroup; † significantly different from CD and EM; # significantly greater than any other subgroup. >23 km/h: \* significantly smaller than any other subgroup; † significantly different from CD, CM

Table 3 Total distance covered (meters and %) in possession of the ball by players of different positional roles

	<i>Distance</i>	<i>%</i>
CD	119 ± 67 m	1.2 ± 0.6%
ED	220 ± 99 m	1.9 ± 0.9%
CM	230 ± 92 m	1.9 ± 0.8%
EM	286 ± 114 m	2.4 ± 1.1%
F	212 ± 92 m	1.9 ± 0.8%

Table 4 Distances covered in the first and second half at different work intensities

	<i>First half</i>	<i>Second half</i>	<i>Level of significance</i>
<i>Total</i>	5709 ± 485 m	5684 ± 663 m	n.s.
<i>0–11 km/h</i>	3496 ± 148 m	3535 ± 302 m	p < 0.05
<i>11.1–14 km/h</i>	851 ± 188 m	803 ± 187 m	p < 0.0001
<i>14.1–19 km/h</i>	894 ± 251 m	865 ± 255 m	p < 0.05
<i>19.1–23 km/h</i>	304 ± 118 m	301 ± 110 m	n.s.
<i>&gt;23 km/h</i>	165 ± 95 m	172 ± 94 m	n.s.
<i>With the ball</i>	104 ± 62 m	109 ± 61 m	n.s.

Table 5 Differences between the first versus the second half according to positional roles

	<i>0–11 km/h</i>	<i>11.1–14 km/h</i>	<i>14.1–19 km/h</i>	<i>19.1–23 km/h</i>	<i>&gt;23 km/h</i>
CD	n.s.	1st half > 2nd half p < 0.05	n.s.	n.s.	n.s.
ED	n.s.	n.s.	n.s.	n.s.	n.s.
CM	2nd half > 1st half p < 0.001	1st half > 2nd half p < 0.001	1st half > 2nd half p < 0.01	n.s.	n.s.
EM	2nd half > 1st half p < 0.05	1st half > 2nd half p < 0.05	n.s.	n.s.	n.s.
F	n.s.	1st half > 2nd half p < 0.05	n.s.	n.s.	n.s.

n.s. = nonsignificant differences

data (for review see [11,31]) for the distance covered by players in soccer matches, our results are in accordance with recent investigations using sophisticated measurement technologies, which show that the mean distance covered by male elite out-field players is about 11000 m [3]. Also, the highest distances covered by an individual player, about 14 km, are comparable to those reported in literature [11].

When comparing different positional roles, it could be demonstrated that both midfield team formations (CM, EM), probably because of their linking role in the team, covered a significantly greater distance ( $p < 0.0001$ ) than both defender groups, as well as the group of forwards. The shortest distance, however, was

covered by the CD. To date, there have been only a few comparable studies [4,6,11,16,20,22,29], to our knowledge, that have investigated the influence of positional role on the distance covered during a game. However, recent data confirm the results of these earlier, above-mentioned studies showing that distance covered during the match appears to be related to the position on the team. In these studies, midfield players also covered a significantly greater distance per game than defenders or forwards [4,11,16,20]. The distances reported for midfield players in these earlier studies by [4,11,22] (9.9 km, 10.6 km and 11.4, respectively) are markedly shorter, compared to data of this current study. However, our results are comparable to the study performed by [20], who analyzed 18 Premier League and 3 Cham-

pions League games and reported mean  $\pm$  s total distances of  $11720 \pm 524$  m for central midfield players. It would appear, therefore, that the physical demand for elite midfield players has increased over the last decades. Comparing distances covered by forwards and defenders in these earlier soccer studies, mentioned above [4,11,22], with current data, suggests that the same is true for other positional roles, indicating the game is becoming more intense.

Based on results obtained from Danish elite players [3], Bangsbo and Michalsik (2002) showed that midfield players had, on average, higher  $\dot{V}O_{2\max}$  values than fullbacks, who where, in turn, superior to forwards, with central defenders having the lowest values among outfield players. Relating to our study, it can be speculated that these greater distances covered at higher intensities are connected with the higher  $\dot{V}O_{2\max}$  values in accordance with the different positional roles of a team. The hypothesis is also supported by results of an intermittent endurance test (Yo-Yo test) with elite Portuguese male soccer players showing a correlation between the distances covered in this test and the positional role of the players [3].

In the current study, distances covered were categorized into 5 levels of intensity. The overall distance covered by outfield players during a match consists of 58.2–69.4% walking and jogging (0–11 km/h) corresponding to 6958–7080 m, 13.4–16.3% low speed running (11.1–14 km/h) corresponding to 1380–1965 m, 12.3–17.5% moderate-speed running (14.1–19 km/h) corresponding to 1257–2116 m, 3.9–6.1% high-speed running (19.1–23 km/h) corresponding to 397–738 m and 2.1–3.7% sprinting (> 23 km/h) corresponding to 215–446 m. Masked beneath these broad categories are backward, sideways and diagonal movements running and walking activities and several other movement patterns like jumping, dribbling, tackling, shooting as well as rapid changes in speed and direction.

