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Last minute in NBA games

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LAST MINUTE IN NBA GAMES

KEYWORDS: Basketball, NBA, Fractal, Performance.

ABSTRACT: Apparently the behavior during a basketball game, as in other team sports, shows tremendous variability manifested in both individual and collective ways. However, when a significant number of games are studied, we can observe the unpredictability that characterizes the game. The degree of complexity of the game is not stable. Patterns change during all the game time, but the last minute is completely different reality. Our aim was to test and evaluate the existence of these patterns and their apparent complexity, by analyzing the NBA games scoring and substitution dynamics. Therefore, we examined the difference between the last minute and the rest of the game from the collected scores (1, 2 and 3 points), substitutions and timeouts. The underlying chaotic behavior of non-linear interactions is inherent in Complex Systems. The data showed the existence of symmetries and repeated patterns of play during basketball games of the NBA but the last minute, which can be considered a completely different game.

Basketball is a collaboration-opposition sport, where teams struggle to prevail over his rival. Throughout all the game time, behavior patterns characteristic of each period are shown, up until reach the last minute. At this stage, in the last minute of the game, the dynamic of the game is different from the rest, emerging new patterns of game where certain characteristic elements of the game such us fouls, substitutions, timeouts, etc., acquire more weight.

Despite its complexity, we observe patterns that explain the nature of the game, this allow us establishing strategies that lead to optimize performance in a game or competition. Non-linear systems can display a variety of behaviors, including: self-organization, emergency, order-chaos, networks, fractal, etc. (Chatterjee and Yilmaz, 1999; de Saá Guerra et al., 2012; Gould, 1989; McGarry, Anderson, Wallace, Hughes and Franks, 2002; Ribeiro, Mendes, Malacarne, Pîcoli and Santoro, 2010; Yilmaz and Chatterjee, 2000).

In this work, we will study the evolution of game dynamic from the collected scores (1, 2 and 3 points), substitutions and timeouts. These systems are not random but characterized by high sensitivity to initial conditions (e.g. rules, scores, game time, etc.) therefore slight changes in the beginning may result in significant different responses, what characterizes them as chaotic systems. Initial conditions are never perfectly known but inherently unpredictable.

This effect of chaos, is particularly evident in the last minute, where if the game is competitive, the result is very unpredictable, which becomes this sport in something particular and where the last minute can be extended over time, creating a state of high expectation on fans.

Method

Sample.

We analyzed 5 NBA regular seasons (6.150 games). We used the official statistics published by NBA which describe all the events that occur during the game: two and three point shots, free throws, rebounds, turnovers, violations and substitutions. We also analyzed the last minute of each quarter, without taking into account the team. From the analysis of the histogram of the differences in points at the end of each game, de Saá et al. (2013) find a Power Law distribution which basically identifies two situations related here: competed games, which finalized by less than 11 points difference and the non-competed games.

Procedures.

The number of points scored per minute in principle should follow a random process characterized by the Poisson distribution. This distribution is characterized because the ratio between the variance and the mean, known as the Index of Dispersion (ID), is one. For other results there are two cases:

- The first one happens when the Index of Dispersion is less than 1. This is considered as under-dispersed, which means that the probability data are more clustered around the mean making

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more predictable. This condition is related with more regular patterns than the randomness associated with Poisson. Points are scattered more regularly.

- The second one, when de Index of Dispersion is more than1, called over-dispersed, indicates larger data dispersion. This case usually treated by testing a negative binomial distribution. This case points out the possible existence of clusters in data throughout time.

Results

The number and kind of score changes regularly in each phase of the game and at the beginning, half and end of each quarter (Figure 1). Unlike what happens in each game phase, the last minute presents a score significant increase, especially in 1-point baskets. We also observed a totally different score distribution in each phase.

The Figure-2 shows the evolution of the number of substitutions of each player every ten seconds of the game, emphasizing game key moments (upper plot).

