

Influence Of Release Angle And Release Height On Free Throw Accuracy In Basketball

Anuj, Mitul Saini, Ranjan Mondal, Dr. Amar Kumar

M.P.Ed. Student, Department Of Sports Biomechanics, Lakshmibai National Institute Of Physical Education, Gwalior, Madhya Pradesh, India

M.P.Ed. Student, Department Of Sports Biomechanics, Lakshmibai National Institute Of Physical Education, Gwalior, Madhya Pradesh, India

M.P.Ed. Student, Department Of Sports Biomechanics, Lakshmibai National Institute Of Physical Education, Gwalior, Madhya Pradesh, India

Assistant Professor, Department Of Sports Biomechanics, Lakshmibai National Institute Of Physical Education, Gwalior, Madhya Pradesh, India

Abstract

Background: Free-throw performance is a critical skill in basketball that can significantly influence game outcomes. Biomechanical factors such as release angle and release height play an important role in determining shooting accuracy. However, variations in anthropometric characteristics, particularly player height, may affect these release parameters and overall free-throw success. Therefore, examining the interaction between release mechanics and player stature is essential for optimizing shooting technique.

Methods: Thirty right-handed university-level male basketball players participated in the study and were divided into three groups according to their height: Group 1 (165–175 cm), Group 2 (175–185 cm), and Group 3 (185–195 cm). Each participant attempted 20 free throws under three different release angle conditions: below 45°, between 45°–55°, and above 60°. Ball release mechanics were recorded using two-dimensional video analysis at 60 frames per second, and release angle as well as release height were calculated using Kinovea motion analysis software. The Shapiro–Wilk test was used to assess the normality of the data distribution. To determine differences among the three height groups under different release angle conditions, one-way ANOVA was applied, followed by Tukey HSD post-hoc analysis where appropriate. The level of statistical significance was set at $p < 0.05$.

Results: The results revealed statistically significant differences in free-throw accuracy among the three height groups across all release angle conditions. The highest shooting accuracy was consistently observed within the 45°–55° release angle range for all groups. Taller players (Groups 2 and 3) demonstrated significantly greater free-throw accuracy compared to shorter players (Group 1). However, no statistically significant difference was found between Groups 2 and 3. Additionally, shooting accuracy declined significantly when the release angle was below 45° or above 60° across all groups. These findings indicate that both release angle and release height play a crucial role in determining free-throw performance.

Conclusion: The findings indicate that both release angle and release height significantly influence free-throw accuracy. An optimal release angle between 45° and 55°, combined with a higher release point, provides biomechanical advantages that enhance shooting consistency. The study highlights the importance of individualized technique optimization based on player anthropometry and provides practical implications for basketball coaching and performance training.

Key-Words: Free-throw accuracy, Release angle, Release height, Basketball biomechanics

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I. Introduction

Shooting efficiency is one of the key performance parameters capable of differentiating winning from losing game outcomes on various levels of basketball competition¹. A recently published study found that field-goal, three-point, and free-throw shooting percentages were all significantly greater in winning than losing teams during both regular and post-season competitive periods². However, unlike other types of shooting motions (e.g., lay-up, jump shot), the free-throw shot is an uncontested scoring opportunity that allows players to score points without the presence of a defender. It has been found that the desired game outcome is partially contingent on the team's ability to secure and make more free-throw shooting attempts, especially close to the end of the game³. Free-throws generally make up 20 to 25% of all points scored in a game⁴. Kozar, Vaughn, Whitfield, Lord, & Dye (1994) found that during the last five minutes of basketball games, free-throws constitute 35% of the points

scored. They also found that in games decided by nine points or less, free-throws comprised 48% of the winning team's points during the last five minutes, and 69% during the last minute of the games. Since opportunities to shoot free-throws increase near the end of close games, it is imperative that these opportunities be converted into points⁵. Yet, despite efforts of coaches and players, National Association of Basketball Coaches (NABC) records show that free-throw shooting by men's collegiate teams has remained between 68 and 69% over the last 20 years⁶. The range of successful paths is influenced by the entry angle of the ball into the basket ring. This is because a higher entry angle (closer to perpendicular) provides a larger area for the successful paths of a ball passing through the basket. Since the trajectory of the ball after it is released from the hand of a player can be regarded as parabolic motion, the release parameters such as the release speed, release angle, and release height are the main factors that influence the trajectory and arrival position of the ball⁷. Based on the previous biomechanics research on shooting a basketball for mid-range to long-range jump shots, a high point of release provides a greater margin of error and probability of success. In jump shots the angle of release is about 52 degrees above the horizontal. Shooting the ball between 49 and 55 degrees ensures a proper angle of entry and minimise ball speed⁸.

