THE POINT SYSTEM AND KINEMATIC PARAMETERS' ANALYSIS OF FREE THROW WITH THE USE OF "94FIFTY SMART BASKETBALL" TESTING TOOL

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Keywords:
- basketball,
- the point evaluation of free throw,
- *94Fifty Smart Basketball.*

Abstract:
Introduction: Free throws in basketball are a complicated technical element. Mastery of free throws takes time, because there are many variables. Technological progress enabled the use of different research methods to assess the kinetics and kinematics of free throws. These methods require the use of highly specialized equipment, and thus considerable financial resources. Therefore, it raises the conception that we should look for a solution that will take into account the optimal technique and improve the effectiveness of the free throw at minimal financial expenditures. Additionally, this could be used at every stage of sports advancement. The aim of this study is to confirm the effectiveness of the point system in free throw. The study was based on the ball with motion sensors „94Fifty Smart Basketball". **Material and method:** The researches were conducted on a group of 13 players (girls) (13.0 years ± 0,0; 170 cm ± 6,7 cm body height), who have a 5-years training experience in basketball. The developed method involves the recreation of the recorded material and assessment of free throw in a point scale: 1 – can, 0 – cannot. The maximum number of points to obtain was 12. **Conclusions**: Missed free throws were characterized by a higher speed along players, whose technique was estimated at 5 or more points, but the results did not show statistical significance. The correctness that the angle of ball's shooting is bigger in accurate shots was observed at each technical level.

INTRODUCTION

Free throws in basketball are complicated technical elements. Their mastering requires time, because there are many variables that determine high efficiency [Okazaki, 2002]. Literature of this subject shows different aspects of the free throw. Researches included skill level [Batton et. al., 2003], patterns of coordination [Elliott &White, 1989], age and sex [Okazeki, Radecki, 2005]. Researches also drew attention to the emotional sphere [Hardle, Vickers, 2001, Englert C. et al. 2015], as well as the impact of fatigue on accuracy in the free throw [Uygur et al. 2010, Padulo 2015].Furthermore, mathematical algorithms that optimize the ball's trajectory were developed [Gablonsky, Lang 2005]. You can also find some researches abou the optimization of shooting angle during the free throw and speed of the ball fly [Hamilton, Reinschmidt. 1997; Satti, 2004; Tran, Silverberg, 2008]. Technological development allowed the use of various testing methods to evaluate kinetics and kinematics of throws. AN example can be studies conducted by Tiena et al., who determined the optimum conditions for the free throw. The research was based on hundreds of thousands of three-dimensional simulations of throw trajectory [Tien et al. 2007]. Moreover, researches carried

out by Mullineaux and Uhl are noteworthy. They examined kinematic relations between accurate and missed free throws [Mullineaux and Uhl, 2010].

Different information algorithms, which analyze the acquired video material, are used to evaluate kinetics and kinematics of motion [Lenik et. al. 2015, Przednowek et. al. 2014, Krzeszowski et. al. 2016]. These methods require the use of highly specialized equipment and thus considerable financial resources. Therefore, there is the idea that we should search such a solution that will take into account the optimal technique and improvement of the effectiveness of free throw at minimal costs. Additionally, this solution could be used at every stage of advancement of sports. In the source literature, it is difficult to find researches of this nature, so authors undertook to develop and test a solution that meets the above-mentioned assumptions.

MATERIAL AND METHOD

The researches were conducted on a group of 13 players (girls) (13.0 years±0,0; 170 cm ± 6,7 cm body height), who have a 5-years experience in basketball training and train twice a week for 1,5 hours. These players did not have injuries or inabilities, which could affect the effectiveness of free throw. Before the beginning of the trial, all participants were informed about the procedures, and their guardian has signed a consent form. Before starting the test, a warm-up was carried out. During this warm-up, players performed a set of general exercises controlled by the coach. The distance and the height of a basket were consistent with the provisions of the basketball game (Rules and regulations FIBA 2016).

The study was based on the ball with motion sensor under the name „94Fifty Smart Basketball" produced by Info Motion Sport Technologies, Inc. (Photo 1). The measurement of kinematic parameters allows to specify the speed of throw; angle, at which the ball falls to the basket; and rotations during the shot. The ball is equipped with a series of sensors, which enable a direct monitoring of throws. Data from the ball are sent via Bluetooth connection to a mobile device. The usefulness of the device is confirmed by the previously performed researches [Rupčić T. et al. 2016].

Photo 1. 94Fifty Smart Basketball
Source: www.94fifty.com

All shots were recorded via a digital camera (JVC, HD Everio GZ-HM650BE). For the purposes of this study, each player made 10 throws, which were separately rated in terms of technique. The method is based on the reconstruction of the recorded material and the evaluation of the free throw in accordance with 12 components in a point scale: 1 – can, 0 –

cannot. If a given element was not consistent with the assumptions, the participant received 0 points. On the other hand, if the estimated component was correct, the participant obtained 1 point. The maximum number of points was 12. The evaluated elements along with their description are presented in Table 1.

