# Activity Profile in Elite Italian Soccer Team

Authors G. Vigne[1], C. Gaudino[2], I. Rogowski[1], G. Alloatti[3], C. Hautier[1]

Affiliations Affiliation addresses are listed at the end of the article

**Key words**
- football
- time and motion analysis
- match performance
- activity profile

## Abstract

The purpose of this study was to analyse the activity profile of players in a top-class team in the Italian national football league over the course of a season (n = 388). The effect of playing position and the two halves on the number and duration of short, intense bursts of effort and recovery phases was studied. The main results show that midfielders cover significantly more distance than players in other positions ($p < 0.001$). For midfielders, the number of displacements of 2–40 m and the number of sprints covering between 2 and 9 m and between 30 and 40 m are considerably greater than for other positions ($p < 0.05$). The distances covered in the second half compared to the first half are significantly lower for all categories of run ($p < 0.05$). In the second half, the distance covered at very high intensity is significantly lower ($p < 0.01$), whilst the number of recovery times greater than 120 s increases significantly compared to the first half ($p < 0.01$). This study provides data which could be used as a basis for the work of scientists as well as football professionals.

accepted after revision
January 11, 2010

**Bibliography**
**DOI** http://dx.doi.org/10.1055/s-0030-1248320
Published online: March 18, 2010
Int J Sports Med 2010; 31: 304–310 © Georg Thieme Verlag KG Stuttgart · New York
ISSN 0172-4622

**Correspondence**
***Dr. Christophe Hautier***
Centre de Recherche et d'Innovation
Sur le Sport
Université de Lyon
Université Lyon 1
27–29 bd du 11 nov 1918
69100 Villeurbanne
France
Tel.: +33/472432848
Fax: +33/472432830
Christophe.hautier@univ-lyon1.fr

## Introduction

Over the last twenty years, scientific interest in football has grown considerably. In order to gain a greater knowledge and information on football, it seemed necessary to analyse the periods of activity during a match [4, 5, 7, 8, 14].The understanding of the various sequences of play performed by players seeks to improve training methods by favouring individualised physical workouts and techniques and to evaluate the workload during a match [6]. The analysis of match effort also aims to allow fine modelling of the activity in order to assess the effect of the playing position, to adapt the content of training sessions, and to measure the effect of fatigue for the purpose of improving the athletic preparation of players and guiding tactical choices [3, 9–11].

Football is characterised as an intermittent activity with brief bursts of intense effort [15, 16]. During a match, each player performs from 1 000–1 400 actions with a short duration. Sprints, whose duration is equivalent to 2–4s, are repeated approximately every 90 s [15]. It is widely accepted that these anaerobic efforts constitute an important key to success in sport [1, 13]. Mohr et al. [11] have shown that a player performs between 150 and 250 brief, intense actions during a match, and that the number of actions of this type increases with level of play and varies over the course of a season according to the phase of the competition. This author has also shown that a player's position has a significant effect on the number of sprints performed during a match. The players performing the greatest number of sprints are the left and right backs (defenders) and the forwards, whilst the centre backs perform the smallest number of sprints [12].

Certain data are still lacking or require further investigation on a very high-level homogeneous population. The most interesting recent results were obtained from several teams over a season, where each team had its own formation [5, 7, 14]. Consequently, although the distances calculated, the number of actions performed and the recovery times make it possible to model top-class football from an overall point of view, they are not representative of the style of play of a homogeneous team. This analysis was carried out over thirty home matches in order to highlight the effect of the tactical plan and to minimise the effect of the opposing team. Moreover, the analy-

sis of the effort model is refined by an analysis carried out according to playing position.

Recent analyses have also examined the effects of fatigue on the number and quality of bursts of effort performed in the second half compared to the first half. These studies show a decrease in the number of brief, intense bursts of effort in the second half [7,12]. These very interesting studies quite rightly interpret this decrease in the number of actions as a significant effect of fatigue. According to Mohr et al. [12], the performance slump periods during a match are caused by an accumulation of extracellular potassium and to electrical disorders within the muscular cell. This author also explains the performance slump at the end of a match by a depletion of muscular glycogen of the Type I and IIa fibres, as well as hyperthermia due to dehydration experienced by players during a match. To our knowledge, no study has attempted to eliminate the effect of player substitutions on these variables. Players may leave the pitch following an injury or a slump in performance, to be replaced by players who are more rested. Consequently, the difference between the first and second halves is minimised because the new player is likely to perform as many sprints as someone at the start of the first half. Moreover, we believe that the loss in performance capacity between first and second halves could be revealed through an analysis of recovery times taken by players following intense actions. This type of information is not currently found in the literature, even though it is likely to change the physical training to specific sprint times and recovery times quite significantly. An analysis of effort density during a match and according to the half is therefore an original objective, which should provide better guidance for the training of top-level players. That is why the primary objective of this study was to supplement our knowledge by analysing the effort model of an international-level Italian team, characterised by a 4-4-2 formation.

This study had two main objectives. The first was to analyse the effect of the playing position on the effort profile in high-level football, using a top-ranking Italian league team. The second was to compare intense bursts of effort and recovery times in the first and second halves of the match to analyse the possible performance decrease within the match.