By investigating the actual selection of variability in the release parameters (the release angle and release height) for basketball free throw and the influence on the accuracy, Thus, we hypothesized that there would be significant influence of the release angle, release height on accuracy in free throw in basketball, we believe that the results will provide reference for selecting release parameters during coaching or training of free throw.

II. Methodology

Sample

The sample was made up of **30** right-handed male basketball players. The players were all basketball athletes, at least at the university level, and were chosen from the Lakshmi Bai National Institute of Physical Education in Gwalior, Madhya Pradesh, India. The subject was divided into three groups (10 in each group) according to their height.

Height of Group 1 is ranging from 165 to 175 cm (Age 21.8 ± 2.66 years; Weight 62.8 ± 8.60 kg; Height 171.5 ± 2.27 cm) with 7.6 ± 3.69 years of experience.

Height of Group 2 is ranging from 175 to 185 cm (Age 20.8 ± 1.81 years; Weight 64.7 ± 4.03 kg; Height 178.8 ± 2.04 cm) with 7 ± 1.25 years of experience.

Height of Group 3 is ranging from 185 to 195 cm (Age 23.4 ± 3.41 years; Weight 80.3 ± 7.60 kg; Height 190.4 ± 3.66 cm) with 10.7 ± 3.74 years of experience.

Before the evaluation started, the subjects were informed about the research procedures and given a term of consent. None of the subjects reported any prior injuries or incapacity that could interfere with the shoot's tests conducted.

Basketball Court and Ball Release Parameters

In this study, an optimization study was carried out based on the ball release parameters (the release height, the release angle) for Free Throw. The court dimensions in FIBA (International Basketball Federation, 2024) standards are 28 x 15 meters. The height of the basket from the ground is 3.05 meters, and the diameter of the basket is 0.45 m. In FIBA standards, the free throw line is drawn 5.8 meters from the base line. Also, ball number 7 having a circumference of 0.75 m, a diameter of 0.24 m and a weight of 0.575 kg was used for free throw⁹. COSCO Challenge size 7 were used for free throw shooting.

Experimental Procedures

There was a general and specific warm-up (15–20 minutes) prior to record the video. Each participant was allowed to select his own set of activities during the uncontrolled warm-up to prevent any effects of weariness. Shoots in the basket were used for the particular warm-up in a forward position for ten minutes from mid-range and free throw. To investigate the influence of the parameters, controlled shooting experiments were conducted. Participants of each groups performed 20 free throws under varying conditions: Release angles: Below 45°, 45° to 50° and above 60°

The performance of every player was recorded by Samsung S22 Ultra Camera with a speed of 60fps. At a distance of seven meters, a camera was positioned perpendicular to the subject's sagittal plane (right side). For the measurement of selected linear and angular kinematical variables, 2-D analysis will be done by Kinovea software and release angle (degree) and release height (cm) variables was calculated.

Statistical Technique

The normality of the data was verified using the Shapiro-Wilk test. In order to examine the hypothesis of the study, One Way Anova will be used to analyse the data by using SPSS software. The level of significance will be set at 0.05.

