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Comparison of Physical Activity in Small-Sided Basketball Games Versus Full-Sided Games

**Brian T. McCormick¹, James C. Hannon¹, Maria Newton¹,
Barry Shultz¹, Nicole Miller¹, and Warren Young²**

¹Department of Exercise and Sport Science, University of Utah

²University of Ballarat, Australia

ABSTRACT

Organized youth sports leagues attempt to meet many goals. Three primary needs for a youth sports league are to meet the participants' desires, provide quality learning experiences, and develop the competencies needed for continued participation. Possessing the ball, shooting more, and being more involved with a team's offense lead to more enjoyment and feelings of competence. Therefore, increasing the involvement of each player through more ball contacts should be a goal of youth sports leagues. Twelve male basketball players (age=15) from one high-school basketball team participated in this study. This study used paired t-tests to examine the differences between three-on-three basketball games and five-on-five basketball games that lasted for eight minutes in terms of average heart rate, moderate to vigorous intensity physical activity, vigorous intensity activity, and ball contacts. There were no significant differences between average heart rate, moderate-to-vigorous intensity activity, or vigorous intensity activity in the two conditions, but there were significantly more ball contacts on average in the three-on-three games. These results suggest that three-on-three leagues may be an appropriate sport for the initial exposure to basketball for youth players.

Key words: Basketball, Heart-Rate Monitoring, Small-Sided Games, Youth Sport

INTRODUCTION

Youth basketball leagues modify the game by eliminating zone defenses, outlawing full-court presses, using smaller balls, lowering the rims, and shortening the free-throw line [1,2], but few leagues reduce the number of players. The effects of modifying the game from five-on-five full-court games to three-on-three half-court games are largely unstudied. Reducing the number of players is a common strategy used to make a sport more skill appropriate and

to promote skill development without sacrificing the fidelity of the sport. The English F.A. and U.S. Soccer do not recommend full-sided 11-on-11 soccer until under-13s [3]. The play practice [4], teaching games for understanding [5], and sport education [6] philosophies use modified or small-sided games extensively, and basketball coaches use small-sided games extensively during practices for developmental purposes.

Beginners and less-skilled players need more time and space [4], but youth basketball is played within a more constrained environment than the professional game. A youth (22.5 m) or high school (25.6 m) basketball court is shorter than an NBA court (28.65 m) and narrower (12.8m to 15.24m versus 15.24 m). In the half-court, offense is played from just outside the three-point line to the basket. The NBA three-point line (7.24 m) is deeper than the college (6.25 m) or high school/youth (6 m) three-point line. In the half-court, the player density (total area divided by the players) is 38.1 m² per player for the NBA and 25.6 m² per player for youth games on a 12.8m wide court [7], giving less time and space to the developing youth player compared to an NBA player.

Beyond space constraints, every additional player increases the interactions and decision-making load. A five-on-five basketball game has 90 potential interactions; playing one-on-one has only two [8]. Interactions are the tactical possibilities [8], and more interactions equal greater task complexity. When more players are added to a constrained area, individual tasks become more complex, require greater accuracy, and must be made in less time. Expert players possess the perceptual-cognitive skills to respond skillfully to situations with high demands of task complexity, speed, and accuracy [9], but young or inexperienced players lack these skills. Three-on-three increases the available space to 42.76 m² per player on a 12.8 m wide court and reduces the potential interactions to 30, reducing the task complexity and providing more time and space for developing players.

Small-sided games also have been shown to increase more skill-related activity. Arias et al. [10] suggested that the most significant way to participate in sport is ball contacts. A pilot study by Canada Basketball found more ball contacts for each player in a three-on-three game compared to a five-on-five game. In a study by Pinar et al. [11], each player participated more often in an offensive attack in a modified three-on-three basketball game compared to a five-on-five game. The opportunity for more players to participate in more ball possessions offers a greater opportunity for individual and collective development [10].

