

## KINEMATICS OF PUSH-HAND STRUGGLE IN TAI CHI CHUAN

Jia-Hao Chang<sup>1,2</sup> and Yao-Ting Chang<sup>1</sup>

Department of Physical Education<sup>1</sup>, and Graduate Institute of Exercise and Sport Science<sup>2</sup>, National Taiwan Normal University, Taipei, Taiwan

The push hand in Tai Chi Chuan is a practice of tactile sense to make the opponents lost their own balance. The interaction of Tai Chi masters and their opponents during performing push hands is still unknown. The purpose of this study was to investigate the kinematics of both participants during fixed-steps push-hand struggle in Tai Chi Chuan. Six male subjects, divided into three couples, were involved in this study. Three dimensional kinematic data during push hand were collected by VICON motion analysis system and were analyzed by Visual3D software. The results showed that the winner made the opponent lost his balance to move step in the attacked mode and the defensive mode. In summary, the winner in the push hand competition had less movement of center of mass in vertical direction and rotated the waist to prevent the balance lost.

**KEY WORDS:** human movement, range of motion, center of mass, motion analysis.

**INTRODUCTION:** Tai Chi Chuan is a famous Chinese traditional martial art. The push hand in Tai Chi Chuan is a process to improve the tactile sense to make opponents lost their own balance. The push hand is also a kind of competition in somewhere. In the competition, the contestants try to find the timing to attack and to get the victory. However, the interaction of contestants during push hand competition is still unknown. The purpose of this study was to investigate the kinematics of both contestants to find the timing to attack in push-hand struggle.

**METHODS:** Six male subjects ( $28 \pm 2$  y,  $177 \pm 6$  cm,  $64 \pm 5$  kg) practicing Tai Chi Chuan at least five years were divided into three couples in the current study. The movements of both subjects during performing fixed-steps push hand (Figure.1) were collected by three dimensional motion analysis system (VICON) at the sampling rate of 200 Hz. The center of mass (COM) could be a factor to determine the balance of human movement and the ranges of motion (ROMs) of the elbow and waist were the major joints while performing Tai Chi Chuan. Therefore, the kinematics including COM calculating by segmental method and the ROMs of elbow and waist of both subjects were analyzed by Visual3D software. The ROMs of elbow and waist were defined as the angles of the forearm relative to the upper arm and trunk relative to pelvic respectively. The COM was normalized by the body height. The force plates were used to record the ground reaction forces of both feet of the subjects. The winner in the push hand competition was considered as the subject who made the opponent moved his step during the fixed-step push hand struggle. The push hand competition was finished when the ground reaction force equaled zero. The data of one couple were shown from the start to the end of competition in figures.



Figure 1: Single hand operation for fixed-steps push-hand.

**RESULTS:** The winner made the opponent lost his balance to move step in two conditions. One was in the attacked mode (forward direction) and the other was in the defensive mode (backward direction). In the attacked mode, the trajectories of COM and the ROMs of waist and elbow were showed in figure 2-4. The movements of COM of winner were smaller than loser and the ROMs of elbow and waist of winner were larger than loser. In figure 5-7, the trajectories of COM and the ROMs of waist and elbow were showed in the defensive mode. The movement of COM of winner was similar to loser.

