International Journal of Economic Perspectives,17(06) June 2023 Page 254-261
Retrieved from https://ijeponline.com/index.php/journal

An Imperial Study on the Importance of Body Alignment and its Impact on Badminton Smash Training

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Abstract- The forehand overhead smash, which often comprises of 1/5 attacks during matches, is one of the game's prominent techniques. Empirical research demonstrates that in order to produce a strong and precise smash, one must modify their body position in relation to the approaching shuttlecock. As a result, placement has a significant impact on smash quality. Unfortunately, a review of the literature revealed that little or no research has been done on this important topic. This study set out to find out how placement and training experience affected smash quality in order to understand more about how to develop and master the talent. 14 seasoned players and 15 newcomers were studied using 3D motion capture and full-body biomechanical modelling. Results showed that the offensive player's body placement directly affects the shuttlecock release angle and clearance height. The findings also imply that one might undertake a self-selected comfort position towards a statically hung shuttlecock and then walk one foot back - a useful reference point for learning - to instruct the positioning of beginners. Improved limb coordination would raise smash quality more as one obtains experience via consistent training. We anticipate that practitioners may find our findings useful in creating novice training programs.

KEYWORDS- Shuttlecock release speed; shuttlecock release angle; clearance height, Smash

Introduction- More than 2000 years ago, in ancient European and Asian civilizations, badminton was invented [1]. It is currently the second most popular sport in the world, behind football, with an estimated 220 million people playing badminton regularly, ranging from pros to leisure players [2]. Football is second to badminton in popularity and participation in Asia. Unexpectedly, according to a 2017 scientific study, badminton has about two million registered players and is the most popular sport in Great Britain [3]. Each year, a number of important international competitions take place, including the World Individual Championship, the World Grand Prix Finals, the Uber Cup for Women's World Team Championship, the World Mixed Doubles Championship, and the Thomas Cup for Men's World Team Championship. Olympic badminton features five different competitions, including mixed doubles, men's and women's doubles, and men's and women's singles. Simply said, fewer of us realize the popularity of badminton.Unfortunately, scientific studies on badminton abilities are not nearly as common as the sport. The amount of literature on biomechanical investigations is rather modest, according to a literature search. Due to significant advancements in measuring technology, earlier studies are either insufficient (e.g., incomplete body analyses, qualitative descriptions, or brief conference abstracts) or out of date [4,5]. In order to find elements that are dominant and desirable in the advancement of badminton skills during learning and training, new systematic research are required to explore the fundamentals of the sport.The forehand overhead smash, which makes up 1/5 of attacks in a game of

Submitted: 27April 2023, Revised: 09 May2023, Accepted: 18 May 2023, Published: June 2023

badminton [6], is the most important technique. The smash entails intricate motions that call for the coordination of all main body parts. According to Adrian &Enberg and Davidson &Gustavson , an efficient smash is the only essential way to score points to win a game. The opponent may be forced into a passive defense or directly score. Accordingly, the smash technique in badminton assault is more effective than any other approach and leads to (1) direct scoring, (2) favorable scoring opportunities, (3) thwarting an opponent's attack, or (4) turning a defensive position into an offensive one [8]. As a result, the smash is crucial in all of the game's level matchups. The skill is always difficult for players to perform with a high level of quality due to a significant demand for athletes' physical exertion, such as speed, power, smash precision, flexibility, and coordination [7]. In order to execute a strong and precise smash during a match, an athlete must first modify his or her body position in respect to the approaching shuttlecock [9]. According to the empirical data, body placement may directly affect a smash's quality, particularly its power and precision. Power and accuracy have been proven to be two fundamental parameters that are often used to evaluate effectiveness of many sport skills [10]. Since little research has been done on the topic of body positioning, which may be strongly related to smash quality in badminton, we need to first understand efficient smash control for the skill before we can explore the significance of positioning. Determining the relationship between body placement and smash quality through a 3D full-body motion analysis is the primary goal of the current study. Additionally, training (experience) should play a role in proper placement. Therefore, in order to identify the long-term training effects, a secondary goal is to compare player characteristics across novice and proficient players. When taken as a whole, this data can help with the creation of training plans based on statistically calculated "ideal" placement. Early consideration of placement can help coaches design drills with specific objectives, thereby accelerating the learning process and producing more effective smash skills in athletes.

