Statistical analyses of basketball team performance: understanding teams' wins and losses according to a different index of ball possessions

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Abstract

The aim of the present paper is to investigate the discriminatory power of game statistics between winning and losing teams in the Portuguese Professional Basketball League. Methodological issues concerning game rhythm contamination and data organization according to game type (regular season or play-off), game final outcome (win or loss), game location (home or away) and game final score differences are discussed. Archival data were obtained for the 1997-1998 and the 1998-1999 Portuguese Professional Basketball League seasons for (a) all 353 regular season home and away games and (b) all 56 play-off home and away games. Cluster analysis was conducted to establish, according to game final score differences, three different groups for the subsequent analysis (close games, with final score differences between 1 and 8 points; balanced games, with final score differences between 8 and 18 points and unbalanced games, with final score differences above 18 points). Afterwards, discriminant analysis was used to identify the game statistics that maximize mean differences between winning and losing teams according to previously defined factors (type, location, cluster groups). Obtained results allowed us to understand that in balanced and unbalanced games, losing teams performed poorly in all game statistics. In contrast, results from close games allowed us to identify different team performance profiles according to game type and location. Globally, regular season profile was best discriminated by successful free-throws, whereas play-offs profile was best discriminated by offensive rebounding. On the other hand, home wins were best discriminated by committed fouls whereas successful free-throws discriminated away wins. Coaches and players should be aware of these different profiles in order to increase specificity at the time of game planning and control.

1 Introduction

Quantitative analysis of basketball performance, particularly through game statistics, is being widely used among coaches in order to analyse game events with more valid and reliable data. Published research on this subject is mainly focused on the identification of the most discriminant statistics according to game final outcome (winning and losing teams - Akers *et al.*, 1991; Trninic *et al.*, 1997; Sampaio, 1998), game final score differences (close, balanced and unbalanced games - Sampaio, 1998), game location (home and away games - Pickens, 1994; Madrigal and James, 1999) and game type (regular season and play-off games - Sampaio, 2001). Accepting the differences between samples studied and methodological approaches between researchers, it seems clear that winning teams exhibit a higher offensive quality that is well expressed by higher two point field-goal percentages and, as a consequence of opponents' worse field-goal percentages, a higher number of defensive rebounds. This evidence is more powerful in close games (Sampaio, 1998). On the other hand, home advantage in team sports is well documented (e.g., Courneya and Carron, 1992; Nevill *et al.*, 1996; Nevill and Holder, 1999). In basketball, this phenomenon is explained through different game statistics (Silva and Andrew, 1987 – field-goal percentages, rebounds, turnovers and personal fouls; Pickens, 1994 – field-goal percentages and assists; Madrigal and James, 1999 – field-goal percentages, steals, fouls and rebounds). Finally, it seems clear that play-off games are more slowly paced than regular season games; a fact that seems to contribute to the establishment of different game statistics profiles between these game types (Sampaio, 2001).

Although the important information that previous research has provided about the game, the use of game statistics in pre-experimental and quasi-experimental research has been associated with important threats to internal validity, as pointed by Turcoliver (1990; 1991). In fact, game statistics can be very useful when the coach wants to analyze team performance against their opponents, but may lack validity when performance needs to be analyzed across the season(s), due to game rhythm contamination, i.e. the simultaneous presence of fast and slow paced games throughout the season. For example, the performance of a team A that makes 35 field-goals in an 80 possession game must be different to the performance of a team B that makes 35 field-goals in a 90 possession game. This fact points out the imperative need of normalizing game statistics according to game rhythm.

Additionally, previous research did not study simultaneously all the presented factors: game final outcome (winning or losing), game final score differences (close, balanced or unbalanced), game location (home or away) and game type (regular season or play-off). The purpose of the present study is therefore to identify basketball game statistics that best discriminate between winning and losing teams, according to game final score differences, type and location. With an overview of these results based on a different methodological foundation it may be possible to provide the coach with more useful information about team performance in several contexts making practice and game plans more specific and detailed.