III. Results

Table No 1 The Shapiro–Wilk test was applied to examine the normality of free-throw accuracy scores for Group 1 across different release angle conditions. The results showed that accuracy below 45° ($p = .124$), between 45° to 55° ($p = .883$), and above 60° ($p = .410$) were all non-significant. Since all p -values were greater than 0.05, the data for Group 1 were normally distributed across all release angle categories. This confirms that the assumption of normality was satisfied for Group 1 accuracy scores

Table No 1: Tests of Normality Group 1

	Shapiro-Wilk		
	Statistic	df	Sig.
Accuracy (Below 45 Degree)	.878	10	.124
Accuracy (45 to 55 Degree)	.969	10	.883
Accuracy (Above 60 Degree)	.926	10	.410

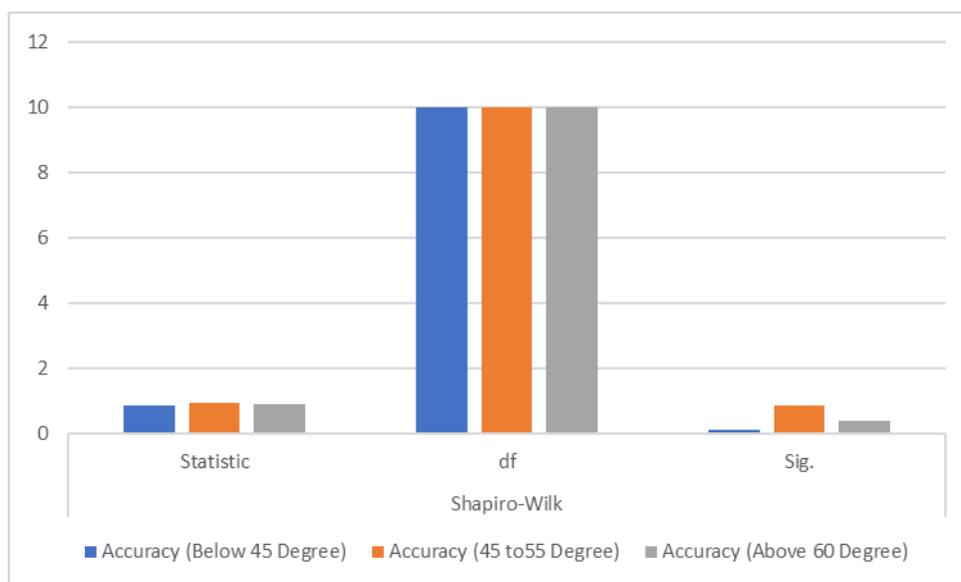


Table No 2 For Group 2, the Shapiro–Wilk test results indicated that free-throw accuracy scores followed a normal distribution for all release angles. The accuracy below 45° showed a p -value of .575, accuracy between 45° to 55° showed a p -value of .258, and accuracy above 60° showed a p -value of .854. As all significance values exceeded the 0.05 threshold, the normality assumption was met for Group 2 across all shooting angle conditions.

Table No 2: Tests of Normality Group 2

	Shapiro-Wilk		
	Statistic	df	Sig.
Accuracy (Below 45 Degree)	.942	10	.575
Accuracy (45 to 55 Degree)	.907	10	.258
Accuracy (Above 60 Degree)	.966	10	.854

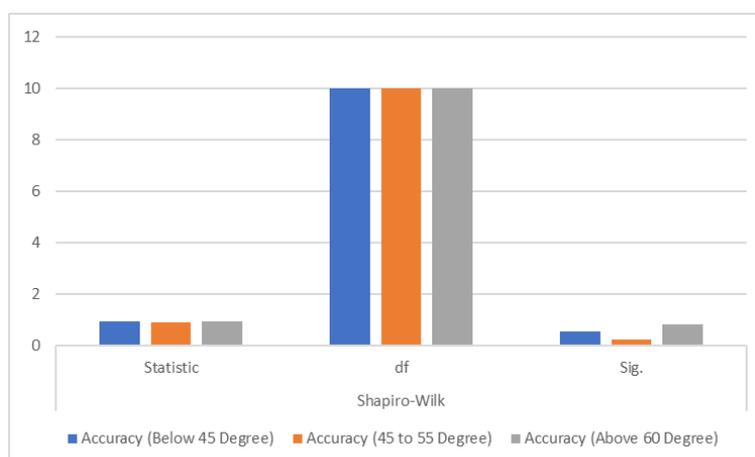


Table No 3 The Shapiro–Wilk test conducted for Group 3 also demonstrated normal distribution of free-throw accuracy scores under all release angle conditions. The obtained p-values for accuracy below 45° (p = .445), between 45° to 55° (p = .575), and above 60° (p = .392) were all greater than 0.05. These results confirm that the data for Group 3 satisfied the assumption of normality, making them suitable for further parametric statistical analysis

