

Technical Indicators registered as a function of the playing time in Brazilian basketball

Indicadores de desempenho registrados em função do tempo no basquetebol brasileiro

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Abstract – Basketball performance analysis using technical indicators dissociated from the moment they occurred in the game seems to no longer respond to emerging issues of the game as it does not identify the periods when a team's offensive efficiency has increased or decreased. The aim was to characterize and compare the technical indicators in the positive and negative periods and in the whole game of winning and losing teams in men's professional basketball. Fourteen games of professional men's teams of the "Novo Basquete Brasil" Championship in the regular 2011/2012 season were filmed and analyzed. The Kolmogorov-Smirnov test was used to verify data normality. The independent T test was used for variables with normal distribution and the Mann-Whitney test for variables that did not present normal distribution, in order to compare teams' performance. Analysis in the whole game showed that winning teams had significantly higher averages in successful 3-point field goals but in the positive periods, they showed higher averages for successful free throws, successful layups, defensive rebounds and defensive fouls, and in negative periods, losing teams made more defensive and offensive fouls. The teams' performance in the whole game may not elucidate the determinant indicators for building the difference in the scoreboard. It is suggested that coaches should identify the periods of best and worst teams' performance in the game and the indicators involved, preparing teams to overcome the negative periods and obtain more positive periods in the game.

Key words: Basketball; Statistical analysis; Time series studies.

Resumo – A análise de desempenho no basquetebol a partir de indicadores técnicos dissociados do momento em que ocorreram no jogo parece não mais responder às questões emergentes do jogo, pois não se identificam os períodos em que a eficiência ofensiva de uma equipe aumentou ou diminuiu. O objetivo foi caracterizar e comparar os indicadores técnicos nos períodos positivos, negativos e no jogo todo, entre equipes vencedoras e perdedoras no basquetebol profissional masculino. Foram filmados e analisados 14 jogos de equipes profissionais masculinas do Novo Basquete Brasil, na temporada regular de 2011/2012. Recorreu-se ao teste de Kolmogorov-Smirnov para verificar a normalidade dos dados. Para as variáveis com distribuição normal recorreu-se ao teste T de amostras independentes e para as variáveis que não apresentaram distribuição normal ao teste de Mann-Whitney, a fim de comparar o desempenho das equipes. A análise no jogo todo mostrou que as equipes vencedoras tiveram médias significativamente maiores em arremessos de três pontos certos, já nos períodos positivos tiveram em lances livres certos, bandejas certas, rebotes defensivos e faltas defensivas. Nos períodos negativos as equipes perdedoras fizeram mais faltas defensivas e ofensivas. O desempenho das equipes no jogo todo pode não elucidar os indicadores determinantes para a construção da diferença no placar. Sugere-se que os treinadores identifiquem os períodos de melhor e pior desempenho das equipes no jogo e os indicadores neles envolvidos, para preparar as equipes para superar os períodos negativos e obter maior número de períodos positivos no jogo.

Palavras-chave: Análise estatística; Basquetebol; Estudos de séries temporais.

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INTRODUCTION

As a collective invasion sport, basketball has cooperative-opposition characteristics, involving phases of attack, defense and transition in the game¹. By being a dynamic, unpredictable and competitive game, understanding the technical indicators involved in victory and defeat has been the great mission of different groups, such as coaches, sports media and sports researchers⁵. Several indicators are investigated in the basketball game⁶⁻⁸, in positioned attacks or counterattacks⁹⁻¹¹, with technical performance being the preferred factor of scientific investigation¹². The performance in the different technical indicators allows concluding on the quality of individual and collective actions¹³. However, in most studies, the frequency of these indicators is recorded considering the whole game^{4,5,13}, presenting limitations to answer some emerging questions, such as the periods in which the technical performance of a team increases or decreases and which indicators are involved in these periods.