2 Methods

Archival data were obtained for the 1997-1998 and the 1998-1999 Portuguese Professional Basketball League for; i) all 353 regular season games, and, ii) all 56 play-

off games. Each of these two game types was divided according to game location (home or away) and game category (close, balanced or unbalanced). Game categorization was accomplished through k-means clustering (Norušis, 1993). This classification method produced three different clusters of greatest possible distinction according to game final score differences: i) 1 to 8 points (close games); ii) 9 to 17 points (balanced games) and iii) above 18 points (unbalanced games).

Game statistics were collected by a team of experts working for the Portuguese Basketball Federation and included: 2 and 3 point field-goals (both successful and unsuccessful), free-throws (both successful and unsuccessful), defensive and offensive rebounds, blocks, assists, fouls, steals and turnovers.

2.1 Procedures

Collected game statistics were normalized according to ball possessions which represented game rhythm. A ball possession was defined as a period of play between when one team gains control of the ball and when the other team gains control of the ball (Turcoliver, 1990; 1991). According to this definition, offensive rebounds are included in the same possession. The opposing teams in a game will always have the same number of possessions (or be within two of each other). In this way, normalized game statistics can be used to access team performance across the whole season(s). Additionally and in order to get a more convenient ratio after their normalization, we have multiplied all game statistics by 100.

Ball possessions were calculated by the Turcoliver equation (Turcoliver, 1991): ball possessions = (field-goals attempted) – (offensive rebounds) + (turnovers) - 0.4 × (free-throws attempted). This equation was previously validated against video observations (intraclass correlation, R=0.98).

The main sample was divided according to game type, location and category producing twelve independent subsamples. Discriminant analysis was applied to the thirteen normalized game statistics in order to determine: i) which of the game statistics are useful in predicting game final outcome; ii) the best mathematical equation so that the group means on the function were as different as possible and iii) the accuracy of the equation (Klecka, 1980). In each of the twelve subsamples one discriminant function was obtained and interpreted based on examination of the structure coefficients greater than |0.30| (Tabachnick and Fidell, 1989). Validation of discriminant models was conducted using leave-one-out classification (similar to jack-knifing, Norušis, 1993), i.e. each case is classified by applying the classification function computed from all the data except the case being classified (Lachenbruch, 1975).

The statistical analyses were performed using the SPSS software and significance was set at $P<0.05$.

3 Results

From the total sample of the regular season, 43% were close games, 37% balanced games and 20% unbalanced games. In the play-offs, 45% were close games, 34% balanced games and 21% unbalanced games. Univariate statistical differences ($P<0.05$) were found for all game statistics in balanced and unbalanced games, showing that losing teams perform poorly in all game dimensions. On the contrary, in close games

differences were only identified in some game statistics (see Tables 1 and 2). These results were normalized to ball possessions and multiplied by 100, in order to control for game rhythm contamination.

Table 1. Descriptive results in close games from the regular season (values are Mean±SD and were normalized to ball possessions and multiplied by 100).

Regular season	Home games		Away games		
game statistics	Losses	Wins	Losses	Wins	
Assists	26.5 ± 11.8	30.0 ± 12.9	25.3 ± 11.7	27.4 ± 11.1	
Blocks	03.3 ± 02.4	03.6 ± 02.7	03.0 ± 02.6	03.8 ± 03.0	
Fouls	29.5 ± 04.5	26.3 ± 04.1	28.7 ± 04.9	26.6 ± 04.6	#†
2pt successful	31.6 ± 06.2	32.0 ± 05.8	31.4 ± 05.3	32.4 ± 05.6	
2pt unsuccessful	30.2 ± 08.1	25.8 ± 06.5	27.8 ± 06.9	27.7 ± 06.8	#
3pt successful	08.4 ± 03.9	08.8 ± 03.2	08.2 ± 03.1	08.1 ± 03.5	
3pt unsuccessful	18.1 ± 05.8	15.7 ± 05.4	17.6 ± 05.1	14.2 ± 05.0	#†
Free-throw successful	19.1 ± 06.5	22.6 ± 06.2	19.4 ± 07.0	24.3 ± 07.0	#†
Free-throw unsuccessful	08.6 ± 04.0	09.8 ± 04.9	08.3 ± 04.0	10.0 ± 04.5	
Turnovers	19.5 ± 04.9	20.3 ± 05.6	20.9 ± 04.7	18.9 ± 04.7	†
Defensive rebounds	30.2 ± 05.3	31.8 ± 05.8	29.9 ± 05.4	32.8 ± 06.0	†
Offensive rebounds	18.2 ± 06.8	15.8 ± 05.8	16.6 ± 05.9	15.6 ± 05.5	#
Steals	17.3 ± 05.6	19.0 ± 05.1	18.5 ± 06.2	17.4 ± 05.1	