Table No 3: Tests of Normality Group 3

	Shapiro-Wilk		
	Statistic	df	Sig.
Accuracy (Below 45 Degree)	.930	10	.445
Accuracy (45 to 55 Degree)	.942	10	.575
Accuracy (Above 60 Degree)	.924	10	.392

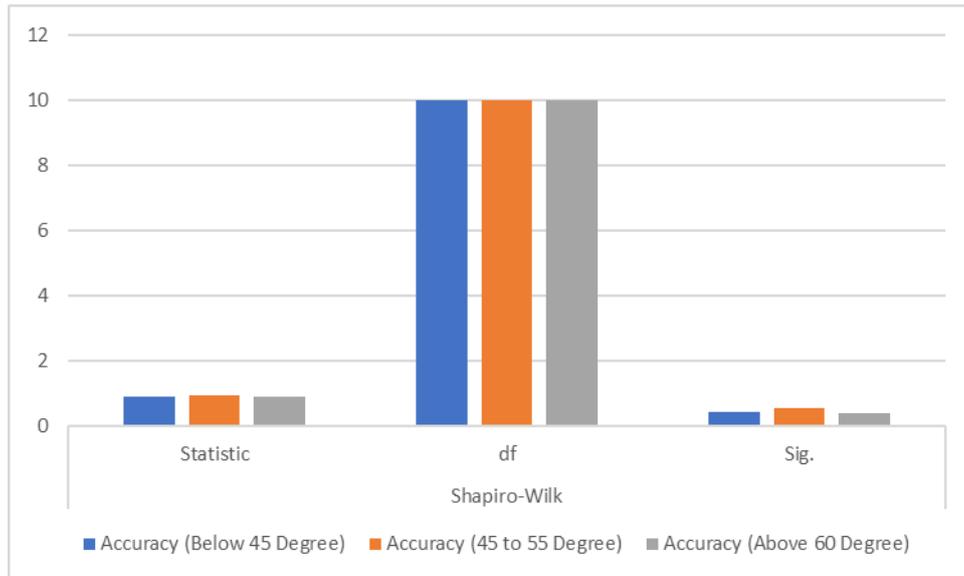


Table No 4 The ANOVA results indicate a statistically significant difference in free-throw accuracy at a 45° release angle (accuracy below 45 degree) among the three groups. The between-groups sum of squares was 39.467 with 2 degrees of freedom, while the within-groups sum of squares was 42.400 with 27 degrees of freedom. The calculated F-value was 12.566, which was significant at the 0.05 level (p = .000). This result confirms that there is a significant variation in accuracy scores among the groups, suggesting that group differences play an important role in influencing free-throw accuracy at the given release angle.

Table No 4 ANOVA Accuracy Below 45 Degrees

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	39.467	2	19.733	12.566	.000
Within Groups	42.400	27	1.570		
Total	81.867	29			

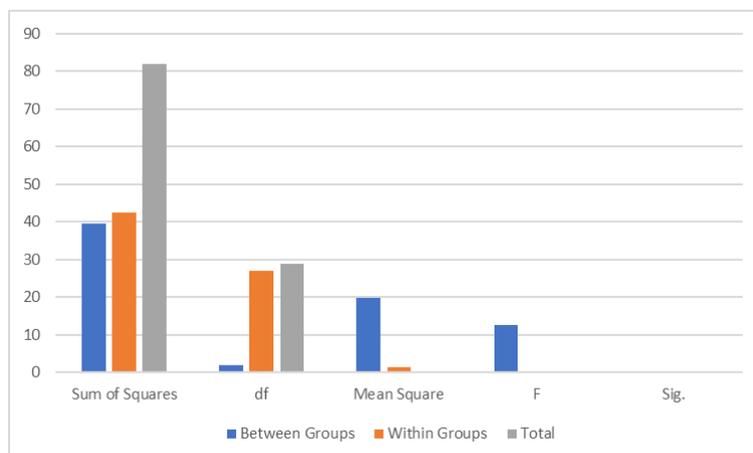


Table No 5 The Tukey HSD post-hoc test was conducted to identify specific group differences in free-throw accuracy. The results revealed that Group 1 differed significantly from Group 2 (mean difference = -1.60, $p = .022$) and Group 3 (mean difference = -2.80, $p = .000$). Additionally, Group 3 showed a significant difference when compared with Group 1 (mean difference = 2.80, $p = .000$). However, the difference between Group 2 and Group 3 was not statistically significant ($p = .100$). These findings indicate that the significant overall ANOVA result is mainly due to differences involving Group 1, while Groups 2 and 3 demonstrate relatively similar accuracy levels.

