INFLUENCE OF BALL WEIGHT ON SHOT ACCURACY AND EFFICACY AMONG 9-11-YEAR-OLD MALE BASKETBALL PLAYERS

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Abstract:

The goal of the study was to analyse with which ball the 9-11-year-old participants achieved higher shot accuracy and efficacy during real basketball games. The participants were 54 children from six basketball teams. Three situations were established in which the participants played four games with each of the following balls: (a) a regulation ball (485 g, 69-71 cm), (b) a lighter ball (440 g, 69-71 cm), and (c) a heavier ball (540 g, 69-71 cm). A group of six experts delimited and defined the variables: (a) accuracy: the score obtained according to whether the ball hit the backboard and the rim at each shot; and (b) efficacy: the number of points that the participants achieved at each shot. Four observers were trained, and the reliability obtained was higher than .95. The properties of the ball that were controlled were: (a) weight, (b) circumference, and (c) bounce height. Two collaborators recorded the games and the four observers recorded the data. Accuracy and efficacy were higher with the 440-g ball in comparison to the regulation ball (accuracy: U=215448.5, p=.000, and efficacy: U=212377, p=.001), and to the 540-g ball (accuracy: U=198869, p=.000, and efficacy: U=223932, p=.002).

Key words: *basketball, mini-basketball, game analysis, rule modification, team sport*

Introduction

Various studies support the use of basketball equipment that is suitable for the characteristics and needs of children (Chase, Ewing, Lirgg, & George, 1994; Isaacs & Karpman, 1981; Juhasz & Wilson, 1982; Regimbal, Deller, & Plimpton, 1992; Satern, Messier, & Keller-McNulty, 1989). Children normally lack the strength and physical characteristics that are required for the use of equipment and rules of adult sports (Evans, 1980; Kirk, 2004). The justifications provided 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 the success of motor behaviour, and creating the habit of practicing sports.

Motor praxiology establishes that the rules designate the necessary requisites for the development of game action (Parlebas, 1999). The rules determine four types of participants' relationships that cause the game action to emerge: (a) with other participants, (b) with the game space, (c) with the equipment, and (d) with the way they should adjust to the game time. According to the characteristics of these four components, different game systems emerge. When changing an element of the system, such as the game ball, the game actions may change. This requires the use of studies that analyse game action. Game action is seen through motor behaviours that are susceptible to being objectively observed (Jones, James, & Mellalieu, 2008). Recent studies have conceptualized team sports as dynamic complex systems (McGarry, Anderson, Wallace, Hughes, & Franks, 2002; Passos, et al., 2008).

The ball is one of the most important pieces of equipment that mediates confrontation in team sports. In volleyball, Pellett, Henschel-Pellett and Harrison (1994) analysed the effect of a ball of the same size but that was 25% lighter. The results showed increases in the number of successful sets and serves, in the time that the ball was in play, and in learning. A review of the literature on youth basketball found several studies that analysed the effect of the ball's dimensions through shooting tests. Isaacs and Karpman (1981) analysed shot accuracy according to the dimensions of the basket and the ball. They found that accuracy 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. (1989) also studied the effect of the dimensions of the ball and the height of the basket on free-throw efficacy and mechanism. The results revealed biomechanical differences. The height of the basket affected shot efficacy, but the dimensions of the ball did not. Chase et al. (1994) examined the effects of the modification of ball dimensions and the height of the basket on shot efficacy. The participants scored more with the lowest basket (2.44 m) but not with the smallest ball (538.65 g and 72.5 cm). Regimbal et al. (1992) assessed the preference of 10-year-old children and analysed whether this was related to shot technique and the score 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.

Studies that use tests have shown that changes in ball weight may improve shot performance. However, the studies have paid little attention to the effect of modifying ball weight on shot performance during real games in youth basketball. The changes to be carried out in youth basketball should increase shot accuracy and efficacy (Arias, Argudo, & Alonso, 2009; Chase, et al., 1994; Palao, Ortega, & Olmedilla, 2004; Piñar, 2005; Piñar, Cárdenas, Conde, Alarcón, & Torre, 2007; Regimbal, et al., 1992). The shot is the action that youth basketball players most prefer (Palao, et al., 2004). It is one of the aspects from which children claim to derive the most fun and which they feel best performing (Piñar, et al., 2007). Children should frequently achieve high values in accuracy and efficacy. High values in these variables produce a positive practical experience. Therefore, the theoretical proposals determine that successful shots contribute to increasing motivation (American Sport Education Program [ASEP], 1996; Grawer & Rains, 2003; Hanlon, 2005; Piñar, 2005).