Legend: # differences in home games; † differences in away games

Table 2. Descriptive results in close games from the play-off (values are Mean±SD and were normalized to ball possessions and multiplied by 100).

Play-off	Home games		Away games		
game statistics	Losses	Wins	Losses	Wins	
Assists	30.9 ± 14.0	29.0 ± 10.0	27.9 ± 13.8	28.0 ± 13.3	
Blocks	03.6 ± 02.5	03.1 ± 02.3	02.8 ± 02.2	03.2 ± 01.9	
Fouls	34.6 ± 04.8	27.7 ± 05.2	31.0 ± 05.0	29.4 ± 02.6	#
2pt successful	30.6 ± 04.4	29.4 ± 06.5	30.7 ± 07.0	30.7 ± 04.4	
2pt unsuccessful	28.3 ± 05.8	24.0 ± 06.8	24.1 ± 05.8	27.2 ± 06.6	
3pt successful	09.6 ± 03.6	11.0 ± 04.4	10.0 ± 04.7	09.3 ± 03.4	
3pt unsuccessful	19.3 ± 04.9	17.2 ± 06.1	18.6 ± 04.9	15.7 ± 03.1	
Free-throw successful	22.0 ± 06.8	25.0 ± 07.2	18.8 ± 08.1	29.0 ± 08.2	†
Free-throw unsuccessful	09.0 ± 04.1	10.1 ± 04.3	12.6 ± 05.9	07.9 ± 04.1	†
Turnovers	17.7 ± 02.8	19.0 ± 05.0	20.3 ± 04.6	18.6 ± 05.9	
Defensive rebounds	29.8 ± 05.5	31.8 ± 08.5	31.9 ± 06.6	33.2 ± 03.8	
Offensive rebounds	17.6 ± 03.6	14.5 ± 04.0	14.6 ± 04.3	18.5 ± 03.2	†
Steals	17.9 ± 09.5	18.5 ± 05.2	17.3 ± 05.5	14.9 ± 03.8	

Legend: # differences in home games; † differences in away games

In the discriminant analysis, all obtained functions were statistically significant (P<0.05). The leave-one-out test summarizes the ability of the model to classify correctly the games in their respective final outcome (see Table 3). All balanced and unbalanced games were correctly classified by the computed models.

Table 3. Results from the discriminant functions and leave-one-out test for each subsample.

Subsample			Wilks' lambda	*P*	leave-one-out
Regular Season	Home	Close (n=83)	0.54	0.000	82.8%
		Balanced (n=70)	0.14	0.000	100.0%
		Unbalanced (n=37)	0.06	0.000	100.0%
	Away	Close (n=68)	0.60	0.000	78.6%
		Balanced (n=62)	0.17	0.000	100.0%
		Unbalanced (n=33)	0.09	0.000	100.0%
Play-off	Home	Close (n=15)	0.15	0.040	92.0%
		Balanced (n=12)	0.03	0.000	100.0%
		Unbalanced (n=9)	0.00	0.001	100.0%
	Away	Close (n=10)	0.19	0.050	96.0%
		Balanced (n=7)	0.01	0.000	100.0%
		Unbalanced (n=3)	0.02	0.030	100.0%

Table 4. Discriminant functions structure coefficients.