In the next plot (Figure 3a) we show the comparison substitutions evolution according to the level of uncertainty of the final result (competed games vs. non-competed games). As a consequence, we show graphically the relationship between this parameter and the timeouts used by teams (Figure 3b). Note that, idem with the points scored, there is a self-similarity between the first and second half and between the first and third quarter. Significant changes are only observed at the end of the last quarter, where both parameters are clearly different from the second.

Substitutions in the last minute vary according to the score achieved during the last minute of the game. Games with a high uncertainty present a higher number of events, in comparison to those which are already decided, therefore, the number of events is reduced.

Discussion

Apparently, basketball games show a high variability in individual and collective actions. However, when we analyze a significant sample of NBA basketball games, within their unpredictability, we observe repetitive behavior patterns such as free scale (de Saá et al., 2011; de Saá et al., 2013; Gabel and Redner, 2012; Vaz de Melo et al., 2012). These behaviors are detected repeatedly but specifically for each variable during the NBA games of the regular season.

However, the degree of complexity is not always the same. Patterns change between the first and second half of the game, first and third quarter compared to the second and fourth, or the first, half and end of each quarter. Furthermore, unlike what happens during the rest of the game, when the game is competitive, in the last minute the game dynamics change significantly, thus has an influence in the substitutions of the players, game systems, personal fouls and, of course, number of baskets scored per unit time, ID (variance/mean) and the result of the game.

Also, there is a clear difference in how points are scored during the last minute of the game in comparison with the rest of quarters. At the end, most points are scored at intervals of ≤10 seconds, while in the rest of quarters most of the points are scored at intervals of 12 and 24 seconds. In table 1 note that between zero and three points, the distribution of one, two or three point shots are similar to any other stage of the game, except that the percentages of triple is greater. Between 4 and 9 the number of Free Throws is higher, and over 10 is dominant, being clearly a case of extreme complexity, dominated by fouls and the time remaining as a limiting factor.

The use of timeouts is a special characteristic of basketball that allows managing the game time depending on the needs of each team (Saavedra et al., 2012a; Skinner, 2011). Some authors consider this element as a team strategy to alter the game

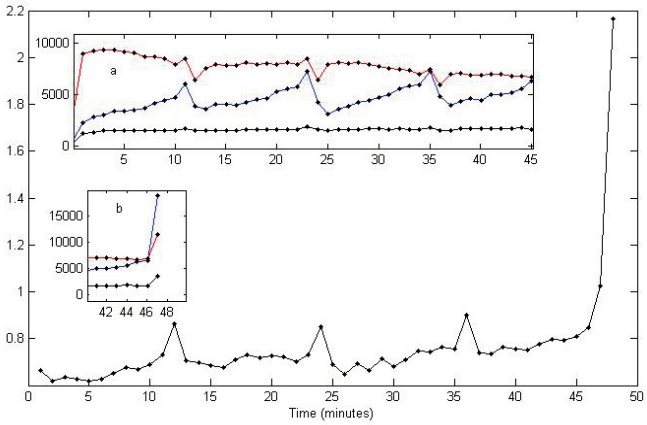

Figure 1. Index of Dispersion of the point scored by minute. We can observe that the trend of the values is to rise over time. Only at the end of each quarter there are a significantly increase, closer to 1, but only at the minute 47 reach the value 1 (pure Poisson). The minute 48 is completely out the range of the rest of the game, reaching values higher than 1. The minute 48 requires special attention. As we can observe, the minute 48 exceed the value 1 significantly (over-dispersed). This suggests that the last minute in a basketball game is a completely different process than the rest of the game, meaning the game has changed its dynamic. The subplot "a" represents the sum of points every minute throughout the game time until minute 45. The red line represents 2 points, the blue line 1 points and the black line 3 points. The subplot "b" shows the difference the last minute, where it is emphasized that the number of failures is much higher.

