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Kinematic Analysis of Shooting Techniques in Successful Free Throw

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ABSTRACT

To examine the shooting strategies of skilled basketball players during free throw attempts, this research uses a kinematic method. During the preliminary phase, wind-up I, and wind-up II of the firing action, angular kinematic variables from multiple joints were collected and analyzed. The shooting method of successful shots was analyzed by the computation of descriptive statistics, skewness, and kurtosis. The results show clear segmental coordination and movement synchronization patterns, emphasizing the role that ideal biomechanical patterns play in effective free throw shooting. These insights may be used by coaches and trainers to create focused coaching plans and training programs that improve shooting technique and overall performance. Furthermore, by identifying certain biomechanical factors linked to effective shooting, biomechanical feedback treatments may be developed, allowing for real-time modifications to enhance shooting skills. This research advances the use of evidence-based coaching techniques and training programs to maximize basketball players' ability to make free throws.

Keywords: Kinematic variables, Segmental coordination, Shooting technique, Performance optimization.

1. INTRODUCTION

The free throw, one of the most significant shots in basketball, tests players' accuracy and dexterity. Given how simple it seems in comparison to the complex physics at work, it's a fascinating point for kinematic study. From the perspective of kinematics—the study of movement independent of its causes—researchers and aficionados examine the subtle innovations that go into a good free throw. Kinematic analysis dissects every element, from the player's initial setup to the basketball release, revealing the mechanics that underlie the skill and consistency of exceptional players.

First, we want to examine the initial posture and circumstances. To make a successful free shot, the competitor must position themselves appropriately behind the free throw line. Kinematic analysis closely examines the player's body alignment, specifically focusing on the positioning of their feet, shoulders, and hips. Every component helps to provide the stability and security needed for a successful shot. Analysts focus on the points and body motions throughout this time to get accustomed with the optimal situating that increases shot accuracy.

After then, the actual shot movement is carefully examined. Every aspect of the shooting action is examined in detail, starting from the moment the basketball leaves the player's hands and moves in the direction of the container. Experts may use kinematic analysis to measure characteristics including point, velocity, and discharge level. These limits provide important information on the consistency and repeatability of the firing approach. In order to provide players with useful information for improving their performance at the free throw line, analysts may find instances and correlations between these factors and successful shots.

Furthermore, kinematic analysis pays close attention to the shot's completion phase. The fluid movement of the player's body that occurs after they release the basketball is referred to as the completion. This step is essential for maintaining accuracy and consistency because it makes sure that the energy needed to shoot is directed towards the basketball in the proper way. Scientists may examine the player's arm and hand direction during the shot using kinematic analysis to get insight into the mechanics involved in a good shot.

The kinematic study of completing effective free throws provides a thorough comprehension of the complex motions required for this essential skill in basketball. By means of an itemised study of every stage involved in the termination operation, researchers are able to identify critical components that enhance accuracy and reliability. In the end, this information not only helps us comprehend the level of ability required to make free throws, but it also provides coaches and athletes with insightful advice on the most effective way to improve on the court. Analysis of engine knowledge is crucial to comprehending, deconstructing, and optimising engine capacity in games and sports. Within the discipline of sports biomechanics, the evaluation of coordinated motions is seen as a deliberate and rational approach that explores the evolution of a competitor's skill set while taking into account the unique anatomical constraints of their body. The standards and norms of mechanics are essential to this subject. This provides the coach and sports biomechanics expert with an X-beam perspective of what can and cannot be accomplished, as well as best practices and worst practices for managing the execution strategy of a particular engine ability. This assists in locating errors and offering crucial solutions as well. The overarching objectives of engine expertise analysis are to: (1) enhance advice; (2) enhance preparation; (3) enhance offices and equipment; and (4) prevent injuries.

Every mentor eventually develops an interest in development analysis, which is perhaps one of the most beneficial applications of biomechanics. Sometimes the goal is to observe a passable presentation and identify its strongest points. Mentors are especially concerned about poor display and how errors might be corrected. The results of the study may be used to plan how to use skills so that better displays are produced. The following techniques may be used alone or in combination to analyse athletes' motions and skills.

