

ELECTROMYOGRAPHIC ANALYSIS OF TAI CHI CHUAN: A PILOT STUDY

Suk-Ping Chan and Youlian Hong
The Chinese University of Hong Kong, Hong Kong SAR

This investigation determined the electromyographical characteristic of the Tai Chi Chuan. An experienced Tai Chi Chuan Master was asked to perform the basic movements of Ward off, Roll Back, Press and Push. Both "gentle practising mode" and "strenuous defense mode" were performed. The Push movement was used for data analysis. The results revealed that the large muscle groups of the entire body were activated during Tai Chi Chuan. In most of the time, the work of muscles was quite low in both modes. However, it could generate a peak electromyographic activity as high as the fourth times of the maximal voluntary contraction in the "strenuous defense mode". It's ability for defense combat shouldn't be neglected. The results also demonstrated that Tai Chi Chuan involves the work of muscles of the trunk and the lower limbs greater than the upper limbs.

KEY WORDS: balance, electromyography, flexibility, Tai Chi Chuan, maximal voluntary contraction

INTRODUCTION: Tai Chi Chuan (TCC) is an exercise derived from martial art folk traditions. TCC consists of thirteen essential and basic movements. These thirteen movements are ward off, Roll back, Press, Push, Pull, Split, Elbow Strike and Shoulder Force together with Step Forward, Step Backward, Look Left, Look Right, and Center (Huang, 1993). Previous studies have suggested that TCC can be beneficial to health (Lai et al., 1993). It is also suitable and recommended for the aged and for patient with chronic illness (Channer et al., 1996). Long-form TCC may be classed as moderate exercise. Its intensity does not exceed 50% of individual's maximum oxygen during TCC (Zhuo et al., 1984) and it had been revealed that the changes of heart rate, noradrenaline cortisol and mood during Tai Chi were comparable to those found in moderate exercise (Jin, 1989). From the recent literature, little is known about the biomechanical analysis of TCC. Besides, many people have a misconception that TCC is a slow, gentle exercise that only suitable for old people. In the past, however, the application of TCC as self-defense was often tested in competitions or tournaments. Whether TCC is trained to improve health or to learn its application as a form of self-defense, it requires physical work of different muscles. The purpose of the study was to work out an electromyographic profile of the large muscle groups of the entire body of the "gentle practicing mode" and the "strenuous defense mode" of TCC.

METHODS: A master of TCC (49 years of age, 161.2 cm body height, 67.4 kg body weight) participated in this study. Subject had been practicing Yang TCC for 22 years with one and a half-hour-practicing daily.

Balance. A time "single-leg stand with eyes closed" was used to assess static balance capability. The longest time in seconds was recorded for each foot. Besides, a "reaching arm forward while standing" (Berg et al., 1989) was used to access the balance with eyes open. The subject stood with arm lift to ninety degrees. Stretch out the fingers and reach forward as far as possible. The recorded measure was the distance forward that the finger reached while the subject was in the most forward lean position without lost balance.

Electromyographic analysis. The subject was asked to demonstrate the essential and basic movements of Ward Off, Roll Back, Press and Push with two different modes. In "gentle practising mode", the subject underwent the movements in a slow and usual training speed. While in "strenuous defense mode", the subject underwent the movements for imaged self-defense with opponent'. Each mode was carried out for two trials. TELEMEG Multichannel Electromyography LBITIS Bioengineering Technology and Systems S.r.l., Italy) was used. Bipolar silver silver-chloride surface electrodes were placed longitudinally on the left and right sides of the large muscle groups including Pectoralis Major, Biceps, Triceps, External Oblique, Erector Spinae, Rectus Femoris, Hamstrings and Gastrocnemius. Before

the study, the subject was asked to perform maximal voluntary contraction (MVC) through isometric contraction against manual resistance for each muscle group.