In addition to the number of players on the court, a player's position may affect his involvement in the game reflected in the number of ball contacts. Many teams rely on the point guard to be a primary ball handler and initiate the team's offense, so point guards would be expected to have more ball contacts than other positions. However, no known studies have examined the effect of position on the number of ball contacts.

In addition to creating a more skill-appropriate game and offering more ball contacts, research indicates that small-sided games increase average heart rates when compared to games with more participants. Small-sided games have been shown to increase average heart rates in basketball [12], rugby [13], soccer [14], futsal [15], and field hockey [16]. No differences were found in average heart rates when comparing three-on-three to four-on-four games in basketball [17]. No known studies have directly compared three-on-three basketball with five-on-five basketball.

The purposes of this study were two: a) to compare small-sided basketball games (three-on-three) to full-sided basketball games (five-on-five) in terms of ball contacts and physical activity as measured by a heart-rate monitor, and b) to examine the influence of positions on ball contacts in three-on-three and five-on-five basketball games. Based on the review of literature, it was hypothesized that three-on-three games would provide more ball contacts,

and would induce higher mean average heart rates than five-on-five games. On the contrary, it was hypothesized that five-on-five games would provide a higher percentage of vigorous intensity (VI) due to full-court sprints, whereas the three-on-three and five-on-five games would provide the same percentage of moderate-to-vigorous intensity (MVI). Finally, it was hypothesized that point guards would possess the ball more than wings and post players in five-on-five games, whereas possessions would be distributed equally in the three-on-three games.

METHODS

PARTICIPANTS

The participants in this study were 12 boys (15 years of age) from a high-school freshmen basketball team in the southwestern United States, and each had at least one season of prior playing experience. One high-school team agreed to participate in the study, which limited the study to 12 participants. Each player played two three-on-three and two five-on-five games. The study occurred early in the team's regular season after approximately six weeks of practice. None of the players had a history of injury in the previous three months. The study was approved by the University IRB, and subject and parental informed consent was received prior to the start of data collection.

PROCEDURE

This was a quasi-experimental study using a within-groups repeated measures design. The study took place during the team's normal Saturday morning practice. The subjects were assigned to five-on-five and three-on-three teams. The order of participation was randomized, and players competed with and against different players. Teams were balanced to account for height differences. Each player participated in two five-on-five games and two three-on-three games. The games were eight minutes in duration, and the clock did not stop. Fouls were called, but no free throws were attempted. The ball was returned to play as quickly as possible after all fouls, violations, and out of bounds.

The players warmed up as they would before a game with a dynamic warm-up and basic lay-up drills. The players wore their practice uniforms: Shorts and loose fitting reversible jerseys with numbers clearly visible. After the warm-up, the players were fitted with heart-rate monitors (Polar E600). The players wetted the transmitter before fitting the chest strap around their chest. The delay between the warm-up and the start of the first game was approximately 10 minutes, as each player received a monitor and strap, fitted the strap, and turned on the heart-rate (HR) monitor to check if it was registering values.

At the start of each game, the players were instructed to start the HR monitor. Each player made a visual check. Once each player confirmed his HR monitor was working, the official started the game with a jump ball, and the clock was started. The videographer started to record the action in advance of the jump ball to ensure that no activity was missed. At the final buzzer, players were instructed to stop the HR monitor. At the conclusion of the games, the HR data from each of the monitors was inputted into a Microsoft Excel file manually for statistical analysis. The manual download allowed for a thorough check of the data, and incomplete data were excluded.

After each game, players rested for at least five minutes before returning to play. Exact heart-rate recovery depends on the exercise intensity, physical fitness, and other factors, but generally decreases by 15-20 beats in the first minute [18]. Hebestreit et al. [19] showed that prepubertal boys could recover fully from a Wingate anaerobic test after two minutes. Five minutes of passive recovery appeared sufficient for active adolescents performing below

90% of their maximal effort, and inspection of the data showed that players started each game with a similar heart rate.