Methodology

Participants- Advertisements in the regional media were used to find the participants. For the novice group, the selection criteria were being physically active and available, no prior badminton training (personal claim), and more than four years of regular (6–8 h/w) or intensive (>15 h/w) training. The skilled group included 14 participants (age: 23.7 3.7 years, weight: 71.56 7.37 kg, height: 1.77 0.05 m, active training: 6.6 3.1 years), four of whom were provincial level athletes, while the novice group included 15 participants (age: 24.3 4.7 years, weight: 62.05 9.24 kg, height: 1.71 0.07 m). The testing protocols were explained to all study participants. They freely took part in the data gathering and signed an approved consent form.

Apparatus

Using 56 reflective markers, including 39 on the body (diameter = 9 mm), 13 on the racket (4 mm tape), 3 on the net (12 mm), and 1 on the shuttlecock (7 mm tape), a 3D motion-capture system was utilized to measure full-body movement. The markers were followed by a 10-camera VICON MX40 motion capture system at a 200 frames per second frame rate. Using the 39 body indicators, a 15-segment full-body biomechanical model was created. A 3D computer reconstruction of the capturing setup is shown in Figure 1. The 39 markers were positioned on the participants' bodies as follows: on the head (4), sternal end of the clavicle, xiphoid process of the sternum, C7 and T10 vertebrae, right scapula, left and right anterior superior iliac, posterior superior iliac, right and left acromion, lateral side of each upper arm, lateral epicondyles, lateral side of forearms, styloid The participants had a great deal of flexibility of movement because to the use of 10 cameras and small markers, ensuring that their motions inside the capture volume were as similar to their typical "motor control style" as feasible.

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Procedures
Both a static shuttlecock (hanging at the user's selected height) and a dynamic shuttlecock were used to measure the impact of location. For all players, a highly skilled badminton athlete served the powerful shuttlecock towards the right rear-court (about 4 meters from the net and about 1.3 meters from the right side line for single). Two participant groups were selected and evaluated to determine the impact of experience: a novice group and a skilled group. Both groups were mixed with males and females because gender was not a factor in the investigation. Subsequent statistical analysis using the General Linear Model (univariate test, gender as covariate) demonstrated that gender had no significant impact on the results ($P > 0.05$ for release speed, clearance height, and release angle, respectively). (SPSS V16.0).

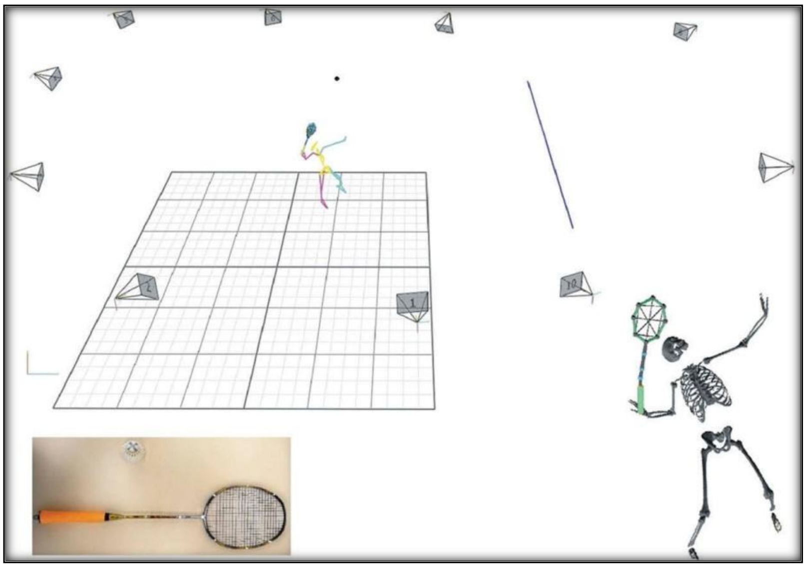

Figure 1 shows a reconstruction of the 3D motion capture data using 10 camera locations, a wire frame mesh recreation of a smash (on the left), a 15-segment biomechanical model (on the right-bottom), and a racket model (on the left-bottom).