In the perspective of sequential and temporal analyses, methods for characterizing the game in different moments, called critical moments (CM) have emerged in literature. Ferreira, Volossovitch and Jaime Sampaio¹⁴ defined CM as the time interval in which the difference in the scoreboard varies between 6 and 10 points, scored in 4 to 8 ball possession (BP). "Balance" was characterized by a difference of up to 3 points in the scoreboard for the four quarters of the game and "imbalance" by a difference of over 15 points in the first three quarters and above 10 points in the last quarter. Ferreira and Gomes¹⁵ proposed to determine and analyze CM through the coefficient of variation of the difference in the scoreboard (CVDIFP), counted every minute of the game and every 6 BP. In this study, CMs were defined as CVDIFP values equal to or higher than the 95th percentile, which means that the CM value varies according to points scored every 6 BP. However, these analyses do not allow identifying the times when each action was performed and their performance throughout the game. In addition, the critical periods that occur in the game in a period shorter than 4 and 6 ball possessions, as proposed by the authors, may not be identified. In this sense, the registration of the technical indicators according to the playing time allows characterizing the actions and periods involved in the construction of the difference in the scoreboard, establishing two types of periods in the game: a) periods of balance, in which teams alternatively score points or miss attacks, and the difference in the scoreboard does not vary by more than 3 points¹⁴ and b) positive/negative periods, in which one team scores points and the other accumulates successive errors, and that the difference in the scoreboard increases (for the winning team) or decreases (for the losing team) by four or more points, considering that a difference of up to three points can be reversed in a single attack, such as successful free throws and/or technical fouls⁵.

Highlighting positive and negative periods favors the identification of technical indicators that were decisive for constructing the difference

in the scoreboard, characterizing the winning and losing team. Thus, it is possible to plan trainings in order to optimize the positive periods and minimize the negative ones. Therefore, the overall aim was to characterize and compare technical indicators in the positive and negative periods, and in whole game of winning and losing teams in professional male basketball.

METHODOLOGICAL PROCEDURES

The non-participatory observational method proposed by Anguera et. al.¹⁶ was used. The sample was composed of 14 games of professional men's teams that participated in the "Novo Basquete Brasil" (NBB) in the 2011/2012 regular season. The selection of the sample was intentional, due to the agreement with one of the participating teams and to the authorization of the NBB League. The 14 games were of the same team against all the other 14 participating teams. All procedures were approved by the Research Ethics Committee of the University of Campinas.

Procedures

The games were filmed by four digital cameras (JVC, model GZHD10, 30 Hz) set in the same conditions of focus, shutter and white adjustment. The images were analyzed with a sampling frequency of 7.5 Hz¹⁷. For the synchronization and calibration of cameras and record of technical indicators and number of attacks, the DVideo software^{18,19} was used. The temporal synchronization of cameras was performed using the 24-second ball possession clock²⁰.

Among the technical indicators (TI) most used in scientific research, successful and unsuccessful free throws, successful and unsuccessful two- and three-point field goals, defensive and offensive rebounds, blocks, defensive and offensive fouls and turnovers^{2-4,21}, in addition to successful and unsuccessful layups, successful and unsuccessful domains, successful and unsuccessful passes, successful and unsuccessful ball replacements, ball possession recoveries, interceptions, violations, technical fouls, right and wrong dribbles, and technical time-outs, in order to describe any game. The frequency of the technical indicators was recorded as a function of playing time and normalized by the number of attacks (ATs) of each team, and multiplied by 100 (TI Normalized = $TI / ATs \times 100$) in order to distinguish the game rhythm^{2,8,21}.

Considering that in a period of game balance, the score does not change more than three points¹⁴, the positive period (PP) in this work was considered as the time interval in which a team scored four or more points and the opponent scored no point, and the negative period (NP) as the corresponding to the positive period of the opponent. The number of PPs and NPs, and the number of attacks, scored points and duration of those periods, of winning and losing teams were recorded.

Data reliability

Five observers, with at least six years of experience in basketball, were systematically trained and two of them, randomly selected, were evaluated

for the consistency of data obtained^{16,22}. The test-retest procedure²³ was used, with an interval of 30 days²⁵ to establish intra- and inter-observer reliability, with 3,804 TIs in 2 games, representing 14.3% of the total sample, in accordance with literature recommendations²⁴. Reliability was verified using the Cohen Kappa index²⁶ and the results obtained (0.93 and 0.97 for intra-observer and 0.91 for inter-observer) were classified as “perfect”²⁷.

