BIOMECHANICAL ANALYSIS OF THE UPPER EXTREMITY IN THREE DIFFERENT BADMINTON OVERHEAD STROKES

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The purpose of this study is going to analyze the biomechanical variables (net joint forces, moments and powers) on the upper extremities of the international elite badminton player when he was performing different (smash, clear and drop) overhead stroke movements. In this study, we are interested in analyzing from the phase of the period before and after the point of making contact with the shuttle. The 2D inverse dynamical solution was the method to calculate the net force, net moment and the power of the upper extremity around the contact. The results showed that dynamical pattern of the three overhead strokes were different. The player experienced eccentric contraction before or after the contact. The regular training on the wrist extensors will be necessary for reduce the risk of the injury of wrist extensors.

KEY WORDS: badminton, biomechanics, inverse solution, smash, clear, drop

INTRODUCTION: Badminton is one of the most popular sports in Taiwan. Previous studies related to badminton skills had been conducted by several researchers, Poole, (1970); Adrian, (1971); and Gowetzke, (1979), they all described the smash strokes in 2D model. Tang, et al, (1994, 1997) who used 3D model to measure the rotation of the forearm and the wrist. Among the badminton skills, the forehand grip overhead (Figure 1) is the typical technique. The purpose of this study is going to analyze 2D biomechanical variables (including the net joint forces, moments and powers) on the upper extremities of the elite badminton player when he was performing different overhead stroke movements. These were smash, clear and drop. In this study, we are interested in analyzing from the phase of the period before (-0.06sec) and after (0.03sec) the point of making contact with the shuttle.

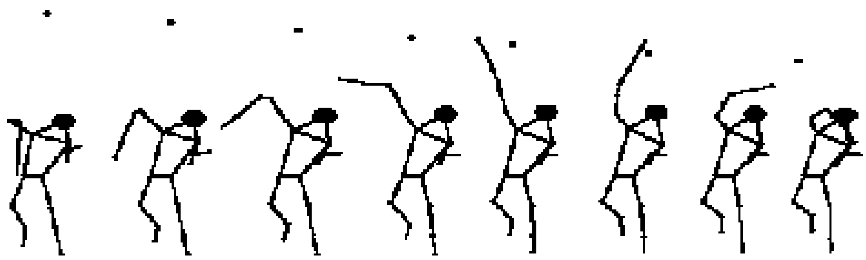

Figure 1 - Badminton forehand overhead stroke.

METHODS: A world champion badminton player (top 2 ranking in the world, age 29yrs, high 182cm) was served the subject for this study. He was filmed in using his own racket to ensure that he would feel comfortable in the experiment. One Kodak Ekta-Pro 1000 high speed video camera operating at 500hz was used to record the subject when he was performing the smash, clear strokes and the drop shot actions. The camera was setup to record the movements of the upper limbs in saggital plane (figure 2). In this study, we are interested in analyzing the motions from the phase of the last part of swing phase to the point of making contact with the shuttle, 0.06sec before contact and 0.03sec after contact. The center of mass (CM) and the moment of inertia of the segments were estimated by using the Dempster's parameter. Inertia data of the racket were directly determined by a pendulum technique and included in a three-segment (upper arm, forearm and hand+ racket) model of the dominant arm (figure 3). The inverse dynamical solution was used to assess the net force, moment of force and the power of the upper limb joints.

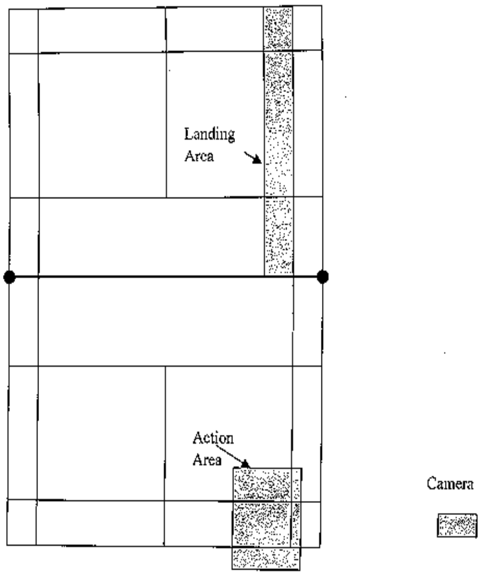

Figure 2 - The Experimental setup.

