Differences in Kinematic Characteristics Between 2-point and 3-point Basketball Shooting Motions – A Case Study

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Abstract

Basketball has become one of the most popular international sports in which a successful game outcome is highly contingent upon optimal shooting performance. The purpose of this case study was to quantify and examine the kinematic changes in shooting motion as a player progresses from mid-range 2-point shots to beyond the 3-point line. One former collegiate basketball player performed 50 mid-range 2-point (5.20m) and 50 3-point (6.75m) shots divided into 10 sets separated by 1-2-minute rest intervals. Two high-definition cameras recording at 30 fps positioned perpendicular to the subject’s sagittal plane of motion were used for data collection. The first camera positioned 10 m away was used to capture body kinematics, while the second camera positioned 15 m away was used to capture the trajectory data. The kinematic variables captured at the initial phase of the shooting motion (Phase1) were knee angle, hip angle, ankle angle, elbow height, shoulder angle, elbow angle, and basketball height and at the time point of ball release (Phase 2) were shoulder angle at release, heel height, basketball release height, trajectory height, and ball entry angle. The findings of this case study indicate that greater flexion in the knee joint during the Phase 1 and greater heel height indicating larger vertical displacement during the Phase 2 of the shooting motion were the main kinematic adjustments influenced by the increased shooting distance. Therefore, we may assume that these changes were made to achieve greater ground reaction forces to compensate for the increased distance from the rim.

Keywords: Sport, coaching, basketball, sport performance, shooting technique, biomechanics.

INTRODUCTION

Basketball has become one of the most popular international sports in which successful game outcome is highly contingent upon optimal shooting performance. Previous research has found that shooting accuracy factors favorably to scoring greater number of the overall points and points per quarter [1, 2]. Winning teams had significantly greater number of successfully made free throw, 2-point, and 3-point shots when compared to losing teams [1, 2]. Besides superior offensive efficiency, the 2-point shooting percentage was one of the critical variables capable of discriminating between the winning and losing team in both balanced (10-22 point difference) and unbalanced (22-34 point difference) basketball games [1]. Moreover, Trninic et al. discovered that the ability to control the offensive strategy and hold the ball until an open shooting opportunity develops resulted in an improved shooting percentage [3]. Therefore, it is understandable why many players on various levels of basketball competition are constantly looking for techniques that can help them improve their shooting performance and help increase the team’s winning probabilities.

In the lay literature there are as many different coaching cues for the enhancement of shooting performance as there are coaches. Those cues include but are not limited to greater knee bend, proper follow-through, optimal elbow flexion, greater shooting arc, etc. [4-6]. Although they may be greatly effective, there is a lack of scientific literature addressing kinetic and kinematic characteristics of the most commonly used shooting motions as well as how they change with increased shooting distance. A couple of recently conducted studies focused on examining ground reaction forces for sport specific motions such as basketball dunking and volleyball blocking approaches [7, 8]. Hence, the purpose of this case study was to quantify and examine the kinematic changes in shooting motion as a player progresses from mid-range 2-point shots to beyond the 3-point line.
METHODS
One former collegiate basketball player (age=27; height=208 cm; body mass=115.2 kg) performed 50 mid-range 2-point (5.20 m) and 50 3-point (6.75 m) shots divided into 10 sets separated by 1-2-minute rest intervals. Two high-definition cameras (Canon PowerShot SX530) recording at 30 fps positioned perpendicular to the subject’s sagittal plane of motion were used for data collection. The first camera positioned 10 m away was used to capture body kinematics, while the second camera positioned 15 m away was used to capture the trajectory data. Kinematic variables were derived from the video recordings by utilizing video analysis software (Kinovea, Version 0.9.3). All testing procedures performed in this study were previously approved by the University’s Institutional Review Board.

Dependent variables analyzed during the initial concentric phase of the shooting motion (Phase 1) were: knee angle (internal angle between thigh and Shank), ankle angle (internal angle between Shank and an imaginary horizontal line parallel to the ground), hip angle (internal angle between torso and thigh), shoulder angle (internal angle between the upper arm and torso), elbow angle (internal angle between upper arm and forearm), basketball height (perpendicular distance from the center of the ball to the ground), and elbow height (perpendicular distance between the olecranon process and the ground). Dependent variables analyzed at the time point of the ball release (Phase 2) were: shoulder angle at release (angle between fully extended upper limb and an imaginary horizontal line parallel to the ground), basketball release height (perpendicular distance from the center of the ball to the ground), heel height (perpendicular distance from the heel to the ground), entry angle (internal angle between the ball entry trajectory and an imaginary horizontal line parallel to the ground), and trajectory height (perpendicular distance from the greatest basketball trajectory height to the ground). The graphical representation of the kinematic variables is presented in Figure 1.

One-way Analysis of Variance (ANOVA) was used to determine differences in kinematic parameters between 2-point and 3-point shots. Cohen’s D effect sizes were calculated to compare the difference between the means. Pearson product-moment correlations were used to examine the correlation pattern between the dependent variables. Statistical significance was set a priori to p<0.05. Statistical software SPSS 25.0 (SPSS Inc., Chicago, IL, USA) was used for data analysis.

RESULTS
Mean values and standard deviations (±SD), 95% confidence intervals (95% CI), p-values, and the effect sizes are presented in Table-1. Correlation matrix is presented in Table-2. Significant differences between mid-range 2-point and 3-point shooting motions were found to exist for all dependent variables except for ankle, hip, and shoulder angle during the Phase 1 and shoulder angle at release during the Phase 2 of the shooting motion.

Figure-1: Graphical representation of the dependent variables examined in this study. Knee angle (A); ankle angle (B); hip angle (C); shoulder angle (D); elbow angle (E); basketball height (F); elbow height (G); shoulder angle at release (H); basketball release height (I); heel height (J); entry angle (K); trajectory height (L). Phase 1 – initial concentric phase of the shooting motion. Phase 2 – shooting phase at the time point of the ball release.
DISCUSSION

The findings of the present study indicate notable differences in the examined kinematic parameters as the player progresses from the mid-range 2-point shots to beyond the 3-point line. The increase in shooting distance during Phase 1 of the shooting motion led to decreased elbow height and basketball height positioning as well as greater flexion in the knee, elbow, and shoulder joints. Despite reaching the level of statistical significance, the effect size of the change in the shoulder angle was much smaller than the one observed in the knee joint. Also, the shoulder angle demonstrated lower correlation magnitudes with the elbow and basketball height when compared to the knee angle variable. Therefore, the observed decrease in the elbow and basketball height during the Phase 1 of the 3-point shooting motion is primarily attributed to the greater flexion in the knee joint, not as a consequence of greater shoulder flexion resulting in an elbow drop. Although resembling the similar pattern of the smaller knee, hip, and elbow angles observed during 3-point shooting, the differences observed by Elliot & White within a cohort of highly trained female basketball players were not significantly different as were the ones obtained in the present study [9]. This may be attributed...
Based on the findings of this case study we can conclude that greater flexion in the knee joint during the *Phase 1* and greater heel height indicating larger vertical displacement during the *Phase 2* of the shooting motion were the main kinematic adjustments influenced by the increase in the shooting distance from a 2-point to a 3-point shot. We assume that these changes were made to achieve greater ground reaction forces, and to compensate for the increased distance from the rim. Further research needs to examine the relationships between kinetic and kinematic variables in order to obtain a better understanding of the biomechanical demands as the player progresses from 2-point to 3-point shooting range that can potentially lead to enhancement in shooting performance. Furthermore, understanding the mechanics of successful basketball shooting will also permit a better understanding and role of physiological influences on game and practice performances.

**REFERENCES**