Data analysis

The Kolmogorov-Smirnov test was used to verify data normality. For variables that presented normal distribution, the t test for independent samples was used and for variables that did not present normal distribution, the Mann-Whitney test was used to compare the average frequency of TIs in the whole game (JT) in PPs and NPs, the duration and points per PP, and points per minute in PP, between winning and losing teams. The significance level was set at $p \leq 0.05$.

Figure 1 shows the dynamics of the difference in the scoreboard as a function of time of one of the games analyzed, each attack represented by a straight line with length given by the attack duration, the red color corresponding to PP of the winning team and the blue color, the losing team. Technical time-outs are represented by triangles. The positive difference of scores is a function of the winning team. Figure 2 represents the dynamics of scores of the same example game, with PPs in black rectangles and NPs in orange rectangles, highlighted as a function of the winning team.

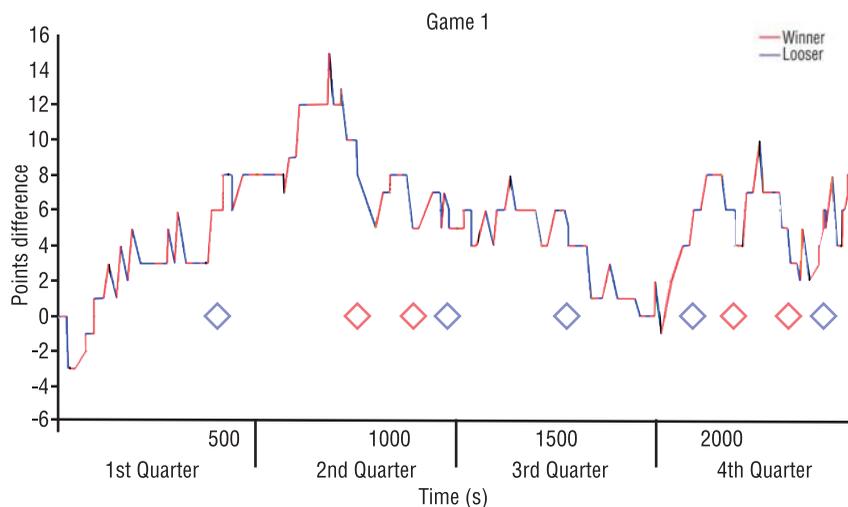


Figure 1. Example of the dynamics of point variation (Y axis) as a function of playing time in seconds (X axis)

In all PPs and NPs, the TIs involved were also identified. Table 1 shows the sequence of TIs performed in the first attack of the first PP of the winning team. In this example, the PP of the winning team started with a pass interception at 89 seconds. Then, the team dominated the ball, obtaining the possession, and at 97 seconds was given a foul in the act of the 2-point field goal that was not converted. Thus, the team was rewarded with two free throws and finalized the first attack of the PP with converted free throw.

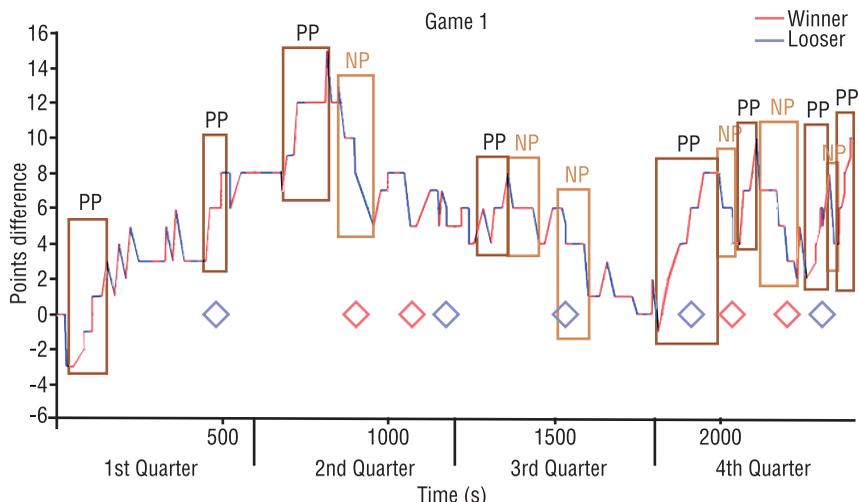


Figure 2. Example of the dynamics of point variation (Y axis) as a function of playing time in seconds (X axis), with positive periods (PPs) and negative periods (NPs) as a function of the winning team, respectively.

