Effect of Basketball Mass on Shot Performance Among 9-11 Year-Old Male Players

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ABSTRACT

The goal of this study was to analyse with which ball the participants achieved a greater number of shot attempts and successful shots. The participants included fifty-four 9-11 year-old children from six basketball teams. We established three situations in which the participants played four games with each of the following balls: a) regulation (485 g, 69-71 cm); b) ball of smaller mass (440 g, 69-71 cm); and c) ball of greater mass (540 g, 69-71 cm). The results reflected statistically significant differences for the ball possessions in which there was no shot attempt ($\chi 2$=11.751, df=2, p=.003), for the free throw shot attempts ($\chi 2$=14.213, df=2, p=.001), the 2-point field goal attempts ($\chi 2$=6.921, df=2, p=.031), successful free throws ($\chi 2$=6.273, df=2, p=.043), and successful 3-point field goals ($\chi 2$=5.545, df=2, p=.05). The highest frequency of shot attempts and successful shots occurred with the ball that had a mass of 440g.

Key words: Ball Mass, Basketball Shooting Performance, Equipment Modification, Youth Sport

INTRODUCTION

Various studies support the use of basketball equipment that is suitable for the characteristics and needs of children.[1-5] Children normally lack the strength and physical characteristics that are required for the use of equipment and rules of adult sports.[6,7] The justifications given for adapting the equipment include the importance of having children play and enjoy the game according to their possibilities, developing motor patterns that are technically correct, increasing success of motor behaviour, and creating the habit of practicing sport.

The motor praxeology has conceptualized each sport as motor systems.[8] Each motor system is defined by a set of rules. The rules determine four types of relationships of the participants that make the game action emerge: a) with other participants, b) with the game space, c) with the equipment, and d) the mode in which they should adjust to the game time.

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When changing a rule of the motor system, such as the game ball, the game actions could possibly change. This requires the use of studies that analyze the game action. The game action is shown by means of motor behaviours that are susceptible to being objectively observed.[9]

The ball is one of the most important pieces of equipment that mediates the confrontation in team sports. In volleyball, Pellett et al.[10] analyzed the effect of a ball of the same size but that was 25% lighter. The results demonstrated increases in the number of successful sets and serves, in the time that the ball was in play, and in learning. A literature review for youth basketball found several studies that analyzed the effect of the ball's dimensions through shooting tests. Isaacs and Karpman[2] analyzed shot precision according to the dimensions of the basket and the ball. They found that shot precision was greater with the lowest basket (2.44 m) and with the smaller ball (496-552.8 g and 72.5 cm). Satern et al.[5] also studied the dimensions of the ball and the height of the basket on the mechanism of the free throw. The basket's height affected some of the performance parameters in a manner consistent with projectile motion mechanics, but the ball's dimensions did not. Chase et al.[1] examined the effects of the modification of the ball's dimensions and the height of the basket on shot effectiveness and self-efficacy. The participants scored more in the lowest basket (2.44 m) and they obtained higher self-efficacy when they shot at the lowest basket with the ball of smallest dimensions (538.65 g and 72.5 cm). Regimbal et al.[4] assessed the preference of 10-year-old children and analyzed whether this was related to shot technique and score that they obtained. The children preferred a ball that was smaller than the usual one (496-552.8 g and 72.5 cm) and with which they improved their scoring and their shot technique.

Piñar[11] and Arias et al.[12] executed two studies during actual youth games. One of the objectives by Piñar[11] was to increase the frequency of shot attempts and successful shots, especially those attempts and successful shots that were worth three points. Piñar modified: a) court size, b) free-throw line, c) three-point line, d) game duration, and e) number of players. This study found differences in the percentage of successful shots after introducing the modifications (one point: 14.8% vs. 6.9%, three points: 1.3% vs. 8.8%). Arias et al.[12] compared the effect of two shapes of the three-point line on the dynamics of the game and successful shots, among other variables. The results demonstrated a decrease in the percentage of ball possessions in which the participants did not attempt a shot (37.2% vs. 43.6%), and an increase in unsuccessful shots (44.4% vs. 39.8%), successful two-point field goals (17.2% vs. 16.5%), and successful three-point field goals (1.2% vs. 0.1%) with the three-point line delimited by the restricted area.

