ACTA SCIENTIAE | Revista de Ensino de Ciências e Matemática | ONLINE ISSN 2178-7727 | ULBRA

BIOMECHANICAL ANALYSIS OF SMASH ANGLE FOR OPTIMIZING PERFORMANCE IN BADMINTON

Mayanglambam Sangita Devi
Guest Faculty, Department of Sports Biomechanics, Rajiv Gandhi University, Arunachal Pradesh
Elangbam Monika Devi
Mayanglambam Surchand Singh
Assistant Professor, National Sports University, Khuman Lampak Manipur
Khoisnam Somibala Devi
Assistant Professor, DM College of Science, DMU
Correspondent Author: Khoisnam Somibala Devi

Received: 10th July, 2025
Revised &Accepted: 15th November, 2025
Published: 25th December, 2025
DOI: https://doie.org/10.65985/AS.2026319704

Abstracts

Smash is a continuous series of movements involving coordination of the entire body. Maximum force is needed, along with a complex movement supported by body parts like the strength of the muscles in the hands, arms, legs, and abdomen. Therefore, this present study sheds information on how the smash angle influences badminton players' performance to outsmart their competition and can optimize body alignment to increase smash proficiency. A total of 12 male national badminton players of the Manipur Badminton Association served as the subject of the study. The subjects were all right-handed players, and their mean age was 14.83±1.58 years. Poole test Battery of Smash was assigned to analyze the angle of the standing smash stroke. The standing Smash was recorded by using GoPro Hero 8. The camera captured a sequence of badminton stroke movements, from the position one holds the racket to the stroke motion. The stroke's contact phase was analyzed using Kinovea software 0.8.15. This study's parameters focused on the angle of the elbow joint, shoulder joint, hip joint, knee joint and ankle joint. The result of the study enhances the understanding of the biomechanics of badminton and has beneficial implications for coaches and players striving to improve their forehand smashes, particularly for beginners.

Keywords: Badminton, Smash, angle, Poole test battery, GoPro

1.Introduction

Biomechanical analysis is used in sports to analyze athletes' movement patterns and identify the factors that affect their performance. In badminton games, a smash is the most common killing shot, which accounts for 53.9% of the distribution of the killing shot (Tong & Hong, 2000). Sakurai and Ohtsukiss (2000) stated that the power/speed of the badminton smash is a very offensive weapon. The forehand smash is an effective attacking shot in badminton, accounting for 54% of "unconditional winner" and "forced failure" shots in international matches. These powerful attack techniques are used to dominate the opponents and score as many points as possible; these techniques account for 39.8% of all scored points (Barreira et al., 2016). When the player moves their arms during a smash, it is crucial to the success of the stroke. The pattern included an overarm with a medial rotation of the humerus and elbow flexion during the forward or force-producing phase. The arm rotates powerfully inward during

ISSN:1517-4492 | **E-ISSN:**2178-7727

this phase, followed by the forearm's inward rotation and the hand's flexion, according to the biomechanical analysis of a smash. Numerous biomechanical analyses of forehand smashes in badminton have been conducted in recent years. During overhead forehand smashes, the internal rotation velocity of the shoulder joint, elbow angular extension, and wrist palmar flexion are the primary contributors to upper limb movement (Rusdiana et al., 2021). According to research by King et al. (2020), increasing proximal linear velocities, which increase post-impact shuttlecock speed, require proximal segment movement or the separation of the pelvis and thorax. Furthermore, a smash is a fast stroke that relies on the wrist's strength, velocity, and flexion with the shuttlecock swooping down towards the opponent's field area (Lam et al., 2020).

Smash is a series of continuous motions related to whole-body coordination. Maximum force is required, as well as a complicated action supported by bodily components such as the strength of the hands, arms, legs, and abdomen muscles. Davidson and Gustavson (1953) claimed that, of all the badminton strokes, an efficient smash is one of the most essential ways to score points and win a game. For this reason, every player must enhance their smash performance along with technical and tactical abilities. Therefore, this study investigates how upper and lower limb segment rotations affect smash shots at the point of contact phase. To get additional information about how various deceptive shots work and how these kinematic joint angles affect an individual's ability to execute an effective deceptive shot, the elbow, shoulder, hip, knee, and ankle joint angles will be the focus of the collection.