Table1.Rated elements in the technique of free throw

Number	Can – 1 point	Cannot – 0 points
1.	The ball lies on fingers	• The ball rests on the pastern • The ball lies on 4 fingers
2.	At the time of throw, the elbow is completely straight	• At the time of throw, the elbow is not fully straightened
3.	Wrist is pulled down at the moment, when the ball leaves the hand	• Wrist is straight at the moment when the ball leaves the hand • The wrist twisted in any direction at the moment when the ball leaves the hand
4.	Fingers of both hands are widely placed on the ball	• Fingers of both hands are placed on the ball – throwing arm and arm supporting the ball
5.	Legs on the width of hips	• Legs placed too wide or too narrow
6.	Leg on the side of throwing arm ½ distance of foot from the front	• Leg on the side of throwing arm is at the back • Parallel feet
7.	Straight back, shoulders parallel to the basket	• Hunched shoulders • Rotation of shoulders in the direction of throwing arm
8.	Legs and arm are simultaneously straightened	• Legs and throwing arm are not straightened at the same time
9.	Thumbs form „T" letter	• Thumbs do not form „T" letter • Supporting hand set from the front of the ball • Thumbs are tangentially placed to each other
10.	Elbows are close to each other	• Elbows and widely placed • Elbow and throwing are not exactly under the ball
11.	The ball is held so that the thumb of throwing arm is at the eye's height	• The ball kept above or below the eye level
12.	After the throw, arm (in the shoulder) is directed towards the throw	• After the throw, arm on the shoulder is faced inside or outside the body

The obtained results were analyzed by basic statistical measures, i.e. M – arithmetic mean, sd – standard deviation, min – minimum value, max – maximum value, V – coefficient of variation.

RESULTS OF RESEARCHES

The examined group made 130 throws including 72 accurate throws and 58 missed throws. The average technical level in accurate throws was ranked at a level of 7.2 points, while missed throws – 6.4 points. Firstly, results of the ball's speed parameter (when the throw starts – i.e. the ball leaves hands) were analyzed. The value of speed parameter was presented in the amount of points scored for the technique of performance and in terms of throw's accuracy.

Te highest speed of 2.2 seconds was observed among girls throwing inaccurately. Their technical level has been assessed in the range of 5-7 points. In contrast, girls, who presented the highest technical level (8 points and more), were throwing at a speed of approx. 1.8 m/s in accurate throws and 1.9 m/s in inaccurate throws. Variability within the group in accurate throws was ranked at a similar level in all technical ranges (26-29%). In inaccurate throws, the lowest variation (14%) had the worst rated throws (up to 4 points), and the highest variation (33%) – throws rated from 5 to 7 points. It should be noted that inaccurate throws

were characterized by a higher speed among people, whose technique was estimated at 5 or more points (Figure 1), but there were not any statistically significant differences at any technical level.

Table 2. Numerical characteristics of the speed parameter

Speed [m/s]														
Technique	Accurate shots (N=72; p=0,625)						Missed shots (N=58; p =0,200)						d	p
	N	M	sd	min	max	V	N	M	sd	min	max	V		
4 and less points	8,0	1,7	0,5	1,2	2,8	27%	13,0	1,7	0,2	1,5	2,3	14%	0,0	0,916
5-7 points	25,0	1,8	0,5	0,8	2,8	26%	20,0	2,2	0,7	1,2	3,8	33%	-0,3	0,207
8 and more points	39,0	1,8	0,5	0,9	3,1	29%	25,0	1,9	0,5	1,2	3,0	28%	-0,1	0,494
Total	72,0	1,8	0,5	0,8	3,1	28%	58,0	1,9	0,6	1,2	3,8	29%	-0,1	0,211

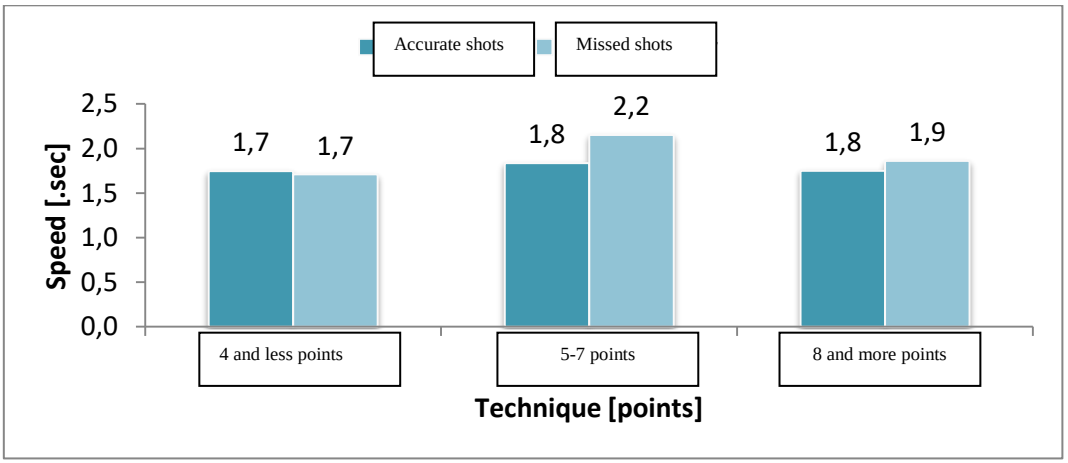

Figure 1. Ball speed during the free throw in terms of accuracy and throw and technique of its performance

