Biomechanical analysis of the three-point shoot in basketball: shooting performance

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Journal of Physical Education and Sport ® (JPES), Vol. 22 (issue 12), Art 379, pp. 3003-3008, December 2022
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Biomechanical analysis of the three-point shoot in basketball: shooting performance

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Published online: December 25, 2022
(Accepted for publication December 15, 2022)
DOI:10.7752/jpes.2022.12379

Abstract:
The purpose of this study was to analyze the three-point shooting motion. Biomechanics is a branch of science that is involved in the process of analyzing the motion of a technique in sports. Through biomechanics, the effectiveness and efficiency of a movement can be known which is useful for improving athlete performance. One of the shooting that is quite difficult for basketball athletes to practice is the three point shoot. Therefore, the researcher is interested in conducting an analysis of the three-point shot. The research method was quantitative using a descriptive approach. The population used in this study included 20 people and a sampling technique in the form of purposive sampling. The samples in this study included 10 male athletes with the inclusion criteria of being athletes from the Dubas club in the age category of U-21 years and having participated in the Regency POPDA. The data are presented in a kinematic table obtained from video analysis using Kinovea version 0.9.4, which were then processed using IBM Statistic SPSS series 25. This study passed ethical clearance by the Health Research Ethics Commission (KEPK) at Universitas Negeri Semarang. All participants agreed to full informed consent, as required for full participation in the study. The results indicate that the average shoulder angle formed in the release was 135.39° and the follow-through phase was 134.83°. The average knee angle in the preparatory phase was 103.04° with an average knee angle in the release phase of 166.68° and 164.27° in the follow-through phase. This research was limited to kinematic data analyzed and the scope of the video field used for research. Future study is expected to discuss the kinetic data with 3D video and its effect on the success rate of three-point shooting and factors in the potential to cause injury.
Key Words: **basketball, shooting, three-point shoot, biomechanics**

Introduction

Sport is a method to explore motion experiences (Sitepu, 2018). With time, sports have begun to be used as a means of achievement (Winata et al., 2018). This can be observed in sports competitions, both nationally and internationally. Basketball is one of the most popular sports because the atmosphere of each game is more competitive. This is because the tempo of the game presented is faster than in other sports, such as volleyball and football (Yuliato, 2018). Basketball was first created by James Naismith in 1891 in Massachusetts, United States. This sport began to compete at the Olympics in 1936. Then, in 1920, basketball was introduced in Indonesia by immigrants from China (Anugrarista & Riswandi, 2021). Basketball is played in teams. Players in a basketball game include five people, and each person must score as many points as possible. Every basketball player needs good basic technical skills to master the game (Erčulj et al., 2010).

According to Wissel (2012), several basic techniques can support each player in a basketball match, including footwork, passing, catching, dribbling, shooting, and rebounding. When a player has a good mastery of basic techniques, it will benefit the team in a match (Hapsari et al., 2013). To score in a match, players are required to put the ball into the opponent's ring. Shooting at the opponent's ring is the only way to score in basketball. There are several types of shooting, among others such as: one hand set shot, jump shot, free throw, and three point shot. The highest score in a basketball game can be obtained by shooting three points. The level of difficulty when shooting three points makes shooting quite difficult to practice and can be an advantage if someone can shoot from various directions. When shooting three points, there are several things to consider, such as power in the arm muscles, accuracy, and eye–foot coordination (Margono et al., 2018). In addition, body angles such as elbow angles; shoulder angles or knee angles also have a significant influence influence on shooting succes, especially three point shot.