In literature reviews, no study was found about youth basketball that assesses the effect on shot accuracy and efficacy of the decrease and/or increase in ball weight while maintaining ball circumference, nor was any found in a real game context. According to the study of Pellett et al. (1994), reduction of ball weight while maintaining its circumference favours successful actions. Studies that analysed the effect of modification of ball weight on shot accuracy showed that a ball of lower mass could either increase accuracy (Isaacs & Karpman, 1981; Regimbal, et al., 1992) or not affect it (Chase, et al., 1994; Satern, et al., 1989). The goal of this study was to analyse with which ball the participants achieved higher shot accuracy and efficacy. The hypothesis was that the values of both variables will increase with a lighter ball, and they will decrease with a heavier ball in comparison to a regulation ball.

Methods

Participants

The participants were 54 children (age: mean=10.63, SD=0.55 years) from six basketball teams, aged between 9-11 years. They had practised basketball on official, federated teams for 2.52 years (SD=0.75). Each week, they practised on an average of 3.57 (SD=0.51) days for a total of 5.03 hours (SD=0.80). The teams were federated and played regionally. 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 lighter ball (440 g), and 704 to the four games played with the heavier ball (540 g). The selection of the teams and players was deliberate (Babbie, 2005), because these teams fulfilled the following inclusion criteria: (a) that the teams participated 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. Selection of ball possessions was through total sampling (Anguera, 2003). 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.

Experimental set-up

We established three situations that consisted of all participating teams playing with three balls that differed only in their mass: (a) four games with the regulation ball (485 g, 69-71 cm), (b) four games with the lighter ball (440 g, 69-71 cm), and (c) four games with the heavier ball (540 g, 69-71 cm). We organized a 3-day tournament consisting of 12 games in which the six teams were randomly matched. Each day, the teams played between one and two games. The game ball for each game was also randomly chosen. Among 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 weight according to: (a) the proposals that were the most extreme within the lightest balls that are included in studies about ball modification and (b) in agreement with the proposals stating that the difference between balls should be greater than 57 g (Chase, et al., 1994) and 60 g (Juhasz & Wilson, 1982). Both balls were compared to the regulation ball. The coaches and the players did not know the purpose 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. In all the games, the requirements were: (a) the players were always the same ones, (b) the participants played all the games on identical courts (28x15 m), (c) rest interval between games was a minimum of one hour, (d) each game consisted of four 10-minute periods, (e) the participants warmed up with a ball that was similar to the game ball, (f) individual defence was compulsory, (g) the height of the baskets was 2.60 m, (h) the balls were the same in texture, colour, circumference and bounce, and (i) the games followed the same rules.

Procedure

A group of six experts delimited and defined the variables:

1) Shot accuracy refers to shooting precision or marksmanship. To measure accuracy, a scoring system was implemented depending on whether or not the ball went into the basket and whether or not it hit the backboard and the rim at each shot. The experts determined the following scores from the literature reviewed (Button, MacLeod, Sanders, & Coleman, 2003; Chase, et al., 1994; Landin, Herbert, & Fairweather, 1993; Regimbal, et al., 1992; Satern, et al., 1989): (a) zero points indicated that the subject missed the entire basket on the shot; (b) one point was awarded if the ball hit the backboard or net only but did not go into the basket; (c) two points were awarded if the ball hit the rim or the rim and the backboard but did not go into the basket; and (d) three points indicated that the subject made the basket.
2) Shot efficacy refers to the capacity to achieve the desired or expected effect from shooting. Efficacy was measured through the number of points that the participants achieved at each shot. The experts estimated the scores according to the value of the shot as determined by the basketball rules (zero points, two points, three points).

We created a register instrument (Anguera, 2003) from the adaptation of a Microsoft Excel 2003 worksheet (Microsoft Corporation, USA) to which a tool to capture and process the videos was added (Virtual Dub, v. 1.7.0.). This instrument allowed the observers to register the number corresponding to each variable in the Excel sheet while viewing the recording at a speed of 25 frames per second.