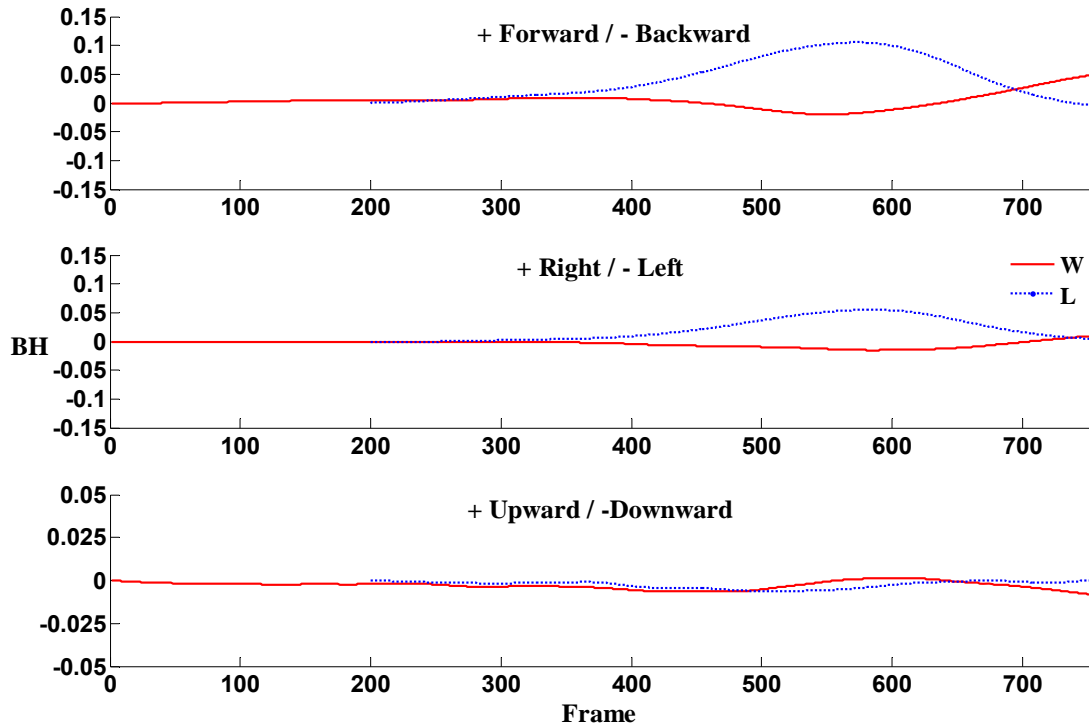


Figure 2: Trajectories of COM in the attacked condition. W and L represent winner and loser.

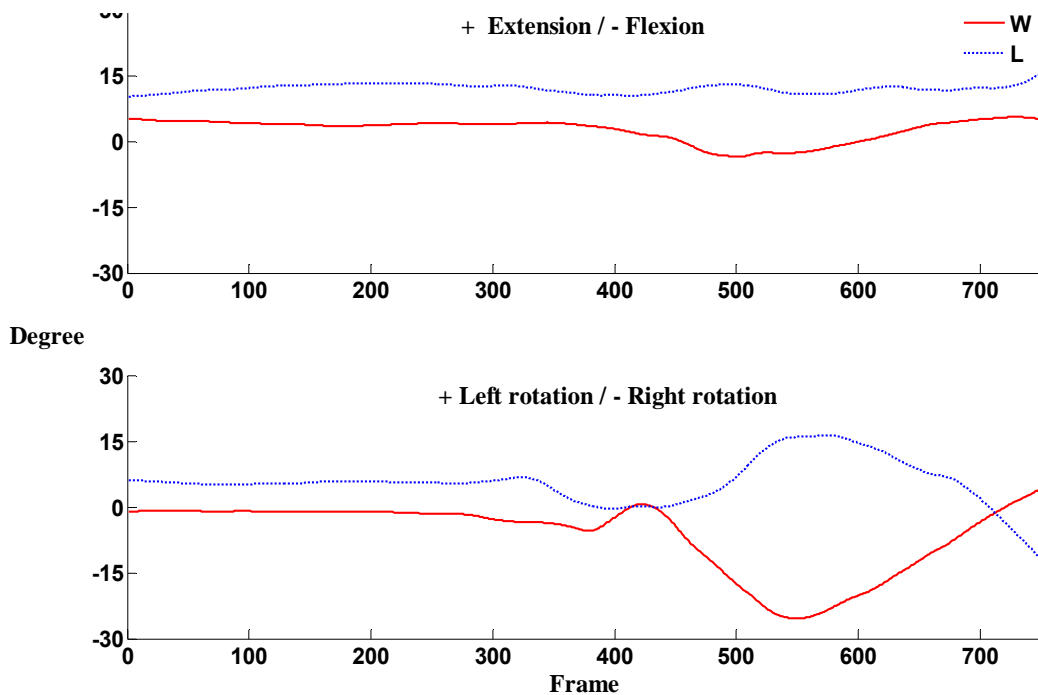


Figure 3: ROM of waist in the attacked condition.