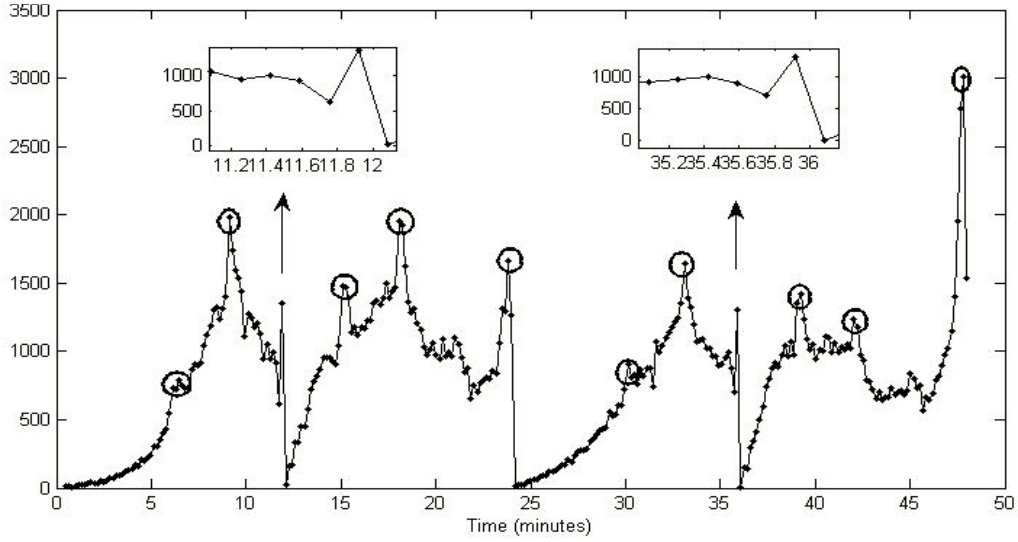

Figure 2 evolution of the number of players substitutions every ten seconds of the game, highlighting the game key moments (upper plots).

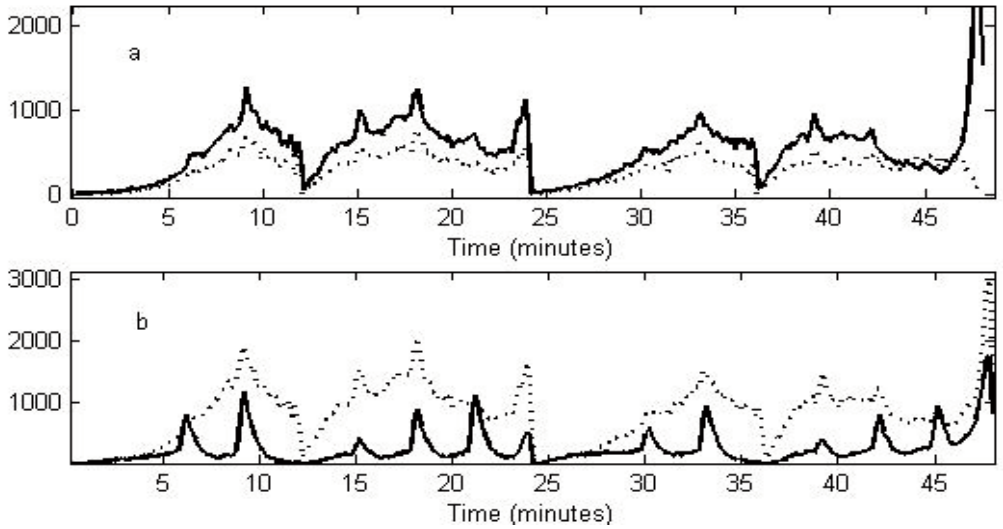

Figure 3 : Subplot A: compares the evolution of substitutions according to the level of uncertainty on the final scores (competitive games vs non-competitive games). Subplot B shows the relationship between changes of the players and the timeouts used by the teams throughout the game time.