The five-on-five games were played on a regulation high-school court (25.6m x 15.24m) and used high-school rules with the exception of the running clock and lack of free-throw attempts. The three-on-three games were played on a modified half court with the depth restricted to 9.14m. The three-on-three games were played with the FIBA33 rules. "The game is played on a half court, on one basket.... If the defensive team rebounds the ball, it must return the ball (by passing or dribbling) behind the three-point line" [20, p. 26-27]. After a made basket, the new offensive team inbounded and cleared the ball.

The games were recorded on a video camera (Sony Handycam DVD 850) for further analysis. The video camera was located at center court on the top of the bleachers to allow for an angle where every player was captured at all times, and jersey numbers remained visible. The video recording was used to observe the ball contacts for each player in each game condition.

INSTRUMENTS

The researcher used the DVD recording and the Team Sport Assessment Procedure (TSAP) to measure each player's involvement through his ball contacts [21]. Nadeau et al. [22] reported a discriminant validity of -0.77 and a percentage of agreement of 81% with student-observers in ice hockey using the TSAP, similar to the original study which reported a concurrent validity of .74 and inter-observer reliability greater than .90 [21].

To approximate the ball contacts when the player had the opportunity to shoot, make a move in a one-on-one situation, or make a decision against defenders in the attack zone [10], the researcher subtracted neutral balls (NB) from the volume of play (PB) to create the offensive-played-balls (OPB) category (because the researcher noted that a high number of non-essential plays affected the correlation between an instrument's results and an expert's ratings in a previous pilot study). To create a consistent NB measure, any inbound pass was considered to be a neutral ball. The OPB category was considered to give the best approximation of ball contacts within the game where the player had an opportunity to shoot, make a move against a defender, or make a decision against a defender, thus providing the opportunity to participate and improve.

The researcher observed each player and tallied each ball possession and outcome using the TSAP. After one week, the researcher re-watched the DVD and randomly picked two players in each condition to observe. The Pearson's correlation coefficient for intra-observer reliability was .976, $p = .024$. To measure the inter-observer reliability, a college basketball coach viewed one three-on-three game and one five-on-five game and observed two players in each condition. The Pearson's correlation coefficient for inter-observer reliability between the researcher and the college basketball coach was .987, $p = .013$.

HEART-RATE MEASURES

Heart-rate values were recorded every 15 seconds to reduce sampling error without sacrificing the quality of interpretation [23, 24]. The use of Polar Heart Rate monitors has been validated against ECG readings in activities as diverse as rowing, dance, and jogging [25, 26], and has been recognized as the most accurate tools for heart-rate monitoring and registering heart rates in the field [27]. HR monitors have been used to determine the intensity of activity in numerous basketball studies [23, 24, 28-30].

The Center for Disease Control and Prevention [31] set moderate intensity (MI) physical activity at 50% to 70% of the person's age-predicted maximum heart rate. The 50% threshold

was used to determine percentage of time spent in moderate to vigorous intensity (MVI) activity. Using the CDC formula [31] of subtracting age from 220, the threshold for a player who is 15 years of age is 103 beats per minute ($220 - 15 = 205$. $205 \times .5 = 102.5$ bpm). The formula $\%MVI = (\text{number of heart rate readings over } 103 \text{ bpm} / \text{total number of heart rate readings}) \times 100$ was used to determine the percentage of time spent in MVI [32].

The CDC [31] set vigorous intensity (VI) physical activity at 70% to 85% of the person's age-predicted maximum heart rate. Using the CDC formula [31], the range for a 15 year-old for vigorous activity is between 144 bpm ($220 - 15 = 205$. $205 \times .7 = 143.5$ beats per minute) and 174 bpm ($207 \times .85 = 174.25$ bpm). Strong et al. [33] suggested 80% of age-predicted maximal heart rate as a recommended threshold for vigorous physical activity. Using the CDC formula [31], a 15 year-old's target heart rate for 80% of age-predicted maximum would be 164 bpm, which is close to the cut-point for high-intensity work (170 bpm) used with 11-year-old boys [32] and referenced with 13-year-olds [14].

