THE GRIP PRESSURE ANALYSIS OF THREE BADMINTON FOREHAND OVERHEAD STROKES – A CASE STUDY

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The purpose of this study was to analyze the palm distribution variables (finger forces and pressure) on the dominant hand of a collegiate 1st class female badminton player when performing drop, clear, and smash overhead strokes. We aimed to analyze from the preparation period to the contact point with the shuttle. A high-speed digital camera (2000Hz) and a grip measurement system (500Hz) were simultaneously used to record the 2D movement and collect 18 palm areas of grip force and pressure of the dominant hand. The results showed that the finger signal of the forehand overhead strokes of the participant was similar for both clear and smash strokes. The peak grip pressure of the movements appeared before the contact point in all three different overhead strokes. Based on the results, we suggest that increasing grip strength training might enhance shuttle velocity.

KEYWORDS: finger force, grip distribution, smash, female player

INTRODUCTION: The forehand overhead stroke (Figure 1) is one of the most important techniques in the game of badminton. This stroke can be divided into three main techniques: drop, clear, and smash strokes. Previous studies on badminton have primarily focused on motion analysis, inverse dynamics (Tang, Abe, Katoh, & Ae, 1995), and EMG analysis (Tsai, Hsueh, Pan, Chang, & Yu, 2008). Only a few researchers have analyzed badminton stroke movements using grip measurement methods (Figure 2) (Pan & Tsai, 2023). Since the hand is the final part of the body segment responsible for gripping and controlling the racket, the dynamics of finger involvement are still not fully understood. The purpose of this study was to compare the grip signals among the forehand drop, clear, and smash strokes of female collegiate badminton players. We aimed to analyze variables such as shuttlecock velocity at initiation, contact height, grip force, and grip pressure of the dominant hand around the contact point.

1. Distal phalanx of thumb
2. Proximal phalanx of thumb
3,4,5. Distal, Middle, Proximal phalanx of index finger
6,7,8. Distal, Middle, Proximal phalanx of middle finger
9,10,11. Distal, Middle, Proximal phalanx of the ring finger
12,13,14. Distal, Middle, Proximal phalanx of little finger
15. Metacarpal of index finger
16. Third to fifth metacarpal
17. Thenar 18. Hypothenar

Figure 1. The Badminton Forehand Over Strokes **Figure 2. The Tekscan Palm pressure sensors**

METHODS: One female badminton player, a first-year college student at level 1, right-handed, with a height of 163 cm and weight of 49 kg, participated in the study. She performed forehand drop, clear, and smash strokes. The schematic drawing of the experimental setup is shown in Figure 3. Palm pressure sensors (Tekscan Grip 4256E, South Boston, MA, USA. 500Hz) were affixed to the fingers of the dominant hand (Figure 2). Tekscan software was utilized to collect 18 areas finger grip force and pressure signals while the badminton player executed the three forehand overhead strokes. A PHANTOM VEO 710L-18GB-Mono high-speed camera (2000Hz) was concurrently employed to capture the player's 2D movement image. The grip signal was calibrated using a 4.55kg dumbbell to calculate the linear regression line for each area using the Tekscan software. Our focus was on analyzing the grip signal from the preparation period, through the racket's downswing, acceleration to the contact, and continuing 0.1 second after the contact point. Kinematic data of the participant were processed using Phantom CineViewer 3.4 software. Biomechanical variables included initial shuttle speed, contact height from the kinematics data, grip signal pattern, grip force and pressure at the shuttlecock contact point, and the peak grip force and pressure during the execution of the three forehand overhead strokes.

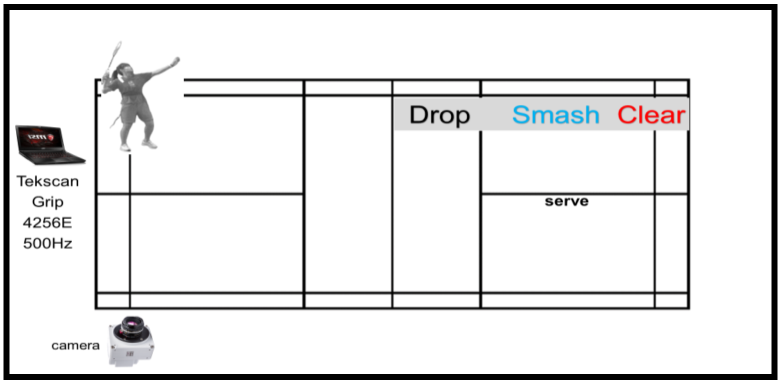

Figure 3. The Schematic of the Experimental Setup

RESULTS: Table 1 presents the kinematic data of the participant. Figure 4 displays the palm force distribution for the three overhead strokes, while Figure 5 illustrates the finger resultant force curves executed during the movement of the same strokes. The variables of finger force and pressure are shown in Tables 2 and 3, respectively.