Studies that utilize a test have demonstrated that changes in the ball's mass may improve shot performance. However, the studies have given little attention to the effect of modifying the ball's mass on the shot during real games in youth basketball. The changes that should be made in youth basketball rules should increase the frequency of shot attempts and successful shots.[1,4,11-16] The shot is the action that youth basketball players most prefer.[15] The shot is one of the aspects from which children claim to derive the most fun and with which they feel best executing.[16] Children should frequently be successful, given that successful shots and points scored are stimuli that encourage them to continue shooting.[17,18] Successful shots produce a positive practical experience, which can increase the levels of perceived self-efficacy.[1,19] Therefore, the theoretical proposals determine that successful shots contribute to increasing motivation.[11,13,14,20]

In the literature review done, no study was found about youth basketball that assesses the effect of the decrease and/or the increase in the ball's mass while maintaining its circumference on shot attempts and successful shots, nor was any found in a real game context. The objective of this study was to analyze with which ball the participants achieved a greater number of shot attempts and successful shots. According to a study by Pellett et al.,[10] the reduction of the ball's mass while maintaining its circumference facilitates ball handling. From this result, the hypothesis made was that there would be a decrease in the number of ball possessions in which there was no shot attempt and there would be an increase in the number of possessions in which the shot attempts were taken with a ball of smaller mass. The studies that analyzed the modification of the ball's mass on the shot's effectiveness demonstrated that the ball of less mass could increase effectiveness.[2,4] Therefore, the hypothesis was that there would be an increase in the frequency of successful shots with the ball of less mass.

METHOD

PARTICIPANTS

The participants included 54 children from six basketball teams with ages 9-11 (age: *M*=10.63, *SD*=0.55 years). They had practiced basketball on official, federated regional teams which had competed for 2.52 years (*SD*=0.75). Each week they practiced an average of 3.57 (*SD*=0.51) days for a total of 5.03 hours (*SD*=0.80). The sample consisted of 2,100 ball possessions from 12 games, of which 736 corresponded to the four games played with the regulation ball (485 g), 660 to the four games played with the ball of smaller mass (440 g), and 704 to the four games played with the ball of greater mass (540 g). The selection of the teams and players was deliberate,[21] because these teams fulfilled the following criteria for inclusion: a) that the team participate in all the scheduled games; and b) that the children from each team were the same in all the games. Further, eight coaches selected the teams from the league that had the highest playing level and were most homogeneous in age, previous experience, and game level. The selection of the ball possessions was through total sampling.[22] Both the parents of the participants and the coaches completed an informed consent form to participate in the study. The Research Ethics Committee of the University approved the study.

DESIGN

Three situations consisting of all participating teams playing with three balls that differed only by their mass were established: a) four games with the regulation ball (485 g, 69-71 cm), b) four games with the ball of a smaller mass (440 g, 69-71 cm), and c) four games with the ball of greater mass (540 g, 69-71 cm). A 3-day tournament was organized consisting of 12 games in which the six teams were randomly matched. Each day the teams played one or two games. The game ball for each contest was also randomly chosen. Between all the teams, four games were played with each ball. Each team played a minimum of one game and a maximum of two games with each ball. We selected the ball's mass according to: a) those proposals that were the most extreme within those of least mass that are included in studies about ball modification, and b) in agreement with the proposals in which the difference between balls should be greater than 57 g[1] and 60 g.[3] The coaches and the players did not know the objective of the study. One month before, the principal researcher informed the coaches that they would play in a tournament: a) with the balls that the organizing committee provided, b) in which the games would be previously determined, c) in which all the participants would receive a diploma, and d) in which they would have to respect the inclusion criteria as well as the requisites of inter-sessional consistency (Table 1).

Table 1. Requisites for Inter-Sessional Consistency

Criteria	Requisite
Participating players	- Same players in all games
	- 8-12 per game
	- Five on the court
Age of players	- 9-11 years
Game duration	- Four periods of 10 minutes
Rest time per game	- One minute between periods
	- Five minutes between second and third period
Rest time between games	- One hour minimum
Court dimensions	- Identical courts (28 × 15 m)
Game ball	- Same texture, colour, circumference, and bounce
Basket height	- 2.60 m
Warm-up	- With a similar ball to the game ball
	- Minimum duration of 30 minutes
Defence	- Man-to-man
Regulations	- The same in all games

PROCEDURES

A group of six experts delimited and defined the variables and their categories. The categories for each variable were exhaustive and mutually exclusive,[22,23] and were coded utilizing a numerical system to facilitate its recording. The variables were the following:

1. Shot attempts. Shots taken according to their score value. The categories were: a) no shot attempt, b) 1-point free throw attempt, c) 2-point field goal attempt, and d) 3-point field goal attempt.
2. Successful shots. Baskets scored according to their value. The categories were: a) unsuccessful shot, b) successful free throw, c) successful 2-point field goal, and d) successful 3-point field goal.

