THE SURFACE EMG ACTIVITY OF THE UPPER LIMB MUSCLES IN TABLE TENNIS FOREHAND DRIVES

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The purpose of this study was to analyze the 3D kinematics variables and the upper limb muscle surface EMG activity of Taiwan elite table tennis players when they were performing forehand drives after receiving topspin and backspin services. Ten Vicon MX-13^{+} cameras (Vicon, Oxford, UK, 250Hz) were used to record the 3D kinematics data and measured the EMG signals of seven upper limb muscles of the players. The results showed that the tactics of the table tennis players performed the forehand drive to receive backspin were both to increase the racket tilt angle in advance and to raise the path angle during the upswing phase. The players exerted greater muscular activity during receiving the backspin forehand drive than receiving topspin forehand drive in the wrist extensor, the biceps and the triceps.

KEYWORDS: biomechanics, IEMG, topspin, backspin.

INTRODUCTION: Table tennis is one of the most popular racket sports in the world. The forehand drive is one of the most classical and effective technique of the table tennis skills. When the table tennis players perform forehand drive, they will meet several situations, including the topspin and the backspin shots from the opponent and so on. The comparison of forehand drives between receiving topspin and backspin is a great topic that the table tennis players are interested. Previous studies of table tennis focused on 3D kinematics and EMG methods to describe the motions of table tennis forehand strokes. This includes the studies such as, Kasai, & Mori (1992) described the movement appearance of the forehand table tennis drives. Neal (1991) he found the elite Chinese players performed the faster initial velocity of ball than the Australian young players. Only a few researchers analyze the movement of table tennis strokes with the methods of EMG. Yoshida, Sugiyama, & Murakoshi (2004) observed the muscular EMG activity patterns of the table tennis forehand shots. They found that the EMG patterns and the movement duration time were similar in different forehand drives while returned the different spin and found that the duration time from the ball rebound on the table to the contact point of the forehand drives were about 0.2 seconds. The purposes of this study were to compare the kinematics variables and the EMG signal patterns of the forehand drives when the players were receiving the topspin and the backspin table tennis services.

METHOD: Five male table tennis elite players in Taiwan (with an average age of 22.6±3.36 years, height of 175.2±6.14 cm and weight of 66.2±13.21 kg) served as the participants. Figure 1 shows the schematic drawing of the experimental setup. The players were standing at one end of the table to return the services. The opponent server served the topspin and the backspin services into the circle (25cm) on left end corner of the participant player's. The players moved to the left side to play a straight forehand drive into the 50×50cm square at right end of the opponent. The 3D kinematics data were recorded by using ten VICON Motion Capture systems MX13+ (250 Hz) of forehand drives, and the Vicon Nexus 1.4 software was used to calculate the kinematical parameters. One Biovision EMG system (1000Hz, Biovision, Wehrheim, Germany) was to collect the EMG signals of seven upper limb muscle groups, which were the wrist flexor, wrist extensor, biceps brachii, triceps brachii, pectoralis major, deltoid and trapezius. The EMG data were analyzed by using the Acknowledge software (1000Hz). Raw EMG signals were band-pass filtered (20-500Hz) and the full wave rectified by passing it through a linear envelope with a window of 10 ms. The EMG signal of the muscle was standardized by the peak amplitude of each muscle during the experiment. The integrated EMG (IEMG) signals from the preparation phase, the contact

point to the follow through phase were analyzed. The sequence of the EMG signal activities, the EMG amplitude at the contact point, the peak EMG amplitude and the IEMG of the upper limb muscle groups during different movement phases were the selected variables. The kinematics, the standardized EMG and IEMG of the selected muscles were tested between the forehand drives after returning topspin and backspin services by the Wilcoxon matched-paired signed rank nonparametric statistical test. All the variables were tested by SPSS 18.0 statistical software at a 0.05 significant level.