Table 1: The Kinematics Variables of 3 Strokes

Variables	Drop	Clear	Smash
Initial Shuttle Velocity (m/s)	25.11	67.13	47.53
Contact Point Height (m)	2.202	2.413	2.342
Down Swing Duration Time (sec)	0.356	0.3075	0.176
Up Swing Duration Time (sec)	0.250	0.1435	0.120
Total Swing Movement Time (sec)	0.606	0.4510	0.296
Wrist Angle at Contact (deg)	146	150	158
Racket Angle at Contact (deg)	99	103	86
Shuttle Flight Angle after Contact (deg)	18	24	0
Contact Duration Time (sec)	0.0055	0.0025	0.0025

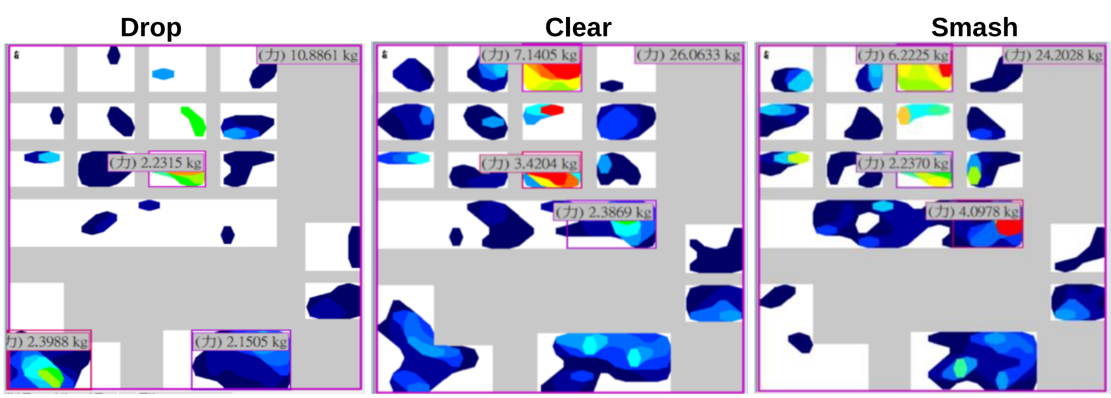

Figure 4: The finger force distribution of three forehand overhead strokes at contact

