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Kinematic Analysis of Basketball Jump Shot

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Abstract: *Technique in sport is defined as rational and efficient performance of movement aimed to resolve motoric tasks in the training and competition process. Insight into the available literature resulted in selection of 3 kinematic variables used for analysis: release angle, release velocity and release height. Consequently, aim of this research is systematic review of kinematic parameters influencing the success of performance in basketball jump shot. Throwing angle is considered to be the most important factor for success of jump shot. Increased release angle is in correlation with the height of basketball trajectory which renders it a function of increased angle of entry of the basketball. Increased angle of entry enables the maximum use of the basket ring but demands increased release velocity. It is possible to control the release velocity using the spin created by the wrist flexion. Second manner of regulation of the velocity is increased release height. Influence on the release height is, however, reduced because it is determined by the constant basket ring height, player's height, jump height and organisation of segmented movements of body parts. Understanding the interaction of variables influencing the structure of basketball movement in duration of shot provides insight into the complexity of movement performance in basketball. It is therefore necessary to indicate these variables during trainings, which is possible under the current conditions due to the fact that the technology has advanced significantly in past few years and follow-up of the said parameters demands very little effort.*

Key words: *Kinematics, basketball trajectory, release velocity, release angle, release height.*

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Introduction

Technique in sport is defined as rational and efficient performance of movement aimed to resolve motoric tasks in the training and competition process[15]. Technical preparation in sport can be general and specific[15]. General technical preparation is related to the development of various motor skills with positive transfer and provide solid basis for specific technical advancement. Specific abilities relevant for successful basketball playing are situational-motor abilities and they are shooting, efficient basketball manipulation and players movement with basketball[13].

Shooting is significant final procedure whose accuracy in final score influences overall success in the game[2]. Precise shooting is conditioned by the performance technique. Shooting technique is form of movement with its dedicated kinematic and dynamic structure. Kinematic structure is mechanic of body movement from the perspective of time and space without further insight into the forces causing the movement[31]. Optimal combination of kinematic parameters is important for successful shooting performance[21]. Successful shooting performance is dependant of very large number of factors, starting with biomechanical parameters[8], stability[22,3,17], body's ability to adapt to load with differences in intensity and type[19,23] and ranging to ones such as player's mental capabilities[32]. Biomechanical parameters

of jump shot have been thoroughly analysed[1,10], and the followed kinematic variables have mostly determined the basketball trajectory characteristics[10].

Upon insight in available literature three kinematic variables have been selected for further analysis: release angle, release velocity and release height. Therefore, aim of this study is systematic review of kinematic parameters determining the success of jump shot performance.

Basketball trajectory

In duration of shooting basketball trajectory is in the shape of the ballistic curve (except in case of layup shots) because the release point is always lower than the end of trajectory – ring level. Arc or ballistic curve can be high, medium and low[13] (Figure 1).

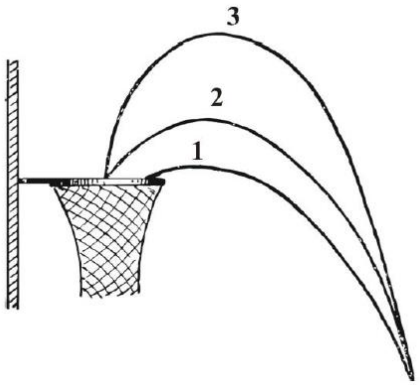

Figure 1. Ballistic curve[13]

Regarding the fact there are three marked heights of the ballistic curve and numerous numbers of unmarked ones in between, we may say that the optimal ballistic curve or trajectory of the basketball in course of jump shot towards the basket never maintains constant height. Height of the parabolic arc of the basketball is in direct correlation with the angle of entry which determines precision and probability of placing the ball inside the basket[13]. High basketball trajectory causes the most favourable angle of entry. Angle of entry is in direct correlation with the release angle[1]. Release angle is considered to be one of the most significant factors determining the shot success[21,24]. With the angle increase also increases the probability of basketball entry into the basket[14]. On the other hand, virtual target is reduced with the minor angle of entry[1,21,20].

