THE GRIP DISTRIBUTION ANALYSIS BETWEEN BADMINTON SMASH AND JUMP SMASH

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Badminton smash is one of the most powerful and fastest techniques in racket sports. The purpose of this study was to analyze the grip force and pressure of a collegiate first-class badminton player while performing smash and jump smash movements. A grip pressure system (500Hz) and a high-speed digital camera (2000Hz) were simultaneously used to collect eighteen areas of grip force and pressure of the dominant hand, along with 2D kinematics motion images. The results revealed that the initial shuttle velocity of the jump smash was faster than that of the smash stroke. Additionally, the swing movement of the jump smash was faster than that of the smash. The maximum grip force and peak finger force point during the jump smash were greater compared to the smash. Furthermore, it was observed that the middle finger played a primary role when executing both the smash and jump smash strokes.

KEY WORDS: biomechanics, finger measurement, finger force, finger pressure

INTRODUCTION: Badminton is recognized as the fastest sport globally (PledgeSports, 2024), and it ranks as the second most popular participation sport worldwide (Guinness World Record, 2024). Among the various badminton skills, the smash (Figure 1) stands out as one of the most powerful strokes, which can further be categorized into the standing smash (smash) and the jump smash (Figure 2). Previous studies on badminton have primarily focused on motion analysis, often combining it with other dynamic analysis methods to scrutinize badminton strokes. In the 1970s, Gowetzke (1979) described the smash stroke using a 2D model, while Tang, Abe, Katoh, & Ae (1995) employed a 3D approach to measure smash movements. Tsai, Huang, Chang, & Lai (2003), compared the smash and jump smash of elite players using a 3D model and found that the jump smash was faster than the regular smash. The dominant hand is responsible for holding and controlling the racket, with fingers movement significantly influencing the final stroke outcome; however, the grip measurement method for analyzing badminton stroke movements remains unclear. The primary aim of this study was to compare the grip signal differences between the regular smash and the jump smash, focusing on variables such as shuttle velocity, contact height, grip force, and grip pressure across 18 areas of the dominant hand for both types of smashes.

Figure 1: The Smash Movement

Figure 2: The Jump Smash Movement

METHODS: One badminton college level 1st player (170 cm, 68 kg) was recruited as the participant to perform the smash and jumping smash on the badminton court. The schematic drawing of the experimental setup was shown on Fig. 3. One PHANTOM VEO 710L-18GB-Mono high-speed camera (2000Hz) was used to record the 2D movement image of the participant. The palm pressure sensors (Tekscan Grip 4256E, South Boston, MA, USA. 500Hz) were pasted on the fingers and the palm of the dominate hand, the Tekscan software was simultaneously used to collect finger grip force and pressure data while the badminton player was performing the smash and jump smash strokes. The kinematics data of the participant was calculated by using Phantom CineViewer 3.4 software. The grip signal was calibrated and analyzed by the Takscan software. We were interested in analyzing the grip signal was from the phase of -0.6 second before contact to 0.4 second after contact. The initial shuttle speed, contact height, and the grip signal pattern, the grip force and pressure at the shuttlecock contact point, the peak grip force and pressure during the movement of the smash and the jump smash. This study received approval from the ethical review board of National Taiwan Normal University, and the participant provided informed consent before testing.

