



Age and Sex Differences in Shot Distribution and Accuracy in International 3x3 Basketball Tournaments

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Abstract

This study aimed to (a) investigate shot distribution and accuracy in international 3x3 basketball tournaments by classifying shot attempts into three types (two-point, mid-range, and paint shots) and (b) compare them among age and sex categories (senior men, senior women, under-18 men, and under-18 women). Ninety-one games from the FIBA 3x3 World Cup 2019 and the FIBA 3x3 Under-18 World Cup 2019 were analyzed using a notational analysis method. The Mann-Whitney U test with Benjamini-Hochberg correction was used to compare shot attempts and success rates between categories. There were no sex differences in the success rates of two-point and mid-range shots ($p < 0.05$). However, male teams attempted more two-point shots [senior men vs. senior women, $p < 0.01$, $r = 0.40$ (medium effect size); under-18 men vs. under-18 women, $p < 0.01$, $r = 0.21$ (small effect size)] and fewer mid-range shots [senior men vs. senior women, $p < 0.01$, $r = 0.36$ (medium effect size); under-18 men vs. under-18 women, $p < 0.01$, $r = 0.34$ (medium effect size)] than female teams. Differences between senior and under-18 teams in shot distribution were only observed in men's tournaments: senior teams attempted more two-point shots [$p < 0.01$, $r = 0.25$ (small effect size)] and fewer paint shots [$p = 0.04$, $r = 0.19$ (small effect size)] than under-18 teams. Male teams were superior to female teams in terms of scoring efficiency. However, the career transition from youth to senior tournaments may be smoother for girls than boys because of the similarity in the shot selection between under-18 and senior games.

Keywords: Basketball, 3x3, notational analysis, game-related statistics, shooting



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Introduction

Basketball is a ball game in which two teams of five players each try to score points by shooting a ball into a basket placed 3.05 m above the floor. Making a successful shot closer to the basket is easier, but the opponent's defense can be more chal-

lenging. A successful long-range shot, especially from outside the three-point line, results in 1.5 times more points, but it requires strength (Tang & Shung, 2005) and power (Pojskić et al., 2014) as well as skills to make a long-range shot. Given the nature of the game, information on where the shots were

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attempted from and how accurate they were are essential in evaluating technical and tactical performances. A previous study has reported that shot distribution and accuracy differ among age and sex categories in elite-level games (Madarama, 2021). This type of information could provide a basis for developing optimal tactics and training programs based on the age and sex of players.

In the late 2000s, the International Basketball Federation (FIBA) began formalizing another form of basketball that uses only one basket and is played by two teams of three players (Snoj, 2021a). The new discipline was named “3x3” and became one of the Olympic sports in the Tokyo 2020 Olympic Games. There are several differences between 3x3 and 5on5 basketball games besides the number of players on the court. One of the significant differences is the points awarded for a successful shot. In 5-on-5 basketball played under the FIBA rules, two points are awarded for a shot attempted from inside the 6.75 m line and three points for a shot attempted from outside the 6.75 m line. In 3x3 basketball, however, one and two points are awarded for each situation, making long-range shots more valuable. Another difference is the time allowed from gaining possession to attempt a shot: 5-on-5, 24 s; 3x3, 12 s. The shortened shot clock in 3x3 basketball requires the offensive team to complete the offense in less time. Because of these differences, shot distribution and accuracy in 3x3 basketball may differ from those in 5-on-5 basketball.

Research in 3x3 basketball is still in its infancy, but the number of studies is growing (Conte et al., 2019; Erčulj et al., 2019; Ferioli et al., 2022; Figueira et al., 2022; Koh et al., 2012; McGown et al., 2020; Montgomery & Maloney, 2018; Ortega et al., 2021), and several of them (Erčulj et al., 2019; Ferioli et al., 2022; McGown et al., 2020) have compared shot-related statistics between men’s and women’s 3x3 basketball games. Erčulj et al. (2019) investigated shot distribution and accuracy in under-18 teams competing in the 2018 Youth Olympic Games. They reported that although male teams attempted more two-point shots and fewer one-point shots than female teams, male teams showed lower two-point success rates and higher one-point success rates than female teams. The findings that male teams attempted more two-point shots and fewer one-point shots than female teams are consistent with a study by Ferioli et al. (2022) that analyzed the FIBA 3x3 Europe Cup 2019, a senior tournament. While these pioneering studies should be highly valued, they have a limitation in analyzing shot distribution in basketball games: they only classified field goals into one- and two-point shots. It is well known that three-point shot attempts in the National Basketball Association (NBA)

have dramatically increased since the mid-2010s. Instead of an increase in three-point shots, there has been a decrease in mid-range shots, relatively long-ranged shots within a two-point shot area (Goldsberry, 2019; Shea, 2014). This phenomenon indicates that simply classifying shot locations into two, inside and outside the three-point line, limits the analysis.

