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The Influence of Effective Playing Time on Physical Demands of Elite Soccer Players

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Abstract: This paper provides a large-scale study into the motion characteristics of top class soccer players, during match play, according to playing position. 432 top-class outfield soccer players were monitored during the 31 matches of the UEFA EURO 2008 using a computerized match analysis system. Data were analyzed using an analysis of variance (ANOVA) and a paired sample *t*-test. Results suggest that midfield players covered a significantly greater total distance than the groups of defenders and forwards did ($p < 0.01$). Significantly more distance was covered in the first half compared to the second (5136±468 m vs 5063±461, $p<0.01$). However, this difference may be explained by the fact that the effective playing time of the first half was significantly greater than the corresponding one for the second half of the match (27.4±2.2 min vs. 26.9±2.4 min, $p<0.05$). The findings suggest that the consideration of the effective playing time provides more precise information about competitive physicals demands.

Keywords: Association football, distance covered, match-analysis, positional role, time-motion analysis, tracking.

INTRODUCTION

Performance analysis of invasion games has received much attention in recent years. The analysis of performance is vital in soccer if the individual/team is to be successful. For many coaches the information gained from performances will not only form the basis of weekly training programmes, but also may act as the primary source for the scheduling of seasonal plans [1].

Over the last two decades, there has been a growing interest in match-analyses of soccer [2-6]. Match analysis refers to the objective recording and examination of behavioral events occurring during competition. Probably the main aim of match analysis is to identify the strengths of one's team, which can then be further developed, and its weaknesses, which suggest areas for improvement. Similarly, a coach analyzing the performance of an opposition side will use the data to identify ways to counter that team´s strengths and exploit its weaknesses [1, 7]. In this respect, match-analysis has been helpful in identifying the physiological demands of one particular event [8].

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 that mimics the physiological conditions imposed by the game.

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Similar to other field-based team games, the physiological demands of soccer are of an intermittent nature [3, 4, 6, 8-10]. A major limitation of previous match-analyses is that the findings were based on small sample sizes [8]. The purpose of this investigation, therefore, was to provide a large-scale study of top class soccer players and examine the total distance covered according to positional roles during the 31 matches of the UEFA EURO 2008, using a computerized time-motion analysis system. Besides, previous investigations have considered total distances travelled by players during matches as a whole making no differences between ball in play and ball out of play [11-17]. In our opinion, the fact that the effective playing time is a smaller part of the total duration of a soccer game may affect the way we should interpret earlier conclusions, and lead us to a more realistic understanding of the physiological demand of soccer competition.

METHODS

Subjects

A total of 31 matches from the finals tournament of the UEFA Euro 2008 celebrated in Austria and Switzerland were used for analysis. Twenty-four of them corresponded to the group stage, and the other seven games corresponded to the second phase, knockout stage.

Movements of all 20 outfield players (goalkeepers were excluded) of the two competing teams were observed during the whole game duration in all those 31 matches. Altogether, 432 players were profiled.

The match analyses data on these players were used to verify differences among playing positions and quantify demands placed on the players in each of the individual positions. The protocol was approved by the local university ethics committee.

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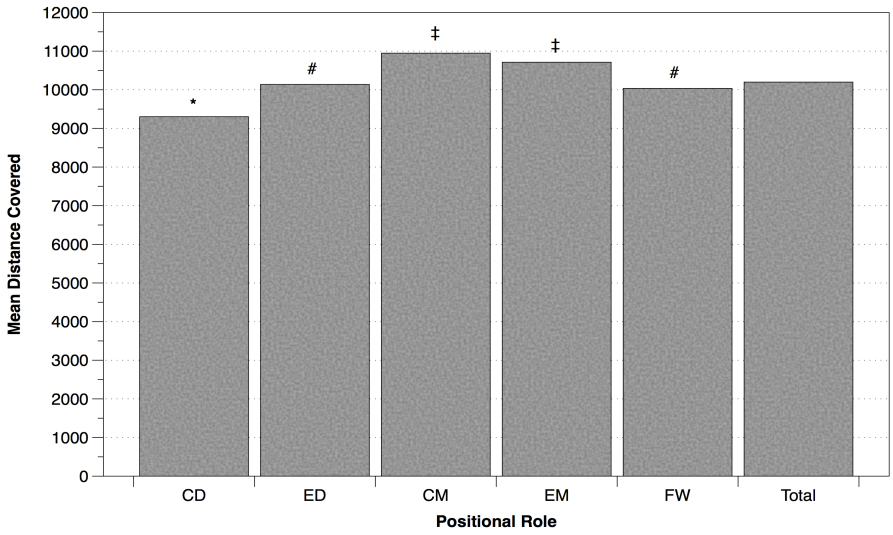