Table No. 5 Tukey HSD post-hoc test

Multiple Comparisons						
Dependent Variable: Accuracy below 45 Degree						
Tukey HSD						
(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Group 1	Group 2	-1.60000*	.56042	.022	-2.9895	-.2105
	Group 3	-2.80000*	.56042	.000	-4.1895	-1.4105
Group 2	Group 1	1.60000*	.56042	.022	.2105	2.9895
	Group 3	-1.20000	.56042	.100	-2.5895	.1895
Group 3	Group 1	2.80000*	.56042	.000	1.4105	4.1895
	Group 2	1.20000	.56042	.100	-.1895	2.5895

*. The mean difference is significant at the 0.05 level.

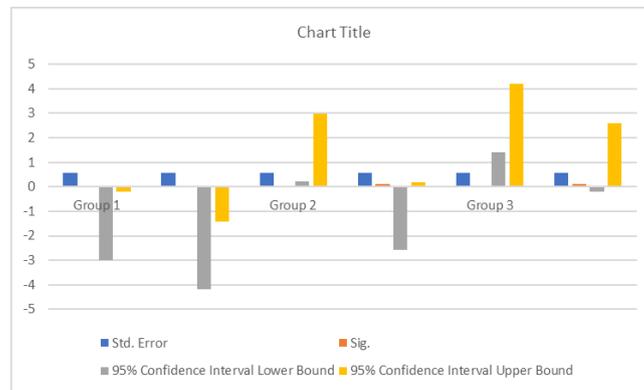


Table No 6 The ANOVA analysis for free-throw accuracy between the 45° to 55° release angle range (accuracy between 45 to 55 degree) revealed a statistically significant difference among the three groups. The between-groups sum of squares was 94.200 with 2 degrees of freedom, while the within-groups sum of squares was 57.000 with 27 degrees of freedom. The obtained F-value was 22.311, which was statistically significant at the 0.05 level ($p = .000$). This indicates that free-throw accuracy significantly varies among the groups within the 45°–55° release angle range, demonstrating a strong group effect on shooting performance

Table No 6 ANOVA Accuracy Between 45 to 55 Degrees

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	94.200	2	47.100	22.311	.000
Within Groups	57.000	27	2.111		
Total	151.200	29			

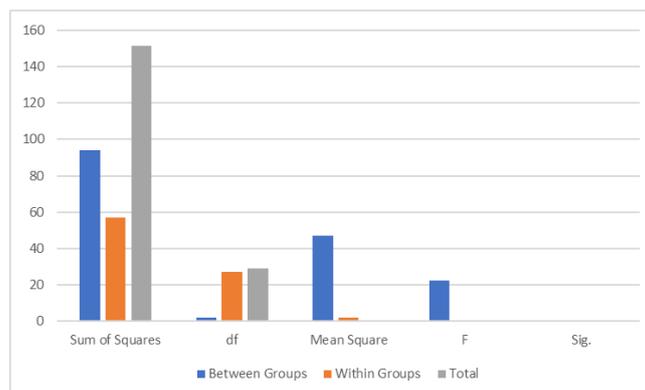


Table No 7 The Tukey HSD post-hoc test was conducted to identify pairwise differences among the groups. The results showed that Group 1 differed significantly from Group 2 (mean difference = -3.60, p = .000) and Group 3 (mean difference = -3.90, p = .000). Similarly, Group 3 also showed a significant difference when compared with Group 1 (mean difference = 3.90, p = .000). However, no statistically significant difference was observed between Group 2 and Group 3 (p = .890). These findings suggest that the significant ANOVA result is mainly attributed to the differences involving Group 1, while Groups 2 and 3 exhibited comparable levels of free-throw accuracy within this release angle range.

