



## KINEMATIC MODELS OF THE SHOT WITH ONE HAND FROM THE SPOT AND THE JUMP SHOT AND THEIR DIFFERENCES

### KINEMATIČKI MODELI ŠUTA JEDNOM RUKOM S GRUDIJU IZ MJESTA I SKOK ŠUTA I RAZLIKE MEĐU NJIMA

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#### SUMMARY

Shooting is the basic way in which the ball is directed towards the basket, it is a technical element that is very often used during a basketball game. In that way, the main goal, to throw the ball into the basket, is achieved. There are two basic forms of shooting used in a player's training: a jump shot and a shot with one hand from the spot. The aim of this research is to define the kinematic parameters of a shot with one hand from the spot and the jump shot, as well as to determine the differences between them. The analysis of parameters was performed on a former member of the U-20 national team of Croatia (26 years, 180 cm, 82 kg, 15 years of training experience). The observed variables (shoulder angle at the moment of ball release, maximal height of release, wrist joint at the moment of ball release, the angle at which the ball enters into the basket and oscillations of the centre of mass of the body along the x-axis during the shot) were measured using the Xsens Awinda kinematic system and 94 Fifty Smart Sensor Basketball. The results showed that the observed kinematic parameters have a statistically significant difference between the jump shot and a shot with one hand from the spot by 2 points distance ( $F = 84.28$ ;  $p < 0.00$ ) and by 3 points distance ( $F = 184.69$ ;  $p < 0.00$ ).

*Key words:* basketball, shooting kinematics, Xsens

#### SAŽETAK

Šutiranje je osnovni način kojim se upućuje lopta prema košu, to je tehnički element koji se vrlo učestalo koristi za vrijeme košarkaške utakmice. Na taj način se ostvaruje glavni cilj, a to je ubacivanje lopte u koš. Postoje dva osnovna oblika šutiranja koja se koriste u obuci igrača: skok šut i šut jednom rukom s grudiju iz mjesta. Cilj ovog istraživanja je definiranje kinematičkih parametara kod šuta s jednom rukom s grudiju iz mjesta i skok šuta, kao i utvrditi razlike između njih. Analiza parametara provedena je na bivšem članu U-20 nacionalne selekcije Hrvatske (26 godina, 180 cm, 82 kg, trenajno iskustvo 15 godina). Promatrane varijable (Kut\_rame, Visina\_izbačaja, Kut\_upada, X\_os) mjerile su se uz pomoć Xsens Awinda kinematičkog sustava i 94 Fifty Smart Sensor Basketball. Rezultati su pokazali da postoji statistički značajna razlika između skok šuta i šuta jednom rukom s grudiju iz mjesta za 2 poena ( $F = 84,28$ ;  $p < 0,00$ ) i za 3 poena ( $F = 184,69$ ;  $p < 0,00$ ).

*Ključne riječi:* košarka, kinematika šuta, Xsens

## INTRODUCTION

Basketball is a complex and dynamic sports game that consists of a rapid and frequent change of defensive and offensive actions during which players perform a large number of sprints, jumps, changes of direction, lateral movements<sup>8</sup>. It is also defined as a team sports game in which two opposing teams compete, each team consists of five players whose goal is to throw the ball into the opponent's basket and prevent the other team from scoring, and the winner is the team that scores more points at the end of playing time<sup>9</sup>. Basketball technique is the basic means by which this goal is achieved, and it consists of movement patterns performed by players with the ball, but also those without the ball, in accordance with the rules of the game. Success in the game is highly predetermined by knowing the various elements of basketball technique<sup>5</sup>. Research<sup>6</sup> shows that the basic technique needs to be learned as early as possible, at the age of 9 or 10. In mini-basketball programs, one starts learning even earlier, at the age of seven to nine, i.e. by including beginners in the process of systematic learning and practicing basketball<sup>4</sup>. One of the elements of basketball technique that requires extremely great attention to proper performance during the learning process due to its complexity is the shooting technique. A shot with one hand from the spot is most often applied in younger age selections. One of the reasons for using this shooting technique is the lack of development of the muscles of the upper and lower extremities, but also because this element, according to biomechanical analysis, is closest to the correct performance of the shot jump and its adoption allows easier transition to the aforementioned shooting technique, which has become universal and general accepted shooting technique<sup>10</sup>. The situational efficiency of each basketball player largely depends on the quality of performance of jump shot, as a complex motor movement and an element of the basketball game technique<sup>13</sup>. Jump shot is a basketball element which is, due to its complexity, improved and perfected throughout the sports career. The situational efficiency of each player during the shooting in a match is determined by numerous parameters such as the duration of contact with the ground, the height of the take-off, maximal height of release, the duration of the shot and the angle at which the ball enters into the basket between shooting from a 2 and 3 points distance<sup>3,6</sup>. Numerous devices and new technologies in sports diagnostics enable fast and accurate measurement of these parameters. Biomechanical analysis can provide data that can later be compared with the model of a top basketball player, and in this way, you can see the player's greatest situational efficiency in the basketball game<sup>16</sup>. A research<sup>12</sup> was conducted on a sample of 10 basketball players who performed shots from a distance of 2.8, 4.6 and 6.4 meters. The results show that by increasing the distance from the basket, the time required to perform the shot is reduced.