Caution is necessary in comparing recent data with reported results from literature [4,8,14,22,34] because different technologies and categorizations were employed. According to Withers et al. [34] 26.3% of total play time is made up of phases of walking, 64.6% of slow runs, and 18.9% of quick runs and sprints. Mayhew and Wenger [14] established that during his game a soccer player walks 46.6%, runs slowly 38%, runs quickly or sprints 11.3% and stands without moving 2.3% of total playing time. Ali and Farrally, [1] analyzing a small group of university players, reported that the ratio of time spent for the players was 56% walking, 30% jogging, 4% cruising, 3% sprinting and 7% standing. During a match, soccer players perform different types of behavior, ranging from standing still to maximum speed runs, the intensity of which may change at any given time. However, intensity parameters are not exactly defined in these papers.

According to Bangsbo [5], the types of runs during a soccer match (for a total length of 8–12 km) can be expressed as follows, keeping in mind, however, that both the total distance covered and the intensity of the runs are extremely variable with regard to the physical conditioning level and the player's position. Walking: 4 km/h (distance covered: about 3400 m), jogging: 8 km/h (distance covered: about 3200 m), low speed run: 12 km/h (distance covered: about 2,500 m), moderate speed

run: 16 km/h (distance covered: about 1700 m), high speed run: 21 km/h (distance covered: about 700 m), and sprint 30 km/h (distance covered: about 400 m).

In the current study among outfield players, CD were found to spend significantly more time ( $p < 0.0001$ ) walking and jogging (0–11 km/h) and cover a longer distance in this activity category, than any other playing position. However, in all other work-intensities, CD spent the smallest amount of time and covered the smallest distance. This is consistent with results from Rampinini et al. [20] showing that centerbacks covered the lowest distance at high intensity activity. Midfield players (CM and EM), on the other hand, were found to be spending the smallest amount of time walking and jogging, but covered the largest distance in low- and moderate speed running. External midfield players (EM) were those who spent the highest percentage of time and covered the greatest distance in high-speed running and sprinting. However, time spent and distance covered by EM players was not significantly different from ED and F.

Our result that central defenders sprint significantly less frequently than forwards is in agreement with previous findings [11,29], however, the finding that external defenders (ED) and external midfielders (EM) perform significantly more sprints compared to the corresponding central team formations has not been discussed in the literature so far.

Only 1.2–2.4% (119–286 m) of the total distance covered by players in a game was with the ball, the vast majority of the efforts were without the ball. However, to our knowledge, these are the first data to demonstrate that EM cover a significantly larger distance with the ball than players of any other position. Data of the current study are higher than those reported by Withers et al. [34], who established that soccer players are in possession of the ball 1.1% of the game. Evidence for increased work intensity during contemporary soccer has been shown by Williams et al. [32] in their quantitative analyses of matches played in the 1991–1992 and the 1997–1998 seasons. Objective match statistics were presented in this paper to highlight the major changes in the game that have occurred in this short period of time. Findings indicate that the game has changed markedly during the intervening period, and matches include more runs with the ball, more passes, dribbles and crosses, suggesting a significant increase in the “tempo” of the game.

Soccer is frequently called a “multiple sprint sport”. However, the average number of sprints in this investigation mentioned above is  $17.3 \pm 7.7$  (range: 3–40). Like in other investigations, sprints covered with highest speed are rarely longer than 20 m in distance [4,17,18,22,32]. On average these more or less frequent sprints correspond to an average distance of  $19.3 \pm 3.2$  meters, which is slightly higher compared to the mean distance of 17 meters for sprints reported by Bangsbo et al. [4], and implies that acceleration capabilities are of primary importance to soccer players.

#### First vs. second half variations

Conversely to earlier research [4,11,16,22,24,29,30], the current study showed no significant second-half decrement for total distance covered, and it did not show a fall in work-rate of high in-

tensity work towards the end of a game. Nevertheless, players seem to spare energy during the second half by increasing distance covered in walking and jogging and by decreasing the distance in medium intensity.

## Conclusion

The purpose of this study was to verify differences among playing positions and to quantify demands placed on elite soccer players in each of the individual positions during match play. Analyzing elite-level match play concerning overall distance covered at different categories of intensity has documented that there are a number of statistically significant differences between the different playing positions. There is a consensus in sport science that the most effective training for preparing athletes for competition is that which most closely replicates competitive performance conditions. Therefore, training prescriptions in soccer should also be based on the specific requirements of the playing positions thereby ensuring players are better able to fulfill their tactical responsibilities during the game.

The data presented here could be considered norms for elite soccer players, serve for present and future comparisons and represent the scientific basis for developing position-specific conditioning/training protocols in soccer. These, however, may not overcome individual deficiencies in genetic potential for the physiological characteristics required for the position [26].

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