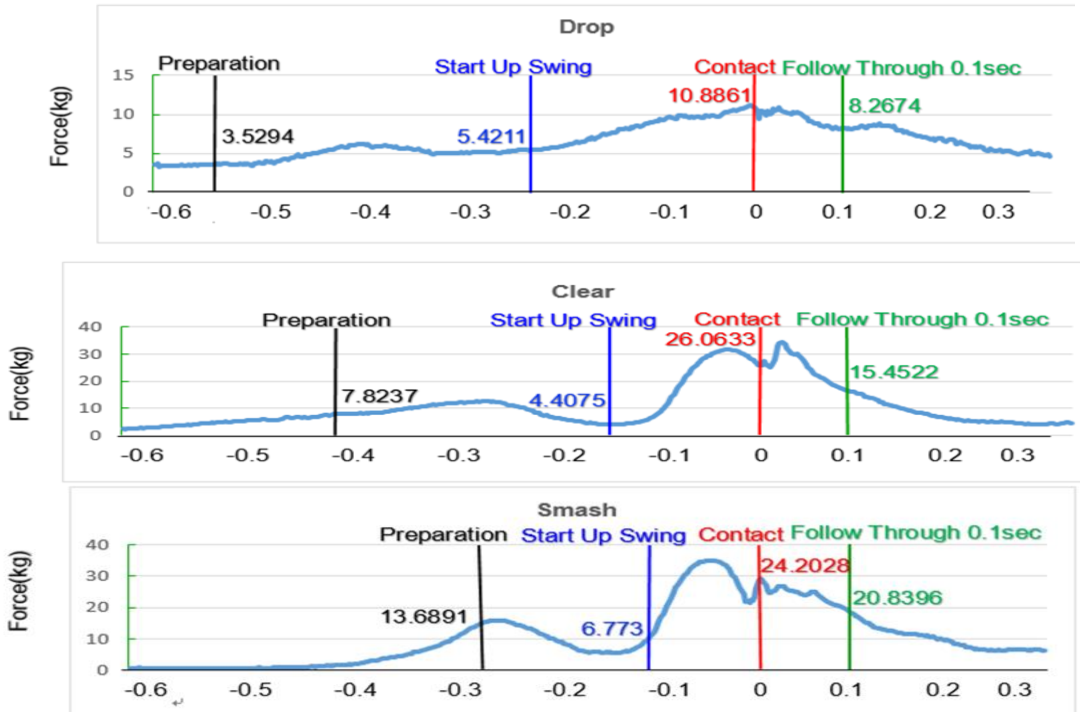

Figure 5: The resultant finger force curves of three forehand overhead strokes

Table 2: The Finger Force Variables of 3 Strokes

Variables	Drop	Clear	Smash
Resultant Force of Preparation (kg)	3.5294	7.8237	13.6891
Resultant Force of Start Swing Up (kg)	5.4211	4.4075	6.773
Resultant Force at Contact Point (kg)	10.8861	26.0633	24.2028
Follow Through 0.1sec After Contact (kg)	8.2674	15.4522	20.8396
Max. Resultant Force (kg)	11.179	34.3674	34.8949
Max. Resultant Force Time from Contact (sec)	0.00125	0.00587	-0.00975
Finger Peak Force (kg)	2.5323	9.4055	9.3613
Finger Peak Force Time (sec)	0.00075	-0.00763	0.00775
Finger Force at Contact (kg)	2.3988	7.1405	6.2225
2nd Large Force at Contact (kg)	2.2315	3.4204	4.0978
3rd Large Force at Contact (kg)	2.1506	2.3869	2.2370

Table 3: The Finger Pressure Variables of 3 Strokes

Variables	Drop	Clear	Smash
Resultant Pressure of Preparation (kg/cm²)	0.2980	0.4612	0.5554
Resultant Pressure of Start Swing Up (kg/cm²)	0.3528	0.3486	0.3413
Resultant Pressure at Contact Point (kg/cm²)	0.4929	0.7718	0.745
Follow Through 0.1sec After Contact (kg/cm²)	0.4005	0.6072	0.6201
Max. Resultant Pressure (kg/cm²)	0.5099	1.0811	1.0231
Max. Resultant Pressure Time from Contact(sec)	-0.005	-.0.0405	-0.037
Finger Peak Pressure (kg/cm²)	2.3961	4.6529	4.7303
Finger Peak Pressure Time (sec)	0.009	-0.0305	-0.031
Finger Pressure at Contact (kg/cm²)	2.2117	3.4963	3.8305
2nd Large Pressure at Contact (kg/cm²)	1.9919	3.0401	3.723
3rd Large Pressure at Contact (kg/cm²)	1.5537	2.6715	2.9712

DISCUSSIONS: In Table 1, we observed that the shuttle's initial velocity and the contact point height followed the order of clear > smash > drop. Interestingly, the performance of the female participant differed from the findings of previous studies (Tsai, Hsueh, Pan, Chang, & Yu, 2008) and (Pan & Tsai, 2023). The movement time of the smash was faster than that of the clear and drop shots. Contact duration times between the racket and shuttlecock were 0.0055 sec for the drop, 0.0025 sec for both the clear and smash strokes, with the clear being similar to the smash. Figure 4 displays the finger force distribution of the three overhead strokes. The finger force distribution varied among the three strokes. The peak finger force was exerted on the distal phalanx of the middle finger during both the clear and smash strokes at the contact point. However, the maximum finger force was observed at the hypothenar muscles during the drop shot, which differed from the clear and smash strokes. We observed that the finger resultant force curve of the drop shot differed from those of the clear and smash strokes for this participant in Figure 5. In Table 2, we found that the maximum resultant force of the smash was greater than that of the clear and drop shots. Additionally, we noted that as shuttle velocity increased, the resultant force at the contact point and peak finger force also increased, which is similar to the results of the study by Pan & Tsai (2023). The maximum resultant force appeared after contact in the drop and clear strokes, but the smash stroke appeared before the contact point. In Table 3, we found that the maximum resultant pressure appeared before contact in all three forehand overhead strokes. We also found that the peak finger pressure of the clear and smash strokes was at the proximal phalanx of the middle finger and the distal phalanx. Besides the distal phalanx of the middle finger, the proximal middle finger and the second metacarpal played the second or third roles in the clear and smash strokes at the contact point.

CONCLUSIONS: In this study, a collegiate female badminton player was analyzed using a high-speed camera and a palm pressure sensor. We observed that the finger resultant force curves for clear and smash strokes were more similar than with drop shot. The middle finger and the second metacarpal of the dominant hand exerted the greatest force during both clear and smash strokes at the contact point. Contrary to a previous study (Tsai, Hsueh, Pan, Chang, & Yu, 2008), we found that although the female player's clear stroke was faster than the smash stroke, some outcomes were still achieved. For instance, as shuttle velocity increased, the height of the contact point, as well as the resultant grip force, finger force, and finger pressure at the contact point, also increased. Moreover, with increasing shuttle velocity, the peak finger force and peak finger pressure also increased. Based on the study results, we suggest that increasing grip strength training might enhance shuttle velocity. As this study represents the first investigation into finger pressure in female badminton player, and the influence of finger dynamics on performance remains unclear, further research should involve a larger sample of badminton players. We hope to identify more important factors to better understand the dynamics of finger movement in badminton techniques.

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