The problem of this paper is manifested in the fact that there is no defined kinematic model of shot with one hand from the spot, and its proper performance is the basis for further learning the technique of jump shot. This is especially important because both ways of shooting are included in the curriculum of Physical Education in the field of basketball. The aim of this research is to define the kinematic parameters of a shot with one hand from the spot and the jump shot, as well as to determine the differences between them by observing the following parameters: (Kut\_rame, Visina\_izbačaja, Kut\_upada, X\_os).

## SUBJECTS AND METHODS

The analysis of parameters was performed on a former member of the U-20 national team of Croatia, who played in the HT premier league (26 years old, 180 cm, 82 kg, 15 years of training experience). He did not have any injuries during the research and did not participate in additional physical activity except for the needs of the research. The research was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Faculty of kinesiology, University of Zagreb. The subject was acquainted with the topic and goal of the research, and the benefits as well as the possible consequences of the research, and he gave a written consent for participation.

The sample of variables in the initial stage of shooting (triple threat position) consists of: right shoulder joint angle (D.rame\_pp); right elbow joint angle (D.lakat\_pp); right wrist joint angle (D.ručni\_zglob\_pp); right hip joint angle (D.kuk\_pp); right knee joint angle (D.koljeno\_pp). In the final phase, i.e. the throwing phase, the following parameters were observed: shoulder joint angle (Kut\_rame); the highest point of the wrist joint at the moment of ball release (Visina\_izbačaja); the angle of approach to basket (Kut\_upada); horizontal axis movement (X\_os).

The parameters were measured on a total sample of 40 shots, 20 shots with one hand from the spot for 2 and 3 points, and 20 shots performed by the jump shot technique for 2 and 3 points.

Prior to the measurement, the subject performed a standardized warm-up that included a three-minute run and general preparatory exercises, followed by a specific warm-up with a basketball. After warm-up, the measurement begins. For the purpose of measuring the kinematic parameters, an Xsens kinematic suit, a 94 fifty smart ball and a GH5 Panasonic camera were used which recorded the performance in the sagittal plane for the purpose of video analysis. The testing was performed using two shooting techniques: shooting with one hand from the spot and jump shot. Both techniques were performed from two distances. First, a shot was taken from a distance for 2 points (6.00 m) and then for 3 points (6.75 m).

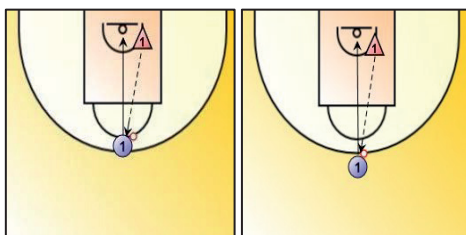


Figure 1 – 2. Illustrations of shot for 2 points (6.00 m) and 3 points (6.75 m)

Slike 1 – 2. Prikazi šuta za 2 poena (6,00 m) i 3 poena (6,75 m)

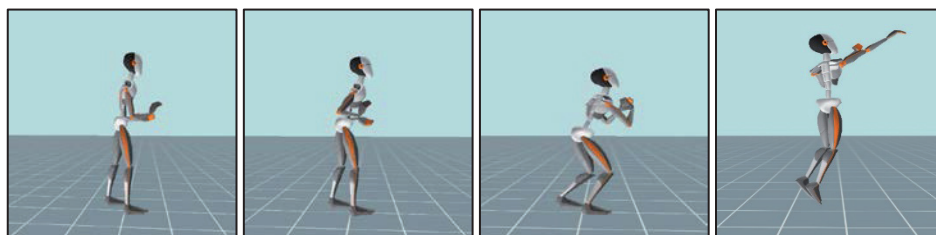


Figure 3 – 5. Illustration of shot with one hand from the spot

Slike 3 – 5. Prikaz šuta jednom rukom s grudiju

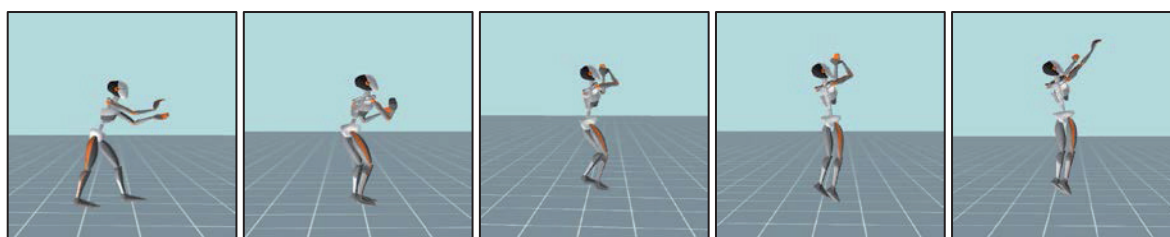


Figure 7 – 11. Illustration of jump shot

Slike 7 – 11. Prikaz skok šuta

The observed variables were measured using the Xsens Awinda kinematic system. Measuring device does not represent a limiting factor and does not affect the motor performance of the basketball element. The following variables were measured with this measuring instrument: D.rame, D.lakat, D.ručni\_zglob, D.kuk, D.koljeno, Kut\_rame, Visina\_izbačaja, horizontal movement (X\_os). The reliability of the measuring device for measuring the stated kinematic parameters has been previously determined in studies<sup>7</sup>.