Four observers were trained according to the training stages suggested by Anguera (2003). This process lasted 11 sessions, from one to three hours, during four weeks. The observers accumulated a minimum of 20 hours of experience. Observer reliability was obtained through intra-observer evaluation at the end of the training process (McGarry & Franks, 1994; O'Donoghue, 2007). For this purpose, the observers observed a fragment corresponding to two game periods, which meant a 20-minute interval of a game and 123 ball possessions from a game other than the research games. Subsequently, the observers again observed the same fragment after seven days of no observation. Reliability of the observation was measured through an inter-observer evaluation at the end of the observation process. For this assessment, 15% of the ball possessions of the investigation games were used (Graham, Ellis, Williams, Kwak, & Werner, 1996; Hopkins, 2000). Thus, the observers observed five randomly selected periods, which meant 50 minutes of a game and 315 ball possessions. Reliability was calculated by means of the intra-class correlation coefficient. Reliability of the observers reached values between .97 and 1. Reliability of the observation reached values between .96 and 1.

In accordance with Crisco, Drewniak, Alvarez and Spenciner (2005), Isaacs and Karpman (1981) and Mathes and Flatten (1982) as well as basketball regulations, the properties of the ball that were controlled were: (a) weight, (b) circumference, and (c) bounce height. Three collaborators monitored the properties of the balls half an hour before and after each game. They followed a protocol that was adapted by Crisco et al. (2005). It 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 metre 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 (measured at the lowest part of the ball) and they measured the height it reached after bouncing (at the highest part of the ball) (Hamilton & Reinschmidt, 1997; Huston & Grau, 2003). The measurements were taken by recording the height points and extrapolating them through the calibration mark. For this purpose, 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 programme. The height of the dribble should have been between 1.20 and 1.40 m (Hamilton & Reinschmidt, 1997). The measurements with a horizontal component were eliminated.

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. The camera was placed five metres off the ground and two metres 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 a 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 using a systematized register from the observation of the game videos (Anguera, 2003). The registering technique consisted of indicating the number corresponding to each variable per ball possession on the registry instrument (Anguera, 2003). The unit of analysis was ball possession. The observers used a protocol of observing each ball possession two times at real speed in order to increase observation reliability. If necessary, the observers observed each possession at a speed of 25 frames per second. The observers attended each variable in each observation. 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 analyses

The statistical analysis of the data was performed with SPSS v. 17.0 for Windows (SPSS, Inc., USA). Descriptive analysis of variables in terms of means and standard deviations was done. The normality of data distribution was determined with the Kolmogorov-Smirnov test. From this test, it was determined that the data were non-parametric. The Kruskal Wallis H was utilized to assess in which categories there were significant differences. Then, *post-hoc* comparisons were done using Mann-Whitney U test to determine with which balls these differences occurred. Statistical significance was set at $p \leq .05$.

Results

As shown in Table 1, the results revealed statistically significant differences for shot accuracy (χ^2=26.670, df=2, p=.000) and efficacy (χ^2=14.978, df=2, p=.001). Accuracy (U=215448.5, p=.000) and efficacy (U=212377, p=.001) were higher with the 440-g ball in comparison to the regulation ball. Accuracy (U=198869, p=.000) and efficacy (U=223932, p=.002) were also higher with the 440-g ball in comparison to the 540-g ball. However, accuracy (U=250886.5, p=.264) and efficacy (U=256744.5, p=.700) were not lower with the 540-g ball in comparison to the regulation ball.

Discussion and conclusions

The goal of this study was to analyse with which ball the participants achieved higher shot accuracy and efficacy. The results did not completely confirm the hypothesis, because accuracy and efficacy increased with the 440-g ball in comparison to the regulation ball and to the 540-g ball, but the values of these variables did not decrease significantly with the 540-g ball in comparison to the regulation ball. The increase in accuracy and efficacy was higher for the 440-g ball than for the 540-g ball. The decrease in the weight of the 440-g ball, in comparison to the regulation ball, produced an increase in accuracy and efficacy. This result is not in accordance with the proposals that the weight difference in the balls to be compared should be higher than 57 g (Chase, et al., 1994) and 60 g (Juhasz & Wilson, 1982). However, the increase in the weight of the 540-g ball with regard to the regulation ball did not produce a statistically significant decrease in accuracy and efficacy. This suggests that the differences between both balls could be due to chance because the results did not have sufficient statistical power (p>.05). This result coincided with previous proposals (Chase, et al., 1994; Juhasz & Wilson, 1982).