Fig. (1). Differences in distance covered during the entire match depending on the player's positional role (mean ± s).*Significantly smaller than any other groups, #significantly different from CD, CM, and EM, and‡ significantly greater distance covered than CD, ED, and FW, all for $p<0.01$.

The techno-tactical profile of each player was defined according to the categories used by Di Salvo *et al*. [8]. This profile is based on the different activity on the pitch, and the primary area in which this activity was carried out. 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 (FW) resulting in the following numbers of subjects in the different subgroups: CD (n = 112); ED (n = 102); CM (n = 111); EM (n = 57); FW (n = 52). This assignment was done according to the information provided by the official webpage of UEFA EURO 2008 (euro2008.uefa.com) and the webpage run by Castrol Limited (www.castrolindex.com) with statistics about the tournament.

Data Collection Procedures

A semi-automatic computerized player tracking system **(**TRACAB Image Tracking System™, Solna, Sweden) was used to characterize match activity profiles. Eight pairs of cameras were installed around the pitch, controlled by a cluster of computers. This multiple-camera system passively tracks the movements of every player, in true real-time. The video stream captured by the cameras is analysed by the TRACAB Image Tracking System™.

The "capture, process, delivery" process is carried out in true real-time, i.e. faster than 1/25 of a second. The outcome of the analysis is a data feed with X, Y and Z coordinates as well as speed and acceleration for all objects. The precision of the measurements is < 0.1 m [18]. The overall distance covered by each player was recorded. The absolute data were corrected to a minute- by-minute analysis of the distance covered in each category (distance divided by effective time played) to enable equal comparison of work-rate over the time period played by each player. The data are presented for 15 min periods.

Effective Playing Time

Effective playing time refers to the duration of play after subtracting the time taken up by stoppages, substitutions, goals and injuries, etc., in other words, subtracting the amount of time in which the ball is out of play [19].

The effective playing time was analyzed through systematic observation by two experienced observers. Reliability was assessed through intra- and inter-observer testing procedures. Subsequently, inter-observer reliability was assessed using data from the first coding session. Kappa (k) values were 0.94 and 0.89 for intra-reliability and inter-reliability, respectively.

Statistical Analyses

Statistical analyses were performed using the SPSS for Windows®, version 17.0 (SPSS Inc., Chicago, IL, USA), software package. Data were analyzed using different methods: one-way analysis of variance (ANOVA) to examine the relation between total distance covered at different positional roles, analysis of variance with repeated measures to examine the total distance covered by players depending on the total effective play in periods of 15 min and to analyze the distance covered by every positional role in group phase and knockout stage, and a t- test for dependent samples to examine differences between distances covered by the players in the first and the second halves. Whenever ANOVA was applied and any significant differences detected, posthoc multiple comparisons were made using Bonferroni's correction. For all analyses, significance was accepted at $p<0.05$. Data are presented as means ± *s*.

RESULTS

Mean total distance (± s) covered over the period of the whole match by all players independent of positional groups was 10199 ± 875 m, ranging from 7645 to 12743 m. The mean total distance (± s) covered over the period of the whole match by the different positional groups is shown in Fig. (**1**).

Time-motion analyses of the observed soccer matches demonstrated that CM and EM players covered a significantly greater distance ($p<0.01$) than CD and ED, as well as FW. The distance covered by the CD, however, was signifi-