Four observers were trained according to the training stages suggested by Anguera[22]. This process lasted 11 sessions, from one to three hours, during four weeks. The observers accumulated a minimum of 20 hours of experience. The observer's reliability was obtained through intra-observer evaluation at the end of the training process.[24,25] The reliability of the observation (Table 2) was measured through an inter-observer evaluation at the end of the observation process.[26,27]

Table 2. Characteristics of Observer and Observation Reliability

Reliability	Fragments of analyzed videos (random selection)				Result (Kappa)
	Game	Periods	Time (min.)	Ball possessions	
Intra-observer (seven day difference)	Different from the ones in the study	2	20	123	1
Inter-observer	Those of the study	5	50	315	1

In accordance with Crisco et al.[28] Isaacs and Karpman,[2] Mathes and Flatten[29] as well as basketball regulations, the properties of the ball that were controlled were: a) mass, b) circumference, and c) bounce height. Three collaborators monitored this a half hour before and after each game. They followed a protocol that was adapted by Crisco et al.[28] This consisted of taking three measurements of each property and calculating the mean. Monitoring the mass was done using a scale (PCE-LS 3000, PCE Group Ibérica S.L., Spain). The values needed to be 440 g for the lightest ball, 540 g for the heaviest ball, and 485 g for the regulation ball. Monitoring the circumference was done using a meter tape (Lufkin, Lufkin Industries, USA). This value should have been 69-71 cm. To monitor the bounce, the collaborators let the ball fall from a height of 1.80 m (from the lowest part of the ball) and they measured the height it reached after bouncing (from the highest part of the ball).[30,31] The measurements were taken by recording the height points and extrapolating them through the calibration mark. For this, with the video camera (Everio Full HD-GZ-HD7, JVC, Japan) connected to the computer (Acer Aspire 3630, Acer Inc., Taiwan), the image was passed to the Virtual Dub 1.6.15 program. The height of the dribble should have been between 1.20 and 1.40 m.[30] The measurements with a horizontal component were eliminated. The balls were the same in regard to texture, colour, circumference, and bounce.

Two collaborators recorded the games, each one with a video camera (Everio Full HD-GZ-HD7, JVC, Japan). The camera was situated transversally to the basketball court, on the opposite side from the scoring table and was placed five meters off the ground and two meters from the sideline. The focus was on the centre of the court and with the open field in order to record the greatest possible space. The camera rotated on the tripod axis when necessary. As a general rule, the recording included the player with the ball, the court, and the basket, in addition to the rest of the players.

The four observers recorded the data utilizing a systematized register from the observation of the game videos.[22] The register technique that was used was the coding of the study's variables on the registry instrument.[22,23] The unit used for analysis was the ball possession. The observers observed each possession as many times as necessary at a velocity of 25 frames per second. The observers registered the numeric code that corresponded to each variable on which the observation was focused. Each observer observed and registered three games.

STATISTICAL ANALYSIS

The statistical analysis of the data was done with the SPSS v. 17.0 for Windows (SPSS, Inc., USA). We executed descriptive analyses through frequencies and percentages. We determined the normality of the data through the Kolmogorov-Smirnov test. From this test, it was determined that the data were non-parametric. The Kruskal Wallis H test was utilized to assess in which categories there were significant differences. Then, post-hoc comparisons were executed utilizing the Mann-Whitney U test to determine with which balls these differences occurred. Statistical significance was set at $p \leq .05$.

RESULTS

As demonstrated in Table 3, the results showed statistically significant differences for the ball possessions in which there was no shot attempt ($\chi 2$=11.751, df=2, p=.003), as well as for those in which there was a free throw attempt ($\chi 2$=14.213, df=2, p=.001), 2-point field goal attempt ($\chi 2$=6.921, df=2, p=.031), successful free throw ($\chi 2$=6.273, df=2, p=.043), and successful 3-point field goal ($\chi 2$=5.545, df=2, p=.05). The participants did not attempt a shot in a smaller percentage of ball possessions when they played with the 440 g ball when compared to the regulation ball (*U*=225352, *Z*=-2.976, *p*=.003) and to the 540 g ball (*U*=214808, *Z*=-3.073, *p*=.002). A higher percentage of shot attempts were worth 1 point (free throws) with the 440 g ball in comparison with the 540 g ball (*U*=223322, *Z*=-2.385, *p*=.017) and with the regulation ball in comparison with the 540 g ball (*U*=242736, *Z*=-3.774, *p*=.000). A higher percentage of shot attempts were worth 2 points with the 440 g ball in comparison to the regulation ball (*U*=225760, *Z*=-2.629, *p*=.009). A higher percentage of successful shots were worth 1 point with the 440 g ball in comparison to the 540 g ball (*U*=225434, *Z*=-2.513, *p*=.012). A higher percentage of successful shots were worth 3 points with the 440 g ball in comparison to the regulation ball (*U*=239112, *Z*=-1.904, *p*=.05) and to the 540 g ball (*U*=228558, *Z*=-1.974, *p*=.048).