Lack of strength is the main reason for children's inaccurate shooting performance (Benham, 1988; Chase, et al., 1994; Cleary, Zimmerman, & Keating, 2006; Juhasz & Wilson, 1982). The lack of strength, in addition to preventing the ball from reaching the basket, also hinders the adequate placing and use of body levers. This leads to inaccurate shots (Cleary, et al., 2006). Weaker players increase their horizontal movements to generate the necessary speed to allow the ball to reach the basket (Elliott, 1992; Liu & Burton, 1999; Miller & Bartlett, 1993, 1996). This causes a decrease of angle and release height of the ball (Elliott, 1992; Kouvelioti, Stavropoulos, & Kellis, 2006; Miller & Bartlett,

Table 1. Mean, standard deviation and significant differences of the compared variables (left of table) and post hoc comparison between the balls (right of table)

Variables	Ball						χ^2	*p*	440-g ball vs. regulation ball		440-g ball vs. 540-g ball		Regulation ball vs. 540-g ball	
	440-g ball		Regulation		540-g ball									
	M	*SD*	*M*	*SD*	*M*	*SD*			*U*	*p*	*U*	*p*	*U*	*p*
Shot accuracy	1.64	1.26	1.36	1.28	1.28	1.28	26.67	.000	215448.5	.000	198869	.000	250886.5	.264
Shot efficacy	0.63	0.95	0.48	0.85	0.47	0.85	14.97	.001	212377	.001	223932	.002	256744.5	.700

1993). An increase in speed release and a decrease of angle and release height of the ball reduce shot accuracy (Brancazio, 1979; Tan & Miller, 1980). Nevertheless, accuracy was higher with the 440-g ball. As the ball weight increased, shot accuracy decreased. This result coincided with those of Isaacs and Karpman (1981) and Regimbal et al. (1992). They found that a reduction of ball dimensions increased accuracy. In contrast, the results do not coincide with those of Chase et al. (1994) and Satern et al. (1989). In their free-throw tests, they found no positive effect of the ball with a lower mass. The difference of our study with regard to the previous ones is that we did not analyse the shots by means of a test from the free-throw line. Free-throw is influenced by several factors of a psychological nature, despite its being a shot that the players perform in the absence of uncertainty about the context, the environment, and the team-mates (Foster & Weigand, 2006; Lonsdale & Tam, 2008; Southard & Amos, 1996).

In accordance with Palao et al. (2004) and Piñar et al. (2007), the children must have seen that their preferences were satisfied and they had more fun when playing with the 440-g ball. The participants would have experienced more reinforcement of their actions (Mace, Lalli, Shea, & Nevin, 1992; Romanowich, Bourret, & Vollmer, 2007; Vollmer & Bourret, 2000). Nevertheless, there could be two reasons for efficacy being so low with all three balls. Firstly, as mentioned previously, strength is usually an argument suggested in the literature reviewed (Benham, 1988; Chase, et al., 1994; Juhasz & Wilson, 1982). Secondly, most youth basketball shots are two-point shots (Arias, et al., 2009; Cruz & Tavares, 1998; Mexas, Tsitskaris, Kyriakou, & Garefis, 2005; Piñar 2005; Tavares & Gomes, 2003). This is because the coaches, aware of the demands involved in a three-point shot, elaborate strategies to prioritize two-point shots near the basket (Mexas, et al., 2005). However, the results suggest that both aspects improved with the 440-g ball. Arias et al. (2009) found a mean efficacy of 0.37-0.33 after comparing two models of the three-point line. Piñar (2005), from the total successful shots, obtained 84.4% of two-point shots and 8.8% of three-point shots after modifying various rules. This reaffirms, along with the rest of the literature consulted, the enhancing effect of the 440-g ball on efficacy. The fact that successful shots increased with the 440-g ball reveals a higher shooting mastery. According to Duda (1996) and Duda and Nicholls (1992), this is one of the indicators related to motivation.