Biomechanics is a branch of science used to study motion in living things (Blazevich, 2007). In the field of sports, biomechanics is one method of improving athletic performance. This is in line with research conducted by Kridasuwarso (2016), who stated that biomechanics is required for the implementation of athlete selection and achievement in coaching. So that the movements performed can improve performance and prevent injury Sports achievement is a benchmark for the quality of coaching in a sport (Wibowo et al., 2017). One method of developing achievement is the motion analysis method from a biomechanics perspective. There are two perspectives in biomechanics, namely kinetics and kinematics. The kinetic perspective is classified as being

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difficult to observe. This is because this perspective focuses on the effect of a force caused by a movement. Meanwhile, the kinematics perspective focuses on data related to displacement, velocity, and acceleration (Ardiyanto & Widiyanto, 2019). The purpose of a biomechanical analysis in a sport is to evaluate a movement/technique performed. Movement evaluation results can be used to identify the effectiveness and efficiency of a movement. In addition, it also serves to prevent injuries caused by improper movements. The role of biomechanics in evaluating motion is also useful for injury prevention.

This opinion is supported by research conducted by Irawan & Long-ren (2019), which states that learning a motion to achieve an effective and efficient technique can prevent an injury from occurring. Through today's technological advances, biomechanical analysis can be performed easily (Verindo & Kusuma, 2021). Kinovea is a video analyzer that is often used to perform motion analysis. According to Puig-Divı et al. (2019), Kinovea software can be used as a valid tool to analyze a movement. Basketball is an interesting game to watch, especially when athletes make shooting movements. Shooting also varies, depending on the distance and ability of the athlete. Motion analysis using a biomechanical approach is highly recommended to determine obstacles and carry out evaluations in the field.

Based on data from observations at the Dubas club in Magelang Regency, it was found that the athletes did not understand three-point shooting well. This was shown by the percent success rate of three-point shooting, which only reached 27.8% of the total shooting performed. This shows that three-point shooting is a shooting that is quite difficult to do. One of the causes of the difficulty in executing three-point shooting is the considerable distance between the shooter and the ring. As the distance increased, it should be balanced by increasing the angle of the ball when the ball is released (Gorshahri & Khazaeli, 2018). According to (Cabarkapa et al., 2021), what affects strength and speed in shooting is flexion of the shoulder joint during the release phase. Thus, we were interested in conducting a motion analysis of three-point shooting. The purpose of this study was to analyze the motion of shooting three-point basketball in terms of biomechanics. It is hoped that this research can be used as information for coaches and athletes regarding the evaluation of motion when shooting three points. In addition, we hope that this research can be used as a reference for further research.

Material & methods

This study used a quantitative descriptive method to determine three-point shooting without giving effecting the result carried out during the research. The population in this study was 20 athletes from the Dubas club in Magelang Regency. Researchers used a purposive sampling technique that aimed to select samples with certain conditions, such active members of the Dubas club, those in the age category of under 21 years, and participated at POPDA event. The number of samples that were screened included 10 male athletes. This study was conducted on November 8, 2021 and took place at the Ztofia basketball court in Muntilan District at Magelang Regency. Each sample in this study was willing to become a subject and participate in the study and signed informed consent. Several tools were used in this research, including 1) a Canon EOS 750D digital camera, 2) Samsung A31 cellphone camera, 3) Camera & cellphone tripods, 4) cones, and 5) stationery. Data collection techniques included observation and documentation. According to Sugiyono (2013), observation can be used when research observes human behavior and work processes. Quantitative data in this study were in the form of kinematic data consisting of 3 phases, namely the preparation phase, release phase, and follow-through phase. Data were obtained from documentation in the form of videos recorded using a Canon EOS 750D digital camera, which was placed perpendicular to the right of the sample at a distance of 2.5 m and focusing on the motion of the participant. A camera that focused on the ball was placed at a distance of 7.90 m and at a height of 1.50 m (Raza, 2014). The video was analyzed for each indicator using Kinovea software version 0.9.4. The results of data analysis using Kinovea were then processed again using IBM SPSS Statistic Software version 25 to determine the data mean, standard deviation, minimum value, and maximum value for each indicator. The indicators studied included elbow angle, leg angle, shoulder angle, ball height, and jump height. According to (Rosendahl et al., 2022), video can be used as learning that represent visuals according to what is happening at that time. This research was approved by the Health Research Ethics Committee of Semarang State University under number 364/KEPK/EC/2021.