## Methods

The study was carried out over 30 home matches of a top-level Italian professional club in the 2004–2005 season, of which 20 were Serie A fixtures, six were Champions League matches, and four were Italian Cup matches. Twenty-five players participated in this study (n = 293), including nine defenders (n = 121), eleven midfielders (n = 111), and five forwards (n = 61). Goalkeepers were not included in the study. The mean height of the players was 181.74 ± 7.10 cm, and their mean mass was 79.71 ± 9.65 kg. In these matches, the team being studied had eighteen wins, nine draws and three losses. It finished the season near the top of the league table. The matches were analysed using the SICS multi-camera match analysis system. As stated by Rampinini et al. [14], the criteria for determining these conditions was based upon the reliability of the video match-analysis system SICS (Bassano del Grappa, Italy).

Effort was modelled as five different intensities: walking (< 5 km.h$^{-1}$), jogging (5–13 km.h$^{-1}$), speed below the anaerobic threshold (13–16 km.h$^{-1}$), speed above the anaerobic threshold (16–19 km.h$^{-1}$), and sprint (> 19 km.h$^{-1}$). Running intensities were determined taking the athletes' characteristics into consideration. Individual maximal aerobic velocity and speed at anaerobic threshold were evaluated at the beginning of the season using the Conconi's Test.

The distance covered at each speed was calculated for the first half and second half. The number of displacements exceeding 2 m carried out above the anaerobic threshold (16–19 km.h$^{-1}$) and at a sprint (> 19 km.h$^{-1}$), and the number of recovery periods of at least 2 sec, were measured. The recovery time represents all the phases during which players are standing, walking or jogging (under 13 km.h$^{-1}$), velocity under aerobic threshold. The length of recovery times after bursts of effort was measured and allocated to the following categories: 2–9 s, 10–30 s, 30–60 s, 60–120 s, and > 120 s. Running distances were chosen in reference to literature [1,5,7,11,14] and recovery durations were chosen in reference to training methods and literature [2].

### Statistical analysis

The data presented include values for all players who participated in at least one match during the season. For the purpose of obtaining uniform results, action distance values were normalised according to the amount of match time played.

Mean values and standard deviations are given for all variables studied. Before using parametric statistical test procedures, the assumptions of normality and sphericity were verified. With regard to variables calculated for the total duration of the match, the effect of playing position was determined by a one-way analysis of variance with repeated measure (ANOVA). Where the effect of playing position was significant, the origin of the difference was determined by Bonferroni's post hoc test. For all statistical tests, the significance threshold was set at $p \leq 0.05$. All tests were carried out using SPSS software, version 11.0 (SPSS Inc., Chicago, USA).

## Results

### Overall analysis of match and playing position

The mean playing time for a match was 73.62 ± 29.4 min. This was calculated on the basis of all players who participated in the match. In the first half, players played an average of 45.5 ± 3.68 min, compared to 43.76 ± 10.62 min in the second half. These two playing times are calculated only for players who participated in the first and second halves. The average total distance covered by players irrespective of playing position was 8 929.84 ± 3 514.7 m. The subjects covered an average of 121.82 ± 9.57 m.min$^{-1}$ overall (taking all intensities into account). The various distances covered according to intensity are shown in **Table 1**.

Ninety-three percent of high-intensity displacements were between 2 and 19 m (**Table 2**). These sprints corresponded to a mean effort duration between 2 and 4 s. Eighty-six percent of recovery times were between 2 and 60 s (**Table 3**).

Because maximal aerobic capacity, speed at anaerobic threshold and activity profils were not significantly different between central and lateral defenders in the present study, the data of these subjects were grouped together.

ANOVA showed that the playing position had significant influence on the time played ($p < 0.001/F = 9.76$), the total distance covered ($p < 0.001/F = 8.442$), the walking ($p = 0.004/F = 5.48$), the jogging ($p < 0.001/F = 16.88$), the running intensities between 13–16 km.h$^{-1}$ ($p < 0.001/F = 29.50$) and 16 to 19 km.h$^{-1}$ ($p < 0.001/F = 21.47$), the recovery times per minute from 10–30 s

**Table 1** Mean distances covered during matches (m) (n = 388).

| | Total | | | Distances covered | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | First half | | | Second half | | |
| | /playing time | distance/minute | % | /playing time | distance/minute | % | /playing time | distance/ minute | % |
| total | 8 929.84 ± 3514.70 | 121.82 ± 9.57 | 100 | 5642.31 ± 626.87** | 124.15 ± 12.43 | 100 | 4995.41 ± 1156.61 | 114.94 ± 15.04 | 100 |
| walking | 3477.86 ± 1433.41 | 46.85 ± 3.85 | 38.95 | 2134.03 ± 258.58*** | 46.97 ± 4.67 | 37.82 | 2046.96 ± 520.52 | 46.92 ± 5.61 | 40.98 |
| jogging | 2631.19 ± 1097.98 | 35.65 ± 5.63 | 29.47 | 1638.40 ± 305.26*** | 36.00 ± 8.48 | 29.04 | 1445.00 ± 269.22 | 33.24 ± 8.10 | 28.93 |
| 13–16 km.h$^{-1}$ | 1192.02 ± 478.22 | 16.40 ± 3.08 | 13.35 | 788.26 ± 175.64*** | 17.34 ± 3.62 | 13.97 | 641.50 ± 204.42 | 14.80 ± 3.55 | 12.84 |
| 16–19 km.h$^{-1}$ | 750.65 ± 314.14 | 10.51 ± 2.48 | 8.41 | 498.68 ± 127.09*** | 11.04 ± 2.93 | 8.84 | 398.33 ± 137.87 | 9.21 ± 2.61 | 7.97 |
| > 19 km.h$^{-1}$ | 878.13 ± 433.2 | 12.4 ± 4.05 | 9.83 | 582.94 ± 208.93*** | 12.8 ± 4.48 | 10.33 | 463.62 ± 195.5 | 10.77 ± 4.2 | 9.28 |