McGown et al. (2020) not only classified field goal attempts into one- and two-point shots but also investigated the number of layup shot attempts and reported no sex differences in any of the shot attempts. However, since they analyzed a domestic tournament in Australia, technical and tactical performances may differ from those in international tournaments. In addition, it should be noted that the study normalized the number of shot attempts per minute of game time. Since the number of offenses is affected by the game’s pace, it is recommended to use per possession values to compare game-related statistics in basketball research (Sampaio et al., 2013; Snoj, 2021b). This recommendation would be supported by a study by Ferioli et al. (2020), which reported sex differences in the number of possessions in 3x3 basketball.

As far as the author is aware, no study has investigated shot distribution in international 3x3 tournaments for youth by classifying shot attempts into three or more shot locations. In addition, no independent study has comprehensively investigated age and sex differences in shot distribution and accuracy in international 3x3 basketball tournaments. Therefore, the aims of this study were to (a) investigate shot distribution and accuracy in international 3x3 basketball tournaments by classifying shot attempts into three types (two-point, mid-range, and paint shots) and (b) compare them among age and sex categories (senior men, senior women, under-18 men, and under-18 women).

Methods

Data collection

Data were collected from the FIBA 3x3 World Cup 2019 and the FIBA 3x3 Under-18 World Cup 2019 using a notational analysis method. The total number of games was 192 (48 in each category); however, one game in the under-18 women’s tournament was excluded from the analysis because the official game footage was only available from 3:02 remaining in the game. An experienced researcher coded each play chronologically in a Microsoft Excel spreadsheet while watching the publicly accessible game footage posted on FIBA 3x3’s official YouTube channel (<https://www.youtube.com/fiba3x3>). Field goal attempts were classified into three types depending on where they were attempted (Table 1).

Table 1. Definitions used to classify field goal attempts

Shot type	Definition
Two-point shot	A shot attempted from outside the two-point line
Mid-range shot	A shot attempted from inside the two-point line but not a paint shot
Paint shot	A shot where the shooter’s last step foot or landing foot is in the paint area

If the play could not be identified from the footage, it was classified as “unclear” and excluded from the analysis. There were 14 cases classified as “unclear,” but since the number was small compared to the 11,117 shots recorded, it was determined that it would not affect the result of the study. In official basketball records, if a player is fouled in the act of shooting, the shot is not recorded as a field goal attempt unless the shot goes in (In-

ternational Basketball Federation, 2018). However, if more shots from a particular location are fouled, the number of shots from that location will be underestimated. Since this study aimed to determine the number of actual shot attempts from each location, the number of unsuccessful shots due to fouls was added to the field goal attempts. However, unsuccessful shots due to fouls were excluded when calculating the success rate of each location.

Data reliability

Intra-rater reliability was tested after at least one month from the initial measurement. Eight games (two games from each category) were randomly selected using the R function “sample,” and the plays were re-coded. Cohen’s kappa was calculated using the R function “kappa2” in the “irr” package and was 0.985.

Data processing

Data were analyzed separately for each game’s winning and losing teams. The number of shot attempts in each game was normalized to 100 possessions. Normalizing the number of shot attempts by the number of possessions is widely used in basketball research to eliminate the influence of game rhythm (Giovanini et al., 2021; Raval & Pagaduan, 2021). In addition, the duration of a 3x3 game varies from game to game because the game ends when either team scores 21 points; hence normalization is essential in 3x3 games. Instead of using an estimation formula to calculate the number of possessions, actual measurements based on the records of this study were used. An offensive rebound was considered a continuation of possession (Snoj, 2021b).

Statistical analyses

Statistical analyses were conducted using the software R version 4.0.5 for Windows (R Core Team, 2021). Beeswarm boxplots were created to visualize the data using the R function “geom_boxplot” in the “ggplot2” package and the R function “geom_quasirandom” in the “ggbeeswarm” package. The Mann-Whitney U test (the R function “wilcox_test” in the “coin” package) was used to compare shot attempts and success rates between categories. Once the p-value for each pairwise comparison was obtained, multiplicity was adjusted using the Benjamini-Hochberg method (Benjamini & Hochberg, 1995) with the R function “p.adjust” to maintain a significance level of $p < 0.05$. The r-value was calculated as an effect size for the Mann-Whitney U test ($r = 0.10-0.29$, small effect size; $r = 0.30-0.49$, medium effect size; $r \geq 0.50$, large effect size) (Cohen, 1988).