Prior to the exam, each subject completed a personalized warm-up. Following a warm-up, he or she successfully executed 12 standing smashes at a distance of 4 meters, 9 of which were directed at a static shuttlecock (the height at which it hung dependent on the subject's height) and 3 of which were directed at a moving shuttlecock. Standing smash was employed in this study even though jump-smash is frequently used in badminton competition. The goals are to (1) standardize the exam and (2) reduce the impact of confounding factors like jumping. Three different positions—the self-selected comfort position (Figure 2, middle), 20% of his or her body height in front of the selected middle position (Figure 2, front), and 20% of his or her body height in back of the selected middle position (Figure 2, rear)—were used for the smashes towards the static shuttlecock. Due to factors affecting human motor control, such as upper limb length, body height is used to standardize positions.According to Shan and Bohn [13], lower limb lengths and stride length are closely connected to body height. A pre-test with six people chose to utilize 20% of body height to determine the other two spots. The simple instruction given to the participants during the testing was "to smash/hit the shuttlecock as hard as possible" because in the study of badminton, smash refers to power or speed. The participants may complete the skill using their typical "motor control style" in

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response to this streamlined command. Therefore, the information gathered might be utilized to show how smash quality and training level relate to one another. Analysis and minimization of data.The Badminton World Federation's approved standard shuttlecocks and net height (1.524 m) were used throughout the test (BWF, 2014). Three markers were used to specify the height. According to empirical data, a successful attack should send a release shuttlecock towards the opponent's court as quickly, steeply downhill, and closely over the net as feasible. As a result, the quality of a smash is directly correlated with these three crucial parameters: shuttlecock release speed (Vrelease), shuttlecock release angle (), and shuttlecock clearance height (Hc) (Figure 3). The three factors in the study were chosen to be quantified using a 3D motion capture technology in order to assess the impact of body alignment and the impact of training on the badminton smash.

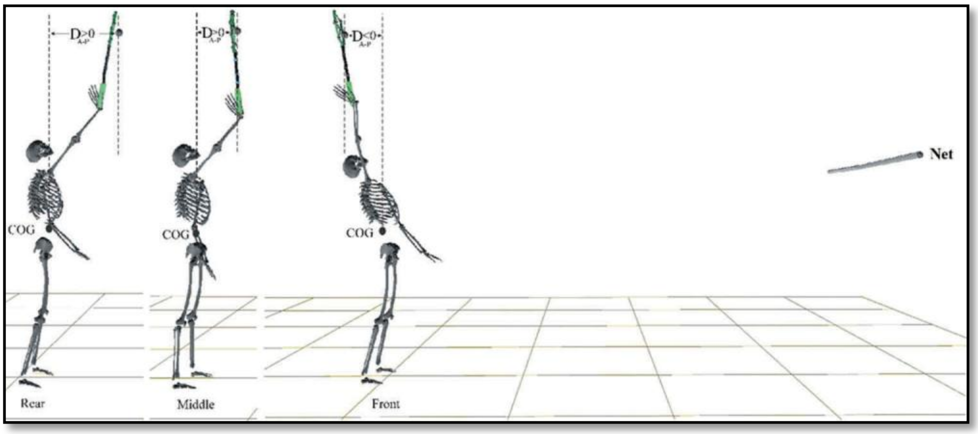

Figure2.Thestaticbodypositioningtestedinthestudy.

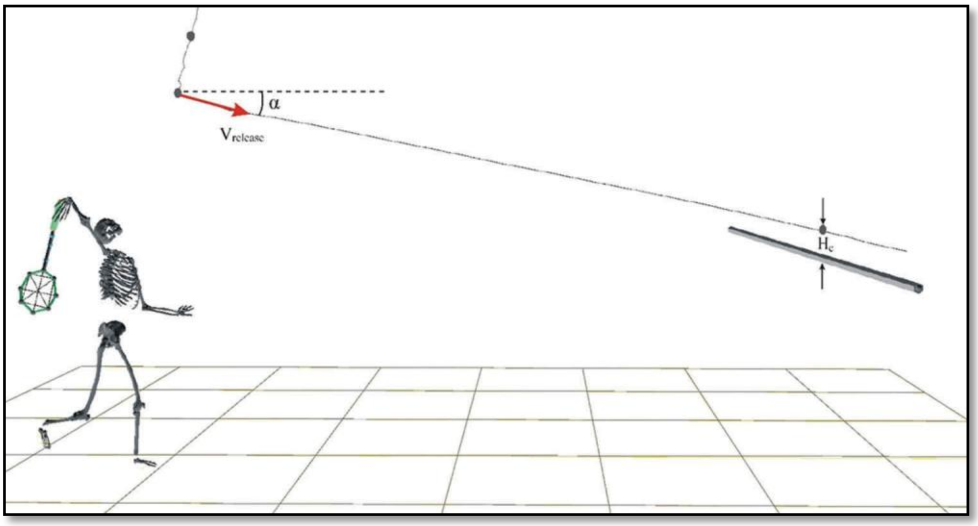

Figure3.Parametersofthesmashquality:$V_{release}$–releasespeed,$\alpha_{release}$–releaseangleandH_c–clearanceheight