Significant difference between first and second half, * p < 0.05 ; ** p < 0.01 ; *** p < 0.001

**Table 2** Average number of displacements according to running intensity (n = 388).

| | Number of displacements | | Total | |
|---|---|---|---|---|
| | 16–19 km.h$^{-1}$ | > 19 km.h$^{-1}$ | | % |
| total | 97.01 | 80.95 | 177.96 | 100 |
| 2–4 m | 43.32 | 25.79 | 69.11 | 38.83 |
| 5–9 m | 41.02 | 24.85 | 65.87 | 37.01 |
| 10–19 m | 11.23 | 19.47 | 30.7 | 17.25 |
| 20–29 m | 1.25 | 6.69 | 7.94 | 4.46 |
| 30–39 m | 0.16 | 2.52 | 2.68 | 1.51 |
| >40 m | 0.02 | 1.63 | 1.65 | 0.93 |

**Table 3** Average number of recovery periods after a run between 16 and 19 km.h$^{-1}$ and above 19 km.h$^{-1}$ (n = 388).

| | Number of recovery periods | % |
|---|---|---|
| total | 145.39 | 100 |
| 2–9 s | 57.16 | 39.31 |
| 10–30 s | 40.28 | 27.70 |
| 30–60 s | 28.16 | 19.37 |
| 60–120 s | 16.13 | 11.09 |
| >120 s | 3.66 | 2.52 |

(p = 0.004/F = 5.73), from 30–60 s (p < 0.01/F = 9.87) and above 120 s (p = 0.012/F = 4.48), the total number of displacements without sprint (p < 0.001/F = 18.376), the number of displacements for distances of 2–4 m without sprint (p < 0.001/F = 12.18), of 5–9 m without sprint (p < 0.001/F = 17.45), of 10–19 m without sprint (p < 0.001/F = 20.50), of 20–29 m without sprint (p < 0.001/F = 11.91) and of 30–39 m without sprint (p = 0.01/F = 4.66). The post hoc tests revealed that the defenders had greater playing time than other positions: 82.92 ± 24.83 min, compared to 70.8 ± 31.6 min for midfielders (p = 0.002) and 67.14 ± 31.77 for forwards (p < 0.001). **Table 4** shows that midfielders covered more distance per minute than defenders and forwards (129.01 ± 9.8 m.min$^{-1}$ compared to 118.37 ± 12.03 (p < 0.001) and 115.38 ± 6.89 (p < 0.001). For running intensities of between 13 and 19 km.h$^{-1}$, defenders covered a greater distance than forwards (p < 0.001) but less than midfielders (p < 0.001) (**Table 4**). With regard to recovery times, there is little difference between the different playing positions. Midfielders have more recovery times per minute from 10–30 s (p < 0.05) and from 30–60 s (p < 0.01) than defenders. Defenders, on the other hand, have more recovery times per minute above 120 s than midfielders (p < 0.01) (0.12 recovery.min$^{-1}$ corresponding to one 120 s recovery period every 8 min 20 s). Concerning the total number of displacements without sprint at all intensities, midfielders perform more displacements than other positions for distances of 2–40 m (p < 0.01). We noted the same trend for the number of sprints performed from 2–9 m and from 30–40 m (p < 0.05) (**Table 5**). Forwards perform the smallest number of displacements per minute (p < 0.001), and cover the greatest distance at a walk per minute compared to other types of players (p < 0.001). In general, forwards run significantly less than other players for intensities from jogging to 19 km.h$^{-1}$ (p < 0.001).

## Half-by-half analysis

ANOVA showed that the playing-half had significant influence on the total distance covered (p < 0.001/F = 64 592), the walking

**Table 4** Playing time, distance covered and number of displacements (without sprint) during a match according to playing position (n = 293) (Calculated only for the subjects who performed the two periods).