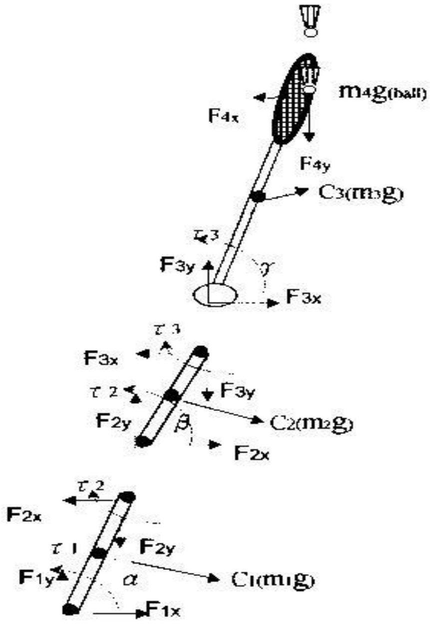

Figure 3 - The model of upper limbs.

RESULTS AND DISCUSSION: Figure 4 shows the stick figure of upper extremity in forehand overhead stroke around the contact. Table 1 shows the kinematics variables of the upper joints in the smash, clear and the drop shots. The duration time of contact of the drop shot (0.008 sec) was longer than the time of smash and clear (0.004 sec). The initial velocity of shuttle of drop shot (29m/s) was less than smash (68 m/s) and clear (64m/s). The angular velocity patterns at the contact of the smash and clear were the same (wrist > elbow > shoulder), but the drop shot was different.

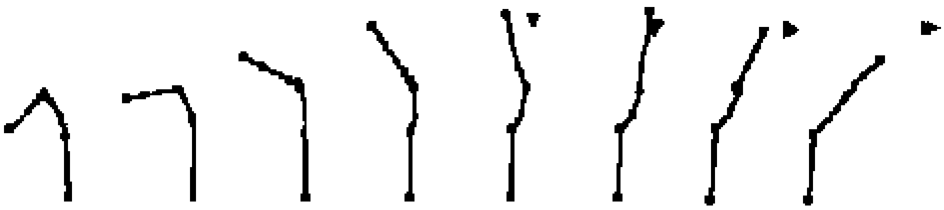

Figure 4 - The stick figure of upper extremity in forehand overhead strokes.

Table 1 The Kinematics Variables of Badminton Smash, Clear and Drop Shot

Variables	Smash	Clear	Drop
Time of Contact (sec)	0.004	0.004	0.008
Shuttle Velocity(m/s)	68	64	29
Shuttle Angle (deg)	-11.5	10.57	-4.5
Shoulder Angle at Contact(deg)	164	152	145
Elbow Angle at Contact(deg)	194	203	202
Wrist Angle at Contact(deg)	166	185	196
Shoulder Ang Vel at Cont.(deg/s)	-224	-266	-401
Elbow Ang. Vel. at Cont.(deg/s)	-784	-484	-174
Wrist Ang. Vel. at Cont.(deg/s)	-985	-1427	-438

Table 2 The Kinetics Variables of Badminton Smash, Clear and Drop Shot

Variables	**Smash**	**Clear**	**Drop**
Force of Shoulder at Contact (N)	448	303	210
Force of Elbow at Contact (N)	379	310	135
Force of Wrist at Contact (N)	234	223	86
Moment of Shoulder at Cont. (Nm)	20	-2	4
Moment of Elbow at Cont. (Nm)	17	44	12
Moment of Wrist at Cont. (Nm)	44	50	10
Power of Shoulder at Cont. (Nm/s)	-79	7	-30
Power of Elbow at Cont. (Nm/s)	-236	-374	-38
Power of Wrist at Cont. (Nm/s)	-752	-1249	-78

Table 2 shows the kinetics variables of the upper joints in the different strokes at the contact. The net force of shoulder joint were the greatest in smash and drop shot, then elbow and the net force of the wrist joint was the least. The net joint force, net joint moment and the power of drop shot were the least among three strokes. The wrist joint is the most powerful joint in all different strokes, then the elbow. The power of shoulder was less than it of wrist and elbow. Figure 5, 6 and 7 showed the angular velocities, the net joint moment and the power graphs of the 3 different badminton strokes. Every graph contained 3 curves, expressed the patterns of