There were several limitations 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.

In conclusion, the present study provides evidence of the effect of modification of ball weight on variables during real games in youth basketball. The results illustrate how modifying the relationship between the participants and the equipment in these encounters produces changes in game actions. Shot accuracy and efficacy are higher with the 440-g ball. Children should frequently achieve high values in accuracy and efficacy to satisfy their preferences, have more fun and feel good (ASEP, 1996; Arias, et al., 2009; Isaacs & Karpman, 1981; Palao, et al., 2004; Piñar, 2005; Piñar, et al., 2007; Regimbal, et al., 1992). A modification that allows improving these aspects of the game and of the participants is 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 the participants of this study. They should seek tasks to increase accuracy and efficacy. The modification of ball weight may be a good strategy. The predominance of these game variables may provide more enjoyable experiences for the children; in turn, they may choose to continue playing basketball and put out more effort for a longer time. In future studies, other game variables should be studied to assess whether the modification of ball weight (maintaining its circumference) favours a game that is suitable for children's characteristics and needs.

References

ASEP. (1996). *Coaching youth basketball.* (2nd ed.). Champaign, IL: Human Kinetics.

Anguera, M.T. (2003). La observación. [Observation]. In C. Moreno (Ed.), *Evaluación psicológica. Concepto, proceso y aplicación en las áreas del desarrollo y de la inteligencia* (pp. 271-308). Madrid: Sanz y Torres.

Arias, J.L., Argudo, F.M., & Alonso, J.I. (2009). Effect of the three-point line change on the game dynamics in girls' mini-basketball. *Research Quarterly for Exercise and Sport*, *80*(3), 502-509.

Babbie, E.R. (2005). *The basics of social research*. (4th ed.). Belmont, CA: Thomson/Wadsworth.

Benham, T. (1988). Modification of basketball equipment and children´s performance. *Journal of Applied Research in Coaching & Athletics*, *3*(1), 18-28.

Brancazio, P.J. (1979). Physics of basketball. *American Journal of Physics*, *49*(4), 356-365.

Button, C., MacLeod, M., Sanders, R., & Coleman, S. (2003). Examining movement variability in the basketball free-throw action at different skill levels. *Research Quarterly for Exercise and Sport*, *74*(3), 257-269.

Chase, M.A., Ewing, M.E., Lirgg, C.D., & George, T.R. (1994). The effects of equipment modification on children's self-efficacy and basketball shooting performance. *Research Quarterly for Exercise and Sport*, *65*(2), 159-168.

Cleary, T.J., Zimmerman, B.J., & Keating, T. (2006). Training Physical Education students to self-regulate during basketball free throw practice. *Research Quarterly for Exercise and Sport*, *77*(2), 251-262.

Crisco, J., Drewniak, E., Alvarez, M., & Spenciner, D. (2005). Physical and mechanical properties of various field lacrosse balls. *Journal of Applied Biomechanics*, *21*(4), 383-393.

Cruz, J., & Tavares, F. (1998). Notational analysis of the offensive patterns in cadets basketball teams. In M. Hughes & F. Tavares (Eds.), *IV World Congress of Notational Analysis of Sport* (pp. 112-129). Porto: FCDEF-UP.

Duda, J.L. (1996). Maximizing motivation in sport and physical education among children and adolescents: the case for greater task involvement. *Quest*, *48*, 290-302.

Duda, J.L., & Nicholls, J.G. (1996). Dimensions of achievement motivation in school work and sport. *Journal of Educational Psychology*, *84*, 1-10.

Elliott, B. (1992). A kinematic comparison of the male and female two-point and three-point jump shots in basketball. *Australian Journal of Science and Medicine in Sport*, *24*(4), 111-117.

Evans, J. (1980). Objectivity and game modification: The next step. *Australian Journal for Health, Physical Education, and Recreation*, *89*, 13-17.

Foster, D.J., & Weigand, D.A. (2006). The effect of removing superstitious behavior and introducing a pre-performance routine on basketball free-throw performance. *Journal of Applied Sport Psychology*, *18*, 167-171.

Graham, K.C., Ellis, S.D., Williams, C.D., Kwak, E.C., & Werner, P.H. (1996). High- and low-skilled target students' academic achievement and instructional performance in a 6-week badminton unit. *Journal of Teaching in Physical Education*, *15*, 477-489.

