THE UPPER LIMB EMG ACTIVITY COMPARISON OF DIFFERENT TABLE TENNIS FOREHAND DRIVES

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The purpose of this study was to combine dynamics and surface EMG methods to analyze the movements of table tennis forehand drives by Taiwan elite table tennis players performing straight and cross court forehand drives from topspin and backspin serves. The kinematical data were collected by 10 Vicon MX13^{+} high-speed cameras and one Biovision system was used to record the EMG signal of seven muscles groups on the dominate hand. The results showed that there were significant differences among the four table tennis drives. The players exerted greater muscular activity in the wrist extensors, the biceps and the triceps for the backspin serve forehand drive than when returning the topspin serve forehand drive, not only on the straight but also on the cross court strokes.

KEY WORDS: biomechanics, topspin, backspin, cross.

INTRODUCTION: The forehand drive is one of the most classical and effective techniques in table tennis. Since the top spin drive can be hit both with great power and increase the success percentage to drive the ball into the opponent table. Previous studies such as Neal (1991) found Chinese elite players were able to hit the ball at a higher initial velocity compared with their Australian counterparts, while Yoshida et al. (2004) found that the duration of time from the ball rebounding on the table to the contact point of the forehand drives was about 0.2 seconds. The EMG patterns and the movement duration times were similar, while returned balls hit with different spin. Tsai et al. (2010) reported players increased the racket tilt angle for a forehand drive and raised the forward trajectory angle to return a backspin serve compared with returning the topspin serve. The players exerted greater muscular activity during receiving the backspin forehand drive in the wrist extensor, the biceps and the triceps. The purposes of this study were to compare the kinematics and the EMG data of Taiwanese elite players when they were performing the forehand drive both down the line and the cross court drive shots when receiving serves hit with topspin and the backspin.

METHODS: Five male Taiwanese table tennis elite players served as the participants. As shown in Figure 1, the players stood at one end of the table to return the serves. The server served the topspin and the backspin shots into the circle (25cm) on the left end side of the player's. The players returned the serves and hit the ball either straight forward or on the diagonal direction. The landing area was the 50×50cm square at right and left of the server's end. A Vicon Motion Capture system with 10 cameras (250 Hz) and the Vicon Nexus 1.4 software were used to collect and analyze the 3D kinematics data of the players. Seven upper limb muscle EMG signals were recorded by Biovision system (1000Hz, Biovision, Wehrheim, Germany) and these were the wrist flexor, wrist extensor, biceps brachii, triceps brachii, pectoralis major, deltoid and trapezius. The EMG signal was standardized by the peak amplitude of each muscle during the experiment. The raw EMG signals were band-pass filtered (20-500Hz) and the full wave rectified by passing it through a linear envelope. The selected kinematics variables and the peak EMG amplitude of the upper limb muscle groups during different movement were tested by the Friedman two-way analysis of variance by ranks nonparametric statistical test. All the variables were tested by SPSS V19.0 statistical software using a .05 significance level.