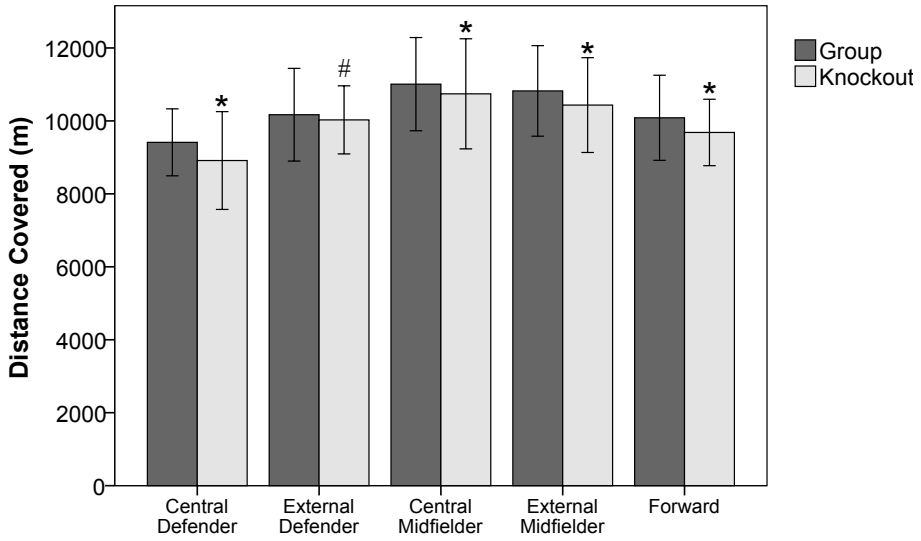

Fig (2). Distance covered by every positional role in group and knockout stages.*significantly smaller than the same positional role in the group phase ($p < 0.01$), and#significantly smaller than the same positional role in the group phase ($p < 0.05$).

cantly shorter ($p<0.01$) than that of any other group, whereas ED did not differ from FW.

Respect to the first versus second half variations taking into account effective playing time, total distance covered by the players in the first halves of the games was significantly greater than in the second halves (5136±468 m vs 5063±461 m, $p<0.01$). However, this difference may be caused by the variation of the total effective playing time between first and second halves of the games. The mean of the effective playing time for the whole match was of 54.4 ± 4 min but the mean value of effective playing time of the first half is significantly greater than the corresponding one for the second half of the match (27.4±2.2 min vs. 26.9±2.4 min, $p<0.05$). The comparison of the ratio between distance covered and effective playing time shows that mean distance covered in the second half is slightly greater than in the first half without significant difference (188.39 $m \cdot min^{-1}$ vs. 188.76 $m \cdot min^{-1}$).

In order to test the consistency of the earlier finding we looked into the relation between the distances covered by the players every 15 min of the match and the effective playing time of these same periods (Table **1**).

The application of the ANOVA with repeated measures to the analysis of the distance covered by the players in each of the 15 min periods revealed a variation in the distribution of the total distance covered by the players along the whole match. It´s must be noted that extra time was included in the last 15 min period of the corresponding half. The distance covered by the players in T_6 was significantly greater than the distance covered in the rest of the periods of the match. The distance covered by the players in $T_5$was significantly smaller than in T_1, $T_2$and $T_6$and shows the smallest value of all periods. The comparison between the effective playing time in all of the 15 min periods reveals the greatest values in the last 15 min of each half ($T_3$and T_6). On the contrary, T_5shows the smallest effective playing time value.

The relation between the total distance covered in the 15 min periods of the game and the effective playing time of each period showed no differences in the mean values of the distance covered by the players, ranging from 188.3 ± 26.1 $m \cdot min^{-1}$ in T_1(1-15 min) to 191.9 ± 25.1 in T_5 (61-75 min). The only significant difference was found between $m \cdot min^{-1}$ covered in T_5, greater than in T_1.

The interaction between the positional roles of the players, the total distance covered in each game and the stage of the tournament allows us to show the significant decrement of the total distance covered by the players in the two stages of the championship. Fig. (**2**) shows that the players covered shorter distances in the knockout stage than in the group stage in all positional roles (8913 ± 670 vs 9411 ± 459 for CD, $p<0.01$; 10027 ± 476 vs 10170 ± 639 for ED, $p<0.05$; 10741 ± 754vs 11007 ± 630 for CM, $p<0.01$; 10434 ± 649vs 10822 ± 620 for EM, $p<0.01$; and 9683 ± 455vs 10080 ± 583 for FW, $p<0.01$).

DISCUSSION

The current study aimed to quantify the work-rate profiles of elite soccer players according to their positional role. Although large discrepancies exist in published data (for review see [5]) for the distance covered by players in soccer matches, our results are in accordance with recent investigations using sophisticated measurement technologies, which show that mean distance covered by elite male outfield players ranging from 9000 to 1200m [8, 9, 19].