During the execution of the shot, 94 Fifty Smart Sensor Basketball (567 - 650 grams and 749-780 mm in range), manufactured by InfoMotion Sports Technologies, Inc., was used. The following variables were measured with this measuring device: the angle of incidence of the ball in the basket. The measurement characteristics of this device were previously determined in studies<sup>2,14,1</sup>.

The collected data were processed using the statistical program Statistica 13.4. For the purposes of testing the normality of the distribution in all observed variables, the Shapiro-Wilk test was used. Basic descriptive statistical indicators of variables (arithmetic mean, minimum,

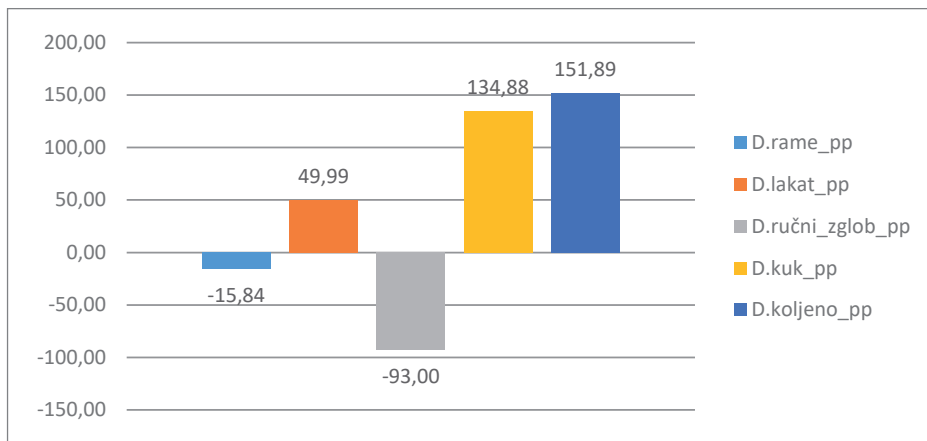
maximum, standard deviation) were calculated. Multivariate analysis of variance (MANOVA) was used to determine the significance of the differences between the shot with one hand from the spot and the shot jump.

### Kinematic models

According to the data from Graphs 1 and 2, the average angular values that the subject achieves in the starting position when shooting with one hand from the spot and jump shot (triple threat position) for 2 points can be seen. The results show that the subject, when shooting with one hand from the spot for 2 points in the initial position, achieves the average value in the right shoulder joint (-15.84°) in relation to the jump shot (37.93°). Also, there are visible differences in the variable (D.lakat\_pp), in which the subject achieves value (73.31°) during jump shot, while this value is lower during the execution of a shot with one hand from the spot (49.99°). When shooting with one hand from the spot, the subject creates greater flexion in the wrist (-93.00°) compared to the jump shot (-72.80°). In the variable D.kuk\_pp and D.koljeno\_pp the subject achieves

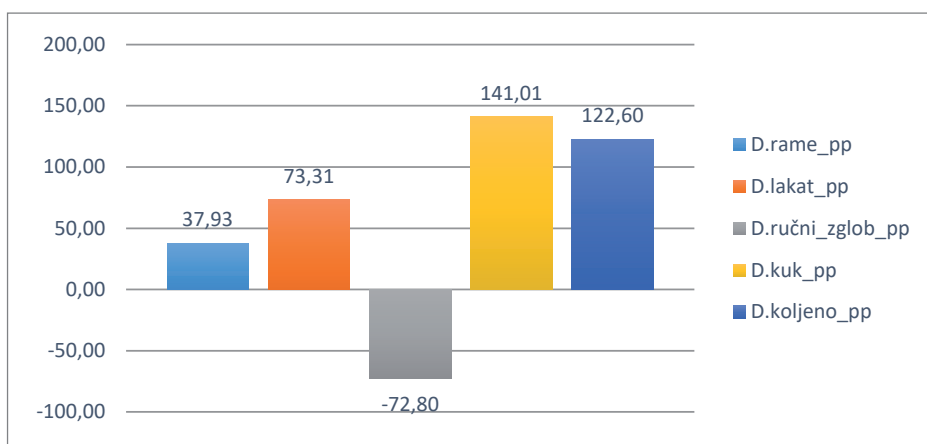
values ( $134.88^\circ$  and  $151.89^\circ$ ) during the execution of the shot with one hand from the spot, while in the jump shot he achieves the following values: ( $141.01^\circ$  and  $122.60^\circ$ ).

