COVERED DISTANCES ANALYSIS OF BRASILIAN PROFESSIONAL SOCCER PLAYERS OBTAINED BY AN AUTOMATIC TRACKING METHOD

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The aim of this study is to present and analyse the covered distances of soccer players obtained automatic and simultaneously. Four matches of eight different teams of the Brazilian 1st Division Soccer Championship were filmed. Applying a previously developed automatic tracking method, the results of 55 outline players who participated in the whole game (n=55 players) are presented. The results of mean covered distance and standard deviations after 90 minutes are 10,012 ± 1,024 m. The mean covered distance in the 1st half was 5,173 m (± 394 m) highly significantly longer ($p<0.01$) than the mean 4,808 m (± 375 m) in the 2nd half time. Comparing the median covered distance minute-to-minute in both periods, the statistical tests revealed that after the fifth minute the data from 1st half presented highly significant differences compared to the data of the 2nd half. These results are compared with the findings of previous studies.

KEY WORDS: soccer, covered distance

INTRODUCTION: The most spread method to analyse soccer players´ covered distances is based on visual estimates. It consists of visually classifying the players' type of movements (e.g. standing, walking, jogging and sprint) and quantifying how long each player remains in each one. The covered distances are calculated by the product of the time remained in each type of movement and the average velocity in each one, obtained previously in controlled experiments (Reilly and Thomas, 1976, Withers et al., 1982; Bangsbo et al. 1991, Mohr et. al. 2003).
Many researchers have proposed new methods to overcome the time-consuming nature and low accuracy of the estimation methods. An alternative approach is the use of methods based on sensor-transmitters. These methods are potentially able to supply the real-time and simultaneous measurements of many players' positions during the game, but they request that the players carry devices attached to the body and many receivers conveniently positioned (Hennig and Sterzing, 1999, Hennig and Briehle, 2000, Holzer et al., 2003).
Methods based on image have also been proposed, but they present only partial results. In D'Ottavio et al., 1993; Ohashi, et al., 1987; Ohashi et al., 2002, only one player was tracked in each game. In Taki et al, 1996, Iwase and Saito, 2004 all players were tracked, but just for a short period of time. In Toki and Sakurai, 2005, all players were tracked during the whole game, but manually (frame-by-frame).
In previous works, we presented a video-based automatic tracking method to obtain the players' positions in function of time (Barros et al., 2001; Figueroa et al. 2003). The method provides the players' positions automatically in 94% of the processed frames (Figueroa et al. 2006). An interface is used to manually complete the trajectories in the situations where the automatic tracking fails. The method presents relative errors of 1.4 % in the determination of the covered distance (Misuta et al., 2003), being more accurate than visual estimates. The aim of this study is to present and analyse the covered distances of soccer players obtained automatic and simultaneously in four whole games.

METHODS: Four matches of eight different teams of the Brazilian 1st Division Soccer Championship were filmed. An informed consent to analyse the images was given by the TV networks that possessed the image rights. Four digital cameras (JVC, model GR-DVL9500) were conveniently placed in the highest location of the stadium. Each camera covered approximately a quarter of the whole field. In order to reduce the amount of data to be processed, the video sequences were analysed at 7.5 Hz.
Applying the mentioned automatic tracking method, one hundred and twelve players were tracked in the four games. In order to allow comparisons, we presented just the results of the

outline players who participated in the whole game (n=55 players). The analysis was limited to 45 minutes in both half periods.
The covered distance was calculated as the cumulated sum of the player's displacement between two successive sample times (0.133s) over the time interval. The covered distance in function of time of all players of one team was used to represent simultaneously the performance of the athletes and the dynamic of the game (Barros, 2005).
The statistical differences between the mean covered distance of the 55 players in the 1st and 2nd halves were tested using a two sample t-test ($p<0.01$), after testing the normality of the distributions (Lilliefors test, $p<0.01$), and compared with the results found in the literature.
The statistical differences between the median covered distance of the 55 players in the 1st and 2nd halves were also minutely verified in order to determine when the distributions start to be different. In this case, the Kruskal-Wallis non-parametric test was applied ($p<0.01$).

RESULTS: The results of covered distances in function of time by the players of the teams A and B are shown in the figure 1.

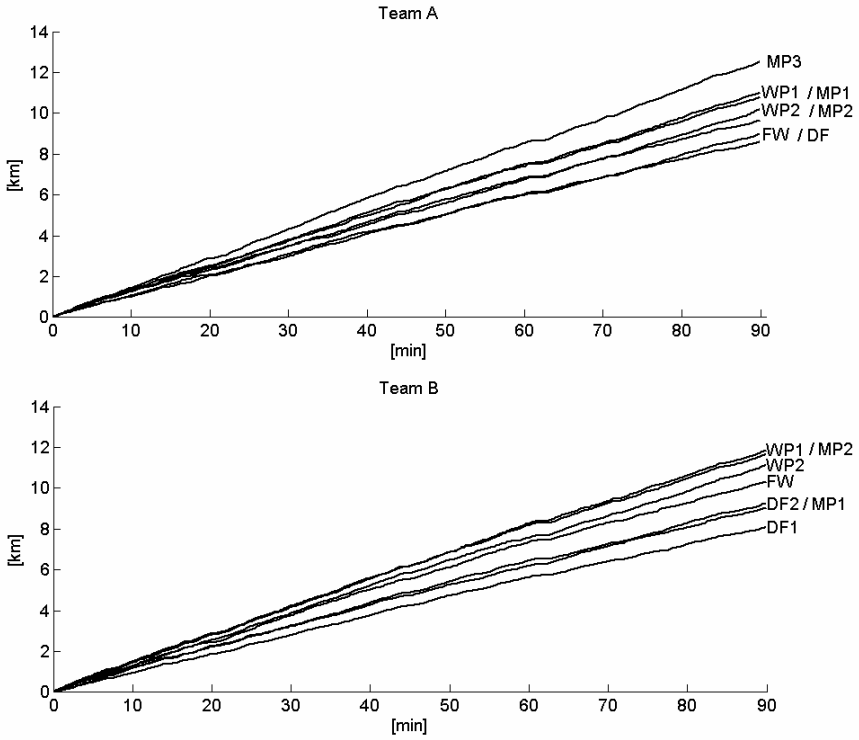

Figure 1: The cumulated covered distances by the players of the teams A and B (90 minutes of the game). The players are identified as defender (DF), wingplayer (WP), midplayer (MP) and forwarder (FW).