Table No 7: Tukey HSD post-hoc test

Multiple Comparisons						
Dependent Variable: Accuracy Between 45 to 55 Degree						
Tukey HSD						
(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Group 1	Group 2	-3.60000*	.64979	.000	-5.2111	-1.9889
	Group 3	-3.90000*	.64979	.000	-5.5111	-2.2889
Group 2	Group 1	3.60000*	.64979	.000	1.9889	5.2111
	Group 3	-.30000	.64979	.890	-1.9111	1.3111
Group 3	Group 1	3.90000*	.64979	.000	2.2889	5.5111
	Group 2	.30000	.64979	.890	-1.3111	1.9111

*. The mean difference is significant at the 0.05 level.

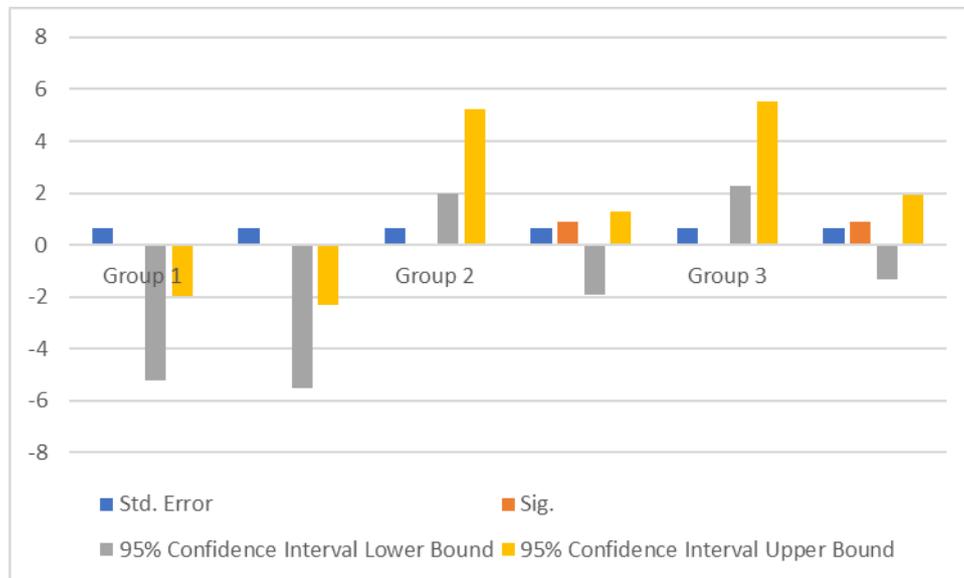


Table No 8 The ANOVA results for free-throw accuracy above the 60° release angle (accuracy above 60 degrees) showed a statistically significant difference among the three groups. The between-groups sum of squares was 56.267 with 2 degrees of freedom, while the within-groups sum of squares was 51.900 with 27 degrees of freedom. The mean square between groups was 28.133, resulting in an F-value of 14.636, which was significant at the 0.05 level (p = .000). This indicates that free-throw accuracy differs significantly among the groups when the release angle exceeds 60°, highlighting the influence of group-related factors on shooting performance

Table No 8: ANOVA Accuracy Above 60 Degrees

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	56.267	2	28.133	14.636	.000
Within Groups	51.900	27	1.922		
Total	108.167	29			