A five-point smoothing filter was used to handle the raw data that had been obtained. The resulting information was used to develop the 15-segment biomechanical model (Figure 1), which could be used to predict the majority of motor control skills in sports [14]. The

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primary data included marker location, position changes, velocities, and accelerations. The head, upper trunk, lower trunk, upper arms, lower arms, hands, thighs, shanks, and feet were the model's distinguishing features. This model provides a mathematical technique to quantify the body posture connected to the shuttle-cock by precisely determining the center of gravity (COG) of the subject's body during any complex action (Figure 2). Anthropometric norms derived from statistical investigations are used in this biomechanical model to evaluate the body's inertial characteristics [16]. Additionally, body positioning and training levels may have an impact on the racket angle upon collision with the shuttlecock from a vertical orientation, which may impair the smash quality. So, in this study, the racket angle was also measured.To describe the parameters derived from biomechanical modelling, descriptive statistics (averages, standard deviation) were used. Utilizing a mixed design analysis of variance (ANOVA), where skill level was treated as the between-subject factor and positioning as the within-subject factor, the quality parameters (Vrelease - release speed, - release angle, and Hc - clearance height) were analyzed in relation to positioning (front, middle, and rear). SPSS V. 16 was used to conduct statistical analyses, and the P .05. was chosen as the significance alpha level.

Results

Two-way mixed-design ANOVA analysis findings revealed that there were no interaction effects ofPositioning and skill level have an impact on the smash quality, specifically on the inter-action impacts on the discharge speed Vrelease (F2, 81 = 0.056, P = 0.846), the release angle (F2, 81 = 1.349, P = 0.262), the clearance height Hc (F2, 81 = 0.708, P = 0.494), and the racket angle at impact with the shuttlecock from vertical direction (F2, 81 = 0.143, P = 0.867). The key implications of placement, skill level, and comparisons among static and dynamic smashes are hence the focus of the results and debates.To examine the impact of placement, both anterior-posterior (A-P) and medial-lateral (M-L) distances across the body COG and shuttlecock (DA-P & DM-L) were used. For each individual in the two test groups, DA-P and DM-L were determined in each of the three static positions and in the dynamic position (Table 1).

Table 1. Body positioning quantified by using the anterior–posterior (A–P) andmedial–lateral (M–L) distances (average ± standard deviation) between bodyCOG and shuttlecock at the instant of racket-shuttlecock contact (D_{A-P}&D_{M-L}) and thec omparisons between the dynamic and static conditions.

		Novice(n=15)	Skilled(n=14)	Diff
D_{A-P}(m)	Dyn	0.45±0.22	0.46±0.11	0.01
SF		0.08±0.11**	0.00±0.14**	−0.08
SM		0.41±0.111	0.42±0.080	0.01
SR		0.67±0.09**	0.70±0.10**	0.03
D_{M-L}(m)	Dyn	0.31±0.10	0.34±0.08	0.03
SF		0.06±0.09**	0.02±0.13**	−0.04
SM		0.29±0.07	0.33±0.07	0.04
SR		0.43±0.11**	0.46±0.11**	0.03

A–P,anterior–posterior;Dyn,Dynamic;SF,static-front;SM,static-middle;SR,static-rear.
Confidenceintervals(95%):ns,notsignificant(P>0.05),*significant(P<0.05),
**highlysignificant(P<0.01).