Table 1. Example of the sequence of TIs of the first attack of the winning team’s first PP.

Playing time (s)	Team	TI	Right/Wrong – Defensive /	Game period	Attack in the
87	Losing	Pass	Wrong	PP winning team	5 th
89	Winning	Interception	-		1 st
89	Winning	Domain	Right		1 st
90	Winning	Pass	Right		1 st
90	Winning	Domain	Right		1 st
91	Winning	Beginning of dribble	Right		1 st
92	Winning	End of dribble	Right		1 st
93	Winning	Pass	Right		1 st
94	Winning	Domain	Right		1 st
95	Winning	Beginning of dribble	Right		1 st
96	Winning	End of dribble	Right		1 st
96	Winning	2-point field goal	Wrong		1 st
97	Losing	Foul	Defensive		1 st
Dead ball	Winning	Free throw	Right	1 st	
Dead ball	Winning	Free throw	Right	1 st	

Technical indicator (TI), positive period (PP).

RESULTS

In the 14 games, 2,057 attacks, 26,603 TIs and 198 PPs/NPs were registered. Table 2 shows the characterization of normalized TIs in the JT, in the PPs and NPs, with the results of the comparison between the means of scored points and number of attacks, as well as the average frequency of each TI of winning and losing teams in the 14 games.

The results in table 2 show that in JT, winning teams had significantly higher averages in scored points and 3-point throws, and losing teams obtained significantly higher averages in technical time-outs and turnovers. In

PPs, winning teams showed significantly higher averages in scored points, number of attacks in PPs, defensive fouls, successful free throws, successful layups, successful dribbles, defensive rebounds and successful ball repositions. In the negative periods, losing teams obtained significantly higher averages in unsuccessful 3-point field goals, defensive fouls, attack fouls, average number of attacks in NPs, right domains and successful ball repositions.

Table 3 presents the characterization and comparison of PPs between winning and losing teams, considering the number of attacks, scored points and duration.

Table 2. Technical indicators in the JT, PPs and NPs of winning and losing teams.

Descriptive Statistics and t Test									
TI	W JT	L JT	p	W PPs	L PPs	p	W NPs	L NPs	p
Mean scores	83.0 ± 6.0	73.1 ± 4.1	0.00*	44.8 ± 6.1	33.7 ± 7.6	0.00*	-	-	-
Mean attacks	73.4 ± 2.5	73.5 ± 2.6	1.00	23.0 ± 3.9	17.4 ± 5.0	0.00*	11.7 ± 4.1	15.2 ± 3.6	0.03*
FT C	12.2	10.2	0.15	4.1	2.5	0.02*	0	0	-
FT E	3.1	3.1	0.90	0.7	0.5	0.85	0.2	0.4	0.39
A2 C	6.9	7.3	0.74	3.5	3.1	0.51	0	0	-
A2 E	10.1	10.3	0.89	1.6	1.5	0.87	2.3	3.0	0.17
Layup C	5.6	5.6	0.99	3.3	2.2	0.02*	0	0	-
Layup E	4.7	5.1	0.63	1.3	0.6	0.06	2.7	3.2	0.31
A3 C	6.4	4.7	0.02*	2.7	2.6	0.10	0	0	-
A3 E	10.3	9.3	0.34	1.3	0.8	0.31	0.4	1.1	0.01*
Rebound defense	14.6	13.7	0.46	6.0	4.4	0.05*	1.0	1.6	0.21
Rebound attack	3.8	4.5	0.43	1.2	0.8	0.26	0.7	0.5	0.65
Domain C	177.6	167.1	0.20	45.0	36.4	0.10	29.6	36.3	0.05*
Domain E	2.4	1.6	0.15	0.4	0.2	0.36	0.4	0.2	0.43
Pass C	136.6	123.7	0.10	35.8	28.4	0.09	21.4	25.0	0.18
Pass E	4.7	4.9	0.75	0.5	0.6	0.54	1.5	1.6	0.70
Ball reposition C	36.2	37.4	0.43	7.3	5.5	0.05*	8.2	11.0	0.00*
Ball reposition E	1.1	1.0	0.91	0.2	0.1	0.26	0.3	0.6	0.26
Recovery	3.0	3.0	0.97	0.8	1.2	0.27	0.5	0.1	0.10
Interception	3.8	4.8	0.13	1.5	1.2	0.41	0.6	0.4	0.39
Defensive foul	12.4	13.9	0.84	1.8	0.8	0.01*	2.4	4.0	0.02*
Offensive foul ^a	0.9	1.1	0.43	0.2	0.2	0.91	0.2	0.6	0.03*
Technical foul ^a	0.3	0.3	0.76	0.0	0.0	0.39	0.1	0.1	0.45
Dribble C	196.6	189.9	0.46	51.2	40.3	0.03*	31.4	39.4	0.08
Dribble E	2.8	3.6	0.29	0.6	0.5	0.70	0.8	1.0	0.65
Violation	2.2	2.9	0.15	0.3	0.4	0.82	0.9	0.7	0.65
Block	1.0	0.7	0.31	0.3	0.1	0.11	0.1	0.1	0.71
Time-out	1.6	2.7	0.02*	0.1	0.0	0.92	0.5	0.7	0.55
Turnover	8.1	10.0	0.03*	0.7	0.8	0.85	3.1	3.6	0.45