This representation allows distinguishing individual player's performances and simultaneously observing some aspects of the dynamic of the game. For instance, the midfield player (MP3) of the team A has better performance than others players during the whole game. Furthermore, it is possible to recognise that the curves of all players presented a little plateau around the minute 62, revealing a reduction of the average velocities. Inspecting the video, we identified that this period corresponded to an interruption in the game.
The results of mean covered distances and standard deviations (in brackets) after 90 minutes were 10,012 m (1,024 m), ranging from 8,053 m to 12,522 m. The data presented normal distribution ($p<0.01$).
The results of 1st and 2nd halves were, respectively, 5,173 m (394 m) and 4,808 m (375 m). The shortest and the longest covered distance in the 1st half was 4,219 m and 6,454 m and in the 2nd half was 3,637 m and 6,067 m. The mean covered distance in the 1st half was

highly significantly longer ($p<0.01$) than in the 2nd half (decrease of 7 %). Fifty one players (93%) covered longer distances in the 1st half.
The curves presented in the figure 2 correspond to the median covered distance of the 55 players in the 1st and 2nd halves in every one minute. The vertical bars correspond to the 95% confidence interval for the median. In the statistical tests performed, after the fifth minute the data from the 1st half period presented highly significant differences compared to the data of the 2nd half.

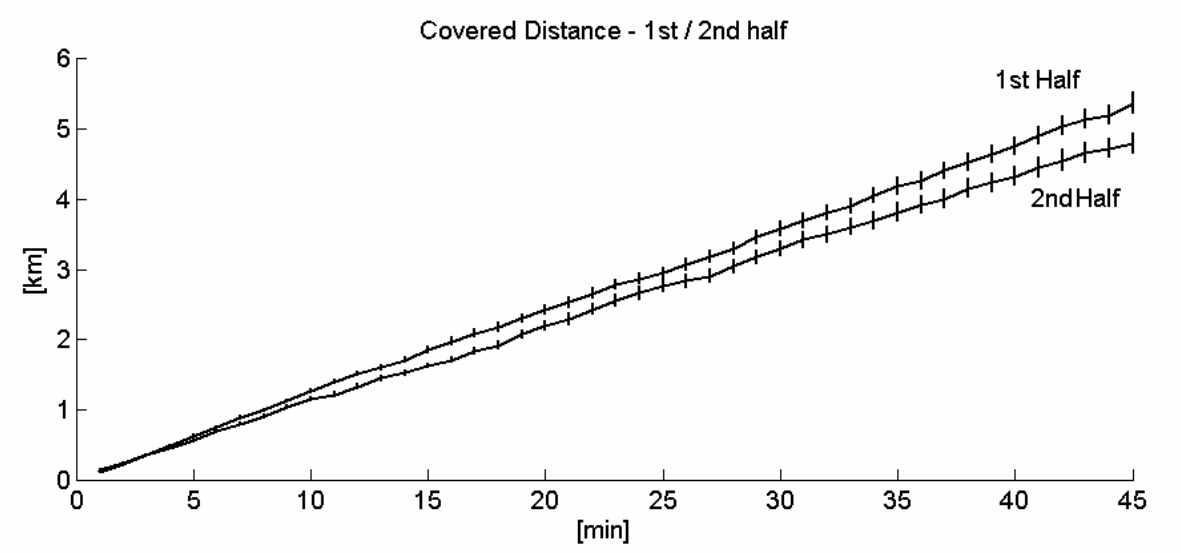

Figure 2: The median and confidence intervals of the covered distance by the players in the 1st and 2nd half.

DISCUSSION: In this paper, we presented the results of covered distances in function of time of the 55 outline Brazilian soccer players obtained by an automatic tracking method. The results of mean covered distance presented in this paper (10,012 m) are close to the obtained by Mohr et al. (2003) and Hennig and Briehle (2000) that found respectively 10,860 m and 10,600 m. However, the results differ of the studies of Reilly and Thomas (1976) and Withers et al. (1982) that presented respectively 8,680 m and 11,520 m. Of course, these similarities and differences can be explained by the methodological differences among the studies, such as, the method to obtain the covered distances or the criteria to select the players.
A more consisted result is related to the decrease of the covered distance in the 2nd half period (7%). Previous studies reported similar values: 3 % (Mohr et. al. 2003), 4 % (Hennig and Briehle, 2000) and 5 % (Bangsbo, 1991).
Beyond the covered distance description about the performance of Brazilian professional soccer players, another original contribution of this paper revealed that the players performances decrease continuously from the beginning of the 2nd half period, not only at the end of the game (Mohr et al 2003, Bangsbo et al., 1991, Reilly and Thomas, 1976).

CONCLUSION: In this paper, the covered distances by Brazilian professional soccer players during official matches were characterised using a novel and accurate video-based automatic tracking method. Furthermore, the analyses revealed continuously decrease in the covered distance since the fifth minute comparing the 1st and 2nd periods.

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