Original Paper DOI: https://doi.org/10.5114/biolsport.2019.83007

Performance profile and game-related statistics of FIBA 3x3 Basketball World Cup 2017

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ABSTRACT: The study aimed to characterize the performance profile of 3x3 basketball and particularly to assess: a) the differences between games in live time (LT) and stoppage time (ST) phases and their ratio, and b) the game-related statistics and derived game indicators differentiating between winning and losing teams. Eight games [quarterfinals, semifinals and finals (1st and 3rd place)] of the FIBA 3x3 basketball world cup (Serbia, 17th-21st June 2017) were analysed. The LT and ST phases were categorized into three phase durations: 1-20 s, 21-40 s, >40 s. The LT/ST ratio was calculated. The game-related statistics and derived parameters were assessed through video-based notational analysis methods, and differences between winning and losing teams were calculated using a mixed linear model. The results revealed no statistically significant differences in the distribution of LT and ST phases between games, with an LT/ST ratio of 0.92±0.13. Moreover, winning teams showed a significantly higher ($p<0.05$) number of free throws made and attempted, team offensive ratings, and recovered balls per possession compared to losing teams. Conversely, winning teams revealed significantly lower ($p<0.05$) values for turnover, rebound (offensive, defensive and total), offensive rebound percentage and team defensive rating compared to losing teams. These results provide coaches and practitioners with novel and applied information regarding the performance profile of 3x3 basketball to optimize training sessions, which should be characterized by short live time phases and a work-to-rest ratio ~1 and focused on developing the ability to avoid turnovers and increase the recovered balls per possession, minimizing the scoring possibilities for the opponent team.

CITATION: Conte D, Straigis E, Clemente FM et al. Performance profile and game-related statistics of FIBA 3x3 Basketball World Cup 2017. Biol Sport. 2019;36(2):149–154.

Received: 2018-07-30; Reviewed: 2018-11-09; Re-submitted: 2019-02-13; Accepted: 2019-02-14; Published: 2019-02-28.

Key words:
Performance analysis
Team sports
Analytics
Tactics
Notational analysis

INTRODUCTION

In the last few years, the popularity of 3x3 basketball has exponentially increased and in 2017 this new sport was included in the Olympic Program, starting from the next Games of the XXXII Olympiad (i.e. Tokyo 2020) [1]. Considering that 3x3 basketball is a relatively new sport, little information is available about teams and players' performance profiles. To the best of our knowledge, only a few studies have investigated the physical and physiological demands of 3x3 basketball [2–5]. The two most recent studies focused on 3x3 elite male and female basketball players participating in under-18 World Championships, Senior European and World Championships demonstrating a high speed inertial movement with a player load of 127.5 ± 31.1 and 128.5 ± 32.0 arbitrary units (AU), respectively [2,3]. Furthermore, the analysis of players' physiological demand demonstrated an average game heart rate of 165 ± 18 and 164 ± 12 beats per minute^{-1} (bpm^{-1}) for male and female players, respectively [3]. These data identified the performance profile of 3x3 basketball and provide coaches and practitioners useful information about the game physical and physiological demands. However, video-based time-motion analysis data can provide further information concerning the performance profile of 3x3 basketball. Previous investigations in basketball identified live time (LT), stoppage time (ST) and their ratio as important factors in order to design sound training sessions [6,7]. Specifically, basketball games are characterized by LT and ST phases with a short duration (mostly up to 20 s) and an LT/ST ratio around 1 [6,7]. In particular, 3x3 basketball has some similarities with traditional 5x5 basketball although it is

characterized by different rules. Indeed, 3x3 basketball is played on a half court (15 m width x 11 m length) with only one hoop and games have only 10 minutes of live time duration with a 12-s shot clock. Moreover, teams are composed of three starting players and one bench player that can be replaced without limitations or official bench interactions during stoppage time. Considering all these differences, it is not possible to generalize traditional basketball data to 3x3 basketball, making fundamental the identification of the 3x3 basketball performance profile through a video-based notational analysis. Therefore, since no previous investigations have analysed the LT, ST and LT/ST ratios during 3x3 basketball games, further studies are warranted in this specific area.

