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KINEMATIC ANALYSIS OF THE DISTANCES COVERED BY BASKETBALL ELITE PLAYERS DURING GAMES

[1]Ana Carolina Panhan, [2]Juliana Landolfi Maia,[2]Lucas Antônio Monezi, [1]Milton Shoiti Misuta and [1]Luciano Allegretti Mercadante
Laboratory of Biomechanics and Instrumentation, School of Applied Sciences, University of Campinas, Brazil
e-mail: carol_panhan@hotmail.com web: www.fca.unicamp.br

INTRODUCTION

One important aspect in recent studies regarding basketball is the description of the players' movements as a function of time considering their different positions (i.e., distances covered and displacement velocity), which provides the characterization of volumes and intensities of the efforts made by the players during the games.

Distances covered by basketball players are presented in the literature by few authors [3,6]. Analyzing 18 Tunisian elite players in six games, [3] found an average distance covered of 7558.0 ± 575.0 m, whereas [6] recently observed significant differences between distances covered by guards (6390.0 ±48.0 m), forwards and centers (6230.0 ± 26.0 m) in two games. As basketball is a timed sport and with large numbers of substitutions, it is interesting to separate the distances covered for the periods of live and dead ball and normalize them by time played, getting the most accurate information on performed movements. The aim of this study was to analyze the distances covered by basketball players, detailing periods of live ball and dead ball, and to verify significant differences between the quarters and the players´positions in the team.

METHODS

A 2011/2012 season game of the main Brazilian male championship, New Basket Brazil (NBB), was filmed by four digital cameras (JVC, model GZHD10), statically positioned at the corners of the gym, at the highest possible point from the ground (approximately 12 m), so that each camera would film the whole basketball court. The study was approved by the Research Ethics Committee of UNICAMP (Campinas, Brazil, No. 1008/2010), and the footage was authorized by the Brazilian Basketball League (LNB), responsible for the championship.

After the acquisition of the images, the measurement of screen coordinates, calibration and temporal synchronization of the cameras, and the reconstruction of 2D coordinates of the players on the court, were held in the System DVideo. The sample analysis frequency was 7.5 Hz, and the measurement process of the screen coordinates was performed manually for all 12 players participating in the game, and the player's position on the screen was estimated by the operator on each frame, considering the projection of its center of mass on the basketball court. For the calibration process of the cameras, there had been used 16 visible points on the basketball court, with coordinates 2D measured by a measuring tape (Leica DISTO D5), and for the temporal synchronization it had been used the transition of the numbers of the shot clock, visible in all the cameras. The 2D reconstruction of players´ position on the basketball court was based on the Direct Linear Transformation method (DLT), proposed by [1]. The position reconstruction of the 16 points of the calibration system was performed to verify the accuracy of the system. The mean errors found were of 0.045 and 0.041 m, respectively, for the x and y coordinates of the reference system.

The distances covered were calculated by the cumulative sum of the displacements between two successive frames. The time division between live ball and dead ball was performed automatically after filming the scoreboard, using the methodology proposed by [5]. These distances covered were described by positions, considering the accumulated sum when there were substitutions. To accomplish the proposed comparisons, the players were divided into three classes: guards, forwards and centers. It was used analysis of variance (ANOVA) to investigate significant differences between distances covered per minute, between positions and the quarters.

RESULTS AND DISCUSSION

The players covered on average a total of 6519.7 ± 290.3 m; 1553.1 ± 903.4 m in the first period, 1547.6 ± 842.8 m in the second period, 1780.3 ± 971.4 m in the third period and 1638.7 ± 928.3 m in the fourth period, considering the five players on the basketball court and accumulating distances when there were substitutions.

The average distances covered by the players, both total and per minute with live ball were, respectively, 1853.4 ± 953.3 m and 115.9 ± 11.9 m and with dead ball there were, respectively, 863.0 ± 479.6 m and 60.1 ± 29.7 m. The results show that the players have covered more distance with live ball rather than with dead ball (paried t-test, $p < 0.001$), because in the periods of live ball occur relevant actions of the game.

Table 1: Distances covered and per minute of the whole game (d_t and d_m), with live ball (dt_v and dm_v) with dead ball (dt_m and dm_m) of each player.

Player	d_t (m)	dm (m/min)	dt_v (m)	dm_v (m/min)	dt_m (m)	dm_m (m/min)
1	4276.8	77.5	3080.3	117.6	1196.3	41.2
2	2200.9	77.8	1482.9	120.6	718.0	44.9
3	4074.2	84.0	2681.2	114.1	1393.0	55.7
4	2235.2	88.0	1552.2	142.4	682.9	47.1
5	4749.6	81.3	2983.6	103.6	1765.9	59.9
6	3113.6	78.8	2104.3	115.0	1009.2	47.6
7	3386.4	82.4	2436.2	109.7	950.1	49.2
8	2489.4	70.5	1608.4	104.4	880.8	44.3
9	3168.1	75.6	2260.2	113.6	907.2	41.2
10	277.8	125.7	185.4	114.8	92.4	130.6
11	2384.5	86.1	1706.4	133.3	678.1	45.5
12	241.8	109.9	159.7	101.9	82.0	113.5
Total	**32598.3**	**1037.6**	**22240.8**	**1391.0**	**10355.9**	**720.7**
Mean	**2716.5**	**86.5**	**1853.4**	**115.9**	**863.0**	**60.1**
SD	**1412.7**	**15.7**	**953.3**	**11.9**	**479.6**	**29.7**

Significant differences were found for distances covered per minute with live ball (p=0.0002) and dead ball (p=0.0005) between the fourth quarter and the first three quarters of the game. There were no significant differences for the distances covered between the players' position (p = 0.58) and between the quarters (p = 0.44), nor for distances covered per minute between positions (p = 0.71) and between the quarters (p = 0.32). There were not also found significant differences for total distance covered with live ball per players position (p = 0.65) and per quarter (p = 0.15), for distance covered per minute with live ball per players position (p = 0.26), total distance covered with dead ball per position (p = 0.41) and per quarter (p = 0.18) and for distance covered per minute with dead ball (p = 0.82).

By comparing our results with those that have been already found in the literature, it may be noted that the players had an average performance similar to the Australian elite players [6] and Tunisians elite players [3] covered, during a game, a little more of d and 1000 m distance. It is considered that [3] used an automatic tracking system, however, do not specify the conditions of this tracking and do inform the percentage of the automation process. It is known that manual intervention is required by the operator in the measurement process, especially in player's occlusion situations. Values of 96% of the measurement process automation were presented by [2] in tracking of professional soccer players, where the author also discusses the difficulties of automatic tracking. In the most recent study of [6], tracking the players was also performed manually, at the same sample frequency.

The average distance covered per minute made by the players was 86.5 m/min, the average distance covered per minute presented by [4] for handball players was 77.2 m/min, smaller than the obtained values for soccer elite players of 111.2 m/min, presented by [2], certainly in terms of dimensions of space game. The scoreboard of each quarter and variables, such as the number of offenses, number of fouls and total duration, can interfere with the distance covered by players.

CONCLUSIONS

The method proved to be applicable in an official game, providing useful information on the movement of basketball players and their physical fitness. Significant difference in distances covered per minute in live ball and dead ball, between the fourth quarter and the other periods of the game, can be credited to the importance of the last quarter in the definition of the winner of the game, because there are no differences between the third and fourth quarters in the variables: number of offenses, number of fouls and total duration. The results of the distances covered per minute are of great importance for coaches and trainers of basketball teams, allowing them a better planning regarding the players' physical fitness.

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