| | | *Absolute* | Total */Minutes* | *%* |
|---|---|---|---|---|
| **playing time (min)** | defenders | 82.92 ± 24.83 + + + | | |
| | midfielders | 70.8 ± 31.6*** | | |
| | forwards | 67.14 ± 31.77*** + + + | | |
| **total (m)** | defenders | 9698.76 ± 2901.48 | 118.37 ± 12.03 + + + | |
| | midfielders | 8943.00 ± 3992.23 | 129.01 ± 9.8*** | |
| | forwards | 7733.77 ± 3650.38*** + | 115.38 ± 6.89 + + + | |
| **walking (m)** | defenders | 3791.45 ± 1171.63 + + | 45.66 ± 3.51 | 38.57 |
| | midfielders | 3226.82 ± 1481.54** | 45.69 ± 3.37 | 35.42 |
| | forwards | 3409.89 ± 1647.06 | 50.56 ± 4.68*** + + + | 43.82 |
| **jogging (m)** | defenders | 2914.10 ± 945.56 | 35.48 ± 5.47 + + + | 29.97 |
| | midfielders | 2712.16 ± 1276.57 | 38.62 ± 4.88*** | 29.94 |
| | forwards | 2066.46 ± 1071.80*** + + + | 31.1 ± 6.53*** + + + | 26.95 |
| **13–16 km.h$^{-1}$ (m)** | defenders | 1299.72 ± 422.47 | 16.12 ± 3.58 + + + | 13.62 |
| | midfielders | 1301.25 ± 594.96 | 18.94 ± 3.31*** | 14.68 |
| | forwards | 848.65 ± 417.22*** + + + | 12.71 ± 2.35*** + + + | 11.02 |
| **16–19 km.h$^{-1}$ (m)** | defenders | 791.34 ± 286.91 | 9.82 ± 2.66 + + + | 8.30 |
| | midfielders | 827.48 ± 376.81 | 12.37 ± 2.97*** | 9.59 |
| | forwards | 562.70 ± 278.69*** + + + | 8.53 ± 1.8** + + + | 7.39 |
| **>19 km.h$^{-1}$ (m)** | defenders | 902.15 ± 406.09 | 11.29 ± 4.44 + + + | 9.54 |
| | midfielders | 875.29 ± 438.64 | 13.39 ± 4.73*** | 10.38 |
| | forwards | 846.07 ± 454.86 | 12.49 ± 2.98 | 10.83 |
| **number of displacements from 2–4 m** | defenders | 45.00 ± 17.83 | 0.58 ± 0.28 + + + | |
| | midfielders | 47.13 ± 23.56 | 0.69 ± 0.21*** | |
| | forwards | 34.54 ± 17.62*** + + + | 0.52 ± 0.15 + + + | |
| **number of displacements from 5–9 m** | defenders | 43.63 ± 16.83 | 0.54 ± 0.15 + + + | |
| | midfielders | 44.56 ± 21.00 | 0.67 ± 0.21*** | |
| | forwards | 31.24 ± 16.31*** + + + | 0.47 ± 0.13* + + + | |
| **number of displacements from 10–19 m** | defenders | 11.79 ± 5.70 | 0.14 ± 0.06 + + + | |
| | midfielders | 12.77 ± 6.93 | 0.19 ± 0.08*** | |
| | forwards | 7.87 ± 4.67*** + + + | 0.12 ± 0.06 + + + | |
| **number of displacements from 20–29 m** | defenders | 1.29 ± 1.32 | 0.02 ± 0.03 | |
| | midfielders | 1.55 ± 1.57 | 0.02 ± 0.03 | |
| | forwards | 0.69 ± 0.90** + + + | 0.01 ± 0.02 + + + | |
| **number of displacements from 30–39 m** | defenders | 0.17 ± 0.41 | 0.002 ± 0.005 | |
| | midfielders | 0.21 ± 0.53 | 0.003 ± 0.01 | |
| | forwards | 0.04 ± 0.21 + + | 0.0006 ± 0.003 + | |
| **number of displacements >40 m** | defenders | 0.01 ± 0.09 | | |
| | midfielders | 0.05 ± 0.43 | | |
| | forwards | 0.01 ± 0.11 | | |
| **total number of displacements** | defenders | 101.89 ± 36.97 | 1.27 ± 0.4 + + + | |
| | midfielders | 106.28 ± 49.28 | 1.58 ± 0.39*** | |
| | forwards | 74.40 ± 36.25*** + + + | 1.13 ± 0.23** + + + | |

Different from defenders, * $p < 0.05$ ; ** $p < 0.01$ ; *** $p < 0.001$

Different from midfielders, + $p < 0.05$ ; + + $p < 0.01$ ; + + + $p < 0.001$

($p = 0.001/F = 10.32$), the jogging ($p < 0.001/F = 10688$), the running intensities between 13–16 km.h$^{-1}$ ($p < 0.001/F = 127.09$), 16–19 km.h$^{-1}$ ($p < 0.001/F = 124.43$), the total sprint distance ($p < 0.001/F = 72.6$), the recovery times from 2–9 s ($p < 0.001/F = 29.32$), from 10–30 s ($p < 0.001/F = 69.55$), from 30–60 s ($p = 0.001/F = 76.53$), from 60–120 s ($p < 0.001/F = 13.99$) and above 120 s ($p < 0.001/F = 23.05$). The post hoc tests revealed that the total distance covered in the second half is significantly lower than the distance covered in the first half. The distance covered at the different running speeds is significantly lower in the second half. Conversely, the distance covered by walking is greater in the second half than the first (▶ **Table 6**).

We observed a significant decrease in the number of recovery times below 60 s in the second half ($p < 0.05$). For longer durations, however, there is no difference between the first half and the second half, except for those in excess of 120 s, which increase significantly in the second half ($p < 0.01$).

There is a position/half interaction effect for two categories only: walking ($p = 0.001/F = 6.75$) and distance covered at 13–16 km.h$^{-1}$ ($p = 0.027/F = 3.66$). Forwards cover significantly more walking distance in the second half ($p < 0.01$).