Results

Comparisons of the number of shot attempts per 100 possessions

The number of two-point, mid-range, and paint shot attempts per 100 possessions are presented as beeswarm boxplots (Figure 1), and the results of pairwise comparisons are shown in Table 2.

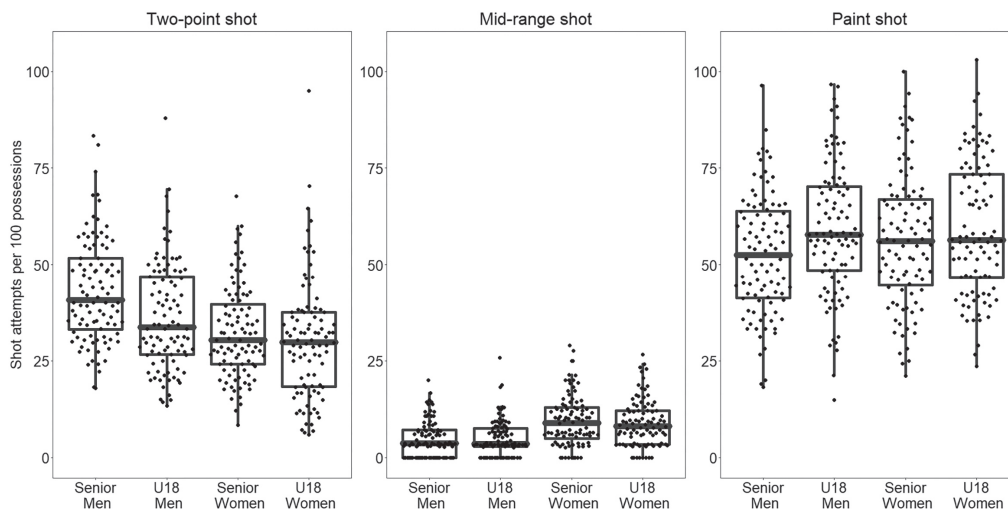


Figure 1. Beeswarm boxplots of two-point, mid-range, and paint shot attempts per 100 possessions. The dots represent the value of each team for each game.

Table 2. Results of pairwise comparisons of shot attempts per 100 possessions between categories

	Two-point shot		Mid-range shot		Paint shot	
	p	r	p	r	p	r
Senior men vs. U18 men	<0.01*	0.25†	0.86	0.01	0.04*	0.19†
Senior men vs. Senior women	<0.01*	0.40‡	<0.01*	0.36‡	0.30	0.10†
Senior men vs. U18 women	<0.01*	0.44‡	<0.01*	0.34‡	0.04*	0.18†
U18 men vs. Senior women	0.06	0.14†	<0.01*	0.36‡	0.34	0.09
U18 men vs. U18 women	<0.01*	0.21†	<0.01*	0.34‡	0.83	0.02
Senior women vs. U18 women	0.21	0.09	0.72	0.04	0.40	0.07

Note. * $p < 0.05$, †small effect size ($r = 0.10-0.29$), ‡medium effect size ($r = 0.30-0.49$).

Male teams attempted a significantly greater number of two-point shots than female teams in both senior [$p < 0.01$, $r = 0.40$ (medium effect size)] and under-18 tournaments [$p < 0.01$, $r = 0.21$ (small effect size)]. Differences between senior and under-18 teams in two-point shot attempts were only observed in men’s tournaments: senior teams attempted

more two-point shots than under-18 teams [$p < 0.01$, $r = 0.25$ (small effect size)]. In contrast to two-point shot attempts, female teams attempted a significantly greater number of mid-range shots than male teams in both senior [$p < 0.01$, $r = 0.36$ (medium effect size)] and under-18 tournaments [$p < 0.01$, $r = 0.34$ (medium effect size)]. Differences between

senior and under-18 teams were not observed in mid-range shot attempts ($p>0.05$). There were no sex differences within the same age categories in paint shot attempts ($p>0.05$). Similar to the results of two-point shot attempts, differences between senior and under-18 teams in paint shot attempts were only observed in men's tournaments; however, in contrast to two-point shot attempts, under-18 teams attempted

more paint shots than senior teams [$p = 0.04$, $r = 0.19$ (small effect size)].