The analysis of game-related statistics can also provide a better understanding of the 3x3 basketball performance. Several studies have previously investigated the game-related statistics differentiating between winning and losing teams in traditional basketball [8–11]. A recent study using the magnitude-based inference approach showed that winning teams performed substantially higher percentages of 3-point, free throw, defensive rebound and steals compared to losing teams in male collegiate players' close basketball games [9]. Furthermore, defensive rebounds, steals, turnovers, shooting percentage and offensive rebounds have been identified through a Bayesian model averaging approach as parameters discriminating winning and losing teams in Euroleague basketball [12]. However, while game-related statistics can provide a global view of a team's efficacy, derived performance indicators such as effective field-goal percentage, offensive rebounding percentage, recovered balls per possession and free throw rate might allow a more accurate prediction of team success [13,14]. Previous investigations analysing these derived game indicators demonstrated that they differentiate between winning and losing teams in the Australian National Basketball League (NBL) [15] and in the 2010 World Basketball Championship games [16]. When investigating only close games, effective field goal percentage and effective free throw rate are the only two parameters showing a substantial difference between winning and losing teams [9]. To the best of our knowledge, only two previous studies have focused on the game-related statistics discriminating between top- and bottom-ranked basketball teams participating in the inaugural Youth Olympic Game 3x3 basketball tournament in 2010, documenting different successful field goal percentage, number of assists and turnover and free throws [4,5]. However, no previous study has investigated the game-related statistics and derived performance indicators differentiating between winning and losing teams in senior 3x3 basketball, although this information might provide coaches and practitioners with useful practical indications. Therefore, this study aimed to characterize the performance profile of 3x3 basketball. Specifically, a) the differences between games in LT, ST and their ratio; and b) the game-related statistics and derived performance indicators differentiating between winning and losing teams were investigated.

MATERIALS AND METHODS

Participants

This study was approved by the Local Institutional Research Committee and meets the ethical standards in sports and exercise science research. The quarterfinals, semifinals and finals (1st and 3rd place) of the International Basketball Federation (FIBA) 3x3 basketball world cup (Nantes, France, 17th-21st June 2017) were analysed. All games were played on the same day from 3 pm to 10.30 pm, which is a typical schedule in a 3x3 basketball tournament scenario [2,3]. A total of eight games were studied, which involved eight teams each composed of four players. All games lasted 10 min or finished as soon as one of the two teams reached 21 points, as specified in the 3x3 basketball regulations [17].

Methodology

The video footage was freely available on a public website (https://www.youtube.com/) and was downloaded on a computer for the analysis. Videos were investigated using the free source software "Longomatch" (version 1.3, https://longomatch.com/en/). The 3x3 basketball profile was identified calculating the LT and ST phases, which were categorized into three phase durations (i.e. 1-20 s, 21-40 s, >40 s) similarly to previous investigations [6,7]. Next, the LT/ST ratio was calculated. The LT and ST phases corresponded to the time in which game clock was running (i.e. the ball was in play) and to when the game clock was stopped (i.e. ball out of bounds, fouls, free throws, time outs), respectively, as previously described in basketball time motion analysis studies [6,7].

A video analysis approach was also adopted to assess the following game-related statistics similarly to previous studies [9,11,12,15,16]: field goals attempted, field goals made (number and percentage), 2-point attempted, 2-point made (number and percentage), free throws attempted, free throws made (number and percentage), total rebounds, offensive rebounds (number and percentage), defensive rebounds (number and percentage), assists, turnovers. It is important to note that unlike in traditional basketball, in 3x3 basketball 2-point shots refer to those executed outside the arc, while shots scored within the arc are considered as 1-point shots.

Derived parameters were further calculated using formulas previously adopted in basketball [9,14–16] as follows: number of ball possessions (field goals attempted - offensive rebounds + turnovers + 0.4* free throws attempted); team's offensive rating (points scored/ball possessions); team's defensive rating (points allowed/ball possessions); effective field goal percentage [(field goals made + 0.5 * 2-point field goals made)/ field goals attempted]; offensive rebound percentage [offensive rebounds / (offensive rebounds + opponent's defensive rebounds)]; recovered balls per ball possession [(steals + blocked shots + opponent's turnover)/ball possession]; free throw rate (free throws made / field goals attempted). One experienced observer with more than one year of experience performed the video analysis. The intra-observer reliability was tested having the observer analysing 5 of the 10 games twice 30 days apart, and

the results showed an intraclass correlation coefficient of 0.93-0.99 (excellent reliability).

