BIOMECHANICAL ANALYSIS OF DIFFERENT BADMINTON FOREHAND OVERHEAD STROKES OF TAIWAN ELITE FEMALE PLAYERS

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The purpose of this study was to analyze the kinematics variables of forehand overhead smash, clear and drop shots by seven Taiwan elite female badminton players. Ten Vicon MX-13$^+$ cameras (Vicon, Oxford, UK, 300Hz) were used to record the 3D kinematics data and calculated by Vicon Nexus 1.2 system. The kinematical variables were tested by Friedman two-way analysis of variance nonparametric statistical tests among three different forehand overhead strokes at a .05 significant level. The results showed that there were significant differences among the three forehand strokes in the initial shuttle velocity, the initial shuttle angle, the contact vertical COM velocity. The greatest angular velocity of the upper arm in each stroke was the shoulder internal rotation. The training on the shoulder would be very important for the badminton players.

KEY WORDS: biomechanics, badminton, female.

INTRODUCTION:

Badminton is the most popular sport class in Taiwan colleges. Badminton forehand (figure 1) overhead techniques may divide into three strokes: drop, clear and smash (figure 2). Poole, 1970; Adrian, 1971; Gowetzke, 1979, Tang, et al, 1995, Tsai, et al, 1997, 2001 & 2004 they used 2D, 3D kinematics and inverse dynamics to describe the different badminton techniques. Tsai, Huang and Jyh, 1997 they compared the kinematics variables among forehand drop, clear, smash and jump smash by elite male badminton players and found that there were significant differences in the initial flight angle, the shuttle velocity contact height, the elbow and the wrist angular velocity. Most of the previous studies were focus on the male badminton players. The purpose of this study was to analyze the kinematical variables of the badminton female players when they were performing forehand drop, clear and smash strokes. The structure of this study shows in the figure 3.

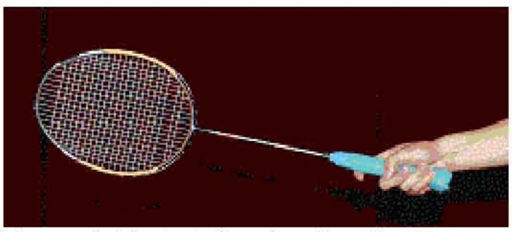

Figure 1: Badminton forehand grip

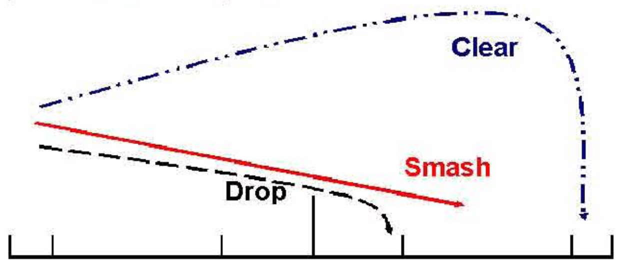

Figure 2: Shuttle trajectories of overhead strokes

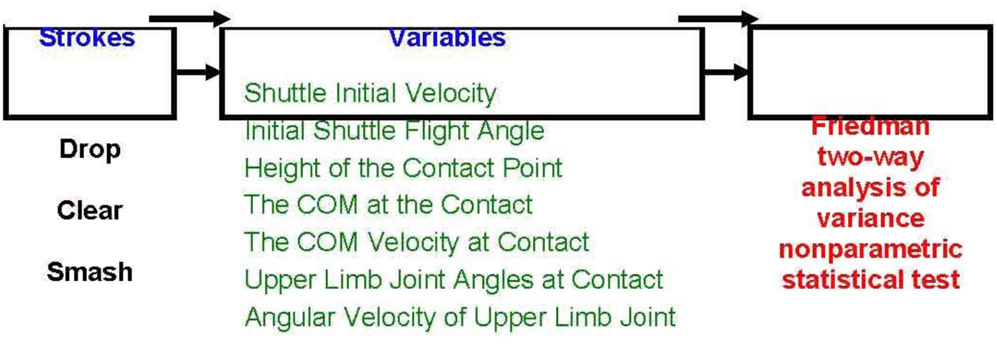

Figure 3: The structure of the study

METHOD:

Data Collection: Seven female, elite collegiate badminton players in Taiwan (age 21±2 yrs, height 161.4±3.3 cm, weight 54.7±6.0 kg) were served as the subjects. In this study, we were interested in analyzing the motions from the phase of preparation while the center of gravity (COG) went down to the lowest position to the point of making contact with the shuttlecock. Ten Vicon MX-13$^+$ cameras (Vicon, Oxford, UK, 300Hz) were used to record the 3D kinematics data. As the figure 4, there were 40 passive markers were stick on each participant and the racket (35 points on the body, 4 points on the racket frame and 1 point on the shuttle). Figure 5 shows the definition of the upper limb joint angle. The figure 6 shows the experimental setup of this study. The participants were standing on the middle of the court to prepare to hit the shuttle that served over the net from the opposite court by a national badminton player. They performed the drop, the clear and the smash strokes in the motion area as in the figure of the experimental setup. The landing areas of the drop, the clear and the smash strokes are shown as in the figure 6.

Figure 4: The marker positions

Figure 5: The upper limb sagittal angles

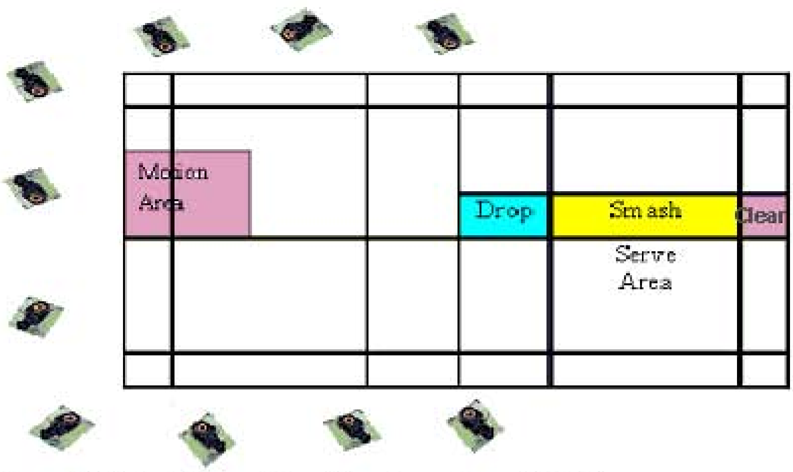

Figure 6: The Schematic of the Experimental Setup

Data Analysis: The 3D kinematics data including the initial shuttle velocity, the initial shuttle flight angle, the contact height, the Center of Mass (COM) during contact, the angle and the angular velocities of the upper limbs were calculated by Vicon Nexus 1.2 system. The kinematical variables of the three different forehand overhead strokes were tested by Friedman two-way analysis of variance nonparametric statistical method by SPSS 12.0 at a .05 significant level.

RESULTS:
Table 1 shows the linear and the angular kinematical data of the drop, the clear and the smash strokes. There were significant differences among the drop, the clear and the smash strokes in the shuttle initial velocity, the shuttle fight angle and the COM vertical velocity. The shoulder axis, the hip axis rotation angle, the elbow flexion and the wrist adduction angle, the flexion angular velocities of the shoulder, the flexion angular velocities of the elbow and the angular velocity of the shoulder internal rotation were significant different among the three strokes.