Comparisons of success rates

Figure 2 shows the beeswarm boxplots of success rates of two-point, mid-range, and paint shots; Table 3 shows the results of pairwise comparisons.

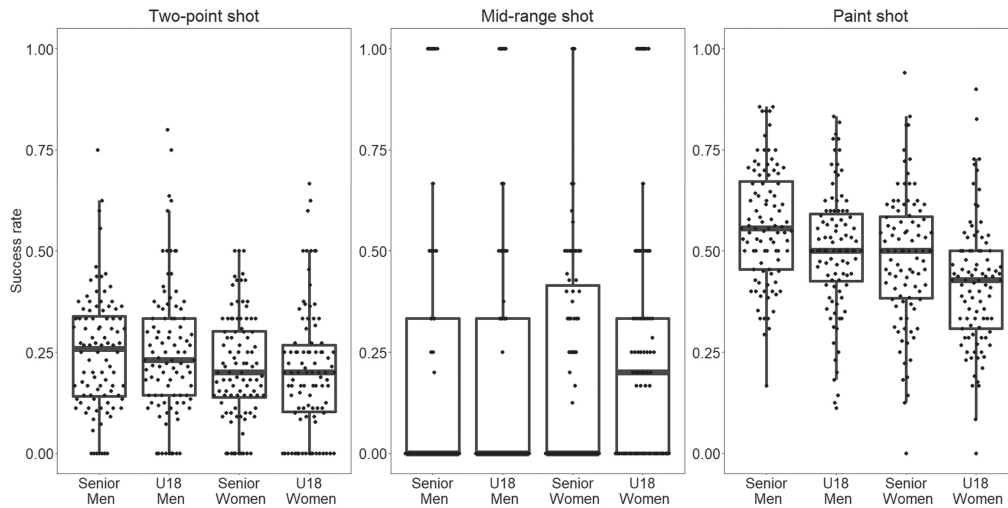


Figure 2. Beeswarm boxplots of the success rates of two-point, mid-range, and paint shot attempts. The dots represent the value of each team for each game.

Table 3. Results of pairwise comparisons of success rates between categories

	Two-point shot		Mid-range shot		Paint shot	
	p	r	p	r	p	r
Senior men vs. U18 men	0.94	0.01	0.94	0.01	<0.01*	0.19†
Senior men vs. Senior women	0.22	0.11†	0.45	0.08	<0.01*	0.24†
Senior men vs. U18 women	0.09	0.16†	0.14	0.16†	<0.01*	0.46‡
U18 men vs. Senior women	0.22	0.11†	0.45	0.09	0.45	0.06
U18 men vs. U18 women	0.09	0.16†	0.14	0.16†	<0.01*	0.31‡
Senior women vs. U18 women	0.56	0.05	0.47	0.06	<0.01*	0.24†

Note. * $p<0.05$, †small effect size ($r = 0.10-0.29$), ‡medium effect size ($r = 0.30-0.49$).

There were no age or sex differences in the success rate except for paint shots. Male teams showed higher paint success rates than female teams [senior men vs. senior women, $p<0.01$, $r = 0.24$ (small effect size); under-18 men vs. under-18 women, $p<0.01$, $r = 0.31$ (medium effect size)]; senior teams showed higher paint success rates than under-18 teams [senior men vs. under-18 men, $p<0.01$, $r = 0.19$ (small effect size); senior women vs. under-18 women, $p<0.01$, $r = 0.24$ (small effect size)].

Discussion

This study aimed to (a) investigate shot distribution and accuracy in international 3x3 basketball tournaments by classifying shot attempts into three types (two-point, mid-range, and paint shots) and (b) compare them among age and sex categories. There were no sex differences in the success rates of two-point and mid-range shots. However, male teams attempted more two-point shots and fewer mid-range shots than female teams. Differences between senior and under-18 teams in shot distribution were only observed in men's tournaments: senior teams attempted more two-point shots and

fewer paint shots than under-18 teams.

Between-sex comparisons showed that male teams attempted more two-point shots than female teams. Previous studies have reported that male teams attempted more two-point shots than female teams in the FIBA 3x3 Europe Cup 2019 (Ferioli et al., 2022) and the 2018 Youth Olympic Games (Erčulj et al., 2019). Since similar results were obtained in several different tournaments, it can be said with considerable certainty that male teams attempted more two-point shots than female teams in recent international 3x3 tournaments. It should be noted that there is a study reporting no sex differences in shot-related statistics (McGown et al., 2020); however, the study analyzed a domestic tournament in Australia. The difference in competition levels between international and domestic tournaments may be a reason for the discrepancy.