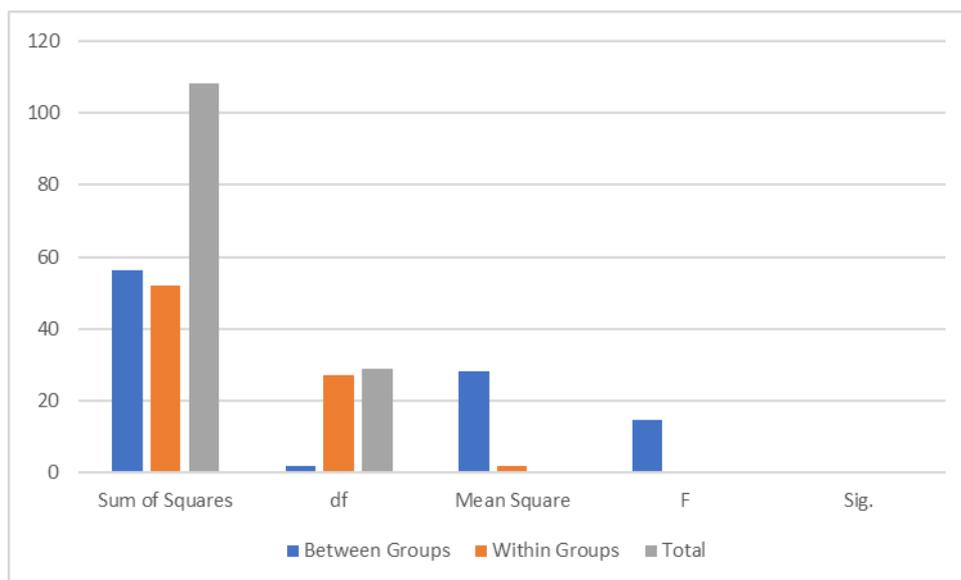
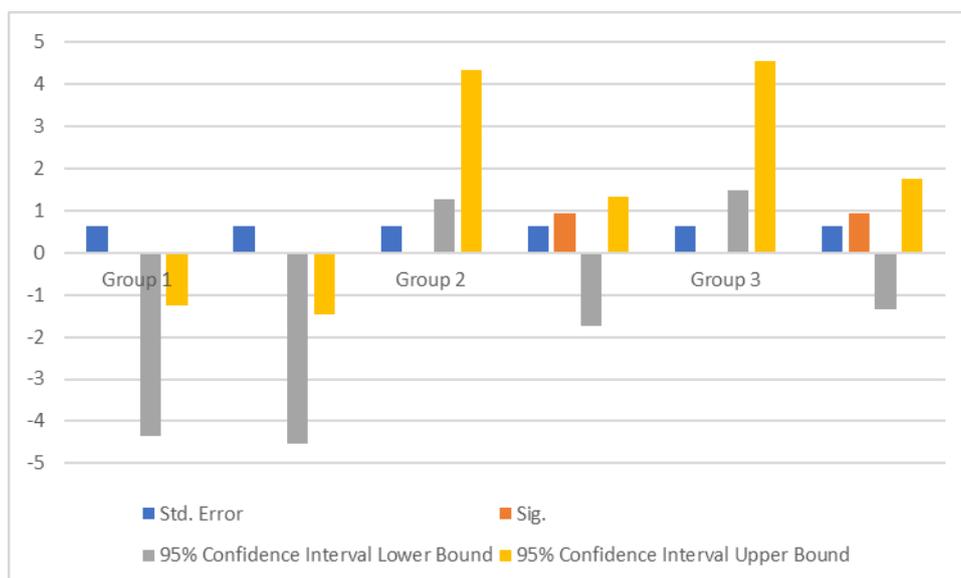


Table No 9 The Tukey HSD post-hoc analysis revealed significant pairwise differences among the groups. Group 1 showed a significant difference when compared with Group 2 (mean difference = -2.80, p = .000) and Group 3 (mean difference = -3.00, p = .000). Likewise, Group 3 differed significantly from Group 1 (mean difference = 3.00, p = .000). However, the comparison between Group 2 and Group 3 did not show a statistically significant difference (p = .944). These results indicate that the significant overall ANOVA effect is primarily due to differences involving Group 1, whereas Groups 2 and 3 demonstrated similar free-throw accuracy levels at release angles above 60°.

Table No 9: The Tukey HSD post-hoc

Multiple Comparisons						
Dependent Variable: Accuracy Above 60 Degrees						
Tukey HSD						
(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Group 1	Group 2	-2.80000*	.62004	.000	-4.3373	-1.2627
	Group 3	-3.00000*	.62004	.000	-4.5373	-1.4627
Group 2	Group 1	2.80000*	.62004	.000	1.2627	4.3373
	Group 3	-.20000	.62004	.944	-1.7373	1.3373
Group 3	Group 1	3.00000*	.62004	.000	1.4627	4.5373
	Group 2	.20000	.62004	.944	-1.3373	1.7373

*. The mean difference is significant at the 0.05 level.