Results

The results are presented in the form of tables and diagrams covering several indicators, such as time, body segment angle (knee angle, elbow angle, shoulder angle), jump height, ball height, and ball speed. Each indicator discussed is identified according to each phase, such as the preparation phase, release, and follow-through phases. According to Darumoyo (2019), the preparation phase begins when the foot is outside the three-point area. Then, the legs are opened shoulder-width apart with the knees bent and elbows in. The position of the ball is between the shoulders and at ear level. Then the shoulder is relaxed with the non-shooting hand next to the ball, and the shooting hand is behind the ball with the thumb relaxed. The next phase is release, which is marked by a jump and shoot. Then, the elbow is in a fully extended position, with the wrist flexed and the fingers forward. The ball is released through the index finger, then gradually goes with the same rhythm on the follow through. The results of the video analysis using Kinovea software version 0.9.4 are presented in Table 1 as follows:

Table 1. Kinematic data for three-point shooting

n = 10	**Mean ± Std. Deviation**	**Min**	**Max**
Total time (s)	2.83 ± 0.79	1.73	4.46
Preparation			
Knee flexion angle (°)	103.04 ± 12.38	82.5	121.6
Elbow flexion angle (°)	67.63 ± 7.89	57.1	86.8
Release			
Knee extension angle (°)	166.68 ± 9.49	150.7	179.2
Shoulder extension angle (°)	113.52 ± 13.98	91.9	136.0
Elbow extension Angle (°)	135.39 ± 13.91	114.4	152.7
Jump height (m)	0.54 ± 0.13	0.34	0.73
Ball height (m)	6.05 ± 0.50	4, 97	6.48
Ball time (m)	1.85 ± 0.45	1	2.4
Ball velocity (m/s)	4.00 ± 1.20	2.81	6.75
Follow-through			
Knee angle (°)	164.27 ± 4,81	156.7	171.7
Shoulder angle (°)	134.83 ± 7.91	121.6	145.5
Elbow angle (°)	170.52 ± 4.97	161.6	178.4

The total time taken by the participant for shooting three points, starting from preparation until the ball lands, was an average of 2.83 ± 0.79 s. In the preparatory phase, the average knee angle during flexion was 103.04 ± 12.38°. The average elbow flexion angle produced in the preparation phase was 67.63 ± 7.89°. In the release phase, the average knee angle produced was 166.68 ± 9.49°.