Grawer, R., & Rains, S.P. (2003). *Youth basketball skills and drills*. (2nd ed.). Champaign, IL: Coaches Choice Books.

Hamilton, G.R., & Reinschmidt, C. (1997). Optimal trajectory for the basketball free throw. *Journal of Sports Sciences*, *15*, 491-504.

Hanlon, T. (2005). *Absolute beginner´s guide to coaching youth basketball*. Indianapolis, IN: Alpha Books Que.

Hopkins, W.G. (2000). Measures of reliability in sports medicine and science. *Sports Medicine*, *30*(1), 1-15.

Huston, R.L., & Grau, C.A. (2003). Basketball shooting strategies - the free throw, direct shot and layup. *Sports Engineering*, *6*, 49-64.

Isaacs, L.D., & Karpman, M.B. (1981). Factors effecting children's basketball shooting performance: A log-linear analysis. *Carnegie School of Physical Education and Human Movement*, *1*, 29-32.

Jones, N.M.P., James, N., & Mellalieu, S.D. (2008). An objective method for depicting team performance in elite professional rugby union. *Journal of Sports Sciences*, *26*(7), 691-700.

Juhasz, M., & Wilson, B.D. (1982). Effect of ball size on shooting characteristics of junior basketballers in comparison to adults. *Australian Journal of Sport Sciences*, *2*(2), 16-20.

Kirk, D. (2004). Framing quality Physical Education: The elite sport model or sport education? *Physical Education and Sport Pedagogy*, *9*(2), 185-195.

Kouvelioti, V., Stavropoulos, N., & Kellis, E. (2006). Biomechanical analysis of shooting in basketball: Relating research with training practice. *Inquires in Sport & Physical Education*, *4*(1), 97-108.

Landin, D.K., Hebert, E.P., & Fairweather, M. (1993). The effects of variable practice on the performance of basketball skill. *Research Quarterly for Exercise and Sport*, *64*(2), 232-237.

Liu, S., & Burton, A.W. (1999). Changes in basketball shooting patterns as a function of distance. *Perceptual and Motor Skill*, *89*, 831-845.

Lonsdale, C., & Tam, J.T.M. (2008). On the temporal and behavioural consistency of pre-performance routines: an intra-individual analysis of elite basketball players` free throw shooting accuracy. *Journal of Sports Sciences*, *26*(3), 259-266.

Mace, F.C., Lalli, J.S., Shea, M.C., & Nevin, J.A. (1992). Behavioral momentum in college basketball. *Journal of Applied Behavior Analysis*, *25*(3), 657-663.

Mathes, S., & Flatten, K. (1982). Performance characteristics and accuracy in perceptual discrimination of leather and synthetic basketballs. *Perceptual and Motor Skills*, *55*, 128-130.

McGarry, T., Anderson, D.I., Wallace, S.A., Hughes, M., & Franks, I.M. (2002). Sport competition as a dynamical self-organizing system. *Journal of Sports Sciences*, *20*, 771-781.

McGarry, T., & Franks, I.M. (1994). A stochastic approach to predicting competition squash match-play. *Journal of Sports Sciences*, *12*, 573-584.

Mexas, K., Tsitskaris, G., Kyriakou, D., & Garefis, A. (2005). Comparison of effectiveness of organized offences between two different championships in high level basketball. *International Journal of Performance Analysis in Sport*, *5*(1), 72-82.

Miller, S., & Bartlett, R.M. (1993). The effects of increased shooting distance in the basketball jump shot. *Journal of Sports Sciences*, *11*, 285-293.

Miller, S., & Bartlett, R. (1996). The relationship between basketball shooting kinematics, distance and playing position. *Journal of Sports Sciences*, *14*, 243-253.

O´Donoghue, P. (2007). Reliability issues in performance analysis. *International Journal of Performance Analysis in Sport*, *7*(1), 35-48.

Palao, J.M., Ortega, E., & Olmedilla, A. (2004). Technical and tactical preferences among basketball players in formative years. *Iberian Congress on Basketball Research*, *4*, 38-41.

Parlebas, P. (1999). *Jeux, sports et sociétés. Lexique de praxéologie motrice*. [Games, sport, and society. Dictionary of motor praxiology]. Paris, France: INSEP-Publications.