Angle of entry is determined by the following factors: vertical movement, horizontal movement and velocity. Vertical movement is reverse proportiional to the release height and directly connected to the release angle[21]. Therefore, lower release height and/or greater release angle causes increased vertical movement. On the other hand, horizontal movement is connected to the distance between the player and the ring. Shots performed from greater distance require increased velocity.

Release velocity

Reduced release velocity is in connection with greater level of accuracy[27,14]. It reduces the movement of body parts and consequently increases the movement

consistency[5a,5b] reduced release velocity provides the player extra time to correct the movement using visual and proprioceptive feedback[30]. This finding points out the fact that players should aim at achieving the release angle which provides for reduced movement speed. However, weaker players are not able to generate sufficient amount of strength and /or shorter players have less potential to generate increased release height and they ought to use the strategy of developing greater segmental velocity for successful shot performance[11].
Second strategy to reduce basketball movement velocity is wrist flexion which causes the spin and increased number of basketball rotations in the course of trajectory. Spin or basketball rotation is key component of smooth shot and ball entry if it fails to pass directly through the ring. Application of backpspin in the course of shot reduces the horizontal basketball velocity in case it hits the ring and pointh the basketball downwards in case it hits the board[9,14]. Backspin is connected to the successful shot performance of the experienced players[33,14]. [13]pointed out in his theoretical study that the basketball makes 2 or three rotations per second in the course of shot. However[7], mentioned the value of 1.66 rotations per second (100.94 rotations per minute) for guards under the age of 20.

Release angle

Release angle and basketball spin are key factors to the shot success[14]. There is no perfect release angle due to the fact that it varies depending on the position and height of player[10]. Angle of entry can be increased with the addition of spin as a consequence of Magnus force[12]. With the increase of angle of entry the probability of basketball entry also increases[14,21] (Figure. 2).

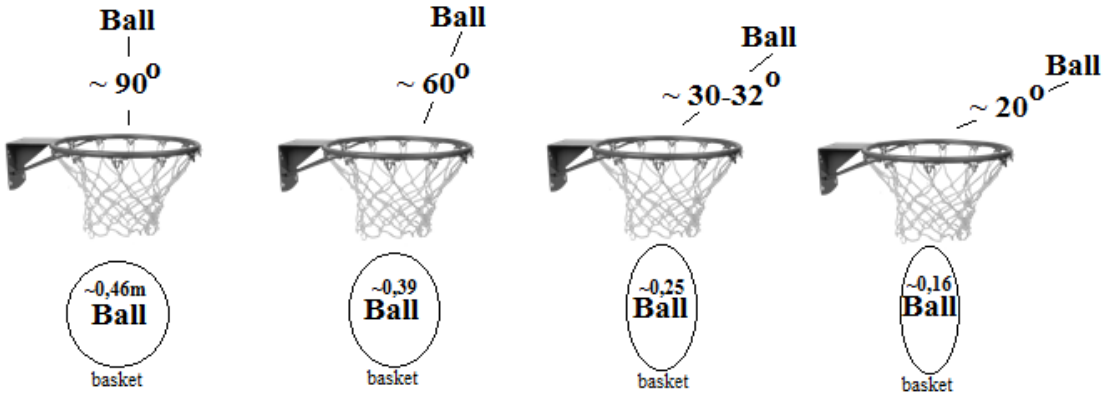

Figure 2. Angle of entry[10]

Although a 90 degree angle of entry enables the player to use entire ring width, it also demands the player to use increased release angle and velocity. In order to utilise full ring width it is necessary to use special shooting technique, especially from greater distance[20,21]. In line with the previous satement, the shooter is required to use the angle which enables motor efficiency required to score with the performed shot.

Angle of entry is in direct connection to the release angle in the course of shot[1]. Many factors may influence the release angle including the shooter's height[28], presence of the opponent[25] shoulder angle[27], as well as shooting distance[28,20].

