# BIOMECHANICAL ANALYSIS OF BADMINTON FOREHAND NET SHOTS

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The purpose of this study was to compare the upper extremity kinematics variables of badminton forehand dab shot, stab shot and cross court net shot. The participants were eight elite collegiate male players in Taiwan. The kinematical data were collected by Vicon system (250Hz) and the Visual 3D software was used to analyze the variables. The results indicated that the elite badminton players perfomed dab net shot with less angular velocity in racket upper limb joints. They performed the stab net shot with faster angular velocity in forearm supination and wrist ulnar flexion. The cross court net shot had greatest angular velocity in shoulder internal rotation, forearm pronation and the least distance between the contact point and the mid-line of body.

**KEY WORDS:** dab, stab, shuttlecock.

**INTRODUCTION:** High levels of skill across a variety of shots are needed for success in badminton. Players often used short service (78%) and returned with net shot (42%) in the men's single (Lu & Huang, 2005) in order to create an initiative attack chance. These situations were similar in doubles competition. It has also been reported that there was a high number of errors in net shots, the errors in men was 30.18%, in women was 44.81% (Huang, 1999), hence when analysing stroke production it is important to include this stroke. However, most previous studies in badminton have been focused on the forehand overhead stroke skills (Tang, Abe, Katoh, & Ae, 1995 and Tsai, Huang, & Jyh 1997, 2000). Previous authors have used 2D, 3D kinematics and inverse dynamics to describe the forehand drop, clear, smash, jump smash and so on. But there is a paucity of research on net shots. So the purpose of this study was focus on three basic forehand net shot (dab shot, stab shot and cross court shot) and we like to compare the kinematics variables among them.

**METHODS:** Eight elite collegiate male players served as the participants (21 ±2 y; 176 ±8 cm; 68 ±6 kg). They were all right-handed and had trained for many years. In this study, we were interested in analyzing the motions in the hitting phase. Ten Vicon MX-13$^{+}$ cameras (Vicon, Oxford, UK, 250 Hz) were used to collect the passive markers data. Fifty-four passive markers were attached on each participant and the racket (47 points on the body, 7 points on the racket in Figure 1), and the accuracy of 3D calibration was 0.3 mm. The Butterworth 2nd order bidirectional lowpass filter with a 6 Hz cut-off frequency was used to filter all markers. The C-motion Visual 3D software was used to calculate body kinematic variables.

Figure 1: The marker positions.

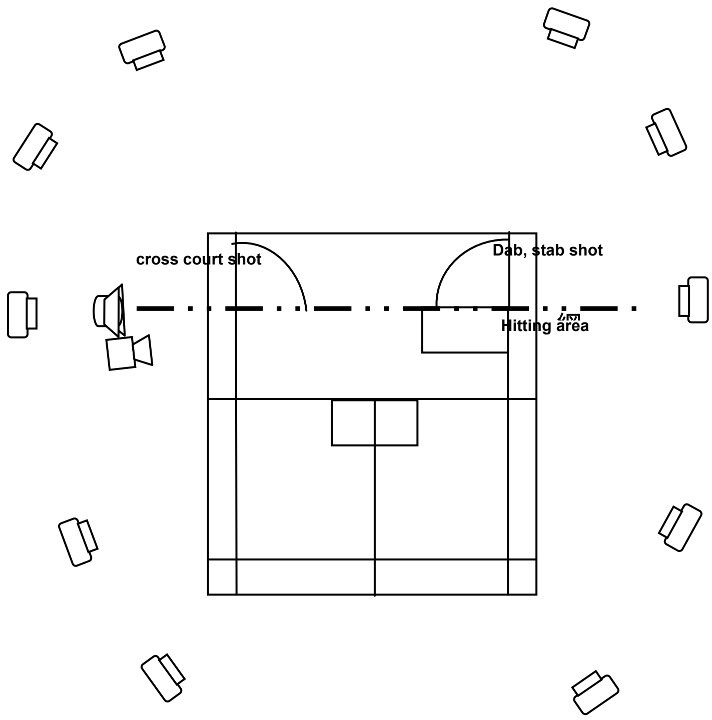


Figure 2: The schematic of the experimental setup.

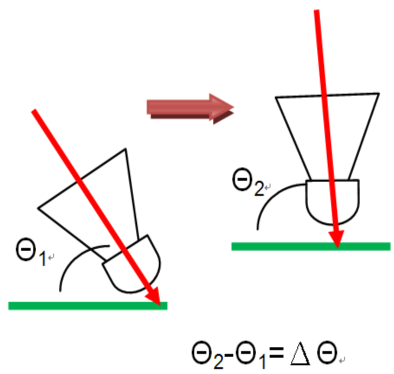


**Figure 3: Shuttlecock tumbling angle definition.**

In the preparation phase, the participants were standing on the middle of the court to prepare to hit the shuttle that was served over the net from the opposite court by a national badminton player. The participants performed five times successful trials in the dab, the stab and the cross court net shots in the hitting area as in Figure 2 with counterbalance, and choosing one of best trial, which had the lowest height when shuttlecock crossed the net, to be analyzed.