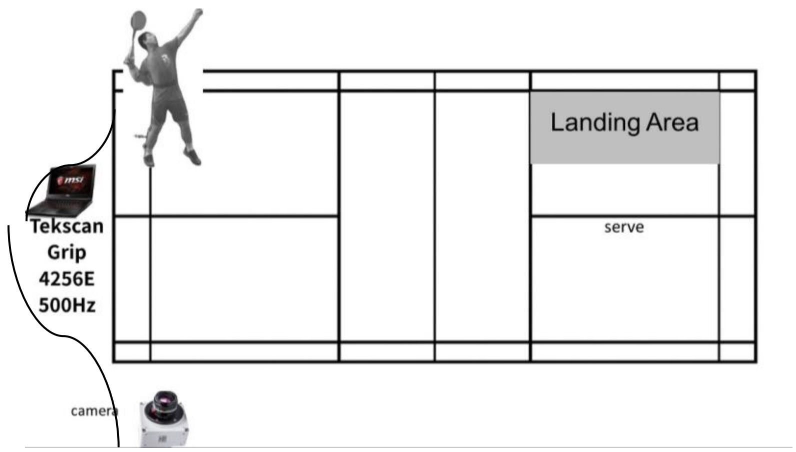

Figure 3: The Schematic of the Experimental Setup

RESULTS AND DISCUSSION: The kinematic data of the smash and jump smash strokes are presented in Table 1. The player performed a shuttle initial velocity of 97.72 m/s for the smash and 102.48 m/s for the jump smash, both faster than those reported in previous studies by Tsai et al. in 2003. The contact duration for both smashes was 0.0025 seconds. Additionally, the player executed the jump smash with a contact height 50 cm higher than that of the smash stroke. Figure 4 illustrates the top three finger forces on the palm at the point of contact, which were also the top three force areas for both the smash and jump smash. Notably, the middle finger exerted the greatest force before the point of contact. Figure 5 illustrates the total force curves of the fingers during the smash and jump smash actions, both exhibiting similar patterns. The colored values represent the values at the onset of each event. We also observed a similar peak force before racket contact with the shuttlecock for both actions. Furthermore, in the jump smash, the total finger force reaches its maximum value at 0.01 seconds after the hit (990N), suggesting that this peak finger force is likely used for braking. However, the braking finger force during the smash action was not greater than the force exerted during the upward swing phase before the contact point.

Table 1: The Kinematics variables of smash and jump smash

Variables	Smash	Jump smash
Initial Shuttle Velocity (m/s)	97.72	102.48
Contact Point Height (m)	2.501	3.026
Down Swing Duration Time (sec)	0.338	0.1415
Up Swing Duration Time (sec)	0.106	0.0855
Total Swing Movement Time (sec)	0.444	0.227
Wrist Angle at Contact (deg)	159	166
Racket Angle at Contact (deg)	80	76
Shuttle Flight Angle after Contact (deg)	-17	-8
Contact Duration Time (sec)	0.0025	0.0025