Statistical analysis

Descriptive statistics (mean ± SD and relative percentage frequency of occurrence) were calculated for each dependent variable (game-related statistics and derived parameters). A chi-square (χ^2) test of independence was used to determine whether a different distribution occurred between games in LT and ST phases. Data were analysed using the IBM SPSS for windows statistical package (version 25, Armonk, NY: IBM Corp.). Furthermore, differences between winning and losing teams were analyzed through a mixed linear model using the *lme4* package in R (R.3.0.2, R Foundation for Statistical Computing). One model for each dependent variable was constructed with game outcome (winning vs. losing) as the fixed effect, while team and game were used as random factors. The influence of the fixed effect was assessed using the likelihood ratio test and creating full models (including the fixed effect) and comparing them with null models (excluding the fixed effect). Significance was set at $p<0.05$. The magnitude of differences in all dependent variables between winning and losing teams was assessed using effect size (ES) statistics with 90% confidence intervals calculated on a modified statistical spreadsheet [18]. Effect sizes of <0.20, 0.20–0.59, 0.60–1.19, 1.20–1.99 and >2.00 were considered trivial, small, moderate, large, and very large, respectively [19].

RESULTS

Descriptive results referring to LT and ST phases are displayed in Table 1. Results revealed no statistically significant differences between games in the distribution of either LT ($P=0.91$) or ST ($P=0.85$) phases. Most of the LT and ST phases had durations shorter than 20 s (58.1% ± 8.9 and 57.6% ± 9.2, respectively). The analysis of LT/ST ratio showed an average of 0.92 ± 0.13 per game.

The results of the game-related statistics are shown in Table 2. The results revealed statistically significant differences between models

TABLE 1. Mean ± standard deviation (SD) of live time and stoppage time phases.

Phase duration	LT (%)	ST (%)
1-20 s	58.1 ± 8.9	57.6 ± 9.2
21-40 s	24.7 ± 4.9	19.4 ± 7.2
>40 s	17.2 ± 5.6	23.0 ± 4.4

TABLE 2. Game-related statistics for winning and losing teams expressed as mean ± standard deviation (SD), percentage (%) mean difference and effect sizes (ES) with their 90% confidence intervals (CI) and interpretation. P-values were calculated using the likelihood ratio test in the mixed linear model (MLM).

Game-related statistics	Teams			Losing vs. winning teams		
	Winning	Losing	MLM	% Mean difference (90% CI)	ES (90% CI)	Interpretation
Field Goal Made	11.9 ± 1.8	10.4 ± 3.0	*P*=0.129	-14.87 (-30.83; 4.77)	-0.65 (-1.49; 0.84)	Moderate
Field Goal Attempt	29.4 ± 2.6	27.9 ± 4.6	*P*=0.283	-5.96 (-17.02; 6.56)	-0.41 (-1.25; 0.42)	Small
% Made field goal	40.6 ± 6.7	37.6 ± 10.5	*P*=0.300	-9.47 (-26.25; 11.12)	-0.40 (-1.25; 0.43)	Small
2-point Made	2.6 ± 2.0	2.1 ± 1.1	*P*=0.582	-24.93 (-58.64; 36.24)	-0.42 (-1.29; 0.45)	Small
2-point Attempted	12.1 ± 5.1	10.3 ± 5.7	*P*=0.438	-21.64 (-50.68; 24.50)	-0.43 (-1.27; 0.39)	Small
% 2pt Made	19.1 ± 10.3	25.1 ± 18.6	*P*=0.322	2.52 (-34.15; 59.64)	0.04 (-0.80; 0.89)	Trivial
Free Throw Made	3.4 ± 1.7	1.8 ± 0.9	**P=0.015**	-48.92 (-66.59; -21.90)	-1.32 (-2.16; -0.48)	Large
Free Throw Attempted	5.3 ± 2.4	2.5 ± 1.4	**P=0.008**	-54.22 (-71.81; -25.63)	-1.34 (-2.18; -0.51)	Large
% Made Free Throw	69.3 ± 24.7	76.3 ± 25.6	*P*=0.555	11.56 (-20.33; 56.24)	0.27 (-0.56; 1.10)	Small
Offensive Rebound	3.5 ± 2.4	5.8 ± 2.8	**P<0.001**	43.63 (-14.69; 141.82)	0.60 (-0.26; 1.46)	Moderate
Defensive Rebound	8.8 ± 2.3	11.4 ± 2.1	**P<0.001**	31.64 (9.21; 58.68)	1.23 (0.39; 2.07)	Large
Total Rebound	12.3 ± 2.9	17.1 ± 2.9	**P<0.001**	41. 97 (15.78; 74.07)	1.43 (0.60; 2.27)	Large
% Offensive Rebound	26.7 ± 16.9	32.6 ± 12.9	*P*=0.103	9.13 (-30.55; 71.51)	0.16 (-0.70; 1.03)	Trivial
% Defensive Rebound	73.3 ± 16.9	67.4 ± 12.9	*P*=0.104	-7.27 (-23.14; 11.88)	-0.33 (-1.17; 0.49)	Small
Assist	5.1 ± 2.9	3.6 ± 1.7	*P*=0.078	-39.95 (-58.20; -13.76)	-1.21 (-2.10; -0.35)	Large
Turnover	3.9 ± 1.3	6.6 ± 1.3	**P<0.001**	76.30 (37.20; 126.61)	1.89 (1.10; 2.72)	Large