According to the data from Graphs 3 and 4, there can be seen the average angular values that the subject achieves in the initial position when shooting with one hand from



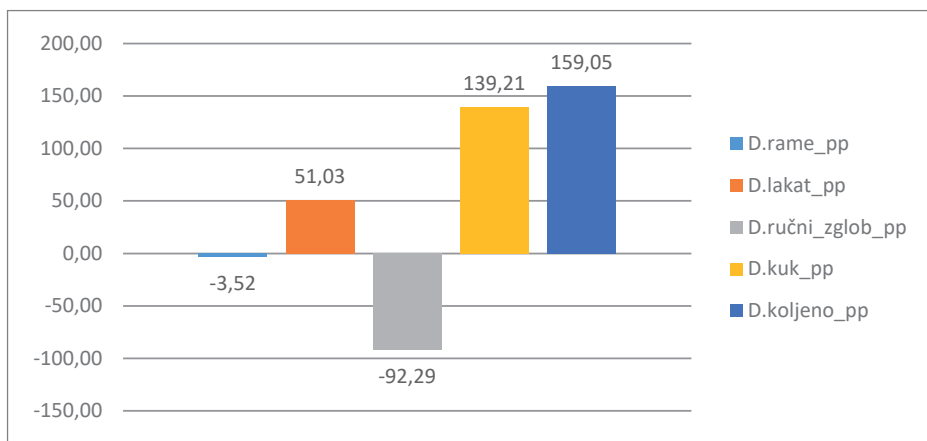
Graph 1. Angular values in the initial position of the shot with one hand from the spot for 2 points

Grafički prikaz 1. Kutne vrijednosti u početnoj poziciji šuta jednom rukom s grudiju iz mjesta za 2 poena



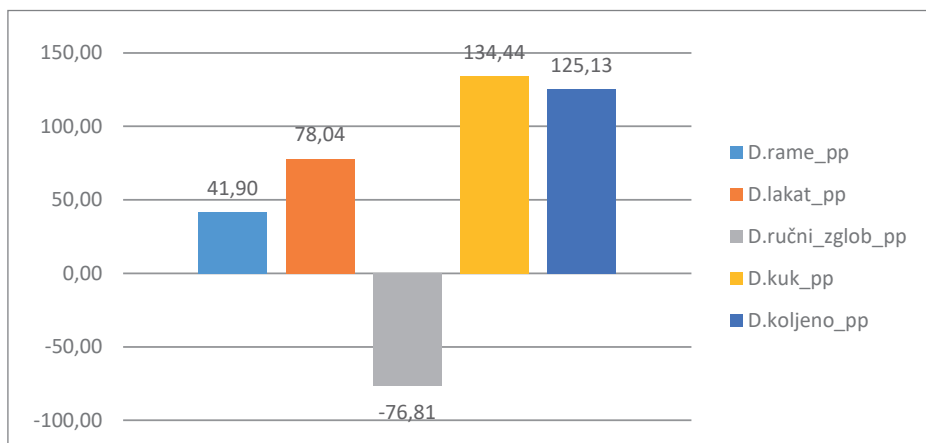
Graph 2. Angular values in the initial position of the jump shot for 2 points

Grafički prikaz 2. Kutne vrijednosti u početnoj poziciji skok šuta za 2 poena



Graph 3. Angular values in the initial position of the shot with one hand from the spot for 3 points

Grafički prikaz 3. Kutne vrijednosti u početnoj poziciji šuta jednom rukom s grudiju iz mjesta za 3 poena



Graph 4. Angular values in the initial position of the jump shot for 3 points

Grafički prikaz 4. Kutne vrijednosti u početnoj poziciji skok šuta za 3 poena

the spot and jump shot (central position) for 3 points. The subject, when shooting with one hand from the spot for 3 points in the initial position, achieves a lower value in the right shoulder joint ( $-3.52^\circ$ ) compared to the jump shot ( $41.90^\circ$ ). There are visible differences in the variable (D.lakat\_pp), in which the subject achieves a higher value ( $78.04^\circ$ ) during jump shot, while the variable is lower ( $51.03^\circ$ ) during the shot with one hand from the spot. During the performance of the shot with one hand from the spot, the subject achieves greater flexion in the wrist ( $-92.29^\circ$ ) in relation to the jump shot ( $-76.81^\circ$ ). Also, there are visible differences in the variables D\_kuk\_pp and D.koljeno\_pp ( $139.21^\circ$  and  $159.05^\circ$ ) when shooting with one hand from the spot in relation to the jump shot for 3 points ( $134.44^\circ$  and  $125.13^\circ$ ).

Table 1. ANOVA results for all observed variables in two different types of shooting (jump shot and shot with one hand from the spot) for 2 points

Tablica 1. Rezultati ANOVA-e za sve promatrane varijable u načinu držanja lopte (skok šut i šuta s jednom rukom s grudiju iz mjesta) za 2 poena

Variables	F	p
R.rame_pp	1617,71	0,00*
R.lakat_pp	1057,77	0,00*
R.zglob_pp	228,87	0,00*
R.kuk_pp	6,86	0,02*
R.koljeno_pp	302,28	0,00*

Legend: F – F-test; p – level of significance, \*marked values are significant when  $p < 0,05$

Table 1 shows that there is a statistically significant difference in two different types of shooting, which was observed during the initial position for 2 points.

Table 2. ANOVA results for all observed variables in two different types of shooting (jump shot and shot with one hand from the spot) for 3 points

Tablica 2. Rezultati ANOVA-e za sve promatrane varijable u načinu držanja lopte (skok šut i šuta s jednom rukom s grudiju iz mjesta) za 3 poena

Variables	F	p
R.rame_pp	507,39	0,00*
R.lakat_pp	1183,92	0,00*
R.zglob_pp	66,84	0,00*
R.kuk_pp	3,74	0,07
R.koljeno_pp	206,06	0,00*

Legend: F – F-test; p – level of significance, \*marked values are significant when  $p < 0,05$

Table 2 shows that there is a statistically significant difference in all parameters observed during the initial position for 3 points, except in the variable R.kuk\_pp ( $F = 3.74, p > 0.07$ ).