2. Materials and Methods

The subjects of this study were all right-handed players between the ages of 12 and 16 who competed in their respective age groups in the National Badminton Championship. The subjects of the study were collected from the Manipur Badminton Association.

To measure and propel the uniformity in performing the skill, Poole test Batteries of Smash were assigned to unify the position and postural alignment, which preferred to videotape the performance of the skill. The scoring and skills tests via test batteries are not considered in the present study, which will indicate Smash's overall performance in skill tests in terms of the raw scores of test batteries. It is a test that considers the space and markings to analyze the objective of the present study. The data was collected under the supervision of badminton experts. Before data collection, the subjects engaged in a thorough warm-up before doing standing smash movements.

It is essential to assess how well sports motions are executed; in this regard, technology is helpful because it makes this feasible. This will provide a systematic approach to measuring and assessing human movement (Rucco et al., 2020), as stated in a study conducted by Sapta Purnama and Rumi Iqbal in 2022. Therefore, a high-speed motion analyzer camera (Go Pro Hero 8) was used to capture the standing smash stroke to create a reliable measurement. The stroke's contact phase was analyzed using Kinovea software 0.8.15. The present study also used equipment like a tripod, measuring tape, radium tape, stadiometer, weighing scale, shuttle, racket, and markers. Particular kinematic features were extracted from the chosen phase by creating a stick figure.

ISSN:1517-4492 | **E-ISSN**:2178-7727

Vol. 8, No. 1 (2025)

Figure 1: Reading of the Standing Smash Performance using Kinovea Software

2.1. Marking of the placement of the camera

The video camera was mounted on the tripod stand at a height of 1.05 meters from the ground. The video camera was placed perpendicularly at the sideline of the badminton court, the sagittal plane, at 3.20mts. The frequency of the camera was 120 frames/second. The subjects performed the skill three-set, and the best trial was used for the analysis.

2.2. Specification of marking angle alignments on the player's images

A radium tape was used to mark the elbow, shoulder, hip, knee, and ankle in the sagittal plane to visualize clearly during videography. The uniqueness of the specific racket and shuttle is also marked with radium tape angles to ensure accurate readings during movement analysis. Using Kinovea 0.8.15 software, it is clear that the angle of the skills is measured in degrees (°).

2.3. Statistical Analysis

IBM SPSS 21 was used to statistically analyze the responses of Manipur's national male badminton players to the measurement. The goal of the current study was interpreted using descriptive statistics such as Mean, standard deviation, minimum, maximum, range skewness, and kurtosis, which were computed for descriptive analysis.

3.1. Result of the Study

The research findings were presented in tables and figures during the smash stage.

ISSN:1517-4492 | **E-ISSN**:2178-7727

Vol. 8, No. 1 (2025)

Table 1: Descriptive Statistic of Angle of Smash Performance

Descriptive Statistics					
	Angle of Elbow Joint(u=º)	Angle of Shoulder Joint (u=º)	Angle of Hip Joint (u=º)	Angle of Knee Joint (u=º)	Angle of Ankle Joint (u=º)
Mean (N=12)	165.50	165.50	188.50	162	117.50
Std. D (N=12)	13.68	16.97	3.89	8.33	16.70
Min (N=12)	136	141	182	146	93
Max(N=12)	178	199	196.00	174	147

Note: N =number of subjects, u=unit were expressed in degree

Table 1 represents the mean and standard deviation of the smash stroke performance at the contact phase in their respective angle of elbow joint, shoulder joint, hip joint, knee joint and angle of ankle joint, respectively. The Mean and standard deviation of the angle of elbow joint, shoulder joint, hip joint, knee joint, and ankle joint were 165.5º±13.68º, 165.5º±16.97º, 188.5º±3.89º, 162º±8.33º and 117.5º±16.70º respectively.

Further, the minimum and maximum angles of the elbow joint, shoulder joint, hip joint, knee joint and angle of ankle joint were 136º to 179º, 141º to 199º, 182º to 196º, 146º to 174º and 93º to 147º respectively.