IV. Discussion

The purpose of the present study was to examine the influence of release angle and release height on free-throw accuracy among basketball players of different height groups. The findings clearly demonstrated that release angle significantly affects free-throw accuracy across all three groups, with notable differences observed particularly between Group 1 and the taller groups (Groups 2 and 3). These results support the biomechanical principle that optimal projectile parameters enhance scoring consistency in basketball shooting tasks.

The significant ANOVA results across all three release-angle conditions (below 45°, 45°–55°, and above 60°) indicate that shooting accuracy is not uniform across player height categories. Players in Groups 2 and 3 consistently demonstrated higher accuracy than Group 1, especially at release angles between 45° and 55°. This finding aligns with previous research suggesting that taller players benefit from a higher release point, which reduces the required ball velocity and increases the effective entry margin at the basket¹⁰.

The superior accuracy observed within the 45°–55° release angle range supports earlier biomechanical models of basketball shooting¹¹, proposed that mid-range release angles minimize sensitivity to small errors in release speed, thereby increasing shot success. Similarly¹², reported that free throws executed within this angle range allow for greater tolerance in execution variability, which is critical during pressure situations. The present findings reinforce these conclusions by demonstrating the highest accuracy scores across all groups in this optimal angular range.

At release angles below 45°, accuracy significantly decreased, particularly for Group 1. Lower release angles require higher horizontal velocity to reach the basket, increasing the likelihood of error due to greater force production demands¹³. Shorter players may be disproportionately affected by this requirement, as they typically compensate for lower release heights with increased ball speed, thereby reducing shot control.

Similarly, although angles above 60° increased the ball's entry angle into the rim, accuracy declined across all groups. Excessively high release angles require greater vertical force and precise timing, which may negatively affect coordination and consistency¹⁴. This finding supports the concept of an optimal rather than maximal release angle for skilled performance.

The Tukey HSD post-hoc results further indicate that most significant differences involved Group 1, while Groups 2 and 3 showed comparable accuracy across all angle conditions. This suggests that increased body height—and consequently greater release height—may reduce the biomechanical constraints associated with free-throw shooting. Previous studies have shown that a higher release point reduces the need for extreme joint torques and improves movement efficiency¹⁵.

Overall, the results of this study confirm that both release angle and player anthropometry play critical roles in free-throw accuracy. Coaches and practitioners should emphasize training within the optimal release angle range (45°–55°) while considering individual player height and release characteristics. Technique-specific interventions tailored to a player's biomechanical profile may significantly enhance free-throw performance.

V. Conclusion

The present study was conducted to examine the influence of release angle and release height on free-throw accuracy among basketball players of different height categories. Based on the statistical analysis and interpretation of results, it can be concluded that both release angle and player height significantly affect free-throw shooting performance.

The findings revealed that free-throw accuracy was highest when shots were executed within the 45°–55° release angle range across all groups. This release angle provided the most favourable balance between ball trajectory, entry angle, and required release speed, thereby maximizing the margin for error. In contrast, release angles below 45° and above 60° resulted in significantly lower accuracy, indicating that extreme angular values negatively influence shooting consistency.

The study also demonstrated significant differences in free-throw accuracy among the three height-based groups. Taller players (Groups 2 and 3) consistently showed higher accuracy compared to shorter players (Group 1) across all release angle conditions. This suggests that greater release height offers biomechanical advantages, such as reduced force requirements and improved control over ball trajectory. However, no significant differences were observed between Groups 2 and 3, indicating that beyond a certain height, the advantage in free-throw accuracy tends to stabilize.

Overall, the results confirm the study hypothesis that release angle and release height have a significant influence on free-throw accuracy in basketball. From a practical perspective, coaches and trainers should emphasize the development of an optimal release angle, particularly within the 45°–55° range, while considering individual anthropometric characteristics during technical training. Incorporating biomechanically efficient shooting mechanics may enhance free-throw consistency and performance, especially in high-pressure game situations.

Future research may include larger sample sizes, female players, and three-dimensional motion analysis to further explore the interaction between biomechanical variables and shooting performance.

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