## Discussion

### Overall analysis

The purpose of this study was to quantify the activity of players playing in different positions and to analyse the differences between the two halves on the effort profile in each category. The study includes 25 players in three categories belonging to the professional contingent of a top-class Italian league club in

**Table 5** Number of recovery periods and sprint during a match according to playing position (n = 293) (Calculted only for the subjects who performed the two periods).

| | | Total | |
|---|---|---|---|
| | | *Absolute* | */Minutes* |
| **number of recovery periods from 2–9 s** | defenders | 21.92 ± 19.20 | 0.29 ± 0.27 + + |
| | midfielders | 24.34 ± 14.77 | 0.38 ± 0.25 ** |
| | forwards | 17.76 ± 23.51 + | 0.26 ± 0.25 + + |
| **number of recovery periods from 10–30 s** | defenders | 19.17 ± 12.32 | 0.24 ± 0.15 + + |
| | midfielders | 19.99 ± 11.67 | 0.31 ± 0.16 ** |
| | forwards | 16.73 ± 11.21 | 0.24 ± 0.11 + + |
| **number of recovery periods from 30–60 s** | defenders | 18.05 ± 8.87 | 0.22 ± 0.09 + + + |
| | midfielders | 18.95 ± 10.53 | 0.28 ± 0.13 *** |
| | forwards | 16.56 ± 10.20 | 0.24 ± 0.1 + |
| **number of recovery periods from 60–120 s** | defenders | 17.62 ± 6.97 | 0.21 ± 0.06 |
| | midfielders | 15.93 ± 7.99 | 0.22 ± 0.07 |
| | forwards | 14.89 ± 7.97 * | 0.22 ± 0.07 |
| **number of recovery periods >120 s** | defenders | 10.14 ± 4.71 + + + | 0.12 ± 0.05 + + |
| | midfielders | 7.42 ± 4.69 *** | 0.1 ± 0.05 ** |
| | forwards | 7.95 ± 4.79 ** | 0.11 ± 0.05 |
| **number of sprints from 2–4 m** | defenders | 27.10 ± 17.79 | 0.34 ± 0.19 + + |
| | midfielders | 27.50 ± 15.57 | 0.41 ± 0.19 ** |
| | forwards | 20.99 ± 20.29 * + | 0.3 ± 0.2 + + + |
| **number of sprints from 5–9 m** | defenders | 24.93 ± 12.90 | 0.31 ± 0.16 + + + |
| | midfielders | 26.64 ± 14.56 | 0.4 ± 0.17 *** |
| | forwards | 21.78 ± 13.33 + | 0.32 ± 0.11 + + + |
| **number of sprints from 10–19 m** | defenders | 19.77 ± 8.96 | 0.25 ± 0.11 + + |
| | midfielders | 19.86 ± 11.07 | 0.3 ± 0.13 ** |
| | forwards | 18.40 ± 10.31 | 0.27 ± 0.1 |
| **number of sprints from 20–29 m** | defenders | 6.93 ± 4.05 | 0.09 ± 0.05 |
| | midfielders | 6.46 ± 4.44 | 0.1 ± 0.08 |
| | forwards | 6.68 ± 3.84 | 0.1 ± 0.04 |
| **number of sprints from 30–39 m** | defenders | 2.69 ± 2.09 | 0.03 ± 0.03 |
| | midfielders | 2.20 ± 1.81 | 0.03 ± 0.04 |
| | forwards | 2.78 ± 1.99 | 0.04 ± 0.03 |
| **number of sprints from >40 m** | defenders | 1.66 ± 1.57 | 0.02 ± 0.02 |
| | midfielders | 1.42 ± 1.33 | 0.02 ± 0.03 |
| | forwards | 1.92 ± 1.54 + | 0.03 ± 0.02 * |
| **total number of sprints** | defenders | 83.08 ± 38.49 | 1.04 ± 0.42 + + + |
| | midfielders | 84.09 ± 42.25 | 1.26 ± 0.42 *** |
| | forwards | 72.55 ± 43.73 | 1.06 ± 0.32 + + + |

Different from defenders, * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Different from midfielders, + $p < 0.05$; + + $p < 0.01$; + + + $p < 0.001$

the 2004–2005 season. The results were obtained from 30 national or international matches. The mean distance covered by players irrespective of position was 121.82 ± 9.57 m.min$^{-1}$, equivalent to an average of 10 964 m for a 90 min match. These results are comparable to the 10 800 m distance covered, as reported by Bangsbo et al. [1] In this study, the distances covered were recorded in five categories according to intensity. In the present study, the total distance covered in a match consisted of 38.9 % walking (3 477 ± 1 433 m), 29.5 % jogging (2 631 ± 1 097 m), 13.3 % running between 13 and 16 km.h$^{-1}$ (1 192 ± 478 m), 8.4 % running between 16 and 19 km.h$^{-1}$ (750 ± 314 m), and 9.8 % sprinting (878 ± 433 m). Although the intensities vary slightly according to different authors and different studies, our results appear to be comparable to those of Di Salvo [7].

