THE SURFACE EMG ACTIVITY OF THE UPPER LIMB MUSCLES OF BADMINTON FOREHAND AND BACKHAND SMASHES

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The purpose of this study was to analyze the surface EMG activity of the upper limb muscles of Taiwan elite badminton players when they were performing the forehand and the backhand smashes. We used two digital video cameras to obtain the 3D kinematics data of the shuttlecock, and measured the surface EMG signals of seven upper limb muscles. The results showed that there were significant differences between forehand and backhand smashes in the following variables: the initial shuttle velocity, the contact height, the initial flight angle of the shuttle, the sequence of the surface EMG activities of the upper limbs and the mean IEMG amplitude in the selected muscles. The reason why the forehand smash was faster than the backhand smash might be because the up swing displacement and up swing racket velocity of the forehand smash was greater than that of the backhand smash.

KEY WORDS: EMG, badminton, forehand, backhand, smash

INTRODUCTION: Badminton is one of the most popular sports in Taiwan, especially in the college sport classes. Two different grip techniques are in Badminton, those are forehand and backhand. The badminton smash is the most powerful stroke in this racket sport. The comparison of the forehand smash (figure 1) and backhand smash (figure 2) was one of the topics that the badminton players were interested in gaining knowledge on. The previous studies of badminton focused on 2D and 3D kinematics and Inverse Dynamic methods to describe the motions of badminton forehand strokes. This includes the studies such as, Poole, 1970; Adrian, 1971; and Gowetzke, 1979, Tang, et al, 1994, Tsai, et al, 1996, 2001 & 2003. Tsai, et al, 2004, studied the differences in the kinematics and kinetics variables between forehand and backhand badminton smashes and found that there were significant differences in initial flight angle, shuttle velocity, contact height and elbow angular velocity between the two different smashes. The kinetic variables were not significantly different between the two kinds of smashes. Only a few researchers have used surface EMG methods to analyze the movement of badminton strokes. Broer, and Houtz, 1967 observed the muscular surface EMG activity patterns of the badminton clear stroke. Tsai, et al, 2005, used surface EMG activity methods to describe the badminton forehand smash and jump smash strokes. The purpose of this study was to compare the differences of EMG signal patterns between the forehand and backhand smashes. We analyzed the shuttlecock kinematics variables and the muscular surface EMG patterns on the upper extremities of the Taiwan elite badminton players. The variables included the shuttle kinematics variables, and the muscular surface EMG activities of the selected muscles.

METHOD: Eight male, elite badminton players from Taiwan (with an average age of 20±2 years, and an average height of 175±5 cm and an average weight of 66±6 kg) served as the subjects, to perform the forehand and backhand smash to the ground in the opposite court. Figure 3 shows the schematic drawing of the experimental setup. Two Redlake 1000 high-speed digital cameras (250Hz, Motion Scope, San Diego, USA) were used to record the shuttlecock 3D kinematics data. One Biovision EMG system (1000Hz, National Instruments, Austin, TX) was synchronized to collect the surface EMG signals of seven upper limb muscle groups, which were the wrist flexor, wrist extensor, biceps brachii, triceps brachii, middle deltoid, posterior deltoid and pectoralis major. The 3D kinematics data was calculated by using the Kwon3D system and the surface EMG data were analyzed by using the DasyLab system. Raw EMG signals were band-pass filtered (20-400Hz) and the full wave rectified by passing it through a linear envelope at 10Hz. We were interested in analyzing the integrated EMG signal (IEMG) from the phase of -0.1 second before contact to 0.1 second after contact. The sequence of the peak surface EMG signal activities, the EMG amplitude at the shuttlecock contact point, the peak EMG amplitude and the mean IEMG of the movement phase of the upper limb muscle groups were the selected variables. The nonparametric statistical test of the Wilcoxon matched-paired signed-rank test for the differences in kinematics, the standardized EMG and IEMG of the selected muscles between forehand and backhand smashes. A Product-Moment Correlation was used to test the selected variables between forehand and backhand smashes at a .05 significant level.