### Kinematic parameters of shooting

Table 3 shows the basic descriptive statistical indicators of the observed variables in the two shooting techniques. It can be seen from the table that the subject had a higher average value in the shoulder joint ( $119.41 \text{ cm} \pm 8.61$ ) during jump shot for 2 points than the shot with one hand from the spot ( $110.80 \text{ cm} \pm 5.14$ ). Also, he achieves higher values in the height of the release during jump shot for 2 points ( $209.94 \text{ cm} \pm 17.41$ ) compared to the shot with one hand from the spot ( $192.53 \text{ cm} \pm 4.88$ ). When shooting with one hand from the spot, the subject achieves higher values in the movement along the X-axis ( $28.05 \text{ cm} \pm 11.53$ ) compared to the jump shot ( $16.52 \text{ cm} \pm 7.05$ ). The angle at which the ball falls into the basket is higher in the jump shot for 2 points

Table 3. Basic descriptive indicators of the jump shot and shot with one hand from the spot for 2 points  
 Tablica 3. Osnovni deskriptivni pokazatelji skok šuta i šuta jednom rukom s grudiju iz mjesta za 2 poena

Variables	Type of shooting	N	AS	Min	Max	SD
Kut_rame	Jump shot	10	119,41	115,45	124,10	3,16
	Shot with one hand from the spot	10	110,80	98,33	116,28	5,14
Visina_izbačaja	Jump shot	10	209,94	206,90	217,70	3,17
	Shot with one hand from the spot	10	192,53	182,10	198,90	4,88
X_os	Jump shot	10	16,52	5,40	31,20	7,05
	Shot with one hand from the spot	10	28,05	23,70	32,30	3,36
Kut_upada	Jump shot	10	35,60	33,00	40,00	1,84
	Shot with one hand from the spot	10	32,60	26,00	37,00	3,13

Legend: N - number of shots taken; AS - arithmetic mean in the observed variables during jump shot and shot with one hand from the spot; Min - The lowest measured value in the observed variables during jump shot and shot with one hand from the spot; Max - The highest measured value in the observed variables during jump shot and shot with one hand from the spot; SD - standard deviation in the observed variables during jump shot and shot with one hand from the spot

(35.60 ± 3.0) in relation to the shot with one hand from the spot (32.60 ± 3.13).

The results of the variance analysis in Table 4 show a statistically significant difference between the jump shot and the shot with one hand from the spot for 2 points (F = 84.28; p = 0.00).

Table 5 shows that there is a statistically significant difference in all the parameters above (p < 0.00).

Table 6 shows the basic descriptive statistical indicators of the observed variables in the two shooting techniques. It can be seen that the subject had a higher average value in the shoulder joint when shooting with one hand from the spot for 3 points at the time of releasing the ball (122.11 ± 6.74) compared to the jump shot (115.37 ± 5.28). He achieves higher values in the height of release during jump shot for 3 points (209.25 ± 21.52) compared to a shot with one hand from the spot (187.73 ± 2.85). When shooting with one hand from the spot, the subject achieves higher values in the movement along the horizontal axis (42.79 cm ± 15.36) in relation to the jump shot (27.43 cm ± 11.61). The angle at which the ball enters into the basket is lower in the shot jump for 2 points (38.90 ± 0.88) in relation to the shot with one hand from the spot (41.20 ± 2.3).

Table 4. MANOVA results in the observed groups

Tablica 4. Rezultati MANOVA-e u promatranim grupama

Test	Lambda value	F	p
Wilks	0,09	84,28	0,00*

Legend: F – F-test; p – level of significance, \*marked values are significant when p < 0,05

Table 5. ANOVA results for all observed variables in two shooting techniques for 2 points (jump shot and shot with one hand from the spot)

Tablica 5. Rezultati ANOVA-e za sve promatrane varijable u dvije tehnike šutiranja za 2 poena (skok šut i šuta jednom rukom s grudiju iz mjesta)

Variables	F	p
Kut_rame	29,72	0,00*
V_izbačaja	203,30	0,00*
X os	44,49	0,00*
Kut_upada	33,51	0,00*

Legend: F – F-test; p – level of significance, \*marked values are significant when p < 0,05

Table 6. Basic descriptive indicators of jump shot and shot with one hand from the spot for 3 points  
 Tablica 6. Osnovni deskriptivni pokazatelji skok šuta i šuta jednom rukom s grudju iz mjesta za 3 poena

Variables	Type of shooting	N	AS	Min	Max	SD
Kut_rame	Jump shot	10	115,37	108,86	127,80	5,28
	Shot with one hand from the spot	10	122,11	115,19	129,97	4,16
Visina_izbačaja	Jump shot	10	209,25	207,40	210,60	1,05
	Shot with one hand from the spot	10	187,73	182,50	191,40	2,85
X_os	Jump shot	10	27,43	12,80	57,50	11,61
	Shot with one hand from the spot	10	42,79	26,80	55,00	9,80
Kut_upada	Jump shot	10	38,90	38,00	40,00	0,88
	Shot with one hand from the spot	10	41,20	35,00	48,00	3,61