Football is an intermittent sport involving brief, intense bursts of effort which seem to be the key to success in sport. In our study, 93 % of high-intensity displacements are between 2 and 19 m. Given the duration of each sprint and the number of sprints, we can determine that the mean duration of effort is 2.2 s (**Table 2**). Eighty-six percent of recovery times were between 2 and 60 s. In most of the cases, the recovery times follow the highest sprint distances. From the duration and number of recovery periods, the mean recovery time can be calculated: 18 s (**Table 3**). In 90 % of the cases, the intermittent effort profile is therefore 2.2 s/18 s, which corresponds to a work/recovery ratio of 1/8. This ratio, could be very interesting to optimise physical preparation in football, i.e. a part of intermittent work should be designed in order to reproduce this work to rest ratio.

## Differences between first and second halves

In the literature, the effect of the playing-half on the average total distance covered is not significant [5, 7]. When examining the different categories more closely, however, the authors note a significant increase in distances covered walking and at low intensity [5, 7]. Indeed, recent studies have shown that the amount of both high-intensity running and sprinting declines as a soccer match progresses. However, Di Salvo et al. [7] reported just the opposite. These differences can be explained by fatigue, calculation, or team result. In our study, we observed a significant influence of the half on the distance covered per minute at a running intensity between 13 and 19 km.h$^{-1}$, on the sprinting distance, and on the number of recovery periods ($p < 0.05$)

**Table 6** Playing time and distance covered per half match according to playing position (n = 293) (Calculted only for the subjects who performed the two periods).

| | | First half | | Second half | |
|---|---|---|---|---|---|
| | | *Absolute* | */Minutes* | *Absolute* | */Minutes* |
| **playing time (min)** | defenders | 45.59 ± 3.2 | | 46.07 ± 8.8 + | |
| | midfielders | 45.61 ± 2.87 | | 42.08 ± 11.29 * | |
| | forwards | 45.29 ± 5.51 | | 42.23 ± 11.93 * | |
| **total distance (m)** | defenders | 5582.07 ± 992.36 | 119.36 ± 22.06 | 5026.54 ± 1182.32 | 111.98 ± 21.76 |
| | midfielders | 5982.69 ± 951.87 | 130.24 ± 17.57 | 4659.02 ± 1356.28 | 121.87 ± 26.02 |
| | forwards | 5427.31 ± 1056.78 | 122.48 ± 25.12 | 4637.63 ± 1308.1 | 109.81 ± 20.21 |
| **walking (m)** | defenders | 2085.98 ± 219.92 | 45.75 ± 3.55 | 2108.6 ± 436.06 | 45.69 ± 4.2 |
| | midfielders | 2079.91 ± 175.6 | 45.63 ± 2.81 | 1945.46 ± 527.54 | 46.76 ± 7.08 |
| | forwards | 2327.81 ± 351.97 * + + + | 51.82 ± 6.02 *** + + + | 2109.36 ± 630.4 | 49.67 ± 3.91 |
| **jogging (m)** | defenders | 1654.71 ± 308.29 | 36.30 ± 8.49 | 1549.40 ± 288.67 | 33.63 ± 8.58 |
| | midfielders | 1810.80 ± 337.38 | 39.70 ± 8.50 | 1543.24 ± 287.53 | 36.67 ± 7.84 |
| | forwards | 1449.69 ± 270.10 | 32.01 ± 8.44 | 1242.37 ± 231.47 | 29.42 ± 7.87 |
| **13–16 km.h$^{-1}$ (m)** | defenders | 770.65 ± 133.88 + + + | 16.92 ± 2.7 + + + | 657.15 ± 177.48 | 14.28 ± 2.89 |
| | midfielders | 903.81 ± 139.73 *** | 19.82 ± 2.82 *** | 705.96 ± 219.29 | 16.88 ± 3.46 |
| | forwards | 612.94 ± 147.5 *** + + + | 13.66 ± 3 *** + + + | 493.18 ± 147.16 | 12.04 ± 2.57 |
| **16–19 km.h$^{-1}$ (m)** | defenders | 472.05 ± 115.66 + + + | 10.39 ± 2.55 + + + | 395.35 ± 131.63 | 8.54 ± 2.41 |
| | midfielders | 579.56 ± 108.44 *** | 12.74 ± 2.38 *** | 441.51 ± 138.3 | 10.65 ± 2.38 |
| | forwards | 404.31 ± 87.74 *** + + + | 9.22 ± 2.96 * + + + | 325.66 ± 118.13 | 7.88 ± 2.15 |
| **> 19 km.h$^{-1}$ (m)** | defenders | 533.99 ± 219.64 | 11.75 ± 4.77 + + | 455.75 ± 204.43 | 9.88 ± 4 |
| | midfielders | 610.69 ± 188.78 | 13.4 ± 4.07 ** | 464.3 ± 195.66 | 11.37 ± 4.78 |
| | forwards | 629.54 ± 205.29 | 13.8 ± 4.2 ** | 478 ± 178.6 | 11.43 ± 3.05 |
| **Number of recovery periods from 2– 9 s** | defenders | 14.28 ± 16.93 | 0.31 ± 0.37 + | 9.79 ± 7.32 | 0.22 ± 0.15 |
| | midfielders | 17.94 ± 8.86 | 0.39 ± 0.19 * | 11.84 ± 7.11 | 0.28 ± 0.17 |
| | forwards | 15.07 ± 26.14 | 0.33 ± 0.57 | 8.38 ± 5.05 | 0.2 ± 0.1 |
| **Number of recovery periods from 10–30 s** | defenders | 12.07 ± 8.53 + | 0.27 ± 0.19 + + | 9.04 ± 6.26 | 0.2 ± 0.13 |
| | midfielders | 14.84 ± 6.71 * | 0.33 ± 0.15 ** | 9.69 ± 5.79 | 0.24 ± 0.17 |
| | forwards | 13.57 ± 7.7 | 0.29 ± 0.17 | 8.48 ± 5.42 | 0.2 ± 0.11 |
| **Number of recovery periods from 30–60 s** | defenders | 11.16 ± 5.02 + + | 0.24 ± 0.11 + + + | 8.62 ± 4.5 | 0.19 ± 0.09 |
| | midfielders | 13.52 ± 5.3 ** | 0.3 ± 0.11 *** | 9.86 ± 5.23 | 0.24 ± 0.12 |
| | forwards | 12.67 ± 5 | 0.27 ± 0.11 | 9.15 ± 5.1 | 0.21 ± 0.11 |
| **Number of recovery periods from 60–120 s** | defenders | 9.88 ± 3.37 | 0.22 ± 0.07 | 9.56 ± 3.91 | 0.21 ± 0.08 |
| | midfielders | 10.38 ± 2.74 | 0.23 ± 0.06 | 9.49 ± 3.6 | 0.23 ± 0.07 |
| | forwards | 10.75 ± 3 | 0.24 ± 0.08 | 8.75 ± 3.38 | 0.21 ± 0.07 |
| **Number of recovery periods >120 s** | defenders | 5.14 ± 2.37 + + + | 0.11 ± 0.05 + | 6.12 ± 2.5 | 0.13 ± 0.05 |
| | midfielders | 4.37 ± 2.18 *** | 0.1 ± 0.05 * | 4.99 ± 2.43 | 0.11 ± 0.05 |
| | forwards | 4.75 ± 1.98 | 0.1 ± 0.04 | 5.7 ± 2.47 | 0.14 ± 0.07 |