* p≤0.05; a = Non-parametric statistics, Mann-Whitney test. X = average; sd = standard deviation; p = significance value. Points (Pts) and attacks (At) of the winning teams (W) and losing teams (L) in the 14 matches, in the whole game (JT), in the positive (PPs) and negative periods (NPs), free throw frequency (FT), 2-point field goal (A2), layup, 3-point field goal (A3), successful (C) and unsuccessful (E), defensive rebound (Defense), offensive rebound (Offense), successful (C) and unsuccessful (E), ball reposition right (C) and successful (E), recovery, interception, defensive foul, offensive foul, technical foul, right dribble (C) and wrong dribble (E), violation, block, technical time-out and turnover.

Table 3. Characterization and comparison of PPs between winning and losing teams

	Winning teams			Losing teams			p
	X ± sd	Min.	Max.	X ± sd	Min.	Max.	
nPP	8.1 ± 1.2	6	10	6.1 ± 1.3	4	9	0.00*
nAT/PP	2.9 ± 0.6	2.2	4.5	2.9 ± 0.7	1.9	4.2	0.89
Score/PP	5.5 ± 1.9	4	12	5.4 ± 1.8	4	12	0.67
t _{mean} /PP (s)	70.2 ± 42.8	5	227	73.9 ± 50.0	4	232	0.59

p ≤ 0.05. X = average; sd = standard deviation; min = minimum; max = maximum; p = significance value. Mean number of positive periods per game (nPP), mean number of attacks per PP (nAT / PP), average points per PP (Score / PP) and average PP duration in seconds (t_{mean} / PP (s)).

The results showed that winning teams had the highest average PPs per game compared to losing teams. There were no significant differences in relation to the mean of PP attacks, average scores per PP and average PP duration.

DISCUSSION

This study allowed identifying PPs and NPs in the games and TIs involved in them, evidencing differences in relation to the JT analysis. According to table 2, the average difference in the scoreboard between winning and losing teams in the JT (average of 9.9 points) is approximately the same difference in the scoreboard in PPs (average of 11.1 points). This result suggests that the other points that contributed to the construction of the final score are involved with the balance periods. Therefore, the performance in the different technical actions of the teams when analyzed in JT, may not present the same results when analyzing through specific moments that led to the construction of the difference in the scoreboard.

The JT analysis showed that winning teams had significantly higher averages in successful 3-point field goals. This result differs from some studies that have analyzed the JT performance in other championships, and found defensive rebounds, successful 2 and 3-point field goals, free throws and assists as discriminating of winning teams^{3,8,9}.