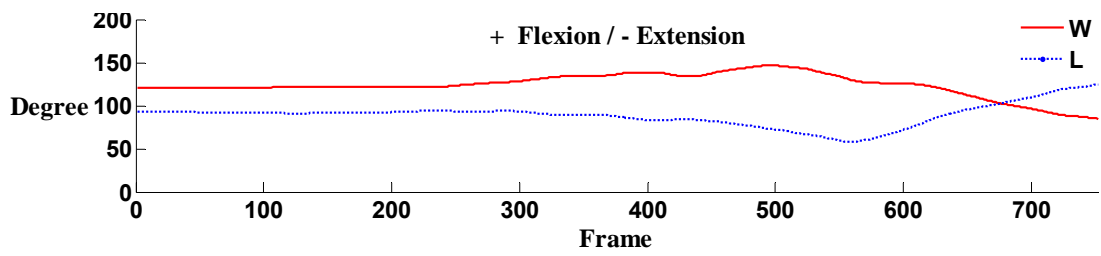


Figure 4: The ROM of elbow in the attacked condition.

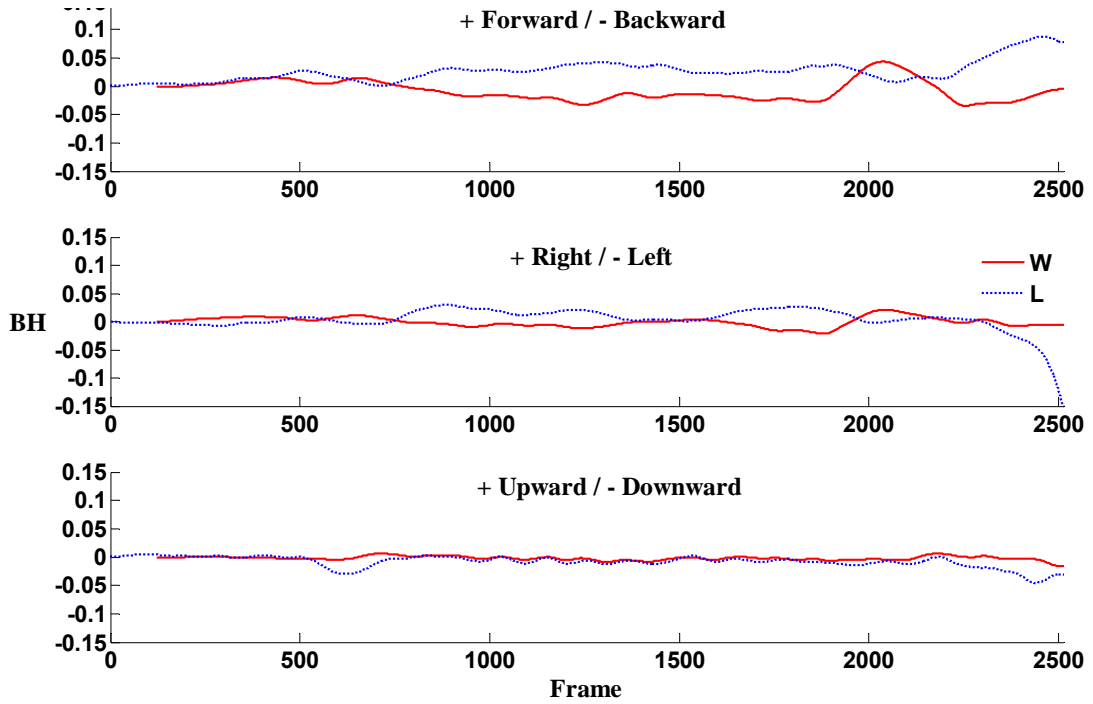


Figure 5: Trajectories of COM in the defensive condition.