Scored Points	**Point Shots Made (in percentage)**		
	1	**2**	**3**
Game Total Points (%)	34.0%	55.0%	11.0%
Minute 48 Total	58.0%	31.0%	11.0%
0-3 Points / Mi	35.6%	49.3%	15.1%
04-sep Points / Mi	63.6%	27.3%	9.1%
More than 10 Points / Mi	73.1%	18.8%	8.1%

Table 1. Shows the point shots made (%) of 1, 2 or 3 points in the total game and in the last minute of the game. This table also shows the distribution of the different kind of baskets when achieving 0-3, 4 to 9 or more than 10 baskets per minute.

dynamics and influence the result (Mace et al., 1992; Roane et al., 2004). However, Saavedra et al. (2012b), in the statistic study performed with 3000 NBA games, suggests that this opinion may be erroneous; indicating that the timeout reinforces the game of the team that is dominating the game at that moment, despite this team is not the one that requested the timeout. In the NBA, to our understanding, timeouts availability is complex.

From the results observed, timeouts significantly mark the strategy that will follow each team at the end of the game, thus possible changes in the game system performed. In NBA league, each team is entitled to six charged timeouts during regulation play. Each team is limited to no more than three timeouts in the fourth period. If a team has two or three full timeouts remaining when the fourth period reaches the 2:00 mark, one of the timeouts will be changed to a 20-second timeout and it will retain one full timeout. In overtime periods, each team shall be allowed two 60-second timeouts. If a team has two full timeouts remaining when the overtime period reaches the 2:00 mark, one of the timeouts will be changed to a 20-second timeout. There must be two 100-second timeouts in the first and third periods and three 100-second timeouts in the second and fourth periods. If neither team has taken a timeout prior to 5:59 of the first or third period, it shall be mandatory for the Official Scorer to take it at the first dead ball and charge it to the home team. If no subsequent timeouts are taken prior to 2:59, it shall be mandatory for the Official Scorer to take it and charge it to the team not previously charged. If neither team has taken a timeout prior to 8:59 of the second or fourth period, a mandatory timeout will be called by the Official Scorer and charged to neither team. If there are no subsequent timeouts taken prior to 5:59, it shall be mandatory for the Official Scorer to take it at the first dead ball and charge it to the home team. If no subsequent timeouts are taken prior to 2:59, it shall be mandatory for the Official Scorer to take it and charge it to the team not previously charged (Official rules of the National Basket Association 2013-14).

Note how rules are a conditioning variable to employ in the voluntary interruption of the game, affecting directly the moments in which players are substituted during the game. Certainly, this circumstance will significantly impact the offensive and defensive potential of each team, their way of solving the game situations and the evolution of the results. If we add these two variables to the points scored in the last minute of each quarter and, especially, at the end of the game, we observe a change in the game complexity which looks forward to solving quickly and favorably every ball possession.

Conclusion

Basketball, understood as a sport where the key to figure out how to abort every offensive opponent action. Basketball shows in the final moments of every competed games, situations that often present some characteristics such as: shorter possessions (especially by the disadvantage team), played with fewer number of passes and participating players, higher number of fouls, higher game stops and number of changes.

ÚLTIMO MINUTO EN LOS PARTIDOS DE LA NBA

PALABRAS CLAVES: Baloncesto, NBA, Fractal, Rendimiento.

RESUMEN : Aparentemente, el comportamiento del juego durante un partido de baloncesto, igual que en el resto de deportes de equipo, muestra una enorme variabilidad que se manifiesta tanto en las acciones individuales y en las colectivas. No obstante, cuando se estudia una cantidad significativa de partidos se detecta que, dentro de la impredecibilidad que caracteriza al juego, existen, al menos en el baloncesto NBA, patrones de comportamiento repetitivos que, frecuentemente, son libres de escala. El grado de complejidad del juego no es estable. Diferentes investigaciones muestran como los patrones cambian entre el primer y segundo tiempo del partido, así como, primer y tercer cuarto respecto al segundo y cuarto, o la parte inicial, mitad o final de cada cuarto. Nuestro objetivo fue comprobar y evaluar la existencia de estos patrones, y su aparente complejidad, analizando el final de los partidos de la NBA y comparando esta fase del encuentro con el final de cada uno de los cuartos. Los datos muestran la existencia de simetrías (fractalidad) y patrones repetidos de juego durante los partidos de baloncesto de la NBA.

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