Table 1 Kinematics variables comparison among drop, clear and smash strokes

Variables	Stroke	Average	SD	Friedman test	p
Shuttle Velocity (m/s)	Drop	22.2	1.86	8.4	*
	Clear	57.8	5.53		
	Smash	59.6	3.74		
Flight angle (deg)	Drop	5.9	4.56	10	*
	Clear	15.2	2.84		
	Smash	-4.3	2.23		
COM – Z Velocity (m/s)	Drop	-0.300	0.123	12	*
	Clear	-0.478	0.159		
	Smash	-0.478	0.159		
Shoulder Axis Rotation (deg)	Drop	72.01	16.55	7.6	*
	Clear	79.92	24.06		
	Smash	90.29	20.98		
Hip Axis Rotation (deg)	Drop	63.44	9.11	7.6	*
	Clear	74.01	12.93		
	Smash	82.37	14.56		
Elbow Flexion Angle (deg)	Drop	214.3	3.58	7.6	*
	Clear	205.0	6.15		
	Smash	205.5	8.70		
Wrist Adduction Angle (deg)	Drop	43.5	7.93	8.4	*
	Clear	33.0	10.86		
	Smash	25.6	9.00		
Shoulder Flexion and Extension Angular Velocity (deg/s)	Drop	-125	102	6.5	*
	Clear	84	136		
	Smash	-78	206		
Elbow Flexion and Extension Angular Velocity (deg/s)	Drop	-110	50	6.5	*
	Clear	203	103		
	Smash	176	131		
Shoulder Intern. Rotation Angular Velocity (deg/s)	Drop	649	277	6.5	*
	Clear	3493	1163		
	Smash	3515	1821		

*$p < .05$

DISCUSSION:
From the results in table 1, the initial shuttle velocity of the drop shot (22.2 m/s) was significant slower than the velocities of the clear (57.8 m/s) and the smash (59.6 m/s) strokes. The shuttle velocity of the smash by female players seemed slower than the velocity of the male players (Tsai, 1997, 67.97 m/s, Tsai, 2001, 68 m/s). There were no significant difference in the initial shuttle velocities between the clear and the smash. The shuttlecock initial velocity of the clear stroke seemed as faster as the male badminton players (Tsai, 1997, 48.04 m/s, Tsai, 2001, 64 m/s). Table 1 shows the shuttle initial flight angle of three forehand overhead strokes. We found that the female players performed drop shot angle was going upward at 5.9 degree after contact. It was different from the previous studies of male players (Tsai, 1997, -2.4 deg, Tsai, 2001, -4.5 deg). The female players were performing the clear stroke at 15.2 degree upward shuttle fight angle. It was greater than the

previous study of male players (Tsai, 1997, 9.66 deg, Tsai, 2001, 10.57 deg). Those might be because of the different height between the male and the female players (175cm and 161cm). Table 1 also shows the COM vertical velocity at contact point, the drop shot (-0.3 m/s) was significant less than the clear strokes (-0.478 m/s) and the smash stroke (-0.478 m/s). The COM velocities of the three strokes at contact were minus, that meant the female players performed all the forehand overhead strokes during the period that the COM were going downward after the peak height. The angular variables of three stokes were shown as in the table 1, there were significant differences among the drop, the clear and the smash strokes in shoulder axis and hip axis rotation angle. The players rotated more in the upper trunk than in the lower trunk during the movements. In the flexion and extension of upper arm movement of the three strokes, the female players bent their elbow more in the drop shot than in the clear and the smash stroke at the contact. The wrist adduction angle was the greatest in the drop shot among the three different strokes at contact. As the angular velocity of the upper arm, there were significant difference in elbow flexion angular velocities in the clear (172.5 deg/s) and the smash (126.4 deg/s) than that in the drop shot (-157.0 deg/s). The greatest angular velocity of the upper arm was found in the shoulder internal rotation, the smash (3569.2 deg/s) and the clear (3545 deg/s) were greater than that of the drop shot (599.6 deg/s).

CONCLUSION:

The results showed that there were significant differences among the three forehand strokes in the initial shuttle velocity, the initial shuttle angle and the vertical COM velocity at the contact. The subjects manipulate the upper arm flexion angular velocities of the clear and the smash as in the sequence as followed, wrist > elbow > shoulder, it obeyed the rule of kinetic chain. We found that the greatest angular velocity of upper arm movement was happened in the shoulder internal rotation. The strength training on the shoulder would be very important for the badminton players. There were some differences in the kinematics variables between female and male badminton players. For instance as in the initial velocity of the smash, the initial shuttle flight angle between the male and the female. The reasons of the differences between the male and the female players should be investigated in the further studies.

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