2. LITERATURE REVIEW

A thorough kinematic evaluation of the 2-point and 3-point jump shots made by young, talented male and female basketball players was conducted by Vencúrik et al. in 2021. Through the use of empirical scientific methods and innovative movement catches, the experts most likely investigated differences in shooting technique and biomechanics across sexual orientations and bounce shot types. This research provides insightful information on the very intricate details of basketball bounce shooting by analysing fundamental kinematic elements including shooting bend, lower body mechanics, and delivery point. Additionally, it provides baseline information that may guide training programmes designed to improve young competitors' shooting skills. Recognising the differences in hop shot technique between different kinds of hop shots and between different sexual orientations may help coaches and players modify their training plans to focus on certain areas of improvement. Vencúrik and colleagues' focus pertains to the current discourse surrounding basketball skill development and execution improvement. They provide insightful insights into the advancement of shooting mechanics and the general improvement of shooting proficiency among elite juvenile players.

Ciacci et al. (2022) examined the use of kinematic analysis in shot put, a basketball-related alternative sport. Despite the differences in sports, this focus likely looked on how kinematic analysis may improve the technique and presentation of shot putters. Using biomechanical evaluations and movement analysis, the researchers undoubtedly looked at important kinematic parameters including delivery point, speed, and direction to improve shot put performance. Although the shot put is the primary focus of this paper, the results may provide important new insights into the application of kinematic analysis methodologies to other throwing sports, such as basketball shooting. Mentors and athletes may apply similar principles to basketball shooting by focusing on how kinematic variables affect the execution of shot puts. With this knowledge, preparation techniques aimed at improving shooting accuracy and consistency might then be further developed. Ciacci et al.'s study highlights the multidisciplinary nature of biomechanics and the potential applications of cross-sport knowledge to improve athletic performance in many contexts.

Caseiro et al. (2022) examined the kinematics of the basketball jump shot as shooting distance increased for both seasoned and inexperienced players. It is most likely that the designers used observational review or exploratory analysis to see how shooting technique varies depending on skill degree and termination distance. This research examines important kinematic aspects like as shooting mechanics, discharge time, and shooting curve to provide insights into how players modify their biomechanical systems to take shots further. The findings of this research may help to clarify the most popular method of developing shooting competence and provide guidance for instructional strategies meant to enhance shooting across a range of basketball skill levels. Mentors who have a thorough understanding of how shooting technique varies with increasing shot distance and skill level may set up preparation tasks to target specific problems and increase players' shooting potential. Basketball players of all skill levels who want to improve their presentation may find immediate direction from Caseiro et al.'s investigation, which advances our understanding of basketball shooting biomechanics.

A jump shot movement study was conducted by Mukhtarsyaf et al. (2022) on basketball players who had improved their shoots. Observational review or exploratory analysis may have been used by the designers to consider the biomechanical characteristics and development examples of skilled basketball players during bounce shot execution. This research sheds light on important kinematic elements such as shooting curve, shooting structure, and discharge mechanics to help comprehend the unique requirements for competent basketball shooting. The results provide useful insight into training and preparation strategies aimed at improving shot effectiveness. Understanding the biomechanical subtleties of successful jump shots may assist coaches in identifying key specialised areas to address in training sessions and providing targeted feedback to competitors looking to improve their shooting technique. Mukhtarsyaf et al.'s study broadens our understanding of basketball shooting biomechanics and has implications for the development of basketball players' skills and execution.

In order to improve basketball players' performance, Gutiérrez and Castellanos (2018) made a major investment in developing and approving a system that would place a particular emphasis on the biomechanical evaluation of the free throw. The experts most likely created an innovative approach that integrated movement catch and perceptive advancements to assess and critique the free throw shooting technique. Through field testing or exploratory investigations, they intended to confirm if the system was beneficial in improving shooting consistency and execution. This evaluation tackles a crucial aspect of basketball player growth by combining biomechanical data with innovation enhancements. The system's continual input of shooting tactics might change preparation strategies and continuously work with basketball players' ability to progress. The focus of Gutiérrez and Castellanos advances basketball player development processes by providing creative methods to improve on-court performance and increase ability mastery.

3. RESEARCH METHODOLOGY

The thorough selection of participants was probably the first step in the study approach for the kinematic analysis of shooting strategies in effective free throw shooting. Proficient free throw shooters who were skilled basketball players were probably recruited for the research. To guarantee there would be enough data for analysis, statistical considerations most certainly had a role in determining the sample size.

The kinematic variables during free throw shooting were recorded using motion capture technology as part of the data gathering process. It is possible that reflective markers were positioned on certain participant anatomical landmarks in order to monitor the movement of different body parts in three dimensions. It's possible that infrared sensors or high-speed cameras were used to precisely record movement data.