3.2. Discussion on Finding

Smash Stroke is the game action that produces the highest percentage of winning strokes and significantly impacts the game's outcome. The aim of this study was the biomechanical analysis to assess the angle of smash performance. Performing a forehand smash starts with a sequence of jumps that begin with the body bending and standing, attempting to maintain energy before the body leaps into a coordinated series of synchronized movements (Chien-Lu Tsai et al. nd). At the highest point, the shoulder swings forward, followed by the striking arm. Skilled badminton players have specific physical characteristics that differentiate them from unskilled players (Spinservesports nd). They exhibit higher shoulder motion angles, faster velocities of shoulder internal rotation, elbow extension, forearm supination, and a distinct shoulder joint angle. Asif M et al. (2018) suggest that specific shoulder and elbow angles are associated with a more effective badminton standing smash.

In this study, the angle of the elbow joint and shoulder joint of the smash stroke performance at the contact phase was 165.5º±13.68º and 165.5º±16.97º. The angle of the elbow joint is inferior, and the angle of the shoulder joint is superior to the result of a study conducted by Chien-Lu Tsai et al. The results of Ramasamy et al. (2021) showed that the shoulder angle was 126.9 ± 5.3º, smaller than the shoulder angle of the present study. However, a study suggests that the elbow and shoulder angles should be obtuse or more than 90º but less than 180º at the point of contact. It allows the players to reach high while hitting with a bent arm, which provides more power (Inky 4u, 2007). Therefore, the studied angle of the elbow and shoulder joint was at the range that can provide more power while performing the standing smash.

ISSN:1517-4492 | **E-ISSN:**2178-7727

Vol. 8, No. 1 (2025)

In badminton, the angle of the hip joint during a standing smash is an essential factor to maximize performance and minimize injuries. The range that the hip joint occupies by the studied subjects is indicated by the given angle of 188.5º ± 3.89º. Complex coordination of multiple joints and muscles is necessary to produce power, and accuracy in the shot is required for the standing smash in badminton. The hip joint is essential to this movement since it transfers force from the lower body to the upper body and racket. According to a study by Wang et al. (2018) and Mottakin Ahmed & G.D Ghai (2020), when badminton players smash, a larger hip joint angle is linked to faster racket speed and shuttlecock velocity. It emphasizes the importance of attaining the ideal hip joint angle to improve performance when using this particular approach. Players can maximize their effectiveness and lower their risk of injury from poor biomechanics during the smash by keeping the angle within the range.

According to the present study, the knee joint angle during a standing badminton smash is 162º ± 8.33º, which is much higher and different from the considered ideal angle. To facilitate a robust and influential force transmission from the legs to the racket, it is usually advised to have a knee joint angle closer to 90 degrees during the impact phase of a smash (Systematic Anomally,2007). A 162-degree angle would indicate a nearly straight leg, which could restrict the ability to produce the maximum force. The possible reason might be that the player might have limitations in their range of motion or flexibility, preventing them from achieving forceful smash or the players might have a unique technique to execute a specific type of smash which focuses more on placement and deception rather than power. However, it is essential to consider that this angle may be part of a specific technique employed by some players, possibly related to the execution phase post-impact, where the leg extends as part of the follow-through. It could also indicate a preference for stability and accuracy over power in specific strategic contexts.

This angle is more significant than predicted, given the smash's explosive movement, which usually results in a smaller angle due to a certain amount of plantarflexion or pointing the toes downward. Dorsiflexion of the foot would occur when the ankle angle was about 117.5 degrees. A less prevalent smash technique that could be a component of a more upright posture while hitting the shuttlecock is indicated by a dorsiflexed foot during the smash. The potential reason might be the player's limited range of motion in the ankle joint, making it harder to produce optimal foot placement and proper alignment.

3.3. Conclusion

In conclusion, biomechanical studies are vital for understanding and enhancing badminton smash performance. The smash's strength, stability, and trajectory are directly related to the angles of the various joints, especially the lower limb joints like the ankle and knee. In order to maximize force and maintain balance during the smash, an effective technique often involves a combination of ankle plantarflexion and knee flexion. However, the ideal joint angles might vary depending on the individual athlete. In competition, deviations from these ideal ranges may result in less potent shots or changed shuttle trajectories, reducing the smash's effectiveness.

Each player may have a different optimal angle for their smashes due to individual physicality, playing style, and tactical approach. Therefore, players must work with coaches and biomechanical experts to analyze their smashing technique and ensure their knee angle allows them to play effectively while minimizing injury risks.