Legend: N - number of shots taken; AS - arithmetic mean in the observed variables during jump shot and shot with one hand from the spot; Min - The lowest measured value in the observed variables during jump shot and shot with one hand from the spot; Max - The highest measured value in the observed variables during jump shot and shot with one hand from the spot; SD - standard deviation in the observed variables during jump shot and shot with one hand from the spot

Table 7. Results of MANOVA in the observed groups  
 Tablica 7. Rezultati MANOVA-e za promatrane grupe

Test	Lambda value	F	p
Wilks	0,05	184,69	0,00*

Legend: F – F-test; p – level of significance, \*marked values are significant when  $p < 0,05$

Table 8. ANOVA results for all observed variables in the two shooting techniques (jump shot and shot with one hand from the spot) for 3 points

Tablica 8. Rezultati ANOVA-e za sve promatrane varijable u dvije tehnike šutiranja (skok šut i šuta jednom rukom s grudju iz mjesta) za 3 poena

Variables	F	p
Kut_rame	10,08	0,01*
V_izbačaja	501,29	0,00*
X os	10,22	0,00*
Kut_upada	3,27	0,08

Legend: F – F-test; p – level of significance, \*marked values are significant when  $p < 0,05$

The results of the analysis of variance in Table 7 show a statistically significant difference between the jump shot and the shot with one hand from the spot for 3 points (method shot) ( $F = 184.69$ ;  $p < 0.00$ ).

Table 8 shows that there is a statistically significant difference in all parameters except in the variable of the angle at which the ball enters into the basket ( $p > 0.07$ ).

## DISCUSSION

Based on the analysis of the results obtained in this study, it can be concluded that there are statistically significant differences in the initial positions between the two shooting techniques (Tables 3 and 4). It is known that the initial positions between the jump shot technique (triple threat position) and the shot with one hand from the spot differ, all with the aim of facilitating the performance of the mentioned elements. Primarily, this refers to a shot with one hand from the spot where the player, in order to more easily unite the entire musculature of the body in one movement, or to direct the ball more easily to the basket from greater distances, noticeably places the foot on the side of the hand with which he shoots in the front position (diagonal position) and transfers the centre of mass of the body (ratio approximately 60:40) to the leg mentioned. Also, the ball is placed on the chest, i.e. in the position which has the greatest “lever” of action on the ball, which will ultimately allow the player to more easily direct the ball to the basket, especially from greater distances. The jump shot is derived from a triple threat attitude from which the player has three options from the aspect of the individual tactics of the attacking player, namely shooting, passing, and dribbling. All of the above elements are derived from the abovementioned way of holding the ball. Precisely this way of holding the ball (triple threat attitude) enables the

“easiest” performance of the jump shot technique. Based on the obtained results in this study, it can be concluded that there is a statistically significant difference in holding the ball in the initial position between the shot with one hand from the spot and the jump shot. According to the data from Graphs 1 and 2, when shooting with one hand from the spot for 2 points in the initial position, the subject achieves an average value in the right shoulder joint ( $-15.84^\circ$ ) in relation to the jump shot ( $37.93^\circ$ ). It should be emphasized that when shooting with one hand from the spot, the ball is at chest height, the forearm is parallel to the ground, and the elbow is pushed back, which ultimately affects the aforementioned result. Also, due to the position of the ball in the initial position, there are visible differences in the variable  $D.lakat\_pp$  ( $73.31^\circ$ ;  $49.99^\circ$ ) when shooting for 2 points, and when shooting from a distance for 3 points (Graph 3 and 4). Since the ball is in the initial position closer to the chest when shooting with one hand from the spot, it therefore creates more flexion in the wrist compared to the jump shot, where the ball is in a slightly lower position which consequently affects the lower value (Graphs 1 and 2). Differences in the variables  $D.kuk\_pp$  and  $D.koljeno\_pp$  ( $134.88^\circ$  and  $151.89^\circ$ ) during the execution of the shot with one hand from the spot in relation to the jump shot for 2 points ( $141.01^\circ$  and  $122.60^\circ$ ), and differences in the shot for 3 points (Graph 3 and 4), are due to the noticeable forward step in the shot with one hand from the spot. The diagonal position in the initial position when shooting with one hand from the spot allows the player a better balance position, which in turn affects the greater use of the muscles of the lower extremities. Observing the obtained results between performing the jump shot technique and shooting with one hand from the spot for 2 points, it can be determined that there is a statistically significant difference ( $F = 84.28$   $p < 0.00$ ). The results of the difference of individual variables were determined using univariate analysis of variance, which determined a statistically significant difference (Table 7) in the variables: shoulder joint angle, height of the release, horizontal axis movement ( $X\_os$ ). Shoulder angle variable during the jump shot for 2 points, the subject on average achieves higher values by 8.61 degrees compared to the shot with one hand from the spot. A higher value in this variable indicates the fact that when jumping, the elbow is raised high towards the so-called central position which will affect the increase in value in the shoulder angle. In further analysis, when performing a shot with one hand from the spot for 3 points, the results show that the subject achieved higher values in the shoulder angle variable by 6.74 degrees compared to the jump shot (Table 8). This result can be affected by the fact that some players will often lower the ball to a lower position when increasing the distance from the basket due to insufficiently developed muscles of the upper or lower extremities, especially with the 3-point line. Also, according to descriptive indicators, differences in horizontal axis movement can be seen, in which the subject achieves higher values in the jump shot