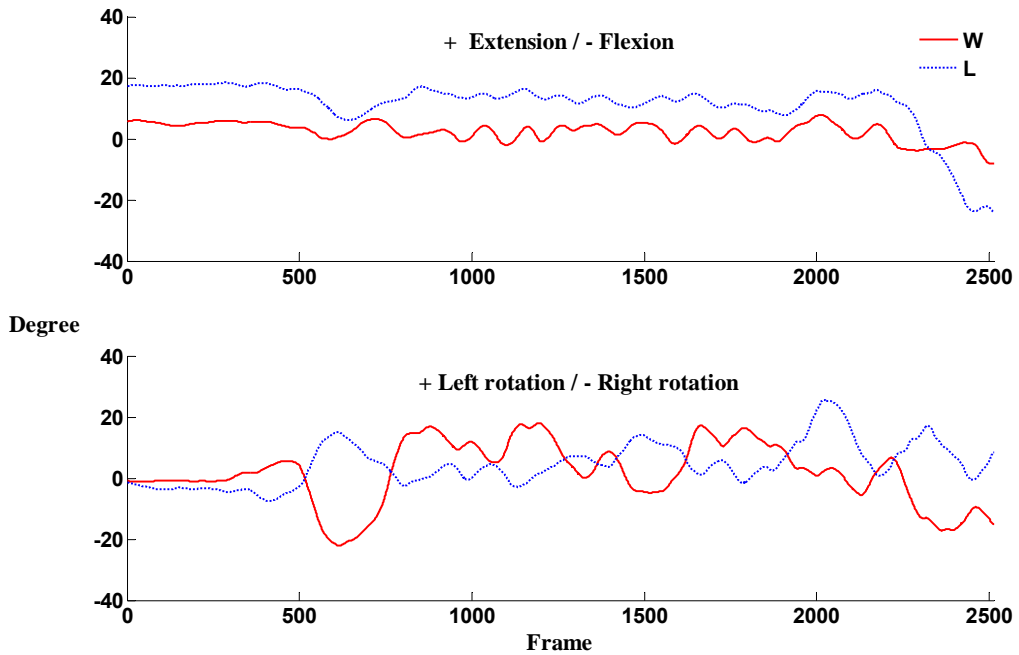
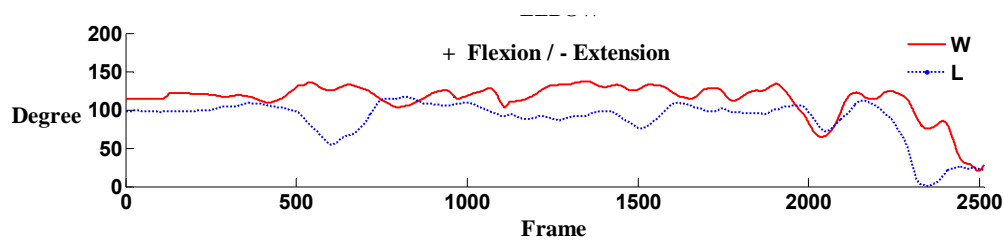


Figure 6: ROM of waist in the defensive condition.



**Figure 7: The ROM of elbow in the defensive condition.**

**DISCUSSION:** In the attacked condition, the winner moved wrist forward quickly to push the opponent backward when he sensed the balance lost of opponent, (Chang, 1997; Chen, 1987). In the current study, the winner rotated the waist to contribute the speed in the forward direction to make the opponent lost balance. If the opponent could not move the COM backward as soon as possible, he would move his step to keep the balance. In the defensive condition, the winner warded off the attack from the opponent by waist right rotating and elbow extending to change the movement of the opponent. If the opponent could not detect the movement changed or change the movement as soon as possible, he would lose his balance. No matter in the attacked or defensive conditions, the winner had less movements of COM in vertical direction. Kept stability of the COM in the vertical direction is a key point to prevent the balance lost (Chan, Luk, & Hong, 1987). It is also important to decrease the movement of waist in sagittal plane to reduce the opportunity of the attack from the opponent. In other words, more stable the subject stood, more chance the subject got the victory in the push hand competition. The movement of lower limbs would affect the trajectory of COM in all direction. It is necessary to investigate the kinematics of the lower limbs to find the key point to win the competition of push hand in Tai Chi Chuan in the future.

**CONCLUSION:** The winner in the push hand competition had less movement of COM in vertical direction and rotated the waist to prevent the balance lost.

**REFERENCE:**

- Chang, S. P., (1997). *The Mechanisms of Force Development and the Sequence of Joints Movement during Nei-Jia-Quan "Explosive Strength-Integration"(A Case Study)*. Unpublished master dissertation, Chinese Culture University, Taipei.
- Chen, W. Z., (1987). *A Kinematic Analysis Of Tai Ji Chuan Two-hand Push*. Unpublished master dissertation, National Taiwan Normal University, Taipei.
- Chan, S. P., Luk, T. C., & Hong, Y., (1987). Kinematic and electromyographic analysis of the push movement in tai chi. *British Journal of Sports Medicine*, 37, 339-344.

*Acknowledgement:* This study is particularly supported by the National Science Council, Taiwan.