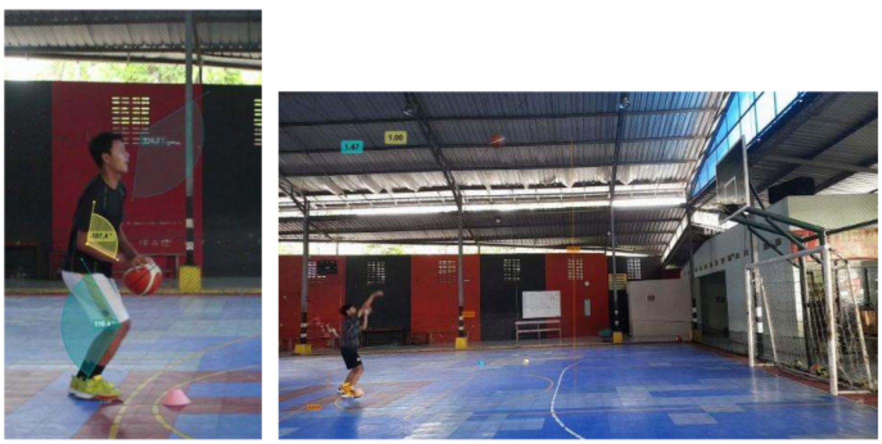

Figure 1. Shooting analysis

The average shoulder angle shown in the table was 113.52 ± 13.98°. Then, the average angle of the elbow produced in the release, as shown in the figure, was 135.39 ± 13.91°. In the release phase, the average ball time to reach the ring was 1.85 ± 0.45 s. The distance determined, following the field size regulations that have been determined by FIBA, was 6.75 m from the position of the axis of the ring. The average shooting ball speed produced by each participant was 4 ± 1.20 m/s. The follow-through phase, which is the final phase, showed an average knee angle of 164.27 ± 4.81°. The shoulder angle in this phase was an average of 134.83 ± 7.91°. The average at the right angle was 170.52 ± 4.97°.

Discussion

The knee angle produced by sample 1 in the preparation phase was 97.4°; then, in the release phase, it was 179.2°; in the follow-through phase, it was 161.8° (Figure 2). The knee angle value of sample 2 in the preparation phase was 105.1° with the knee angle in the release at 171.3°, and in the follow-through phase, it was 171.7°. In the preparatory phase, the knee angle shown by sample 3 was 91.7°; in the release phase, it was 150.7°; in the follow-through phase, it was 156.7°.

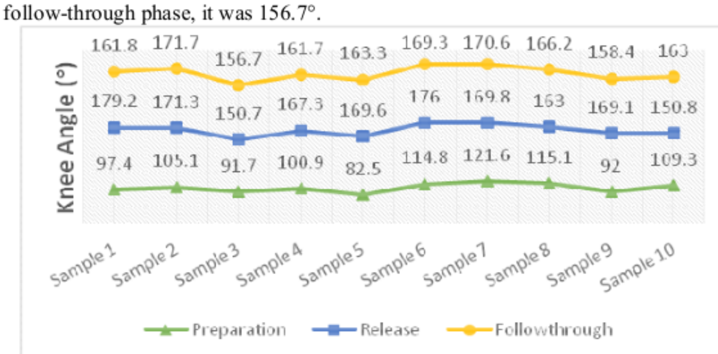

Figure 2. Knee angle data

The knee angle produced in the preparation phase by sample 4 was 100.9° with the results in the release phase being 167.3° and in the follow-through phase being 161.7°. The knee angle of sample 5 in the preparation phase was 82.5° with that in the release phase being 169.6° and in the follow-through phase being 163.3°. Sample 6 had a knee angle in the preparation phase of 114.8°; then, in the release phase, it was 176°, and in the follow-through phase, it was 169.3°. The knee angle shown by sample 7 in the preparation phase was 121.6°, in the release phase, it was 196.8°, and in the follow-through phase, it was 170.6°. In the preparation phase, the knee angle of sample 8 was 115.1°; then in the release phase, the resulting knee angle was 163°, and in the follow-through phase, it was 166.2°. The knee angle from sample 9 in the preparatory phase was 92°, in the release phase, it was 196.1°, and in the follow-through phase, there was a knee angle of 158.4°. The knee angle generated by sample 10 in the preparation phase was 109.3°; then in the release, it was150.8°; in the follow-through phase, it was 163°. Research conducted by Winata et al. (2018) showed the most effective knee angle. This is what emphasizes that the ideal movement must be balanced with the right movement.