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 ($p < 0.01$) than both defender groups, as well as the group of forwards. The CD, however, covered the shortest distance. Recent data confirm the results of the current study. The 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 [5, 20-22].

The comparison of the $m \cdot min^{-1}$covered by the players in the first and second halves did not show significant differences in opposition to previous studies [4, 15, 21].

Table 1. Distribution of the Total Distance Covered, Effective Playing Time and Distance Covered in Meter Per Min in Periods of 15 Min

Period		Total Distance Covered (m)	Effective Playing Time (min)	Ratio m·Min^{-1}
T_1	0-15 min	1738±195*	9.4±1.0*	188.3±26.1
T_2	16-30 min	1630±179$^{\#}$	8.6±1.3$^{\#}$	192.1±27.9
T_3	31-45 min	1767±196*	9.5±1.1*	188.4±26.1
T_4	46-60 min	1639±174$^{\#}$	8.7±1.1$^{\#}$	189.7±28.9
T_5	61-75 min	1566±175$^{\#}$	8.2±1.1‡	191.9±25.1*
T_6	76-90 min	1856±216‡	10.0±1.1^{+}	188.7±30.4

Total distance covered: * significant differences with T_2, T_4, $T_5$and T_6,$^{\#}$significantly smaller than T_1, $T_3$and T_6, and‡ significantly greater than T_1, T_2, T_3, $T_4$and T_5.Effective playing time: * significantly greater than T_5,$^{\#}$significantly smaller than T_6,‡significantly smaller than T_1, T_3 and T_6($p<0.01$), and^{+}significantly greater than T_2, $T_4$and T_5(all for $p<0.01$).Ratio meter per min: * significantly greater than T_1($p<0.05$).

Differences in sample sizes, differences in the level of the players and advances in the technological support for data collection may explain the differences found. Besides, the comparison of the ratio between distance covered and effective playing time shows that mean distance covered in the second half is greater than in the first half without significant difference (188.39 m·min^{-1} vs. 188.76 m·min^{-1}). The smaller mean value of the effective playing time in the second half (27.4 ± 2.2 m vs. 26.9 ± 2.4 m) ($p<0.05$) may explain the shorter total distance covered by the players in the second half.

The mean value of the effective playing time for all the observed games was 54.4 ± 4 min. Even so, the distribution of the ball in playtime was not constant along the match, ranging from 8.2 ± 1.0 min in the period between 61-75 min to 10.0 ± 1.0 in the period between 76 to 90 min. The variation of the quantity of interruptions and the time added by the referee at the end of each half may explain this fact. Therefore, in the last 15 min of each half ($T_3$and T_6) there was more effective time to play and in consequence the mean overall distance covered by the players shows an uneven distribution along the match. Mean distance covered in T_6(75-90 min) was significantly greater than in any other period of the game and mean distance covered in T_3(31 - 45 min) was greater than in periods T_2, T_4, and T_5. We have hardly found differences between the distance covered by the players when we relate the values of the distances covered in the 15 min periods and the effective playing time of the same periods, similar to the results found by Di Salvo *et al*. [8]. To a better understanding, some other contextual variables should be taken into consideration, such as the game location, the opponent's competitive level and the score [1, 10, 23].

The results of this study point out that the overall distance covered by the players may be affected by the format of the competition. Fig. (**1**) shows that the players covered shorter distances in the second phase of the competition (knockout stage) than in the first one (group stage). Probably, the knockout system makes the players more aware of the score and its consequences, whereas in the first phase there is a smaller level of competitive pressure.

A limitation of the present study is that the contextual variables of match status (i.e. whether the team is winning, losing or drawing), and the quality of the opposition (strong or weak) were not taken into account. It is likely the workload of players according to their position is affected differently depending on the contextual variables involved.

CONCLUSIONS

The main findings of the present study were that effective playing time should be taken into account when analyzing the physical demands of elite soccer player., and variations on the workload of the players could be not only linked to fatigue but also to the strategic management of the playing time. In addition, contextual variables (e.g. format of the competition, venue, match status, quality of opposition) can be employed to a better understanding of the underlying mechanisms that explain the behavior of soccer players in competition.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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Declared none.

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