for 3 points compared to the jump shot for 2 points (27.43 cm, 16.52 cm). It is this data that indicates that the player must lower the ball to a lower position due to the increase in distance, which consequently affects the aforementioned results in the shoulder angle, and therefore some players will not have clear differences in certain parameters between jump shot and shot with one hand from the spot for 3 points. The collected data of horizontal movement ( $X\_os$ ) show that the subject achieved higher values of movement by 14.74 cm when shooting with one hand from the spot for 3 points compared to the same technique of shooting for 2 points, which may also be one of the factors why the subject achieved higher values in the shoulder angle during shot with one hand from the spot for 3 points compared to the jump shot for 3 points (higher value of vertical-horizontal take-off allows the player to lift the ball to a higher position which results in increasing the angle of the shoulder joint). In this variable, due to the biomechanical pattern of shooting with one hand from the spot and the influence of inertial force, the subject achieves higher values by 11.53 cm compared to the jump shot when shooting for 2 points (Table 5) and 15.36 cm for 3 points (Table 8). By further interpretation of the obtained results, there is a significant difference in the point along the vertical line where the contact of the ball and the fingers of the hand with which the player performs the shot stops (height of the ball release) for 2 points ( $F = 203.30$   $p < 0.00$ ) and for 3 points. ( $F = 510.81$   $p < 0.00$ ). As already mentioned, by raising the upper extremities during jump shot, or bringing the ball in a semi-circular motion to the central position, it is logical to expect that the point from which the ball will be released will be significantly higher than in the case of a shot with one hand from the spot. Differences in these variables are expected because they show the most biomechanical difference between a jump shot and a shot with one hand from the spot. These results can be compared with the results of a research<sup>15</sup>, which aimed to determine whether there are statistically significant differences in some kinematic parameters during a jump shot and a shot with one hand from the spot. The research was conducted under the assumption that in the case of a jump shot the parameters representing the values of angles and the height of the take-off and releasing of the ball will be higher, while in the case of a shot with one hand from the spot those values will be lower. Furthermore, the results of the research indicate a statistically significant difference in the parameters of shoulder joint angle ( $F = 2.15$  and  $p < 0.00$ ) and the height of the release of the ball in the final stage of shooting ( $F = 6.20$  and  $p < 0.00$ ). Also, the results of the research<sup>15</sup> prove a statistically significant difference in the variable of horizontal movement ( $F = 1.60$  and  $p < 0.01$ ). According to the descriptive indicators of this research, the subject achieves a higher angle of the ball approaching to basket by 3.0 degrees in the jump shot for 2 points, and the results show that there is a statistically significant difference in this variable between jump shot and shot with one hand



from the spot ( $F = 33, 51, p < 0.00$ ). Achieved angular values in D.kuk\_pp and D.koljeno\_pp ( $141.01^\circ$  and  $122.60^\circ$ ) in the initial position for jump shot for 2 points can affect the aforementioned result of the angle at which the ball enters into the basket. In the situation of performing these techniques from a distance for 3 points, there is no statistically significant difference in the angle at which the ball enters into the basket ( $F = 3.27$  and  $p > 0.08$ ). This result may be affected by an insufficient number of shots for 3 points (20 shots) and the number of subjects. Although no correlation between the efficiency and the angle at which the ball enters into the basket was observed in this study, the results of the study can be taken into account for comparison of the variable of the angle at which the ball enters into the basket<sup>7</sup>. They proved that there is a statistically significant correlation between the shooting efficiency for 3 points and the angle at which the ball enters into the basket. Data collected from 50 shots for 3 points showed that the angle at which the ball enters into the basket, which was  $42.44 \pm 6.12$  degrees, statistically significantly affects the shooting efficiency ( $p < 0.00$ ). Another study that observes the angle at which the ball enters into the basket is a research<sup>13</sup>. Based on the obtained results, the researchers determined a higher the angle at which the ball enters into the basket from greater distances ( $43.30^\circ \pm 1.92$  for 3 points), and a statistically significant difference ( $p < 0.00$ ). In accordance with these results, it should be mentioned that the height of the release and the angle at which the ball enters into the basket are one of the most important kinematic parameters on which the player's success during shooting depends and these two parameters are closely interrelated<sup>11</sup>. In order for the player to achieve the highest possible accuracy during the game, it is necessary to perform a structurally correct jump shot of appropriate speed, and its initial phase at the time of receiving the ball, or low position of the centre of mass of the body, is proper leg work that allows the player to use reaction force of the ground, and movement coordination<sup>10</sup>. This will lead to the correct and harmonious execution of the shot in later basketball development. It is recommended that during the process of adopting and perfecting the correct shooting technique, special attention be paid to the initial phase (triple threat position) in which the lower position of the centre of mass of the body and slight flexion in all joints of the lower extremities (Graph 1, 2, 3 and 4) form a prerequisite for the player to make better use of the reaction force of the ground during the shot, which will ultimately allow him to more easily direct the ball towards the basket.