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According to the results of the two-way mixed-design ANOVA, there were no interactions between skill level and positioning for either the DA-P or DM-L (F2, 81 = 2.038 and P = 0.136 for DA-P and F2, 81 = 2.569 and P = 0.080 for DM-L, respectively). According to the results of multiple comparisons (Scheffe), there were very significant variations between dynamic and static-front (SF) and dynamic and static-rear (SR) in both the A-P and M-L directions for both inexperienced and experienced players (P 0.01). Comparing dynamic and static-middle (SM), there was no discernible change (P > 0.05). Scheffe comparisons further supported the lack of any differences in all positions for both directions between the two groups. The features of the three crucial smash quality metrics for the novice group were as follows: (1) From SF, SM to SR, Vrelease steadily increases, but the increase was not statistically significant (P > 0.05) (Tables 2 and 3). (2) Although the decline was significant (P 0.05 or P 0.01), the reverse trend was observed for the variable. Additionally, Hc was discovered to share the same tendency as. Additionally, it was discovered that the racket angle increased from the front position to the rear position, and that this rise was very significant between the pairs SF and SR as well as SM and SR (P 0.01). SR would produce a release speed that is comparable to that of dynamic conditions, and it considerably enhanced the and Hc (P 0.01), making them even better than those of dynamic conditions.

Data from the skilled group revealed the following trends: (1) There are no significant differences between SF, SM, and SR in terms of Vrelease (P > 0.05) , (2) Both and Hc dropped continuously from SF, SM, to SR, although significant differences were only identified between SF and SR for both and Hc (P 0.01), and among SM and SR for Hc only (P 0.05). The Vrelease produced by the dynamic posture was also substantially quicker than that of the static posture (P 0.01). (4) From SF, SM to SR, it was discovered that the racket angle increased significantly (P 0.05). And (5) SM for and SR for Hc were the smash quality locations that were similar to the dynamic situation.

For all positions, there were extremely substantial variations between the two groups (P 0.01) when evaluating the smash intensity using the three crucial factors. The clearance height showed the greatest change (8.7 times difference in dynamic smash), showing that training does/will increase smash effectiveness.

Discussion

According to experience, the inability of most beginners to produce a good badminton smash is a common reason why they play badminton poorly. Typically, they struggle to produce a strong, precise smash. The variables accuracy and power are not autonomous. They naturally interact in opposition to one other [18]. Power and precision can significantly work against each other, especially for inexperienced trainees. According to the study's findings, placement (SF, SM, and SR) has no discernible impact on energy production.As a result, poor placement would likely be the cause of beginners failing to properly prepare for the shuttlecock smash. The current study launched an inquiry into the fundamental function of static positioning in relation to smash quality, and it found that position only affects a smash's clearance height and release angle.Results from static smash experiments show that for both groups, placement significantly affects the release angle (). In general, a location that is at least half a meter behind the shuttlecock will produce an improved attack angle for a smash, or a steeper downwards angle. A greater smash quality is often linked to the more downward angle, according to a prior study [19]. Training significantly improves smash quality, as was to be expected. The novice group could only produce a flying bird in SR placement, whereas the proficient group consistently created a shuttlecock that was flying downhill. The completed smashes produced a higher shuttlecock release angle for the remaining novice ranks. The results

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would show that placement plays a role for novices in learning a proper smash as the test settings are the same for both groups.The association among the releasing speed and the release angle of the shuttlecock is one obvious distinction between the findings of the current study and those of a prior study. While the current study merely demonstrates that a greater downward angle improves the release speed, the increase is not statistically significant (P 0.05) and is not consistent with the skilled smash where the release speed is shown to be connected with the release angle[20]. The outcomes would be equivalent because a fully powerful smash was recommended in both tests and a statically hanging shuttlecock was used in both. The different low limbs techniques utilized in the two studies—the natural leap smash in Zhu's study and the standing smash in the current study—could be a contributing factor to the discrepancy. According to empirical data, a leap smash would have higher force than a standing smash because of an airborne action-reaction between the upper and lower limbs (angular momentum conservation during airborne phase). As a result of the larger power, the airborne action-reaction would favor a quicker momentum transfer between joints than the stationary smash. The combined findings of the two studies suggest that the standing smash would confine the body, reducing the transfer of momentum and force from the proximal to the distal onto the shuttlecock at impact; as a result, a jump smash should be used in practice to improve the smash quality.

Conclusion

We examined the forehand overhead smash in this study to ascertain the impact of placement, a crucial element of badminton training and learning. The results of the current study have revealed that body placement, particularly the shuttlecock release angle and clearance height of an offensive attack, directly affect the quality of a smash. The findings imply that one might conduct a self-selected comfort position towards a statically hung shuttlecock and then walk one foot back - a useful reference point for training - to instruct novices' placement. Improved limb coordination would raise smash quality more as one obtains experience via consistent training.

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Submitted: 27April 2023, Revised: 09 May2023, Accepted: 18 May 2023, Published: June 2023

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