ISSN:1517-4492 | **E-ISSN**:2178-7727
Vol. 8, No. 1 (2025)

Reference

Asif, M., Zutshi, K., Munjal, J., & Dhingra, M. (2018). Relationship Among Height, explosive Power and Shoulder Strength on Smashing Accuracy in Male Badminton Players. European Journal of Physical Education and Sport Science. https://doi.org/10.46827/ejpe.v0i0.1846.

Chien-Lu Tsai, Chenfu Huang, Shaw-Shiun Chang, & Chern-Mau Lai. (n.d.). Biomechanical Analysis Between Badminton Standing Smash and Jumping Smash in the Different Target Set

Enky4u (2007). Discussion on Technique/Training. Badminton Central. Retrieved from January 11, 2024 https://www.badmintoncentral.com/forums/index.php?threads/howmuch-angle-at-elbow-and-between-racquet-forearm-for-optimum-power-transfer

King, M., Towler, H., Dillon, R., & McErlain-Naylor, S. (2020). A correlational analysis of shuttlecock speed kinematic determinants in the badminton jump smash. *Applied Science* 10, 1–14. https://doi.org/10.3390/app10041248

Kunta, S., Purnama, & Iqbal, Rumi, Doewes (2022). Biomechanics analysis of badminton forehand smash in standing classification disability players. Journal of Physical Education and Sport, 2, 3183–3188. https://doi.org/DOI:10.7752/jpes.2022.12404

Li, F., Li, S., Zhang, X., & Shan, G. (2023). Biomechanical insights for developing evidence based training programs: Unveiling the kinematic secrets of the overhead forehand smash in badminton through novice-skilled player comparison. *Applied Sciences*, *13*(22), 12488. https://doi.org/10.3390/app132212488

Li, S., Zhang, Z., Wan, B., Wilde, B., & Shan, G. (2016). The relevance of body positioning and its training effect on badminton smash. *Journal of Sports Sciences*, *35*(4), 310–316. https://doi.org/10.1080/02640414.2016.1164332

Ramasamy, Y., Usman, J., Sundar, V., Towler, H., & King, M. (2021). Kinetic and kinematic determinants of shuttlecock speed in the forehand jump smash performed by elite male Malaysian badminton players. *Sports Biomechanics* 00, 1–16. https://doi.org/10.1080/14763141.2021.1877336

Rusdiana, A., Abdullah, M. R., Syahid, A. M., Haryono, T., & Kurniawan, T. (2021). Badminton overhand backhand and forehand smashes: a biomechanical analysis approach. *Journal of Physical Education and Sport*, 21, 1722-1727

Rucco, R., Ascione, A., & Palma, D. D. (2020). Motion analysis in sport training: the link between technology and pedagogy. Journal of Physical Education and Sport, 20, 2337-2341.

Salim, M. S., Lim, H. N., Salim, M. S. M., & Baharuddin, M. Y. (2010, November). Motion analysis of arm movement during badminton smash. *2010 IEEE EMBS Conference on Biomedical Engineering and Sciences (IECBES)*. http://dx.doi.org/10.1109/iecbes.2010.5742210

M. Tashtarian, A.A. Shalmanov, & E.E. Zhigun. (n.d.). Leg extension biomechanism during badminton forehand «smash» and jump smash. *Teoriya.Ru*.

Spinservesports. (2024, February 1). Analysing the biomechanics of a powerful tennis

ISSN:1517-4492 | **E-ISSN**:2178-7727
Vol. 8, No. 1 (2025)

overhead smash. Premium Badminton, Tennis, and Squash Playing Guides and Gear | Spin Serve Sports Guide and Gear. https://spinservesports.com.au/uncategorized/analysing-the biomechanics-of-a-powerful-tennis-overhead-smash

Williamson, R., & Andrews, B. (2001). Detecting absolute human knee angle and angular velocity using accelerometers and rate gyroscopes. Medical and Biological Engineering and Computing, 39, 294-302. https://doi.org/10.1007/BF02345283.

Acknowledgment
The author would like to thank the coaches and Badminton players of the Manipur Badminton association for immense help in data collection. There was no financial assistant with research work.

Informed Consent
All the subjects gave their informed consent for inclusion before participation in the study.

Conflict of Interest
The authors declare no conflicts of interest

Corresponding Author
Dr. Khoisnam Somibala Devi