The fact that male teams attempted more two-point shots than female teams suggests that male teams attempted fewer non-two-point shots than female teams. Previous studies have reported that male teams attempted fewer one-point shots than female teams in senior (Ferioli et al., 2022) and under-18 (Erčulj et al., 2019) international 3x3 tournaments. Unlike

these studies, this study analyzed one-point shots separately for mid-range and paint shots. The results showed that while there were no differences in paint shot attempts between male and female teams, male teams attempted fewer mid-range shots than female teams. In many cases, male teams did not attempt a single mid-range shot in a game (senior teams, 27%; under-18 teams, 23%). In addition, some mid-range shots seemed to be attempted without intention: accidentally stepping on the two-point line or having no choice but to attempt a shot because the shot clock was about to expire. There were also cases for female teams with no mid-range shot attempts in a game, but the proportion was smaller (senior teams, 9%; under-18 teams, 8%) than male teams. As mid-range shots have come to be considered inefficient, avoiding the attempt has become prevalent in recent 5-on-5 basketball games (Goldsberry, 2019; Shea, 2014). The results of this study suggest that the trend is also seen in both men's and women's 3x3 basketball games but is especially notable in men's games.

Differences between senior and under-18 teams in shot distribution were only observed in men's tournaments: senior teams attempted more two-point shots and fewer paint shots than under-18 teams. From the scoring efficiency point of view, it is preferable to reduce mid-range shot attempts rather than paint shot attempts. However, since men's both age categories rarely attempt mid-range shots, it would not have been capable of further reducing mid-range shot attempts. A previous study on international 5-on-5 basketball has also reported that differences in shot distribution between senior and under-18 games were only observed in men's tournaments (Madarame, 2021). Therefore, women's games likely have more similarities between senior and under-18 tournaments than men's in both disciplines of basketball. It should be noted, however, that the effect size of the difference between the senior and the under-18 men's tournaments was small. Since effect sizes of sex differences observed in two-point and mid-range shot attempts were medium (except for two-point shot attempts in the under-18 tournaments), differences between age categories are likely to be smaller than between sex categories.

Age or sex differences in the success rate were only observed in paint shots. The success rate of paint shots was higher in the men's tournament than in the women's tournament and higher in the senior tournament than in the under-18 tournament. Unfortunately, these results cannot be directly compared to previous studies because success rates of paint shots in 3x3 basketball have not been reported. However, the fact that male teams showed higher success rates than female teams was consistent with a previous report on one-point success rates in under-18 games (Erčulj et al., 2019). In addition, a previous study on international 5-on-5 basketball has also reported that the success rate of two-point shots (one-point shots in 3x3 basketball) was higher in the men's tournament than in the women's tournament and higher in the senior tournament than in the under-18 tournament (Madarame, 2021).

Two-point shots require greater strength (Tang & Shung, 2005) and power (Pojskić et al., 2014) than one-point shots because of a greater distance from the basket. Therefore, it is reasonable to assume that male teams have higher success rates than female teams, and senior teams have higher success rates than under-18 teams. These assumptions are partially consistent with a previous study on international 5-on-5 basketball: the success rate of three-point shots (two-point shots in 3x3 basketball) was higher in the senior tournament than in the

under-18 tournament for both sexes (Madarame, 2021). Sex differences in the success rate were not observed in the 5-on-5 study probably because differences in muscle strength and power were compensated by differences in size and weight of the balls: the ball used in women's 5-on-5 basketball is smaller and lighter than the ball used in men's 5-on-5 basketball. Unlike 5-on-5 basketball, 3x3 basketball uses balls of the same size and weight for both sexes, which may give male players an advantage over female players. However, the results of this study showed neither age nor sex differences in the success rate of two-point shots. Moreover, and surprisingly, a previous study on 3x3 basketball has reported that the success rate of two-point shots was higher in the women's tournament than in the men's tournament (Erčulj et al., 2019). Since 3x3 basketball is usually played on outdoor courts, environmental factors such as wind and light might have been a greater source of variability in the success rate of long-range shots.

A limitation in interpreting this study is that the senior and the under-18 tournaments were held in different locations. Since the games were played on outdoor courts, we cannot rule out the possibility that environmental differences may have influenced the results, especially the age comparison of success rates. While this study analyzed only one tournament per category, future studies analyzing multiple tournaments could overcome this limitation.

In conclusion, it was suggested that male teams were superior to female teams in terms of scoring efficiency. However, the career transition from youth to senior tournaments may be smoother for girls than boys because of the similarity in the shot selection between under-18 and senior games.

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