		Close games (0 to 8 pts)	Balanced games (9 to 18 pts)	Unbalanced games (> 18 pts)
Regular season	Home	Fouls (-0.40) 2pt unsuccessful (-0.33) Free-throws successful (0.30)	None	2pt successful (0.31)
	Away	Free-throws successful (0.43) 3pt successful (-0.33) Defensive rebounds (0.32)	Free-throws successful (0.30) Defensive rebounds (0.30)	None
Play-off	Home	Fouls (-0.51) Offensive rebounds (-0.30)	None	None
	Away	Free-throws successful (0.41) Offensive rebounds (-0.33) Free-throws unsuccessful (-0.32)	None	None

The discriminant functions were interpreted by examining the structure coefficients (see Table 4) in order to quantify the potential of each game statistic to maximize mean differences among game final outcomes. The larger the magnitude of the coefficients,

the greater the contribution of that variable to the discriminant function. In close games, game final outcome variance was accounted for by a reduced set of game statistics (fouls, field-goals, free-throws and rebounds). However, this set changed substantially according to game type and location. Conversely, balanced and unbalanced game final outcome variance could not be attributable to a reduced set of game statistics.

4 Discussion

The main aim of this study was to identify basketball game statistics that best discriminate between winning and losing teams, according to game final score differences, type and location. Results from balanced and unbalanced games indicated that losing teams performed poorly in all game statistics. In fact, the differences between these teams were so wide that we were unable to attach them to a smaller subset of game statistics. Conversely, results from close games allowed us to focus our attention on field-goals, free-throws, fouls and rebounds. These were the most powerful game statistics in discriminating between winning and losing teams.

The methodological approach that we used does not allow us to establish comparisons across the available research because the normalization of game statistics to game rhythm (ball possessions) has never been used before. Moreover, available research has addressed the game statistics in considering only game final outcome or game location.

4.1 Regular season close games

At home, the winning teams' profiles exhibited fewer fouls, less 2 point field-goals missed and more free-throws made than the losing teams' profiles. In away games, winning teams' were discriminated from losing teams' by less 3 point field-goals missed, more free-throws made and more defensive rebounds secured. In both cases (home and away games) it is the particular interpretation of each game statistic that gives us a more powerful understanding of the obtained discriminant models.

Basketball experts acknowledge that one of the keys to excellent team defense is to exert pressure on the opposition without fouling (Pim, 1986; Smith, 1994). Team fouls are directly associated with opponents' opportunities to score from the free-throw line and with the threat of losing players by the disqualification rule. However, it is a fact that teams that foul less exhibit higher defensive performances. However, it is not known if this is originated by their defensive efficiency, by their opponent's offensive inefficiency or by both.

Home wins are associated with a fewer number of committed fouls. This prevents away teams from having more opportunities to score from the free-throw line, which might explain the association of this variable with winning away from home.

Available research recognizes the importance of free-throw shooting because the majority of close games are decided, ultimately, at the free throw line (Pim, 1986; Hays and Krause, 1987; Sampaio, 1998; 2001). In the last 5 minutes of close games, Kozar *et al.* (1994) showed that winning teams scored more than two-thirds of the final score via free throws. These data may help to explain the discriminatory power of successful free-throws in home and away games. Moreover, they move us to the final moments of the game where the home team's defence tries to restrict their opponent's to scoring from the free-throw line.

The explanation for the importance of the away team scoring points from the free-throw line can be found in two factors of having home advantage: i) facility familiarity, i.e. knowledge of the physical characteristics associated with the home facility (Moore and Brylinsky, 1995; Bray and Widmeyer, 2000), and, ii) crowd effects (Agnew and Carron, 1994; Madrigal and James, 1999; Bray and Widmeyer, 2000). In fact, free-throw performance is probably less influenced by these factors because it is the only closed skill in the game (Geen, 1979; Sanna and Shotland, 1990).

In the present study, the fact that teams winning at home missed less 2 point field-goals makes this argument stronger, i.e. facility familiarity and crowd effects might have influenced away teams performance in this complex skill. Thus, as field-goal shooting is one of the most important fundamental skills of the game, the presence of the offensive quality in winning teams is clear (Trninic *et al.*, 1997; Sampaio, 1998). Conversely, missing less 2 point field-goals implies careful selections shoot opportunities. In fact, successful offenses are dependent upon the quality of player decision making and shot execution as well as upon team coordination (Brown, 1995). If home teams' miss more 2 point field-goals, away teams' will probably secure more defensive rebounds, which might explain their association with winning away from home.