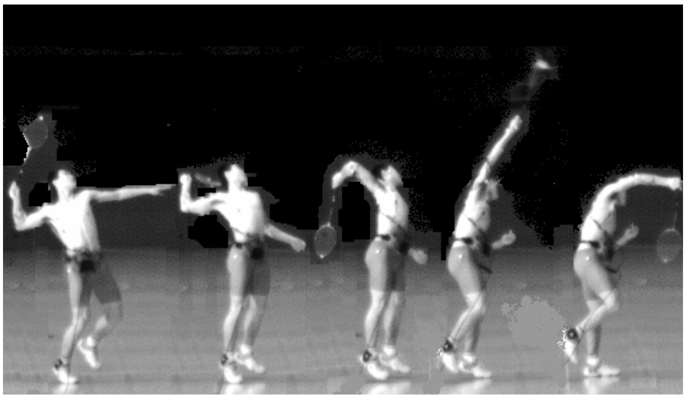

Figure 1. The Forehand Smash

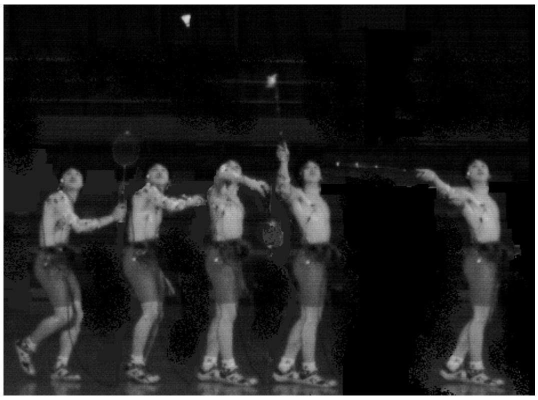

Figure 2. The Backhand Smash

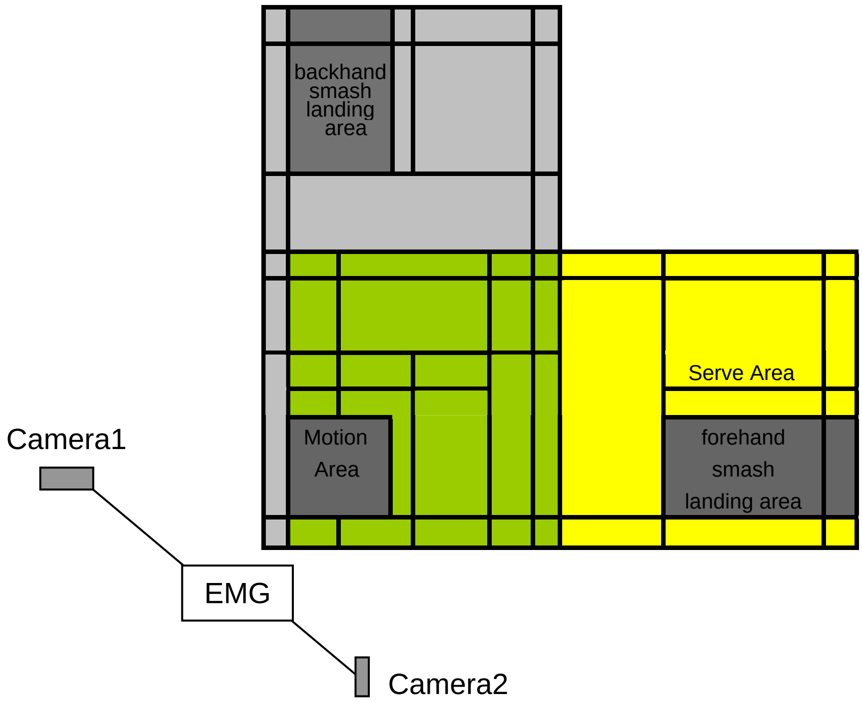

Figure 3 · The Schematic of the Experimental Setup

RESULTS AND DISCUSSION: Table 1 shows the kinematical data of the forehand and backhand smashes. Table 2 shows the surface EMG signal of every muscle group. Figure 4 and figure 5 show the rectified surface EMG signal patterns of the forehand smash and the backhand smash from -0.3 second before contact to 0.1 second after contact point.

Table 1: The Kinematics Variables of Forehand and Backhand Smashes

Variables	**Forehand Smash**	**Backhand Smash**	**Wilcoxon Test**	**r**
Initial Shuttle Velocity (m/s)	76.01	63.55	.017*	-0.25
Initial Shuttle Angle (deg)	-8.41	-3.71	.018*	.293
Contact Height (m)	2.47	2.25	.012*	.347
Time of Contact (sec)	0.004	0.004	.999	.999*
Up Swing Duration Time (ms)	73	88	.018*	-.155
Up Swing Racket Displacement (m)	1.81	1.61	.017*	-.217
Up Swing Racket Velocity (m/s)	24.96	18.4	.017*	-.179

*p< .05

Table 2: The Surface EMG Variables of Forehand and Backhand Smashes

Variables Muscles	Grip	Peak Amp. Time to contact (ms)	W	Contact Amp. (mv)	W	Peak Amp. (mv)	W	r	Mean IEMG A.(mv)	W	-0.1s Mean IEMG A.(mv)	W	0.1s Mean IEMG A.(mv)	W
Wrist Flexor	Fore	-43.50		0.168		1.897			0.680	*	0.418		0.344	
	Back	-61.75		0.133		1.277			0.810		0.437		0.315	
Wrist Extensor	Fore	-63.38	*	0.123		2.500			0.535		0.132	*	0.313	
	Back	20.13		0.321		2.400			0.597		0.248		0.525	
Biceps	Fore	-48.75		0.440		3.214			0.714	*	0.153	*	0.456	
	Back	-42.75		0.185		2.997			0.894		0.505		0.418	
Triceps	Fore	-77.63		0.137		2.480		*	0.486		0.546		0.219	
	Back	-78.88		0.084		2.089			0.624		0.579		0.152	
Middle Deltoid	Fore	-441.25		0.168		3.094	*	*	0.681	*	0.446	*	0.357	*
	Back	-208.63		0.106		1.997			0.257		0.138		0.142	
Posterior Deltoid	Fore	-32.88	*	0.141		3.198			0.641	*	0.439	*	0.375	*
	Back	-171.13		0.204		2.467			0.307		0.175		0.135	
Pectoralis Major	Fore	-172.75	*	0.087		2.963		*	0.302	*	0.266	*	0.097	
	Back	-61.63		0.121		2.881			0.917		0.720		0.193	