One high speed camera operated at 300 Hz was synchronized to record shuttlecock images. Two markers (shuttlecock head, shuttlecock tail) were digitized and analyzed with the Kwon 3D motion analysis system. The Butterworth 4th order zero lag digital filter with a 6 Hz cut-off frequency was used to filter the shuttlecock marker data. We calculated the shuttlecock coronal axis angular displacement variables on sagittal plane from the markers on the shuttlecock (Figure 3). These data were used to calculate tumbling angular velocity of shuttlecock, in order to provide a selection standard for dab shot and stab shot. The instant kinematical variables of three different net shot in the hitting were tested by Friedman two-way analysis of variance nonparametric statistical method by SPSS 12.0 software at a .05 significant level. The rank average method was used for the post hoc test (Siegel & Castellan, 1988).

**RESULTS:** Table 1 shows the linear and the angular kinematical data of the dab, the stab and the cross court shot. There were significant differences among the dab, the stab and the cross court net shots. After the post-hoc testing, we found the cross court shot were significant difference from the stab shot and the dab shot in the horizontal distance between COM and contact point, shoulder internal/external rotation angle, forearm pronation/supination angle and shoulder horizontal addtion/abduction angular velocity variables. But in the variable of forearm pronation/supination angular velocity and wrist ulnlar flexion/radial flexion angular velocity, the significant difference only happened between the cross court shot and the stab shot.

**Table 1: Kinematics and data from post-hoc tests among the dab, the stab and the cross court net shots.**

| Variables | Stroke | Average ±SD | Hoc test | |
|---|---|---|---|---|
| | | | Stab shot | Cross court shot |
| Horizontal distance between COM and contact point (cm) | Dab shot | 82.0 ±9.0 | | * |
| | Stab shot | 83.0 ±8.0 | --- | * |
| | Cross court shot | 61.0 ±8.0 | --- | --- |
| Shoulder int. rotation (+)/ext. rotation(-) angle (deg) | Dab shot | -99.8 ±7.1 | | * |
| | Stab shot | -101.0 ±5.9 | --- | * |
| | Cross court shot | -82.1 ±5.1 | --- | --- |
| Forearm pronation(+)/ supination(-)angle(deg) | Dab shot | 29.2 ±9.6 | | * |
| | Stab shot | 29.1 ±12.1 | --- | * |
| | Cross court shot | 87.9 ±13.9 | --- | --- |
| Shoulder horizontal addtion(+)/abduction(-) angular velocity(deg/s) | Dab shot | 73.9 ±50.1 | | * |
| | Stab shot | 70.7 ±49.1 | --- | * |
| | Cross court shot | -107.5 ±54.4 | | --- |
| Forearm pronation(+)/ supination(-)angular velocity(deg/s) | Dab shot | 30.8 ±49.5 | | |
| | Stab shot | -34.1 ±69.4 | --- | * |
| | Cross court shot | 261.1 ±145.8 | --- | --- |
| Wrist ulnar flexion(+)/ Radial flexion(-) angular velocity(deg/s) | Dab shot | 7.3 ±8.4 | | |
| | Stab shot | 86.9 ±22.9 | --- | * |
| | Cross court shot | -89.4 ±90.2 | --- | --- |

*$^*p$ <.05*

**DISCUSSION:** From the result of horizontal distance between COM and contact point, we found that the contact point of cross court shot was closer to the mid-line of body about 20 cm in average than the other two skills. This was because players should hit the lateral aspect of shuttlecock to make it fly cross the court. In order to hit the suttlecock laterally also make the differences were also recorded in shoulder rotation angle and forearm pronation angle. This result was also found in the double player's serves to the different placement (Chou, Huang, Lin & Won, 2003). We also found that the cross net shot had greater angular velocity in shoulder internal rotation, forearm pronation and wrist radial flexion than the other two skills. But in the wrist joint angular velocity, the cross court net shot only had significant difference from the stab net shot.

The dab net shot joint angular velocity was also less than the two other skills in the distal joint. The joint angular velocity in dab net shot was needed to enable the players hit the shuttlecock over the net gently. In the stab net shot aspect, we found that the angular velocity characteristic in contact point was faster in the forearm supination and wrist ulnar flexion. These two joint movements could make the racket fast to cut the shuttlecock in the transverse plane thus causing the shuttlecock to tumbling irregularly.

**CONCLUSION:** From the results, we found that there were significant differences among the three kinds of net shots. We extracted the strategies of the elite badminton players to performed the fine net shot skills as follows. The elite badminton players perfomed dab net shot with less angular velocity on dominate hand upper limb joints. They performed the stab net shot with faster angular velocity in forearm supination and wrist ulnar flexion movements. They played the cross court net shot with the greatest angular velocity in shoulder internal rotation, forearm pronation and least distance between contact point and the mid-line of the body.

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