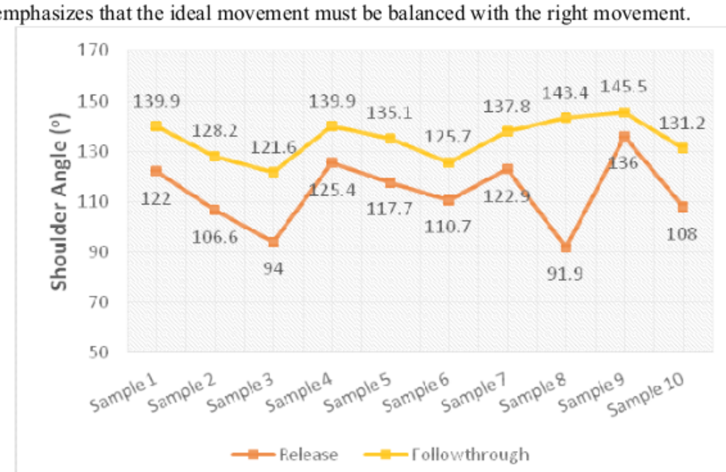

Figure 3. Shoulder angle data

Figure 3 shows that the shoulder angle in the release phase of sample 1 was 122°; sample 2 had 106.6°; and sample 3 had 94°. The shoulder angle of sample 4 in the release phase was 125.4°; then, for sample 5, it was 117.7°; sample 6 showed 110.7°; sample 7 had 122.9°. For sample 7, the shoulder angle in the release phase was 91.9°; sample 9 was 136°; and sample 10 had a shoulder angle of 108°. In the follow-through phase, it was 139.9° in sample number 4; sample 2 had 128.2°; sample 3 had 121.6°; sample 4 had 139.9°; sample 5 showed 135.1°. The shoulder angle shown by sample 6 in the follow-through phase was 125.7°; sample 7 showed 137.8°; sample 8 had 143.4°; sample 9 had 145°; sample 10 had 131.2°. According to research conducted by Darumoyo (2019), the most effective shoulder angle in the release phase is close to 121.7°. The formed shoulder angle can affect the results in the release and follow-through phase. When the angle of the shoulder that is formed is too wide or too narrow, this will affect the energy transfer process when pushing the ball towards the ring. If the angle formed is too large, it will cause the ball to fall before it hits the ring or falls in front of the ring. Meanwhile, when the angle that is formed is too narrow, it will cause the ball to bounce too hard on the ring board and cause the ball to bounce away from the ring.

One part of the body that is quite often injured when shooting three points is the legs, especially the ankles. According to Newman & Newberg (2010), 39.7% of lower extremity injuries experienced by adolescent basketball athletes in the United States are in the ankle. In the upper limbs, the most common injuries are the wrists. This can happen because the technique is not performed correctly. The instability of the landing made when jumping can be a source of many injuries to the ankles (Ihsan, 2017). Injuries to the ankles occur because there is excessive and sudden pressure on the joints, causing the ligament to tear or due to repeated use (Setiawan, 2011). This is in line with research conducted by Irawan et al. (2017) in which muscles that experience overuse or repetitive movements were shown to cause muscle fatigue, as well as damage to tendons and ligaments. This can be circumvented by conducting a motion analysis to create an effective and efficient motion. Through effective and efficient movement, the goal of a technique in a sport will be more easily achieved by minimizing injuries caused by repetitive movements. According to Irawan et al. (2021), when an athlete understands the basic technique well, it can minimize injuries and improve performance to reach peak performance.

Conclusions

The conclusions obtained for the three-point shooting motion of the Dubas athletes in terms of biomechanics were obtained using the shoulder angle in the release phase of 113.52° and in the follow-through phase of 134.83°. The average knee angle formed in the preparation phase was 67.63° with an average knee angle in the release phase of 166.68° and 164.27° in the follow-through phase. The angle of the shoulders that is formed affects the transfer of energy to push the ball towards the opponent's ring. The most effective shoulder angle in the release phase is close to 121.7°. Knee angle also affects the success of a shooting. In this study, the results show that a knee angle that is too large or too small will affect the thrust of the ball so it can fly towards the ring. The limitation of this study is that it only focuses on the kinematic data for the analysis of the motion of three-point basketball shooting and the scope of the video displayed is only limited to 2D. Future research should focus on the effect of kinetic data on the success of shooting three points and the video shows the 3D analysis. In addition, further research should discuss the jumping technique, which has an impact on the ankles.

Conflicts of interest

The authors declare that there are no conflicts of interest.

Acknowledgment

The authors would like to thank Falcon Scientific Editing (https://falconediting.com) for proofreading the English language in this paper.

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