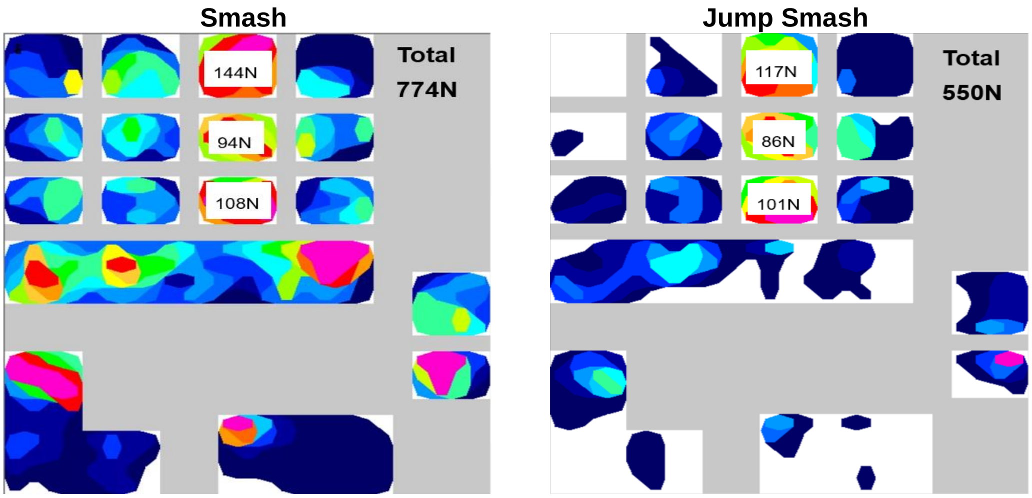

Figure 4: The finger force graphs of the smash and the jump smash at contact

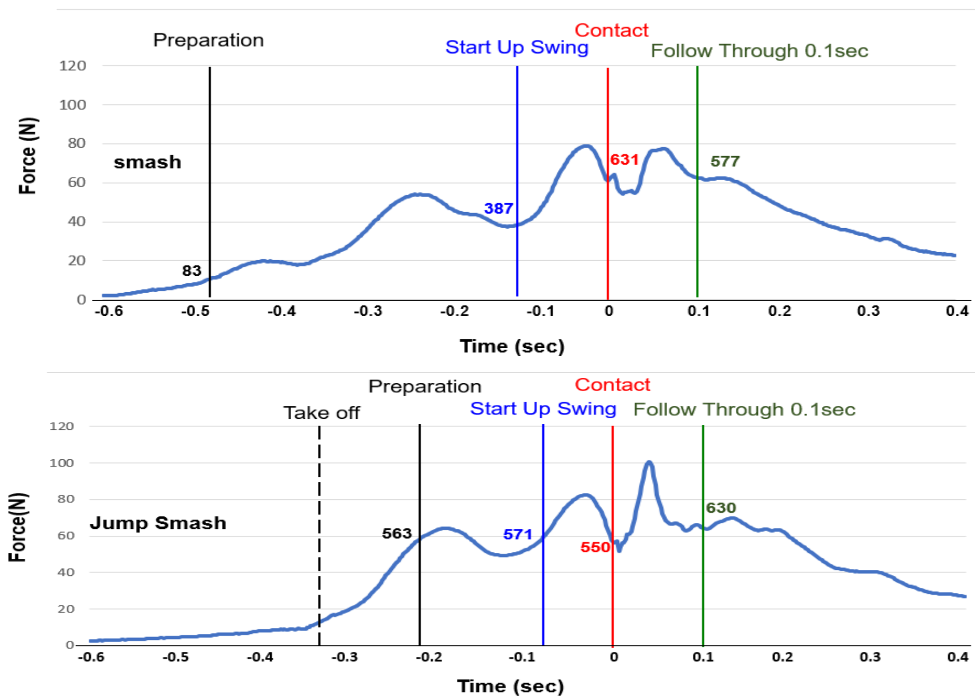

Figure 5: The finger force signal pattern of the smash and jump smash

Table 2: The finger force variables of smash and jump smash

Variables	Smash	Jump Smash
Preparation (Start Down Swing) (N)	83	563
Start Up Swing (N)	387	571
Contact (N)	631	550
Follow Through 0.1sec After Contact (N)	577	630
Maximum Total Force (N)	774	990
Maximum Total Force Time (sec)	-0.008	0.01
Finger Peak Force-Mid. Finger 1^{st} phalanx (N)	144	148
Finger Peak Force Time -Mid. Finger 1^{st} phalanx (sec)	-0.0075	-0.007
Finger Force at Contact- Middle Finger 1^{st} phalanx (N)	112	117
2^{nd} Large Force at Contact- Middle Finger 3^{rd} phalanx (N)	108	101
3^{rd} Large Force at Contact- Middle Finger 2^{nd} phalanx (N)	94	86

Table 3: The finger pressure variables of smash and jump smash

Variables	Smash	Jump smash
Preparation (Start Down Swing) (N/cm^2)	4	14
Start Up Swing (N/cm^2)	10	14
Contact (N/cm^2)	16	15
Follow Through 0.1sec After Contact (N/cm^2)	14	15
Maximum All Palm Pressure (N/cm^2)	18	23
Maximum Total Pressure Time (sec)	0.054	0.038
Finger Peak Pressure- Mid. Finger 1st phalanx (N/cm^2)	68	66
Finger Peak Pressure Time - Mid. Finger 1st phalanx (sec)	-0.03	-0.028
Finger Pressure at Contact- Mid. Finger 3rd phalanx (N/cm^2)	56	53
2nd Pressure at Contact- Mid. Finger 2nd phalanx (N/cm^2)	49	46
3rd Pressure at Contact- Mid. Finger 1st phalanx (N/cm^2)	44	45

The finger force and pressure data are presented in tables 2 and 3. In both tables, we found that during the preparation phase, when the racket started to move downward, the jump smash exhibited greater finger force and pressure compared to the smash. The maximum finger resultant pressure (23 N/cm^2) of the jump smash was greater than that of the smash (18 N/cm^2), and both occurred after the point of contact. However, the total finger force of the jump smash at the point of contact was less than that of the smash. The peak finger force and pressure points were observed at the 1st phalanx of the middle finger in both the smash and jump smash strokes, occurring before the point of contact. Our findings indicate that the middle finger exhibited the greatest finger force and pressure before the contact point in both the smash and jump smash strokes. This study represents the first observation of finger force in badminton smash strokes, which may inspire both players and coaches in the sport.

CONCLUSIONS: This study examined finger pressure signals in the dominant hand of a collegiate badminton player in Taiwan, focusing on smash and jump smash movements. The results indicated that the jump smash features a faster shuttle velocity, higher contact point, and faster swing movement compared to the smash. Additionally, the movement time of the jump smash was faster than that of the smash from preparation to contact point. We found the finger force pattern of both strokes was similar, with the finger total force of the jump smash increasing rapidly after the player jumps off the ground. A similar peak force was observed before the contact point in both actions. Notably, a very high brake force reached in the jump smash exceeded the exerted force. These findings underscored the importance of grip force in executing a fast smash stroke in badminton, with the middle finger of the dominant hand exerting the greatest force in both types of smashes. The results served as a valuable reference for coaches and players and aimed to include a larger sample of badminton players in future studies.

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