*p< .05

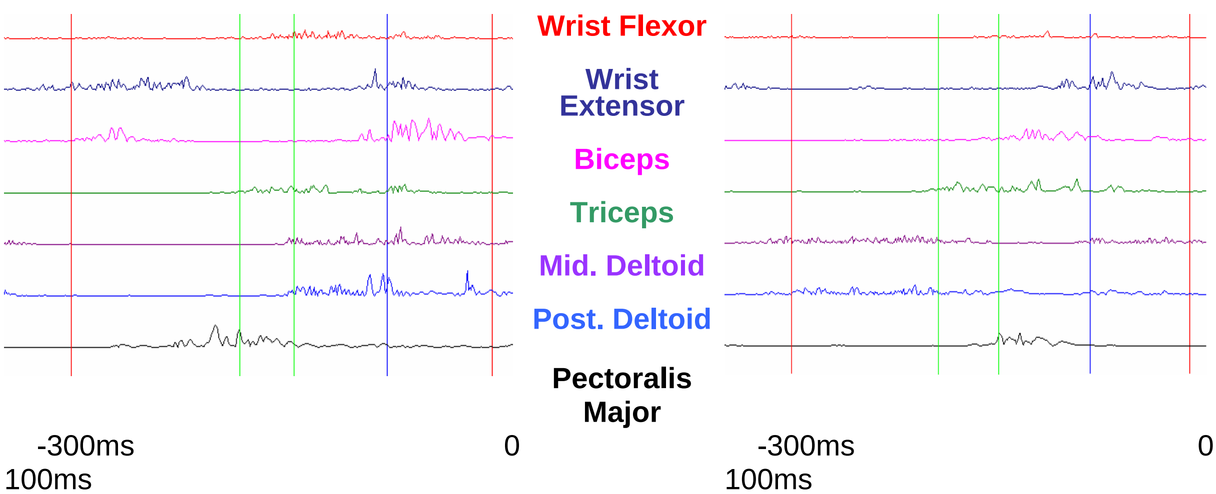

Figure 4. The EMG of Forehand Smash

Figure 5. The EMG of Backhand Smash

There were significant differences between the forehand smash (76.01 m/s) and the backhand smash (63.55 m/s) in the initial shuttle velocity. The Initial shuttle flight angle for the forehand smash (-8.41 deg) was sharper than that of the backhand smash (-3.71 deg). The contact height of the forehand smash was higher than the height of the backhand smash (2.47m vs 2.25m). The contact duration time was 0.004 second in both instances. There was no significant correlation between the forehand smash and the backhand smash in the kinematics variables. The EMG patterns of the forehand and backhand smash were different. There was a significant difference in the peak amplitude timing from the contact point between the two smashes at the wrist extensor, posterior deltoid and Pectoralis Major. For the EMG amplitude at the contact point, there was no significant difference between the two smashes. The peak EMG standardized amplitude of the upper limb muscles for the two smashes was different for the Middle Deltoid. There were significant positive correlations between the two smashes in the peak EMG standardized amplitude for the triceps, Middle Deltoid and Pectoralis Major. For the mean IEMG amplitude integrated from 0.3 second before contact to 0.1 second after contact, there were significant differences between the two smashes at the wrist flexor, the biceps, the Middle Deltoid, Posterior Deltoid and the Pectoralis Major. There was no significant correlation between the two smashes in the IEMG signals. The mean IEMG amplitude integrated from -100 ms before contact between the two smashes was significant different for most of the muscles except the wrist flexor and Triceps. The mean IEMG amplitude integrated for 100ms after contact was different on Deltoids. As the results showed, the EMG activity of the forehand smash was significantly greater than the activity of the backhand smash in some muscle groups of the upper limbs. We found that the forehand smash exerted different EMG activity than the backhand smash in the movement.

CONCLUSIONS: In this study, we combine the 3D kinematics data and surface EMG signals to compare the sequence muscular activity, surface EMG amplitude, mean IEMG amplitude of upper limb muscles between the badminton forehand smash and backhand smash. We found that the initial shuttle velocity of forehand smash was greater than the backhand smash. The forehand smash exerted different muscular activity with the backhand smash during the movement. The reason why the forehand smash was faster than the backhand smash might because from the up swing displacement and up swing racket velocity of the forehand smash was greater than that for the backhand smash.

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