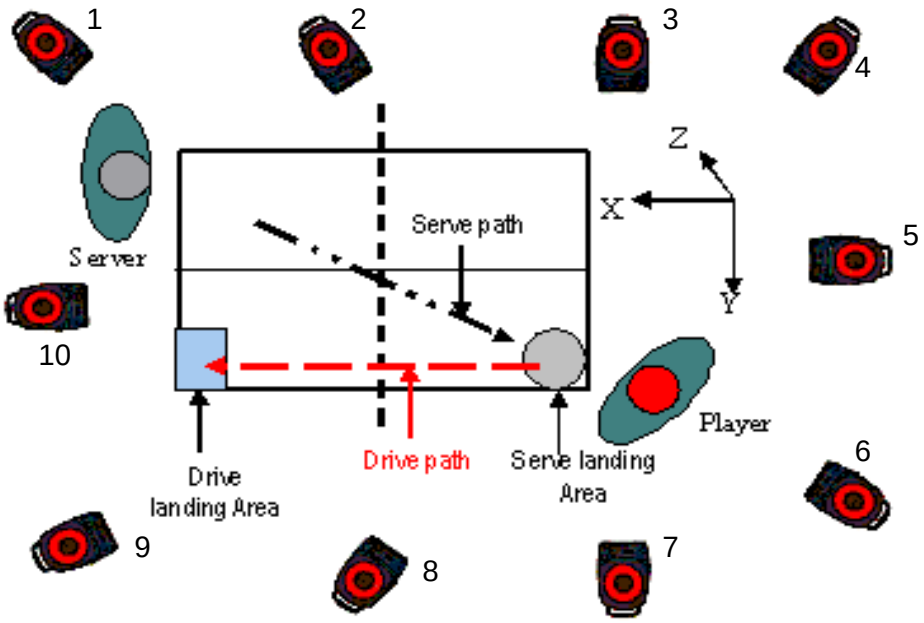

Figure 1 · The Schematic of the Experimental Setup

RESULTS: Figure 2 and figure 3 show the rectified EMG signal patterns of forehand drives by one of the subjects. The lines in the figure 2 and the figure 3, the line 1 means the start of the downswing, 2 means the end of the downswing and the start of the upswing, 3 means the contact point, 4 means the end of the follow through. The phases of the forehand drive were divided into the downswing phase (1 to 2), the upswing phase (2 to 3) and the follow through phase (3 to 4). Table 1 shows the kinematical data of the different forehand drives. Table 2 shows the EMG variables of every muscle group.

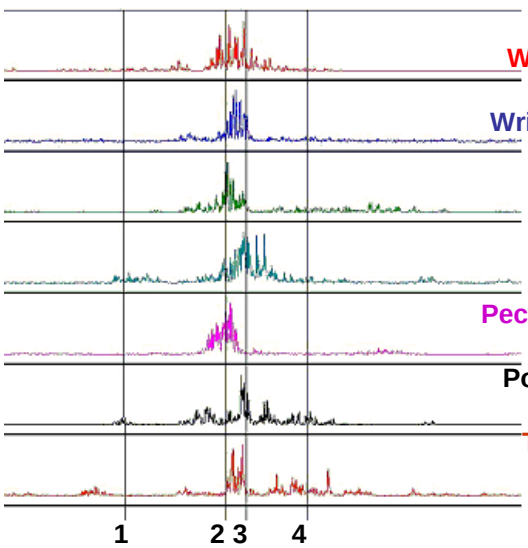

Figure 2. The EMG of receiving topspin drive

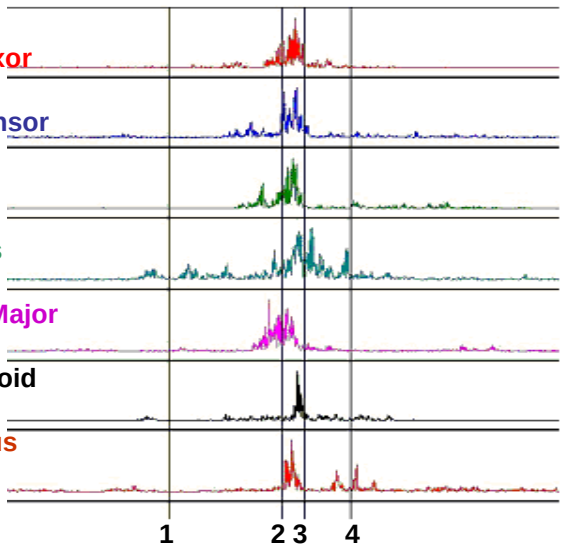

Figure 3. The EMG of receiving backspin drive

Table 1. The Kinematics Variables of Different Forehand Drives

Variables	Receive Topspin Drive	Receive Backspin Drive	*p*
Racket Head Velocity at Contact *(m/s)*	17.31±1.12	18.94±1.70	*
Racket Saggital Tilt Angle *(deg)*	54.84±2.47	70.72±3.34	*
Racket Up Swing Angle *(deg)*	33.12±11.07	42.98±8.27	*
Contact Height *(m)*	0.95±0.03	0.91±0.04	*
Total Movement Time (TMT) *(s)*	0.85±0.10	0.92±0.03	
Down Swing Duration Time *(s)*	0.50±0.07	0.60±0.08	*
Down Swing Duration Time / TMT*(%)*	58.0±5.96	65.2±6.30	*
Up Swing Duration Time *(s)*	0.09±0.02	0.08±0.02	
Up Swing Duration Time / TMT *(%)*	11.0±2.12	9.2±1.92	*
Follow Through Duration Time *(s)*	0.22±0.06	0.18±0.03	
Follow Through Duration Time / TMT *(%)*	25.0±5.66	20.2±4.09	*