with and without the effect of game outcome with higher values for winning teams compared to losing teams for free throws made [P=0.015; ES: -1.32 (90%CI: -2.16; -0.48); large] and free throws attempted [P=0.008; ES: -1.34 (90%CI: -2.18; -0.51); large]. Moreover, statistically significant differences between models were found, with losing teams performing higher numbers of offensive rebounds [P<0.001; ES: 0.60 (90%CI: -0.26; 1.46); moderate), defensive rebounds [P<0.001; ES: 1.23 (90%CI: 0.39; 2.07); large], total rebounds [P<0.001; ES: 1.43 (90%CI: 0.60; 2.27); large] and turnovers [p<0.001; ES: 1.89 (90%CI: 1.10; 2.72); large] compared to winning teams. No significant differences (P>0.05) were found for any of the other investigated game-related statistics.

Derived performance indicators results are displayed in Table 3. Statistically significant differences between models with and without the effect of game outcome with higher values for winning teams compared to losing teams were found in team offensive rating [P=0.015; ES: -1.22 (90%CI: -2.06; -0.38); large] and recovered balls per ball possession [P=0.005; ES: -1.28 (90%CI: -2.12; -0.44); large], while statistically higher values for losing teams were found in team defensive rating [P=0.004; ES: 1.42 (90%CI: 0.58; 2.25); large] and offensive rebounding percentage [P<0.001; ES: 0.97 (90%CI: 0.08; 1.87); moderate]. No statistically significant differences (P>0.05) were found for number of ball possessions, effective field goal percentage or free throw rate.

DISCUSSION

The aim of the study was to characterize the performance profile of elite senior 3x3 basketball with special attention given to assess: a) the differences between games in LT and ST phases and their ratio; and b) the game-related statistics and derived performance indicators that best differentiated between winning and losing teams. The main findings revealed: a) no significant differences in LT and ST phases between games, with an LT/ST ratio ~1; and that b) free throws, turnovers and rebounds were the most discriminating game-related statistics between winning and losing teams.

The analysis of LT and ST phases demonstrated similar results to those documented in previous investigations in basketball [6,7]. Indeed, in our study no differences were found in the distribution of the LT and ST phases between 3x3 basketball games, highlighting a quite homogeneous game configuration. Moreover, our findings demonstrated that the majority of the LT and ST phases had less than 20 s duration (58.1% and 57.6%, respectively). Previous investigations in basketball revealed a lower percentage compared to our results. In fact, LT and ST phases with a duration less than 20 s represented 43.4% and 51.1%, respectively, in elite women's basketball games and 38.5% and 28.3%, respectively, in college basketball games [6,7]. In addition, these studies documented a different percentage of LT and ST phases lasting more than 40 s in elite women's basketball (LT = 27.6% and ST = 19.9%) and college basketball (LT = 35% and ST = 48.3%), compared to the current investigation (LT = 17.2% and ST = 23.0%). A possible reason for this difference could be the fact that 3x3 basketball is played on a smaller court size (half court) compared to traditional 5x5 basketball (full court). The transition phases from one half court to the other, in particular in set offense, might have an influence on the longer LT phases in traditional basketball compared to 3x3 basketball. Moreover,

TABLE 3. Derived performance indicators for winning and losing teams expressed as mean ± standard deviation (SD), percentage (%) mean difference and effect sizes (ES) with their 90% confidence intervals (CI) and interpretation. P-values were calculated using the likelihood ratio test in the mixed linear model (MLM).

