BIOMECHANICAL ANALYSIS OF FREE SHOOTING TECHNIQUE IN BASKETBALL IN RELATION TO PRECISION AND POSITION OF THE PLAYERS

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On a representative sample of subjects - basketball players of the basketball club «Zdravlje» from Leskovac playing on different positions as guard, forward and center - a video recording of the free throws technique was made with the aim to define the differences in kinematic and goniometric parameters related to the success in free throw realization. By means of 2D kinematic analysis 120 attempts of free throws were encompassed and they were categorized as successful, successful with overthrow, successful with underthrow and unsuccessful. The results were statistically processed by: means of the multivariate variant analysis. It was obtained the following: researched kinematic and gonimetric parameters differ statistically in a significant manner depending on the success of the free throw technique in basketball.

KEY WORDS: free throws, kinematics, precision.

INTRODUCTION: There are a certain number of studies showing in detail the kinematic characteristics of successful shooting from different distances (Miller, S. and Barlet 1996), but not enough attention is being paid to unsuccessful shooting and its factors. This study's main subject is to compare kinematic characteristics and successful shooting variability. Some studies tried to identify the differences between individual free shootings. They were using more than one attempt per individual. None of them has found intra-individual variability of the technique. Motor control researches (Newell and Crocos, 1993) state that, considering the level of sensomotoric system's freedom, ″it seems impossible that specific individual makes identical model of movements in on performing the same target″. If intra-individual variability is an inseparable part of sport techniques, more complex measuring is necessary to reach the valid representation and performance. The previous studies on free shooting used 2D analysis techniques. Fault tests for 1024 free throws done by NCAA Division I for men's basketball competitions obtained the following results: 32,8% of missed free throws were too far, to the left, over the line and 19,5% to the right. This is indicative for the movements outside of sagittal plane. Walters (1990) studied the throw techniques from three different distances and came to the conclusion that all of them used the technique of coordination of pushing. Yates and Holt (1982) found out that successful throws demonstrated larger shoulder angle while pushing the ball and that they were using elbow elasticity and flexibility in the starting point of shooting. Considerable part of the study was concentrated on identifying kinematic variables related to successful throws, while ignoring the way they change or don't when distance from the basket changes. According to statistic results obtained on 25. European Championship in Athens 1987, 19,05% out of all results were free throws. It was concluded that the percentage of successful attempts, not more than 40 throws, specifically on this championship, had the highest correlation with other successful types of throws. It means that the precision in free throws is closely related to player's precision. Despite its importance, free throw study is limited. Hadson (1992) researched the relation between chosen biomechanical free throws parameters on a sample of players with different capacities. He came to the conclusion that stability related to higher capacity-training. In addition to this, projection angle and speed are not independent. Ruch (1976) and Hay (1978) found out that successful free throws do not depend on angle, speed or height of the throw. The proof that the consistency of movement models is related to precision, can be found in scientific texts. For example, Higgins and Spaeth (1972) determined that with maximum increase in precision, a successful movement model is being developed and reproduced with every attempt. Similar instructions exist in texts for basketball coaches, especially for free throws (Wissel, 1994) this leads to the conclusion that high reproduction is characterized by a precise movement model. Deviation in successful

movement model might be the cause for imprecision. Since basketball throws from larger distance need greater impulse, one can expect that variable evaluation is positively connected to shooting distance.

METHODS: The principal method used is comparative kinematic method, aimed at finding the differences in kinematic and goniometric parameters wanted, with final purpose in gaining information on prediction of free throw performing success. The free throw technique and appropriate number of repetitions were performed by basketball players on state competition level. The result they had was % free throws of different values. The difference in kinematic and goniometric parameters in accordance to free throw success was obtained. The players used in this research belong to basketball club "Zdravlje" from Leskovac: one player on guard position, three on forward positions and five center positions.