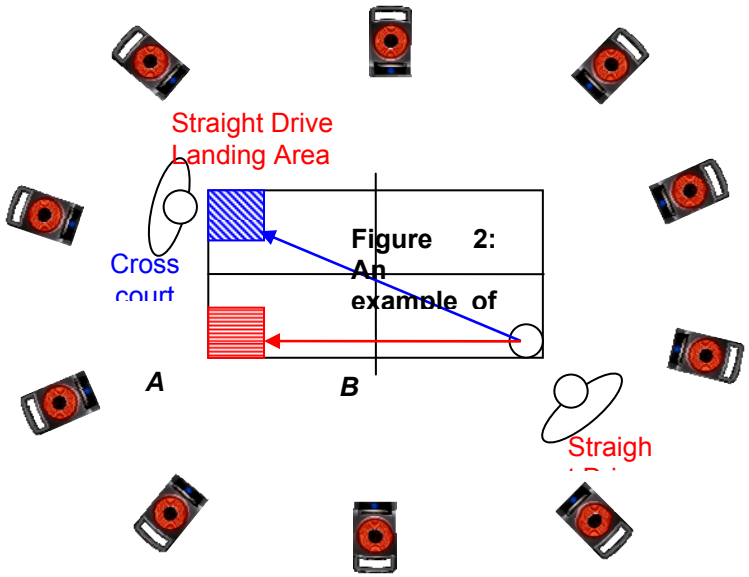
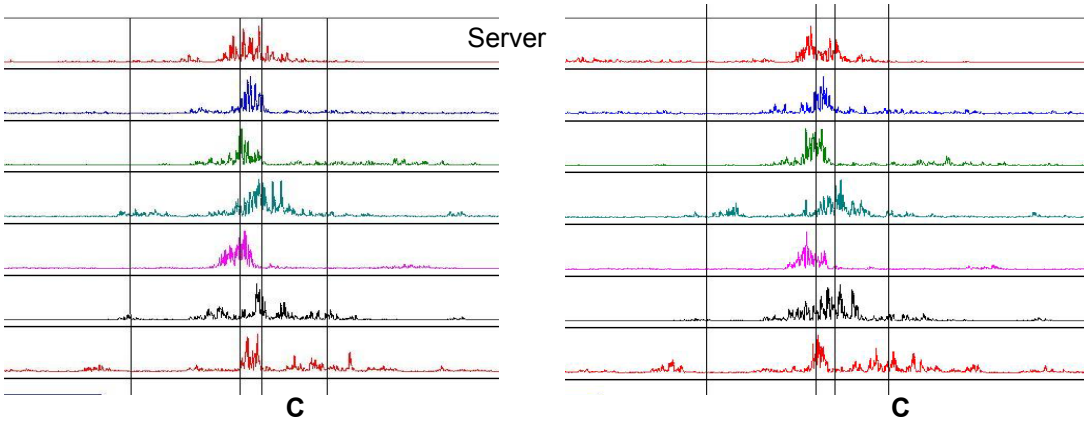


Figure 2: An example of

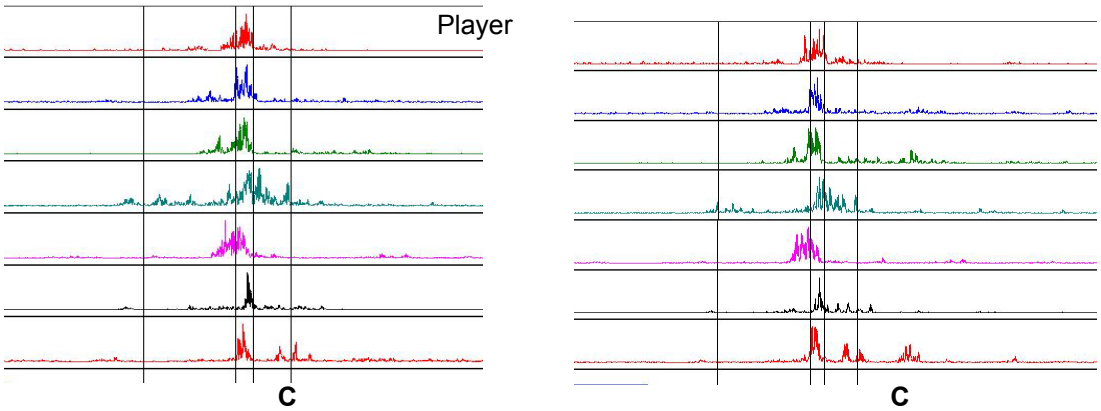
Figure 1: The schematic experimental setup

RESULTS: Figure 2 and figure 3 show the EMG patterns of forehand drives by one of the subjects. The contact point was the line C. Figure 2 shows the patterns when the players performed the straight and the cross court drives after returning topspin serves. Figure 3 shows the patterns when the players drove to straight and cross court after returning backspin serves. Table 1 shows the data of the kinematics and the peak EMG amplitude.



Return topspin serve to straight drive (TS) Return topspin serve to cross court drive (TC)

Figure 2: The EMG patterns of return straight drive and cross court drive after topspin serve



Return backspin serve to straight drive (BS) Return backspin serve to cross court drive (BC)

Figure 3: The EMG patterns of return straight drive and cross court drive after backspin serve