## CONCLUSIONS

The shooting technique, due to its complexity, requires a great deal of attention to proper performance in the learning process. A shot with one hand from the spot is most commonly applied in younger age selections. The lack of development of the muscles of the upper and lower extremities is one of the reasons for using this technique. The aim of the research was to prove the differences in the previously mentioned parameters and, based on the obtained results, to create kinematic models, which will show coaches and teachers the basic differences between these two shooting techniques and thus enable easier training of players or students. By observing and analysing the obtained results, the difference between the jump shot and the shot with one hand from the spot in the parameters; Shoulder angle, the height of the release, horizontal movement and the angle at which the ball enters into the basket was determined. In relation to the shot with one hand from the spot, the subject achieves a higher value in the shoulder angle and the height of the release during the performance of the jump shot. Also, according to the parameters of the angle at which the ball enters into the basket, the subject achieves higher values by 3.0 degrees in the jump shot, and when shooting with one hand from the spot, he achieves higher values in horizontal movement. Each of these two shooting techniques takes its place in player training. After young basketball players correctly adopt the technique of shooting with one hand from the spot and their muscles begin to develop, they move on to learning the correct performance of jump shot, but the fact that jump shot is a more acceptable, attractive and high-quality form of shooting cannot be ignored. The player should strive to master, perfect, and apply it, both in training and in competitive conditions. Young players who are not in a physically optimal condition to perform a jump shot should use a shot with one hand from the spot, as it is a more appropriate element for their current abilities and capabilities. Given that a small number of subjects participated in this research, the possibility opens up for future research in which a larger sample of subjects and variables would be considered.

## References

1. Dobovičnik L, Jakovljević S, Zovko V, Erčulj F. Determination of the optimal certain kinematic parameters in basketball three – point shooting using the 94 fifty technology. *Physical culture* 2015; 69 (1): 5-13.
2. Erčulj F, Marković M, Broder Ž. Uporaba tehnologije 94Fifty pri ugotavljanju nekaterih kinematičnih parametrovmeta na koš. *Šport: revija za teoretična in praktična vprašanja športa* 2014; 62 (1/2): 57-62.
3. Fontanella, JJ. *The Physics of Basketball*. Baltimore: The Johns Hopkins University Press, 2006.
4. Knjaz D. Mini košarka. K. Delija (Ed.), *Zbornik radova X Ljetne škole pedagoga fizičke kulture Republike Hrvatske*, Poreč: Kineziološki fakultet, 2000: 159-63.
5. Knjaz D, Matković B, Janković S. *The Value of Different Motor Teaching Methods in Working with Basketball Beginner*. Zagreb: Kineziološki fakultet Sveučilišta u Zagrebu, 2010.
6. Krause JV, Meyer D, Meyer J. *Basketball skills and drills*. Champaign, Ill.: Human Kinetics, 2008.
7. Krüger A, Edelmann-Nusser J. Application of a full body inertial measurement system in alpine skiing: A comparison with an optical video based system. *Journal of Applied Biomechanics*, 2010; 26: 516-521.
8. Matković B. *Antropološka analiza košarkaške igre*. Zagreb: Kineziološki fakultet Sveučilišta u Zagrebu, 2010.
9. Matković B, Knjaz D, Rupčić T. *Temelji košarkaške igre. Recenzirani priručnik za praćenje nastave iz predmeta Košarka*. Zagreb: Kineziološki fakultet Sveučilišta u Zagrebu, 2014.
10. Matković B, Knjaz D, Rupčić T, Simović S, Antekolović LJ. Utjecaj progresivnog opterećenja na promjene u nekim kinematičkim parametrima kod skok šuta za tri poena u košarci, 2015.
11. Miller S, Bartlett RM. The relationship between basketball shooting kinematics, distance and playing position. *J Sports Sci*, 1996; 14(3):243-53.
12. Okazaki VHA, Rodacki ALF. Increased distance of shooting on basketball jump shot. *J Sports Sci Med*, 2012; 11(2): 231-7.
13. Rupčić T, Knjaz D, Baković M, Borović I, Zekić R. Razlike u nekim kinematičkim parametrima između šutiranja sa različitim udaljenosti u košarci. *Zbornik radova 25. ljetne škole kineziologa RH „Kineziologija i područja edukacije, sporta, sportske rekreacije i kineziterapije u razvitku hrvatskog društva“*. Zagreb: Hrvatski kineziološki savez, 2016: 253-8 .
14. Rupčić T, Antekolović L, Knjaz D, Matković B, & Cigrovski V. Reliability analysis Of the 94 fifty smart sensor basketball. In *10th International Conference On Kinanthropology* (S. 432), 2016.
15. Svoboda I. *Koji parametri utječu na razliku izvođenja dvije tehnike šutiranja u košarci?* Poreč, Hrvatska, 2018: 592-5.
16. Trninić, S. *Analiza i učenje košarkaške igre*, 1996.
17. Šimunović D, Knjaz D, Rupčić T, Krtalić S, Rodić S. Relationship between certain kinematic parameters during the jump shot and their effect on shooting efficiency in basketball, *World Congress of Performance Analysis of Sport XII: Proceedings / Škegro, D; Belčić, I; Sporiš, G; Krističević, T (ed.)*. Zagreb: Faculty of Kinesiology, 2018: 309-314.