p<0 .05

Table 2. The EMG Variables of Forehand Drives

Muscles	Shots	EMG at Contact (%)	*p*	Peak EMG (%)	*p*	Peak EMG Timing (s)	*p*	Down Swing IEMG (%s)	*p*	Up Swing IEMG (%s)	*p*	Follow Through IEMG (%s)	*p*	Total Motion IEMG (%s)	*p*
Wrist Flexor	Topspin	13.87		85.27		-0.043		3.23		2.22		2.08		7.61	
	Backspin	19.62		84.01		-0.027		3.35		2.33		1.69		7.46	
Wrist Extensor	Topspin	32.33		74.23	*	-0.070		2.42	*	2.61		1.47		6.56	
	Backspin	20.74		97.76		-0.067		3.18		2.80		1.25		7.30	
Biceps	Topspin	18.92		81.31	*	-0.043		2.62		2.32		1.06	*	5.23	
	Backspin	16.97		100.00		-0.039		2.12		2.64		0.59		5.40	
Triceps	Topspin	23.36		68.97	*	0.007		1.89	*	2.11		2.89		6.99	*
	Backspin	22.65		96.07		-0.008		2.80		2.65		2.80		8.31	
Pectoralis Major	Topspin	3.80		74.89		-0.089		2.49		1.97		0.65		5.15	
	Backspin	4.32		73.09		-0.103		3.02		1.85		0.77		5.67	
Deltoid	Topspin	16.10		83.17		-0.076		2.66		1.88		1.89		6.51	
	Backspin	18.72		86.12		-0.036		2.43		2.26		1.40		6.14	
Trapezius	Topspin	12.13		87.15		-0.021		2.19		2.35		1.28		5.88	
	Backspin	9.59		82.54		-0.072		2.48		2.00		0.91		5.46	

p< 0.05

DISCUSSION: Table 1 showed that the racket head velocity of receiving backspin forehand drive (18.94 m/s) was significantly faster than the receiving toping drive (17.31 m/s). The saggital tilt angle of the receiving backspin forehand drive (70.72 deg) was significantly

greater than that of the receiving topspin drive (54.84 deg) at contact. And the swing path angle of receiving backspin forehand drive (42.98 deg) was significantly greater than the receiving topspin drive (33.12 deg). The contact height of receiving backspin forehand drive (0.91 m) was significantly lower than that of the receiving topspin drive (0.95 m). The total movement time (TMT) between the different drives was 0.85 second vs. 0.92 second, there was insignificant difference between them. But the percentage of the movement phases were all different, we found that the receiving backspin forehand drive would spend a longer time to the downswing phase to prepare, the receiving backspin serve forehand drive spent a shorter period of time in the upswing phase. Figure 2 and figure 3 showed the EMG amplitude rose from the end of downswing movements. The sequences of two drives were not consistent from the central muscle group to the end of the segment muscle groups. Table 2 showed that there were insignificant differences in the EMG amplitude at the contact point and the IEMG during the upswing phase. The peak EMG amplitudes of upper limb muscles appeared just before the contact point, except the triceps in the receiving topspin serve drive. During the downswing phase of the action, the IEMG signal was different between two drives in the wrist extensor and the triceps muscles. The players increased the racket tilt angle in advance just before the upswing movement. The triceps exerted the greater IEMG signal in receiving backspin serve forehand drive than in receiving topspin forehand drive. That might be the fact that the triceps was to apply a brake in counteracting the upswing movement.

CONCLUSION: In this study, we combined the 3D kinematics and EMG methods to compare the sequence muscular activity, EMG amplitude and IEMG signal of upper limb muscles between two different table tennis forehand drives while received the topspin and the backspin serves. We found that the racket head velocity of receiving backspin forehand drive was greater than the receiving topspin forehand drive. The players performed the receiving backspin forehand drive in a longer downswing duration time and a shorter duration time of the upswing. The tactics of the table tennis players to perform the forehand drive in receiving backspin would increase the racket tilt angle in advance and increase the upswing path angle. The players exerted greater muscular activity in the wrist extensor, the biceps and the triceps during receiving the backspin forehand drive than receiving topspin forehand drive.

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Acknowledgement

First of all, the authors like to thank the financial support from National Science Council. The second, we like to thank the participants of table tennis players. And thank the assistants from the colleagues, the graduated students of the Sports Biomechanics Lab in National Taiwan Normal University.