In PPs, winning teams presented significantly higher averages of successful free throws, successful layups, defensive rebounds and defensive fouls. The defensive rebound favors the accomplishment of the counterattack and the corresponding approach to the hoop⁹, as by layups or free throws, after faults are committed by a destabilized defense. Layups are not separated from 2-point field goals in studies²⁻⁴; however, although they have the same score, they have a particular characteristic, since they are finalizations with the progression of the player very next to the target, from one or two rhythmic times. Thus, to perform a layup, teams must explore the perimeter close to the target, which requires a large destabilization of the opponent's defense, often in counterattack. In relation to fouls, although they are related to an unbalanced defense²¹, in PPs, they may have the function of preventing an easy progression of the opponent to the target, making it difficult to score, and thus, the team maintains its

PP. Therefore, in order to obtain PP, it seems essential that the team has an organized and aggressive defensive posture, which hampers the opposing throws and guarantees defensive rebounds⁸.

In NPs, losing teams made significantly more defensive and offensive fouls, and missed more 3-point throws. In general, the less defense fouls, the better the defensive performance of a team²¹ thus, winning teams seem to have a better defensive organization even in their NPs. When a foul is committed at the moment of the throw or when the team has already reached the limit of collective fouls, fouls benefit the opponents with free throws, corroborating those found in PPs. In addition, unsuccessful 3-point throws can also be the consequence of organized and aggressive defense. Turnovers were not considered significant in NPs, as they may be involved in balance periods. As a result, not all attacks that did not have basket attempts negatively influenced the construction of the difference in the scoreboard.

PPs were characterized by a variation between 4 and 12 points in approximately 2 to 5 attacks, lasting from 1 to 4 minutes, for both winning and losing teams. These results differ from data of perception on CM reported by experienced coaches¹⁴. In addition, the study contrasts the identification method from the CVDIFP value equal to or above the 95th percentile¹⁵, since the results showed, in different games, that PPs have a specific characteristic. In this way, coaches should be aware when the opponent team scores 4 or more points of difference, and possibly interrupt the PP requesting a more aggressive defense and/or technical time-out. On the other hand, to generate a PP, coaches must invest in a defense that makes throws difficult and guarantees defensive rebounds, and builds attacks or counterattacks that facilitate infiltration into the three-point line in order to finish with layups and / or receive fouls that generate free throws.

Dividing PPs into categories for the stages of balance and imbalance of the game based on the score difference^{14,15} can be an important alternative for the characterization of PPs, but it is necessary to consider, in addition to the difference in the scoreboard, its duration. Thus, there may be different types of PPs in the game, of short or long duration and with few or many scored points. Each type of PP can be identified and analyzed separately, based on the proposal of this work. It is also interesting to analyze the types of attacks involved in PPs, dividing them into counterattacks or positioned attacks. In addition, this study has limitations in two aspects: the first one is related to data, which can be influenced by the sample, since the games are of the same team against the other 13 of the championship, making the generalization of results difficult; the second is related to the method, since the instruments available for registration of TIs according to the playing time still require too much operational work, making it difficult to disclosure short-term information to assist coaches. However, it is necessary to analyze the performance of teams according to the playing time to identify the indicators involved in the positive and negative periods.

CONCLUSION

Recording the technical indicators according to playing time in basketball was important to identify positive and negative periods, showing that the indicators that determine the final score difference, that is, those involved in the positive periods, are different from the indicators identified in the whole game.

Winning teams performed better on three-point throws, while losing teams committed more turnovers, according to JT analysis. However, the time-based analysis showed that in PPs, winning teams performed better in free throws, layups and defensive rebounds, and generated more PPs. In NPs, losing teams committed more fouls. Therefore, in the decisive periods for the construction of the difference in the scoreboard, winning teams had better offensive organization to search for approaching the target and a better defensive organization to make it difficult for the opposing throws and to guarantee defensive rebounds.

It is important for coaches to differentiate the performance analyses of teams according to the playing time to identify the team's best and worst performance periods, as well as the players involved in mistakes and successes, guiding decision-making in the aim of overcoming negative periods and obtain more positive periods in the game.

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