Different from defenders, * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Different from midfielders, + $p < 0.05$; + + $p < 0.01$; + + + $p < 0.001$

(**Table 6**). Whatever the running speed, we observed a decrease in the distance covered between the first half and the second half, as well as a decrease in the number of recovery periods between 2 and 120 s ($p < 0.05$). On the other hand, there was an increase in the number of recovery periods above 120 s ($p < 0.01$) in the second half. In agreement with Mohr et al. [11], the last 15 min of play in the second half seem to be linked to a state of advanced fatigue, which would explain the increased number of recovery periods in excess of 120 s. The effect of the half on the various results is significant only when distances are expressed per minute of play. When distances are analysed in terms of raw values, however, as in previous studies, there is no significant difference between the first half and second half. This could be explained by the effect of substitutes on the distance covered in the second half. An incoming substitute would be able to cover large running distances even in the second half, and in an overall analysis of a match, this masks the real difference between the two halves on the performance of team members who have played the entire match. Thus, and in accordance with our study, Burgess [5] obtains significant differences between the first and second halves when values are normalised per minute of play. He notes that the occurrence of actions per minute is 11 % greater in the first half than the second half.

### Effect of position

Over an entire match, defenders have more playing time than other players (83 min, compared to 71 for midfielders and 67 for forwards). These differences are seen mainly in the second half. Playing time is not significantly different in the first half, contrary to the second half ($p < 0.05$). Defenders play an average of 46.07 min in the second half, compared to 42.08 for midfielders and 42.23 for forwards. The effort profile of a defender consists of 38.57 % walking, 29.97 % jogging, 13.62 % running between 13 and 16 km.h$^{-1}$, 8.30 % effort between 16 and 19 km.h$^{-1}$, and 9.54 % sprinting.

Midfielders cover significantly more distance than other players (129 m.min$^{-1}$ compared to 118 for defenders and 115 for forwards) ($p < 0.001$). The effort profile of a midfielder consists of 35.42 % walking, 29.94 % jogging, 14.68 % running between 13 and 16 km.h$^{-1}$, 9.59 % effort between 16 and 19 km.h$^{-1}$, and 10.38 % sprinting. The effect of this position is highlighted in many scientific sources [1, 5, 7, 10, 14]. These values, which are

higher than those for other positions, are explained by the dual role of midfielders, who participate in both offensive and defensive sequences of play.

Forwards cover the least distance in a match compared to other types of players, for both medium- and high-intensity actions. On the other hand, forwards cover a greater walking distance than other players. The effort profile of a forward consists of 43.82% walking, 26.95% jogging, 11.02% running between 13 and 16 $km.h^{-1}$, 7.39% effort between 16 and 19 $km.h^{-1}$, and 10.83% sprinting. Looking at the effort profile of forwards, we see that sprints account for a greater proportion than for other positions. Few injuries were observed during this season. Consequently, the playing time of forwards and middfielders can be explained by tactical choices according to changes in the score. A team which is leading will tend to take a forward out and replace him with a midfielder or defender. A defender, on the other hand, is far more rarely replaced. Whatever the score of the match, it will be a case of maintaining the result or preventing the gap from increasing to have a chance of equalising.