The primary data on subjects is given in the following table:

Name	**Position**	**Weight(kg)**	**High(cm)**	**Birth Year**
Veličković Uroš	1	71	190	1983
Bratić Saša	3	102	200	1981
Mitić Slobodan	5	112	205	1968

The free throws technique as the subject of the research is defined by following variables:

The absolute angle in the shoulder joint	UZRAM
The absolute angle in the elbow joint	UZLAK
The absolute angle in the wrist joint	UZSAK
High of ball	VISLO
Velocity of ball	LBLOP
The shooting angle	UGILOP

The absolute angle in the shoulder joint was made by upper arm, more precisely, the line from the shoulder joint center to the elbow joint center and the vertical. The absolute angle in the elbow joint was formed by lower arm, more precisely the line between the elbow joint center and wrist joint center and the vertical. The shooting angle is the one between the path that the ball moves along and the vertical.

All the parameters were measured and calculated on the basis of two moments (frames). The first is the moment of ball shooting and the second is immediately after. The interval between the two moments was equal to speed of DV camera recording and it was 50 frames/sec (0,02 sec). For processing the video recording we used kinematic analysis program in 2D. Technique was recorded with one camera. The video tape was processed and prepared for further analysis on 14-model system. Consequently, the fundamental kinematic and goniometric parameters were summed up. Statistical method was used as supporting method in this research. The fundamental parameters of descriptive statistics were calculated, as well as multivariate analysis of variance. All of this determined statistically important differences. The process of video recording, video recording digitalization, kinematic and goniometric parameter measurements and their statistic processing were realized in cooperation with Faculty of Physical Culture Institute in Nish.

RESULTS: All subjects tested performed a series of free throws until they accomplished:

- Ten miss (category "prom")

The successful throws they had, are classified into:

- Successful throws (category "pog")
- Underthrow successful throws when the ball hits the front of ring (category "pog-")
- Overthrow successful throws when the ball hits the back of ring (category"pog+")

Some descriptive free throw parameters are given in the following table:

Player	(pog)	(pog-)	(pog+)	(prom)	All	Duration time	Frequency
Bratić	48	14	9	10	81	8 min	6.3
Saša	(59%)	(17%)	(11%)	(12%)		30 sec	sec
Veličković	51	15	23	10	99	10 min	6.2
Uroš	(51%)	(15%)	(23%)	(10%)		13 sec	sec
Mitić	117	17	33	10	177	13 min	4.7
Slobodan	(66%)	(9%)	(18%)	(6%)		53 sec	sec
Summary	216	46	65	30	308		

DISCUSSION: In table 1 the multivariate variant analysis results are given, including all the categories of free throws in kinematic and goniometric variables, done by all types of players. From the results obtained, the following can be concluded: the free throw categories being studied here show statistically significant differences. This statistically significant difference was obtained on the basis of Wilkins lambda value of 0,70 while F approximation of 2,31 and with freedom degree of 18 and 314 and brings about a significant difference on the level of p = 0.00.

Table 1 Multivariate analysis of variance of all free throw categories in kinematic and goniometric variables with all types of players

	Wilks' Lambda	Rao's R	df 1	df 2	p-level
1	0.70	2.31	18.00	314.00	0.00

In univariate analysis, table 2, it can be seen that there is statistically significant difference in elbow angle variable (ULAZAK) on the significance level of p=0.03. Observing table 3, which shows significance values of t-tests between the category pairs of free throws, statistically significant difference can be noticed, the one of means between category of successful free throws and category of successful attempts with overthrow on one hand, and between successful attempts with under throw and unsuccessful free throws on the other hand (p=0.03, p=0.05, p=0.01, respectively).

Table 2 Univariate analysis of variance of all free throw categories in kinematic and goniometric variants with all types of players

	F(df1,2) 3,116	p-level
UZRAM	1.48	0.22
UZLAK	2.99	0.03
UZSAK	1.25	0.30
VISLO	0.36	0.78
LBLOP	0.54	0.66
UGILOP	0.07	0.97

Table 3 Significance of means differences of free throw categories' pairs in variable UZLAK with all types of players

		{1} 167.8000	{2} 170.6207	{3} 170.3000	{4} 171.2581
pog	{1}				
pog+	{2}	0.03			
pog-	{3}	0.05	0.80		
prom	{4}	0.01	0.61	0.44	

CONCLUSION: The aim of this study was to determine the existence of differences in kinematic and goniometric parameters in technique of free throw performance and its dependence on precision. On the basis of the results obtained following conclusions can be made: The angle of the elbow joint while throwing the ball is significently different when having successful or unsuccessful throws.

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