Derived performance indicators	Teams		Losing vs. Winning teams			
	Winning	Losing	MLM	% Mean difference (90% CI)	ES (90% CI)	Interpretation
Number of ball possessions	31.85 ± 2.61	29.75 ± 4.42	P=0.083	-6.56 (-13. 13; 0.50)	-0.77 (-1.61; 0.05)	Moderate
Team's offensive rating	0.56 ± 0.08	0.47 ± 0.06	**P=0.015**	-16.20 (-25.74; -5.43)	-1.22 (-2.06; -0.38)	Large
Team's defensive rating	0.46 ± 0.11	0.62 ± 0.11	**P=0.004**	36.69 (13.81; 64.17)	1.42 (0.58; 2.25)	Large
Effective field goal percentage	0.45 ± 0.08	0.41 ± 0.11	P=0.208	-9.81 (-25.42; 9.05)	-0.45 (-1.28; 0.38)	Moderate
Offensive rebounding percentage	0.22 ± 0.14	0.38 ± 0.12	**P<0.001**	59.09 (4.25; 142.76)	0.97 (0.08; 1.87)	Moderate
Recovered balls per ball possession	0.34 ± 0.09	0.22 ± 0.11	**P=0.005**	-40.22 (-57.24; -16.41)	-1.28 (-2.12; -0.44)	Large
Free throw rate	0.12 ± 0.07	0.07 ± 0.04	P=0.064	-45.68 (-66.62; -11.61)	-1.04 (-1.88; -0.21)	Moderate

3x3 basketball games are characterized by a shorter shot clock duration (12 s) compared to the shot clock adopted in previous basketball investigations (elite women basketball = 24 s; college basketball = 35 s). In this regard, a previous investigation demonstrated that reducing the shot clock duration during 3x3 basketball small-sided games increases the number of shot clock violations [20]. Therefore, players have much less time to finalize a ball possession and this might produce more turnovers and defensive fouls, which consequently lead to more breaks during the LT phases compared to traditional 5x5 basketball. Although 3x3 basketball have a possible different distribution within LT and ST phases compared to traditional basketball, the LT/ST ratio showed a similar value (~1) [6,7]. This finding seems crucial for 3x3 basketball coaches and practitioners in order to optimize their training sessions, possibly reproducing a training stimulus with similar game timing.

While previous investigations focusing on game-related statistics in 3x3 basketball mainly focused on youth competitions and on the differences between the top- and bottom-ranked teams [4,5], to the best of our knowledge, this is the first study focusing on the differences between winning and losing teams in elite senior 3x3 basketball teams. The analysis of game-related statistics indicated that winning teams performed a statistically higher number of free throws made and attempted compared to losing teams, with a large effect size, although no significant difference was found for the percentage of free throws made. These results indicate that losing teams likely foul more during shooting actions, and then allow winning teams to have more attempts to score with free throws, although with a similar scoring percentage. This result is in line with a previous investigation in basketball [9]. In particular, free throws scored has been considered a main indicator in the last quarter of close games, which has the same duration as an entire 3x3 basketball game (i.e. 10 minutes of live time) [10,16,21]. These similarities between traditional 5x5 basketball and 3x3 basketball in game-related statistics differentiating between winning and losing teams are also confirmed when considering the number of turnovers [15,22]. Indeed, our results indicate a statistically lower number of turnovers in winning teams compared to losing teams, making this game-related statistics fundamental for basketball coaches to design their skill training sessions. These findings are in line with a previous investigation documenting that the number of turnovers is a discriminant factor (i.e. discriminant value > 0.30) between top- and bottom-ranked teams in 3x3 female basketball teams involved in international youth competitions [4]. In particular, it seems essential to avoid turnovers in order to win a game, which is confirmed by the statistically significantly higher number of recovered balls per possession [(steals + blocked shots + opponent's turnovers)/ball possessions] documented in winning teams. Interestingly, this derived performance indicator was deemed not powerful enough when predicting game outcome in basketball [23], and the use of "turnover per possession" was suggested as a more powerful indicator. Since this is the first study investigating the derived performance related statistics in 3x3 basketball, further studies investigating both indicators and their power in predicting game outcome are warranted.