The contribution of defensive rebounds to winning basketball games is widely documented (Ittenbach, 1995; Trninic *et al.*, 1997; Sampaio, 1998). This statistic represents the teams' ability to recover the ball after opponent's missed shots (Stewart and Scholz, 1990). A successful defensive rebounding team probably has more opportunities to shoot, score points and win the game (Stewart and Scholz, 1990; Brandenburg, 1994; Sampaio, 1998). Indirectly, high level performances are associated with i) game rhythm, because more defensive rebounds implies more fast-break ball possessions; ii) players somatic characteristics, taller and stronger players secure more rebounds; iii) technical and tactical preparation, pivoting, blocking, anticipation, securing and pulling the ball away, and, iv) muscular fitness, particularly in stretch-shortening-cycle jumping performances.

Generally, away teams have strong perceptions of opponents' home advantage (Bray and Widmeyer, 2000), which may lead them to attempt less long distance shots (because they are unfamiliar with the court and baskets and the crowd is probably hostile). These effects are opposite for the home teams, i.e. facility familiarity and crowd support may lead the players to attempt more long distance shots. Therefore, it is not surprising that the team winning away from home focus their game on shooting inside the keyhole (as a way to reduce these court related disadvantages), which results in attempting and missing less 3 point field-goals.

4.2 Play-off games

At home, winning teams' profiles exhibit fewer committed fouls and less offensive rebounds secured than losing teams' profiles. In away games, winning teams were discriminated by less free-throws missed, more free-throws made and more offensive rebounds secured.

To our knowledge, research focused on the differences in game statistics between regular season and play-off games is limited to only one paper. In this study, Sampaio (2001) found statistically significant differences ($P<0.05$) in ball possessions, points scored, successful 2 point field-goals, fouls and successful free-throws. Therefore, play-

off game rhythm was slower, which resulted in fewer points being scored through field goals (it is possible that additional offensive precautions are taken because these games are more important, so these teams do not take too many chances). However, committed fouls were higher (it is also possible that additional defensive precautions are taken, it is better to stop the offence immediately through fouling), which leads to more points being scored from free-throws and enhances the importance of this statistic. These previous results can explain the higher discriminatory power of fouls in play-off games (see Table 4) and the discriminatory power of additional free-throw statistics (unsuccessful free throws, see Table 4).

On the other hand, home wins were associated with less offensive rebounds while away wins were associated with more offensive rebounds. Home games results are easy to understand; if a team misses a small number of field-goals there cannot be a larger number of rebounds to fight for. Ultimately, offensive rebounds can express a team's field-goal shooting efficiency and indeed, recent research shows clearly that field-goal shooting percentages have declined (Chatterjee and Lehmann, 1997; Chatterjee and Yilmaz, 1999).

Associated with offensive inefficiency is also defensive efficiency, i.e. some teams scout their opponents so well that it may be unusual to see something that surprises them. Therefore, defensive efficiency may lower field-goal percentages and consequently raise rebounding opportunities. Our results suggest that home teams secure less offensive rebounds because they are offensively and defensively more efficient.

In contrast, away wins were associated with more offensive rebounds. In fact, it can be difficult to understand how the winning team can have missed more field-goals than the losing team. However, a complete integrated analysis of our results allows us to suggest that the explanation is in the discriminatory power of free-throw statistics, i.e. in close games, free-throw efficiency compensates for less efficiency in field-goal shooting.

5 Conclusions

Basketball teams' performances can be analysed through game statistics. However, methodological issues must be resolved in this process such as; i) normalizing gathered data to consider game rhythm; ii) organizing data according to game type (regular season *vs*. play-off), game final outcome (win *vs*. loss), game location (home *vs*. away), and, game final score differences (close, balanced or unbalanced).

Discriminatory power of game statistics allows us to understand that in balanced and unbalanced games, losing teams perform poorly in terms of all game statistics. By contrast, results from close games allow us to establish winning and losing team performance profiles according to game type and location. Globally, regular season profile was best discriminated by successful free-throws, whereas play-offs profile was best discriminated by offensive rebounding. On the other hand, home wins were best discriminated by committed fouls whereas successful free-throws discriminated away wins. Coaches and players should be aware of these different profiles in order to increase specificity at the time of game planning and preparation.

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