To ensure consistency and accuracy in data collection, participants were taught to shoot free throws under controlled settings throughout the experimental process. It's possible that standardised shooting protocols and guidelines were given to reduce participant variation in shooting style.

In order to extract angular kinematic variables for various joints throughout different stages of the free throw shooting motion, such as the preliminary phase, wind-up I, and wind-up II, the collected motion data were processed and analysed. To describe the shooting style of successful shots, descriptive statistics were computed for each kinematic variable. These included mean, standard deviation, minimum, and maximum values.

In order to evaluate the distributional characteristics of the kinematic data, statistical analysis required calculating skewness and kurtosis statistics. Significant kurtosis or skewness levels might point to deviations in the data distribution's normalcy. To find out whether any kinematic variables showed statistically significant differences between successful shots and failed ones, hypothesis testing can have been done.

4. DATA ANALYSIS

The findings of the study are presented in the following tables and for ease of understanding are represented and in the following graphs and figures.

TABLE 1: DESCRIPTIVE STATISTICS OF ANGULAR KINEMATIC VARIABLES OF SUCCESSFUL SHOTS DURING PREPARATORY PHASE

Joints	Min	Max	Mean	SD	Skewness	SES	Kurtosis	SEK
Ankle	88	100	94	3.00	0.00	0.58	0.28	1.12
Knee	118	131	125.8	3.73	-0.43	0.58	0.2	1.12
Trunk	133	151	141.7	3.81	0.22	0.58	3.27*	1.12
shoulder	12	16	13.87	1.06	0.30	0.58	-0.23	1.12
Elbow	71	82	76	3.53	0.27	0.58	-0.83	1.12
Wrist	140	152	144.13	3.25	0.92	0.58	1.34	1.12

SES: standard error of Skewness, SEK: standard error of Kurtosis
* Significant at 0.05 level of significance.

Table 1 introduces the discrete measurements of effective exact kinematic factors at the hour of preparatory stage. For different joints in degree, the following were the mean, standard deviation, least and highest incentive for rakish kinematic factors:- Shoulder 13.87±1.06, 12 and 16, Elbow 76.00±3.52, 71 and 82, Ankle 94±3, 88 and 100, Knee 125.80±3.73, 118 and 131, Trunk 141.73± 3.81, 133 and 151, and for Wrist 144.13±3.25, 140 and 152.

The trunk value (3.27) is noteworthy, according to the kurtosis finding, since it is more than twice the standard error (1.12). Leptokurtic distribution characterises the data. Kurtosis and skewness scores for the other joint angles were not significant.

TABLE 2: DESCRIPTIVE STATISTICS OF ANGULAR KINEMATIC VARIABLES OF SUCCESSFUL SHOTS DURING WIND-UP I

Joints	Min	Max	Mean	SD	Skewness	SES	Kurtosis	SEK
Ankle	70	82	76	3.00	0.00	0.58	0.28	1.12
Knee	106	116	111	3.34	0.00	0.58	-0.45	1.12
Trunk	109	127	117.3	4.13	0.27	0.58	1.71	1.12
shoulder	8	12	9.87	1.25	0.29	0.58	-0.52	1.12
Elbow	74	84	78	2.36	0.90	0.58	2.03	1.12
Wrist	139	151	142.9	3.53	0.84	0.58	0.28	1.12