Table 3. Frequencies, Percentages, and Significant Differences of the Means of the Compared Variables

Variables	Ball					
	440 g		Regulation		540 g	
	n	%	n	%	n	%
Shot attempts						
No shot attempt**	164	24.8	236	32.1	228	32.4
Free throw attempt***	79	12	106	14.4	57	8.1
2-point field goal attempt*	355	53.8	344	46.7	354	50.3
3-point field goal attempt	62	9.4	50	6.8	65	9.2
Success of shots						
Missed shot	278	42.1	312	42.2	302	42.9
Successful free throw*	43	6.5	38	5.2	25	3.6
Successful 2-point field goal	154	23.3	138	18.8	138	19.6
Successful 3-point field goal*	21	3.2	12	1.6	11	1.6

Note. *p ≤ .05; **p ≤ .01; ***p ≤ .001.

DISCUSSION

The objective of this study was to analyze with which ball the participants achieved a higher frequency of shot attempts and successful shots. The results confirmed the hypothesis in relation to shot attempts, but free throw attempts increased when playing with the 440 g and regulation balls when compared to the 540 g ball. Two-point field goal attempts increased when playing with the 440 g ball in comparison to the regulation ball, but not in comparison to the 540 g ball. There were no significant differences in 3-point field goal attempts. The results also confirmed the hypothesis in relation to successful shots, but successful free throws increased when playing with the 440 g ball in comparison to the 540 g ball but not in comparison to the regulation ball. Successful 3-point field goals increased when playing with the 440 g ball, while there were no significant differences for successful 2-point field goals.

The results revealed a smaller percentage of ball possessions in which the participants did not attempt a shot when using the 440 g ball. This suggests that during play, there were conditions that favoured the shot attempt with the 440 g ball. In accordance with Palao et al.[15] and Piñar et al.,[16] the children must have seen that their preferences were satisfied and they must have had fun when playing with the 440 g ball. The higher percentages of free throw attempts occurred when playing with the 440 g and regulation balls, probably attributable to the higher number of personal fouls that the defence committed during shot attempts, similar to what happened in the study by Ortega et al.[32] The highest percentage of 2-point field goal attempts occurred with the 440 g ball (53.8%), and there was a 7.1% ($p \leq .05$) difference with regard to the regulation ball and a 3.5% ($p > .05$) difference with regard to the 540 g ball. A high percentage of free throw attempts and an increase in the number of 2-point field goal attempts with the 440 g ball may be due to the increase in the number of situations in which the participants scored 2-point field goals and were awarded a free throw attempt. The smaller percentage of 2-point field goal attempts with the regulation ball may have occurred because of the increase in the situations in which the participants only obtained personal fouls. The percentage of 3-point field goal attempts was similar for all balls. This suggests that the ball of smallest mass did not encourage the participants to attempt more 3-point shots. The 3-point shot is a resource that is used by teams when they cannot shoot from distances that are closer to the basket.[33] Therefore, it seems logical that there are no significant differences for the 3-point field goal attempts. According to the literature, ball possessions in transition and the combination of set and transitional possessions favour shot attempts.[13,14,20,34,35] Therefore, in this study, the players may have tended to use the transition and a combination of set and transition possessions with the 440 g ball. Further, the participants may have committed a greater number of errors with the balls of a higher mass. However, the confirmation of this hypothesis requires studies that analyze game styles (type of ball possession, action with which the ball possession ends, players that obtain ball possession, passes, and dribbles).