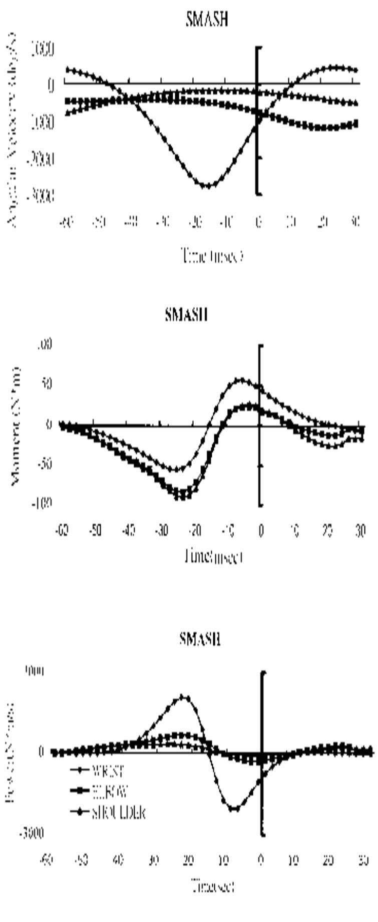

Figure 5 - Smash Kinetic Pattern.

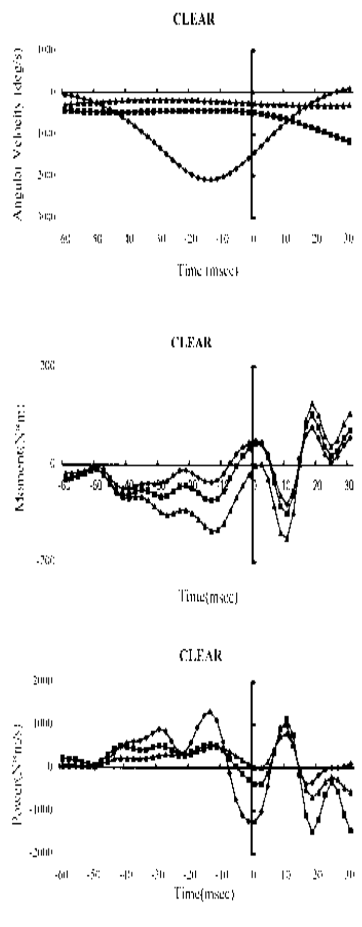

Figure 6 - Clear Kinetic Pattern.

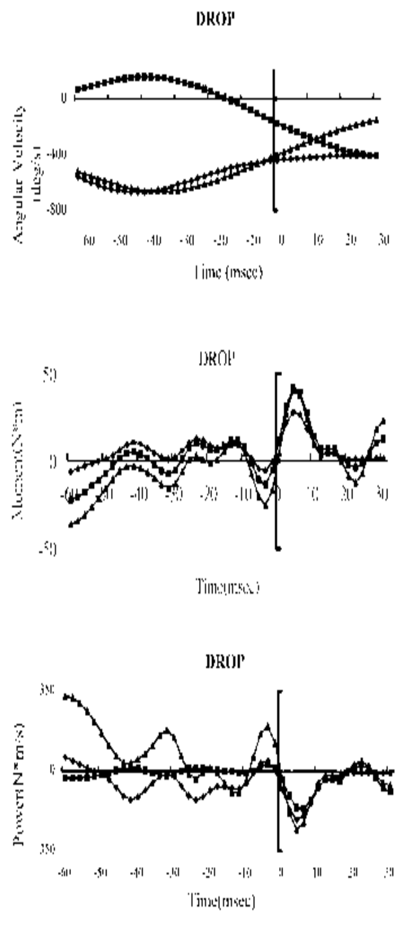

Figure 7 - Drop Kinetic Pattern.

the shoulder, the elbow and the wrist joints. According to the study of Winter (1990), we measure the type of contraction during the movement by calculate the angular velocity, the joint moment and the power of the joint.

$$Power = Force \times Velocity = Moment \times Angular\ Velocity(\omega)$$

Figure 5, 6 and 7 showed different patterns of the 3 strokes. Before contact, the segments exert concentric contraction first in all kinds of strokes. Then as those graphs showed, the type of contraction was eccentric before contact in smash stroke. The type of contraction was eccentric at the contact in clear stroke. The type of contraction was eccentric after contact in drop shot. Though the movement looked very similar among three overhead strokes, they were still different in kinetics patterns.

CONCLUSION: This study described the different biomechanical characteristics between the smash, clear and the drop shot of the elite badminton player. The results showed that the kinematics pattern was similar between smash and clear strokes, but different from drop shot. The wrist joint exerted the greatest velocity and power in all three kinds of strokes than the elbow and shoulder. We found the extensor muscles of wrist were suffering the eccentric contraction before contact. It is the reason why the new learner are always experience the pain of the wrist extensors. It is realized that the regular training on the wrist extensors will reduce likelihood of injury due to stress the wrist extensor through eccentric contraction during acceleration phase.

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