To create a single value for comparison purposes, 164 bpm or 80% of age-predicted maximum heart rate was used. The percentage of time spent in VI was calculated with the formula: $\%VI = (\text{number of heart rate readings over } 164 \text{ bpm} / \text{total number of heart rate readings}) \times 100$ [32].

DATA ANALYSES

Data were excluded if there were readings of zero during the game. One player did not register any heart-rate data, leaving 11 players for the analysis of the heart-rate data. The data for each condition (three-on-three and five-on-five) were averaged for each player for analysis. All 12 players were used for the analysis of offensive-played balls (OPB), and the sum of OPB for the two games in each condition was used. Paired t-tests were used to analyze the data for the average heart rate, percentage of total MVI and VI, and OPB in three-on-three games compared to five-on-five games. A 3x2 mixed factorial repeated measures ANOVA was used to identify any significant differences in OPB by position, and a Tukey's posthoc was used to determine any differences by position. The data were analyzed using SPSS 20.

RESULTS

OFFENSIVE-PLAYED BALLS

The study compared OPB in three-on-three and five-on-five basketball games. The players' OPB in three-on-three games was higher than during the five-on-five games, $t(11) = 8.270$, $p < .01$, $d = 1.948$. The Cohen's effect size value suggested a high practical significance. Table 1 shows the means and standard deviations for each category.

Table 1. Means and Standard Deviations for Measures of Physical Activity in 3v3 and 5v5 Games

Conditions	Mean	n	Std. Deviation
Avg HR 3v3	166.82	11	10.64
Avg HR 5v5	165.0	11	9.60
MVI % 3v3	97.73	11	6.56
MVI % 5v5	98.58	11	3.23
VI % 3v3	69.89	11	16.01
VI % 5v5	67.89	11	20.20
OPB 3v3	26.08	12	6.36
OPB 5v5	14.42	12	5.58

The OPB were compared based on position as designated by the coach (Table 2). There was a significant effect of position on OPB in three-on-three games, $F(2, 9) = 4.44$, $p = .046$. Planned contrasts revealed that the point guard position had significantly more OPB than post players in three-on-three games ($p = .039$). There was a significant effect of position on the OPB in five-on-five games, $F(2, 9) = 8.27$, $p = .009$. Planned contrasts revealed that the point-guard position had significantly more OPB than post players ($p = .018$) and wings ($p = .008$) in five-on-five games.

Table 2. Offensive-Played Balls by Position and Condition

Position	n	3v3	5v5
Point Guard	2	34	24
Wing	6	26.67	12.17
Post	4	21.25	13

HEART-RATE MEASURES

The study compared average heart rate, MVI, and VI in three-on-three and five-on-five basketball games. The players' average heart rate in three-on-three games and five-on-five games was not statistically significant $t(10) = 0.739$, $p = .477$, $d = .179$. The players' percentage of time spent in MVI in three-on-three games and five-on-five games was not statistically significant $t(10) = -0.363$, $p = .724$, $d = .16$. The players' percentage of time spent in VI in three-on-three games and five-on-five games was not statistically significant $t(10) = 0.342$, $p = .740$, $d = .109$. The Cohen's effect size for the heart-rate measures suggested a minimal practical significance.

DISCUSSION

The purpose of this study was to determine the differences in OPB, average HR, and percentage of MVI and VI in three-on-three basketball games compared to five-on-five games. The findings supported the hypothesis that OPB would be higher in the three-on-three games compared to the five-on-five games. The results for position in the five-on-five games supported the hypothesis that point guards would have more OPB than wings and post players, but the results for three-on-three did not support the hypothesis that there would be no difference in OPB in point guards, wings, and post players. The findings for MVI supported the hypothesis that there would be no difference in MVI in three-on-three games compared to five-on-five games. The findings for average heart rate and VI did not support the hypotheses that three-on-three games would induce higher mean average heart rates, and five-on-five games would provide a higher percentage of VI than three-on-three games.