When considering the number of ball possessions, we found similar results compared to those documented by Scanlan et al. [15] and Conte et al. [9], with no statistically significant differences between winning and losing teams. Conversely, statistically significant large differences were found for offensive and defensive ratings, which are calculated based on the points scored and/or allowed and the number of ball possessions (offensive rating = points scored / ball possessions; defensive rating = points allowed / ball possessions). Similar results in these two performance indicators were also reported in traditional basketball with statistically significant [15] and substantial [9] differences between winning and losing teams. Therefore, it seems that both in traditional basketball and 3x3 basketball offensive and defensive ratings are more influenced by the points scored than the number of ball possessions.

Surprisingly, losing teams demonstrated a significantly higher number of rebounds (offensive, defensive and total) compared to winning teams. These findings are in contrast with previous research focused on game-related statistics in traditional basketball [15,22]. The possible reason for this difference might be that traditional basketball is played on a full court and rebound might play a fundamental role for starting the fast break action, which has been considered one of the most successful tactics in basketball [24]. Moreover, defensive rebounds play a fundamental role in basketball to avoid second chance points, which has been considered one of the main scoring strategies differentiating between winning and losing teams in elite women's basketball [8]. However, these results might have been influenced by the small sample of investigated games. Indeed, some of the analysed teams might have different game strategies to win a game rather than focusing on rebounds. Therefore, further studies with a larger sample size are required in order to address this issue.

From a practical standpoint, our results are relevant for 3x3 basketball coaches and practitioners to design appropriate training sessions. Usually, players involved in traditional 5x5 basketball are also involved in 3x3 basketball tournaments. Therefore, it seems fundamental to use specific training sessions for these players considering the uniqueness of this sport. Specifically, it seems essential to use half-court 3x3 basketball small-sided games with a 12-s shot clock duration to increase the training specificity. Furthermore, the indications derived from the analysis of LT and ST phases and their ratio indicate that training sessions should be characterized by short live time phases and a work-to-rest ratio ~1. Moreover, basketball drills should be focused on developing technical skills related to the ability to avoid turnovers and increase the recovered balls per ball possession in order to minimize the scoring possibilities for the opponent team. Finally, training sessions should regularly include free throws, which can be considered a fundamental game-related statistic in 3x3 basketball.

Although this study provides novel and interesting information for 3x3 basketball coaches and practitioners, it has some limitations.

Firstly, only eight games were investigated; secondly, games were from the male 2017 World Cup, so the current findings should not be generalized to other populations such as youth and female 3x3 basketball players. Therefore, future studies should investigate the LT and ST phases and the game-related statistics differentiating between winning and losing teams with a larger sample size and in youth and female competitions. An additional limitation regards the calculation of the derived performance indicator effective field goal percentage, since its formula refers to traditional basketball in which a shot from outside the arc is 1.5 times more valuable than a shot from within the arc (3-point vs. 2-point shots). By contrast, a shot from outside the arc in 3x3 basketball corresponds to 2 points and is 2 times more valuable than one from within the arch (1-point shot). Therefore, future investigations should deeply analyse this derived performance indicator, to develop a new, specific formula for 3x3 basketball.

CONCLUSIONS

In conclusion, no statistically significant differences were identified for the distribution of LT and ST phases, with an LT/ST ratio ~1. In addition, free throws, turnovers and recovered balls per possession are the main game-related statistics differentiating between winning and losing teams. Lastly, losing teams showed a significantly higher number of rebounds compared to winning teams, indicating these parameters as not the most important game-related statistics to win a game and calling for further studies in 3x3 basketball.

Conflict of interest declaration

The authors declare no conflict of interests regarding the publication of this manuscript.

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