Concerning the recovery profile of players, we see no difference with regard to the distribution of recovery periods according to position. They are used homogeneously by players, and each recovery category established according to duration represents approximately 20% of the total number of recovery periods. After establishing a distance/recovery ratio for intermittent work, the quality of recovery (passive, semi-active, or active) could improve the physiological impact of this type of work and make it possible to individualise it according to the position of a player. It can be hypothesized that 4-4-2 formation had an influence on the distance and the time of work or rest during the match. For example, we believe that in a 4-3-3 formation midfielders and defenders would perform more distance during the attack phases of the game, and inversely for the other players.

## Conclusion

The objective of this study was to analyse the effect of playing position on the effort profile of top-class Italian league players within a team over the course of a season and to study the differences between the two halves on the brief, intense bursts of effort associated with changes in the duration of recovery periods. In terms of the overall analysis, our study shows that in 90% of cases, the intermittent effort profile is 2.2 s/18 s. This allows us to calculate a work/recovery ratio of 1/8. This observation points to a development of intermittent work at a supramaximal intensity in football such as to approach competition conditions as closely as possible. The establishment of the effort profile according to position allows a more precise analysis of a player's activity and therefore allows to adapt training sessions according to the requirements of the activity. In this study, we note a significant effect of the playing-half and the playing position on the development of fatigue when the variables studied are normalised per minute of playing time.

In a future study, it would be of interest to perform a longitudinal study of the changes in the various parameters during the season in order to analyse the periods corresponding to a state of major fatigue or overtraining in certain subjects.

## Acknowledgements

The authors would like to thank the medical soccer team staff and Roberta Macchi for their collaboration.

**Affiliations**

[1] Centre de recherche et d'Innovation sur le Sport, Université de Lyon, Université Lyon 1, France
[2] Internazionale Football Club, Milano, Italy
[3] SUISM, Fisiologia – Dipartimento di Biologia Animale e dell'Uomo, Università de Torino, Italy

## References

1 *Bangsbo J*, *Nørregaard L*, *Thorsø F*. Activity profile of competition soccer. Can J Sport Sci 1991; 16: 110–116
2 *Bangsbo J*. Physiology of soccer – with special reference to intense intermittent exercise. Acta Physiol Scand 1994; 151 (suppl 619): 1–155
3 *Bangsbo J*, *Michalsik L*. Assessment and Physiological Capacity of Elite Soccer Players. In: Spinks W, Reilly T, Murphy A (eds). Science and Football IV. London: Routledge; 2002; 53–62
4 *Bangsbo J*, *Mohr M*, *Krustrup P*. Physical and metabolic demands of training and match-play in the elite football player. J Sports Sci 2006; 24: 665–674
5 *Burgess DJ*, *Naughton G*, *Norton KI*. Profile of movement demands of national football players in Australia. J Sci Med Sport 2006; 93: 1–8
6 *Dawson B*, *Hopkinson R*, *Appleby B*, *Stewart G*, *Roberts C*. Comparison of training activities and game demands in the Australian Football League. J Sci Med Sport 2004; 7: 292–301
7 *Di Salvo V*, *Baron R*, *Tschan H*, *Calderon Montero FJ*, *Bachl N*, *Pigozzi F*. Performance characteristics according to playing position in elite soccer. Int J Sports Med 2007; 28: 222–227
8 *Edgecomb SJ*, *Norton KI*. Comparison of global positioning and computer-based tracking systems for measuring player movement distance during Australian football. J Sci Med Sport 2006; 9: 25–32
9 *Eniseler N*. Heart rate and blood lactate concentrations as predictors of physiological load on elite soccer players during various soccer training activities. J Strength Cond Res 2005; 19: 799–804
10 *Krustrup P*, *Mohr M*, *Steensberg A*, *Bencke J*, *Kjaer M*, *Bangsbo J*. Muscle and blood metabolites during a soccer game: Implications for sprint performance. Med Sci Sports Exerc 2006; 38: 1165–1174
11 *Mohr M*, *Krustrup P*, *Bangsbo J*. Match performance of high-standard soccer players with special reference to development of fatigue. J Sports Sci 2003; 21: 519–528
12 *Mohr M*, *Krustrup P*, *Bangsbo J*. Fatigue in soccer: A brief review. J Sports Sci 2005; 23: 593–599
13 *Rampinini E*, *Bishop D*, *Marcora SM*, *Ferrari Bravo D*, *Sassi R*, *Impellizzeri FM*. Validity of simple field tests as indicators of match-related physical performance in top-level professional soccer players. Int J Sports Med 2006; 28: 228–235
14 *Rampinini E*, *Impellizzeri FM*, *Castagna C*, *Coutts AJ*, *Wisloff U*. Technical performance during soccer matches of the Italian Serie A league: Effect of fatigue and competitive level. J Sci Med Sport 2009; 12: 227–233
15 *Stølen T*, *Chamari K*, *Castagna C*, *Wisløff U*. Physiology of soccer: an update. Sports Med 2005; 35: 501–536
16 *Tumilty D*. Physiological characteristics of elite soccer players. Sports Med 1993; 16: 80–96