The percentage of unsuccessful shots was similar with all three balls, which results in a higher percentage of successful shots with the 440 g ball. There was a 7.4% difference with regard to the regulation ball and an 8.2% difference with regard to the 540 g ball. In accordance with the literature,[17,18] the participants may have experienced greater reinforcement for their actions, which may have increased their perceived self-efficacy .[1,19] A higher number of successful free throws came when playing with the 440 g ball. Thus, the greater the ball's mass, the fewer the successful free throws. There was a difference of 2.9% ($p \leq .05$) when compared to the 540 g ball. The frequency of successful 2-point field goals was similar with all three balls. The majority of shots taken in youth basketball are worth two points.[11,12,33,36,37] This is due to the fact that coaches, conscious of the demands that the 3-point shot entails, elaborate strategies that prioritize 2-point shots close to the basket.[33] However, in youth basketball, the practice of shots from different positions and distances is necessary.[38] A higher number of successful 3-point field goals occurred with the 440 g ball, and there was a difference of 1.6% ($P \leq .05$) with regard to the balls of greater mass. This result suggests that the ball of least mass facilitated success when increasing the distance to the basket. Various studies allude to the fact that the reason that the children do not have more success is the absence of strength.[1,3,39] However, the results suggest that this problem was decreased with the 440 g ball. The relationship between the number of shot attempts and successful shots by means of the efficacy percentage provides significant data. The efficacy percentage for free throw attempts was 54.16% with the 440 g ball, 36.11% with the regulation ball, and 43.86% with the 540 g ball. The efficacy percentage for 2-point field goal attempts was 43.31% with the 440 g ball, 40.25% with the regulation ball, and 38.98% with the 540 g ball. Finally, the efficacy percentage for 3-point field goal attempts was 34.04% with the 440 g ball, 23.52% with the regulation ball, and 16.92% with the 540 g ball. As the mass of the ball increased, the efficacy percentage decreased. These results coincide with those found by Isaacs and Karpman[2] and Regimbal et al.[4] who noted that reduction in the ball's dimensions increased effectiveness. However, this relationship was not perfect for free throws. This result was similar to results found by Chase et al.[1] In their tests with the free throw, they found no positive effect with the ball of lesser mass. Satern et al.[5] also found no significant differences of the ball size on the kinematics parameters analyzed. In the present study, this result may be due to the immense number of factors of a psychological nature that influence the free throw, in spite of the fact that it is a shot that players execute without uncertainty of context, means, or teammates.[40,41]

As in the studies by Arias et al.[12] and Piñar,[11] in the present study, as a shot's worth increased, the percentage of possessions in which it occurred decreased. However, this reduction was less pronounced with the 440 g ball. Arias et al.[12] found that in 37.2%-43.6% of the ball possessions the participants did not attempt a shot, in 16.5-17.2% of possessions participants achieved a successful 2-point field goal, and in 0.1-1.2% they achieved success with a 3-point field goal. Piñar[11] found that of all successful shots, 84.4% were worth two points and 8.8% were worth three points. The percentage of ball possessions in which the participants did not attempt a shot was smallest with the 440 g ball, but the rest of the values were greater with the 440 g ball. These results seem to reinforce the favourable effect of field goal attempts and successful field goals with the 440 g ball. The fact that there were more successful shots with the 440 g ball would indicate a greater dominance in the shot. According to previous research, this is one of the indicators related to motivation.[42,43]

Several limitations existed in this study: a) only boys were studied; and b) anthropometric characteristics, biological age, strength, and skill level were not controlled. These conditions may limit the generalization of the results and restrict them to participants with similar characteristics to those in this study.

CONCLUSION

The present study provides evidence to the effect of the modification of the ball's mass on variables during real games in youth basketball. The results illustrate how modifying the relationship between the participants and equipment in these encounters produces changes in the game actions. The highest frequency of shot attempts and successful shots occurred with the 440 g ball. The frequency of free throw attempts is higher with the 440 g and the regulation balls. The frequency of 2-point field goal attempts is higher with the 440 g ball than the regulation ball. The frequency of successful free throws is higher with the 440 g ball than the 540 g ball. The frequency of successful 3-point field goals is highest with the 440 g ball.

Children should shoot and score easily in order to satisfy their preferences, experience more fun, and feel good.[2,4,11-13,15,16] Modifications that allows for improving these aspects of the game and the players are very important in such a complex sport. This article provides information that is relevant to teachers and coaches about the use of basketballs that are adapted to 9-11 year-old children with the characteristics of those in this study. These professionals should propose tasks that facilitate shot attempts and successful shots, and the modification of the ball's mass may be a strategy for achieving this goal. The predominance of these game variables may provide more enjoyable experiences for the children; in turn, they may choose to continue practicing basketball and put forward more effort for a longer time. The results exemplify how the modification of the relationship between the participants and the equipment that mediate the confrontation produces changes in the game actions. This supports the need to base the analysis of the changes in the game action, after the modification, as the result of a change in the interaction of a component of the motor system. The conceptualization of team sports as motor systems allows us to argue and facilitate this analysis. In future studies, other game variables should be studied to assess whether the modification of the ball's mass (maintaining its circumference) favours a game that is suitable for the characteristics and necessities of the children.

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