Rojas [25] have analysed the release angle in the presence of oponent and established it to be 45°. Additionally[21], found that the release angle from closer distance ranges from 52° to 55°, whereas from greater distance it ranges from 48° to 50°. Release angle ranging 55–60° produces optimal angle of entry of 45–50°[16]. In case of free shot, angle of entry ranges from 37.8° to 42.0°[29]. The lowest angle of entry value required for theoretical shot and passing through the basket is around 32°[13]. (Table.1)

Table. 1

Study	Release angle	Record
[14]Knudson (1993)	~52°	Theory
[20]Miller & Bartlett (1996)	48–55°	Jump shot (men)
[25]Rojas et al. (2000)	44–47°	Jump shot against and without opponent (men)
[24]Okazaki & Rodacki (2012)	~65°	Jump shot (men)

In addition to the shot eficciency which is dependent of the release angle and spin, in contemporary game conditions it is also important to mention shot velocity. Total time required for basketball release is around 0.62 seconds[8]. However, this research was conducted on small sample (2 participants) and there is also additional evidence found in research performed by[7] who state that majority of tested basketball players (52 participants) aged 18 and 19 fail to meet the required interval below 0.7 seonds. Due to variability among the participants it is necessary to perform further trials in order to determine time required for shot against and without opponent.

Release height

Height is directly proportional with the point of basketball release in the moment of shooting. As ring height is a constant, release height is determining the vertical distance. Hence, the adjustments to vertical distance are minor for individual shooters at particular moments. Increased release height enables the players to use minor release angle which reduces the need for greater speed of movement[21,9,18]. Player's height jump height and organisation of segmental movements are the variables determining the release height[21] (Figure 3). Consequently, higher players with higher jumps have increased release height.

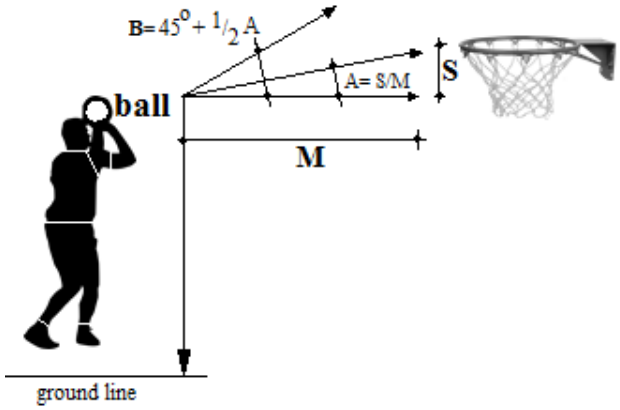

Figure 3. Release height [21]

Generally speaking, it is assumed that the shooter's height indirectly and significantly determines the strength required to perform the shot. It is assumed that taller players require reduced amount of strength to perform a shot from specific horizontal distance from the ring.

In addition to the player's height and jump, there are other factors which influence the release height: shoulder flexion[27,14], elbow extension[14] and optimisation of lower extremities movement which have primary influence on jump height[26,4]. To conclude, adequate organisation of body movement in the course of learning can contribute the development of movement structure which leads to successful shot performance.

Conclusion

Basketball trajectory is to great extent determined by three kinematic parameters of jump shot: release angle, release velocity and release height. Release angle is considered to be the most important factor determining the shot success. Increased release angle is in correlation with the trajectory height and consequently increased angle of entry. Increased angle of entry enables utilisation of the total ring width, but it requires increased release velocity. Release velocity may be regulated by the spin created by the wrist flexion. The second manner of regulation is increased release height. However, influence on release height is reduced due to the fact that it is determined by the constant ring height, shooters height, jump height and organisation of segmental body movement. Understanding the interaction of the above-mentioned variables determining the basketball movement in course of shot is an evidence to complexity of performance of movements in basketball. It is important to point out these parameters in the course of training, which is possible because contemporary technology allows to follow them in relatively simple manner.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

All authors have read and agreed to the published version of the manuscript.

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