Passos, P., Araújo, D., Davids, K., Gouveia, L., Milho, J., & Serpa, S. (2008). Information governing dynamics of attacker-defender interactions in youth rugby union. *Journal of Sports Sciences*, *26*(13), 1421-1429.

Pellett, T.L., Henschel-Pellett, H.A., & Harrison, J.M. (1994). Influence of ball weight on junior high-school girls' volleyball performance. *Perceptual and Motor Skills*, *78*, 1379-1384.

Piñar, M.I. (2005). *Incidencia del cambio de un conjunto de reglas de juego sobre algunas de las variables que determinan el proceso de formación de los jugadores de minibasket (9-11 años)*. [Effect of rule modifications on some of the variables that determine the formative process of mini-basketball players (9-11 year olds)]. Granada: University of Granada.

Piñar, M.I., Cardenas, D., Conde, J., Alarcon, F., & Torre, E. (2007). Satisfaction in mini-basketball players. *Iberian Congress on Basketball Research*, *4*, 122-125.

Regimbal, C., Deller, J., & Plimpton, C. (1992). Basketball size as related to children's preference, rated skill and scoring. *Perceptual and Motor Skills*, *75*, 867-872.

Romanowich, P., Bourret, J., & Vollmer, T.R. (2007). Further analysis of the matching law to describe two- and three-point shot allocation by professional basketball players. *Journal of Applied Behavior Analysis*, *40*(2), 311-315.

Satern, M.N., Messier, S.P., & Keller-McNulty, S. (1989). The effects of ball size and basket height on the mechanics of the basketball free throw. *Journal of Human Movement Studies*, *16*, 123-137.

Southard, D., & Amos, B. (1996). Rhythmicity and preperformance ritual: stabilizing a flexible system. *Research Quarterly for Exercise & Sport*, *67*(3), 288-296.

Tan, A., & Miller, G. (1980). Kinematics of the free throw in basketball. *American Journal of Physics*, *49*(6), 542-544.

Tavares, F., & Gomes, N. (2003). The offensive process in basketball – a study in high performance junior teams. *International Journal of Performance Analysis in Sport*, *3*(1), 34-39.

Vollmer, T.R., & Bourret, J. (2000). An application of the matching law to evaluate the allocation of two- and three-point shots by college basketball players. *Journal of Applied Behavior Analysis*, *33*(2), 137-150.

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UTJECAJ TEŽINE LOPTE NA PRECIZNOST I UČINKOVITOST BACANJA NA KOŠ KOŠARKAŠA U DOBI OD 9 DO 11 GODINA

Cilj je ovog istraživanja bio analizirati kojom će loptom ispitanici u dobi od 9 do 11 godina postići veću preciznost i učinkovitost bacanja na koš tijekom košarkaške utakmice. Uzorak ispitanika je činilo 54 djece iz 6 košarkaških ekipa. Stvorene su tri eksperimentalne situacije u kojima su ispitanici odigrali po četiri utakmice različitim loptama: a) službenom košarkaškom loptom (485 g, 69-71 cm); b) lakšom loptom (440 g, 69-71 cm) i c) težom loptom (540 g, 69-71 cm). Skupina od šest eksperata je definirala i odredila opseg varijabli: a) preciznost: pogodak je postignut s obzirom na to je li lopta udarila u ploču i obruč u pojedinom ubacivanju i b) učinkovitost: broj bodova postignutih svakim bacanjem. Četiri promatrača su uvježbana i pouzdanost mjernog instrumenta je bila veća od 0,95. Sljedeća svojstva lopte su se kontrolirala: a) težina, b) opseg i c) visina odskoka. Dva suradnika snimila su utakmice, a četiri ekspertna promatrača su zabilježili rezultate. Preciznost i učinkovitost ubacivanja lopte od 440 g je bila veća od učinkovitosti i preciznosti ubacivanja službene lopte (preciznost: U=215448.5, p=.000; učinkovitost: U=212377, p=.001) i lopte od 540 g (preciznost: U=198869, p=.000; učinkovitost: U=223932, p=.002).

Ključne riječi: *košarka, mini košarka, analiza igre, modifikacija pravila, ekipni sport*