The increased OPB, decreased task complexity, and similarity in physical activity would appear to suggest that three-on-three basketball is the more appropriate game form for young or inexperienced players. The results also support previous findings for the increased number of ball contacts in three-on-three compared to five-on-five games in basketball [11]. Similarly, young players in three-on-three soccer games were involved in more short passes, kicks, tackles, dribbling, and scoring chances than in six-on-six soccer games [14].

Despite increased OPB for all players, three-on-three basketball failed to distribute possessions more evenly. In each condition, the point guards possessed the ball more. One challenge for coaches is to distribute offensive plays between more players, especially at the developmental level where every player needs the opportunity to possess the ball in order to improve. It was anticipated that three-on-three games would reduce the need for a primary

ball handler and distribute the possessions more equally. Reducing the number of players is a structural modification of the game, which is the most common approach to game modifications [34]. Further functional modifications could be explored to distribute possessions among all players [34]. Possible modifications would be to require each player to possess the ball before a team attempts a shot or to limit the number of dribbles for each player. A simple modification would be to require the player to pass the ball across the line to clear the ball rather than allowing one player to dribble across the line after a change of possession. This would eliminate a player rebounding, dribbling out to clear the ball, and shooting without any passes. Arias et al. [34] concluded that it is more difficult to achieve the goals through structural modifications compared to functional modifications, and these modifications would appear to achieve the goal of dispersing possessions more equally as one player would be unable to monopolize an entire possession, either because of a limit on dribbles or the requirement of a pass or passes before a shot attempt.

Children cite getting or staying in shape as an important reason for participation [35, 36], and team sports contribute significantly to many children's physical activity [37]. Whereas half-court three-on-three games offer the same amount of physical activity as full-court five-on-five games, further modifications could be explored to increase VI. Reducing the space may increase the intensity by ensuring the involvement of all six players in each play, whereas playing full-court three-on-three games may increase the intensity due to the more transition-oriented game created by the reduction in players. Other modifications could be to shoot free throws after shooting fouls to measure the effects of the breaks on intensity, and using a shot clock to increase the speed of play.

PRACTICAL APPLICATION

In the present study a three-on-three league would appear to offer the same amount of physical activity, and more opportunities to develop skills compared to the more common five-on-five leagues. To these results, youth basketball leagues in the three-on-three version could provide the best opportunity for children to have fun, play with their peers, learn and improve skills, and stay active. In a youth league in an average high-school gymnasium, five-on-five leagues utilize two baskets; 20 players play at one time, but only 10 are on the court. A half-court three-on-three league would allow the league to play on four baskets simultaneously; 32 players would be involved, and 24 would be on the court.

CONCLUSION

LIMITATIONS AND FUTURE RESEARCH

The primary limitation of the study was the participants. The mean heart rate and %VI for the three-on-three games were lower than in a previous study [17], suggesting that these participants may not have exerted themselves fully. The lower means for average heart rate and %VI for the five-on-five games could be due to increased time to re-enter play after a violation or foul, as the team set up its out-of-bounds play, or a slower pace as it organized into its offensive sets in the five-on-five games. During the three-on-three games, there were no plays, and no time spent organizing players into the right positions. Neither condition used a shot clock due to National Federation of State High School Associations (NFHS) rules.

A second limitation may have been the procedures. By playing multiple games in one session, players may have been fatigued for the later games. Also, by using a single team, players had established roles and may have deferred to their roles even in the non-structured, un-coached setting. This may explain the higher OPB for point guards in the three-on-three games.

Future research could use players from different teams to eliminate a coach effect on the style of play and the roles of the participants. Also, future research could examine an actual game environment and include the stoppages in play to get a more accurate depiction of the physical activity of an actual game for every player, as breaks in the game for free throws and timeouts [24] and playing time affect the amount and intensity of physical activity. Finally, one could measure enjoyment and perceived exertion through a survey of the participants.

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