The second analyzed parameter was the angle of ball throwing (Figure 2). Similarly to the case of speed, this parameter is illustrated in terms of accuracy of throw and technique of throws. According to the literature, this angle should range between 42° and 48° [Dobovičnik et al. 2015]. The smallest angles were presented in the group, in which the technique was rated at the lowest level (for accurate throws – 39.5°, and for inaccurate – 36.6°). On the other hand, the highest values of this parameter were observed in the group assessed from 5 to 7 points (for accurate throws: 48.7°).The performer analysis showed that at all technical levels, regularity, that this parameter reached the higher values in accurate throws, was observed. It seems that the closest to the optimum angle (47,4°) in accurate throws turned out to be an angle in a group, in which the technique was assessed at 8 and more points. In the case of accurate and inaccurate throws, the variability of parameters was ranked at relatively low level (9-15%). Additionally, it should be emphasized that the results obtained in the highest technically evaluated group differ significantly among accurate and inaccurate throws. Comparison of the results due to the technical level also showed that significantly different values of angles in terms of assessed level of technique were observed among accurate and inaccurate throws.

Table 3. Numerical characteristics of the parameter for ball throwing angle

Arc														
Technique	Accurate shots (N=72; **p=0,002**)						Missed shots (N=58; **p=0,001**)						d	p
	N	M	sd	min	max	V	N	M	sd	min	max	V		
4 and less points	8,0	39,4	5,8	30,0	45,0	15%	13,0	36,6	5,4	28,0	43,0	15%	2,8	0,121
5-7 points	25,0	48,7	6,0	34,0	56,0	12%	20,0	47,9	4,2	41,0	57,0	9%	0,8	0,347
8 and more points	39,0	47,4	5,4	36,0	56,0	11%	25,0	44,5	4,5	38,0	53,0	10%	2,9	**0,033**
Total	72,0	46,9	6,3	30,0	56,0	13%	58,0	43,9	6,2	28,0	57,0	14%	3,0	**0,005**

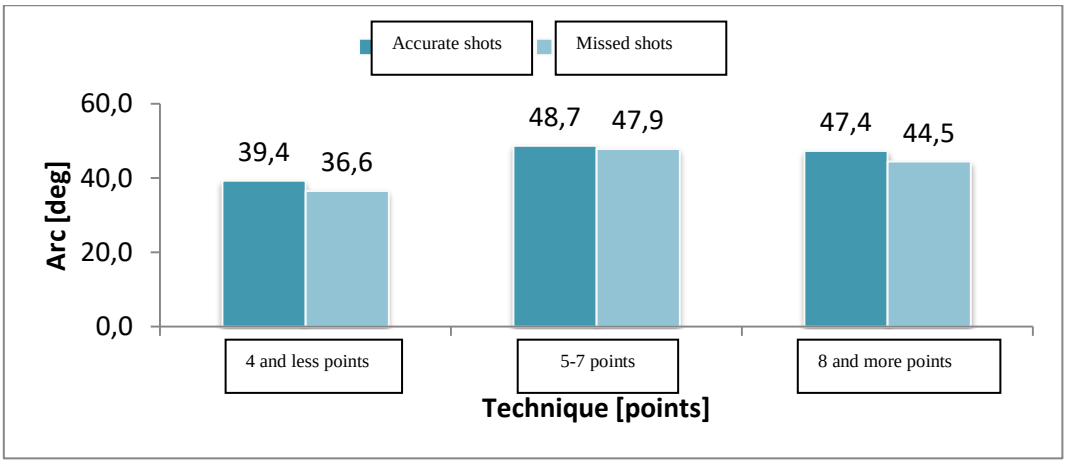

Figure 2. The angle of ball's throwing in the case of free throw in terms of accuracy of throw and technique of its realization

CONCLUSIONS

The conducted analysis showed that the use of a tool in the form of „94Fifty Smart Basketball" ball may significantly support the monitoring of the throw's technique. The obtained results led to the following conclusions:

- Missed throws were characterized by a higher speed among people, whose technique was estimate at 5 or more points, but the results did not show the statistical significance.
- At all technical levels, we observed the regularity that the angle of throw was bigger in accurate throws.
- The proposed method of scoring evaluation of free throw enables the assessment of individual technique and it can be used in the training of children and youth.

However, it should be remembered that the examined group included 13 year old girls, whose individual technique of throw is constantly developed. None of the tested girls reached 12 points, while the highest score was 9. Therefore, further scoring test for free throws on a group of with a longer training experience should be carried out.

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