Table 1

The kinematics variables and peak EMG amplitude of the upper limbs

Variables	Drive Movements	Mean SD	Post Hoc.		
			TC	**BS**	**BC**
Racket Head Velocity (m/s)	**T S**	17.31 ± 1.12		*	
	T C	16.85 ± 0.89	--	*	
	B S	18.94 ± 1.70	--	--	*
	B C	16.82 ± 3.83	--	--	--
Shoulder External / Internal Rotation Angle (deg)	**T S**	-63.95 ± 15.19	*		
	T C	-72.71 ± 15.40	--	*	
	B S	-64.38 ± 14.92	--	--	
	B C	-66.87 ± 15.43	--	--	--
Elbow Flexion / Extension (deg)	**T S**	83.39 ± 9.63			
	T C	85.70 ± 10.28	--		
	B S	84.63 ± 8.40	--	--	
	B C	84.38 ± 12.32	--	--	--
Wrist Flexion / Extension Angle (deg)	**T S**	-0.93 ± 4.23	*		
	T C	-7.39 ± 3.89	--	*	
	B S	-2.04 ± 4.85	--	--	
	B C	-5.12 ± 7.46	--	--	--
Wrist Radial/Ulnar Flexion Angle (deg)	**T S**	29.35 ± 11.96	*		*
	T C	20.89 ± 12.82	--		
	B S	25.69 ± 15.21	--	--	
	B C	19.52 ± 20.97	--	--	--
Shoulder Horizontal Abduction / Adduction Angular Velocity (deg/s)	**T S**	177.23 ± 171.52	*		*
	T C	318.02 ± 132.78	--	*	
	B S	199.47 ± 177.42	--	--	
	B C	266.94 ± 156.99	--	--	--
Shoulder External / Internal Rotation Angular Velocity (deg/s)	**T S**	498.04 ± 102.64			
	T C	432.19 ± 122.62	--	*	*
	B S	608.48 ± 191.32	--	--	
	B C	539.39 ± 127.56	--	--	--
Wrist Extensor Peak EMG Amplitude (%)	**T S**	74.23 ± 8.67		*	*
	T C	79.05 ± 13.29	--	*	
	B S	97.76 ± 5.018	--	--	
	B C	85.52 ± 6.883	--	--	--
Biceps Peak EMG Amplitude (%)	**T S**	81.31 ± 11.10		*	
	T C	68.84 ± 28.90	--	*	
	B S	100.00 ± .000	--	--	
	B C	78.52 ± 10.70	--	--	--
Triceps Peak EMG Amplitude (%)	**T S**	68.97 ± 10.47		*	*
	T C	71.55 ± 19.66	--	*	*
	B S	96.07 ± 7.77	--	--	
	B C	90.30 ± 11.21	--	--	--

p<.05* **TS return **t**opspin serve drive **s**triaght, **TC** return **t**opspin serve drive **c**ross court
BS return **b**ackspin serve drive **s**triaght, **BC** return **b**ackspin serve drive **c**ross court

DISCUSSION: Table 1 showed that the racket head velocity of the straight drive from a backspin serve (18.94 m/s) was significantly faster than the others. We found that the straight drive was faster than the diagonal drive both when receiving topspin and backspin serves. The players increased their shoulder internal rotation angle at the topspin diagonal drive movement both on the topspin and backspin drives at the contact point. The wrist flexion in the diagonal path drive at contact point was the greatest when the players were returning the topspin serve. The wrist radial flexion on the straight drive was the greatest among the four drives at the contact point. We found that the players increased the shoulder horizontal abduction angular velocity when they were performing the diagonal drives

irrespective of service type. The players increased the shoulder external rotation angular velocity on down the line and cross court drives after returning backspin serves. Players exerted greater peak EMG amplitude on the wrist extensor, biceps and triceps in the drives after receiving backspin serve than receiving topspin serve (Table 1).

CONCLUSION: In this study, we were interested in analyzing the 3D kinematics and EMG parameters for four kinds of table tennis drives when the players returned either topspin or backspin serves for both straight forward and on the cross court drive paths. We found that the movements of the players were different when they performed the four kinds of drive. The elite table tennis players performed the different strategies between the straight drive and diagonal drive movements. The way to play better diagonal path drive should follow the following trends: reduced racket head velocity, increased shoulder internal rotation angle, increased wrist flexion angle, decreased wrist radial flexion angle, increased shoulder horizontal abduction angular velocity, decreased the shoulder external rotation angular velocity and decreased peak EMG activity on the biceps muscle both on the receiving topspin and backspin serves. The elite players also showed the trend between the receiving topspin and backspin serves drives, such as reduced wrist radial flexion angle, increased shoulder external rotation angular velocity, wrist extensor, biceps and triceps muscular activity both on the straight and diagonal path drives. The players exerted greater muscular activity in the wrist extensor, the biceps and the triceps when returning the backspin serve than when receiving topspin serve, irrespective of direction.

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