SES: standard error of Skewness, SEK: standard error of Kurtosis

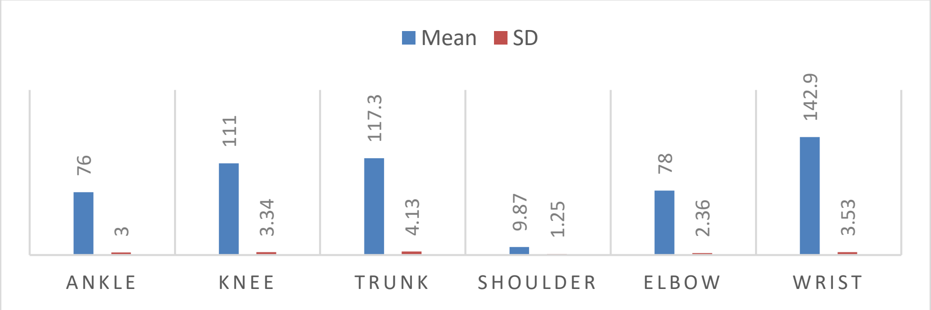

FIGURE 1: DESCRIPTIVE STATISTICS OF ANGULAR KINEMATIC VARIABLES OF SUCCESSFUL SHOTS DURING WIND-UP I

Table 2 presents the descriptive statistics of the successful angular kinematic variables during the Wind Up I phase. at angular kinematic variables at varying degrees of joints, the mean, standard deviation, minimum, and maximum values were as follows:76±3, 70, and 82 for the ankle; 111±3.34, 106 and 116 for the knee; 117.33± 4.13 for the trunk; 9.87±1.25, 8 and 12 for the shoulder; 78±2.36, 74, and 84 for the elbow; and 142.93±3.53, 139, 151 for the wrist. Since the skewness and kurtosis of each variable were not determined to be significant, all of the variables had a normal distribution.

TABLE 3: DESCRIPTIVE STATISTICS OF ANGULAR KINEMATIC VARIABLES OF SUCCESSFUL SHOTS DURING WIND-UP II

Joints	Min	Max	Mean	SD	Skewness	SES	Kurtosis	SEK
Ankle	58	70	64	3.00	0.00	0.58	0.28	1.12
Knee	89	99	94	3.34	0.00	0.58	-0.45	1.12
Trunk	104	122	113	3.93	0.00	0.58	2.51*	1.12
shoulder	5	9	6.73	0.88	0.60	0.58	2.83*	1.12
Elbow	92	102	96	2.30	0.98	0.58	2.66*	1.12
Wrist	132	144	136.1	3.25	0.92	0.58	1.34	1.12

SES: standard error of Skewness, SEK: standard error of Kurtosis
* Significant at 0.05 level of significance.

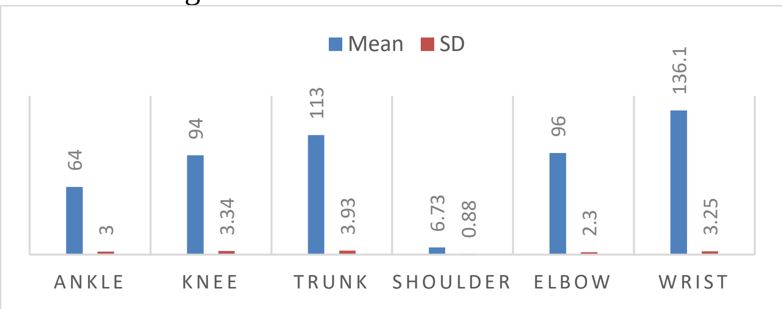

FIGURE 2: DESCRIPTIVE STATISTICS OF ANGULAR KINEMATIC VARIABLES OF SUCCESSFUL SHOTS DURING WIND-UP II

Table 3 displays the descriptive statistics of the successful angular kinematic variables at the moment of Wind Up II. at angular kinematic variables at varying degrees of joints, the mean, standard deviation, minimum, and maximum values were as follows: - Shoulder 6.73±0.88, 5 and 9, Elbow 96±2.29, 92 and 102, Ankle 64±3, 58 and 70, Knee 94±3.34, 89 and 99, Trunk 113± 3.92, 104 and 122, and for Wrist 136.13±3.25, 132 and 144.

The values of the elbow (2.66), trunk (2.51), and shoulder (2.83) are significant according to the kurtosis finding since they are more than twice the standard error (1.12). Leptokurtic distribution characterises the data. Kurtosis and skewness values for the remaining joint angles were not significant.

5. CONCLUSION

The biomechanical nuances underlying this crucial feature of basketball are revealed via the kinematic examination of shooting strategies used in effective free throw shooting. By means of a thorough analysis of angular kinematic variables at different stages of the shooting action, the research clarifies important biomechanical patterns linked to successful shoots. The results highlight how critical it is to have exact segmental coordination between several body segments—such as the ankle, knee, trunk, shoulder, elbow, and wrist—in order to provide the power and precision required for successful free throw shooting. These findings may be used by coaches and trainers to create focused coaching plans and training programmes that improve shooting form and overall performance. Moreover, the discovery of certain biomechanical factors linked to effective shooting presents opportunities for the creation of biomechanical feedback treatments, which allow athletes to instantly refine and enhance their technique. Although this study adds much to our knowledge of the biomechanics of free throw shooting, there is still need for future research to examine other variables that affect shooting performance and assess the long-term efficacy of certain coaching approaches. Overall, this study's conclusions have applications for improving basketball players' ability to make free throws and promoting evidence-based teaching strategies and training regimens.

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