Data analysis. Only the second cycle of Push movement was used for data analysis. The duration of the cycle was measured. The percentage of time of whole cycle that below 10% MVC, on or above 50% MVC were calculated. The peak of each trial was also measured.

RESULTS: The anthropometric data and balance measurements were shown in Table 1. The MVC of different large muscles group was shown in Table 2A and 2B. It ranged from 0.165V to 1.079V. The percentage of time cycle duration of the Push movement of attaining different percentage of MVC was also shown in Table 2A and 2B. It was quite high for IEMG that below ten percentage of MVC in the muscle groups of upper limb. It ranged from 90.4% to 100% in the “gentle practising mode” while it ranged from 79.64% to 92.97% in the “strenuous defense mode”. Whereas for the muscle of trunk and lower limbs, the percentage of time cycle with IEMG below ten percentage of MVC is relatively lower. It ranged from 37.29% to 96.4% in the “gentle practising mode” and from 15.26% to 86.6% in the “strenuous defense mode”. For the MVC on or over fifty percent, it became drastically decreased. The time percentage became zero for the upper limb in the “gentle practising mode” and it ranged from 1.23% to 6.25% in the “strenuous defense mode”. For the trunk and lower limbs, most of the muscle did not exceeded five percent except the left Rectus Femoris (18.27%) in the “gentle practising mode”. Similar trend was found in the “strenuous defense mode”. It did not exceed ten percentage of time cycle duration except in the left Rectus Femoris (41.61%).

In view of peak IEMG, it was 119% to 453% greater than the MVC during performing the strenuous defense style.

Table 1 Subject Characteristics

Subject Characteristics (N =1)	
Age (year)	49
Height (cm)	161.2
Weight (kg)	67.4
Right single- leg stand with eyes closed (s)	9.8
Left single- leg stand with eyes closed (s)	6.4
Reaching arm forward while standing (cm)	34.5

DISCUSSION: The present study results support the common belief that TCC give every part of the body - the muscles - a chance to exercise. It involves work of the large muscle groups of the entire body. The movements of TCC are slow-paced and not strenuous. It provides exercise of a low IEMG in most of the time especially in the “gentle practising mode”. The percentage of time cycle with IEMG below ten percent MVC of the entire body is quite high. Therefore, it implied that the muscle work is low and gentle for whole body in most of the time. On the other hand, it produces a sudden high IEMG in the self-defense situation. The peak IEMG can reach as high as the fourth time of the MVC.

The result of the present study also revealed that the muscle groups of the upper limbs are used less. More involvement in the muscle of the trunk and lower limbs especially for those anti-gravity muscles such as Erector Spinae, Rectus Femoris, and Gastrocnemius were demonstrated. The percentage of time cycle duration of the left Rectus Femoris is especially long. It can be explained by movement analysis. The whole sequence of Push movement involves a bow stance with right foot in front and left foot behind. First of all, Weight shifts on to left leg and right toes are raised, heel on floor, as left fingers and palm slide over top of right hand and then both palms separate at shoulder height, downward facing, elbows bent to 90 degrees. Then, the body weight shifts on to right leg and both palms push downward and forward steeply, then upward in a gradual ascent to shoulder height. This final weight

shifting movement from the rear foot to the front foot was produced by the action of left knee extension and that's why the left Rectus Femoris is especially activated in this action.

In view of peak IEMG, it is 119% to 453% greater than the MVC during performing the strenuous defense style. TCC is a subtle, sophisticated method of self-defense. In application of TCC, attacking is contained in yielding through the technique of borrowing the momentum of the opponent's force and changing its direction. Additional principles of combat include inducing the opponent to advance and making him fall empty; and using lightness to overcome heaviness. Therefore, the muscles of the entire body do not need to contract forcefully at all the time. By using these cues, the practitioner can perform movement in supple and gentle manner but suddenly produce a forceful muscle work by a high IEMG when necessary during martial combat.

TCC involves attaining and maintaining equilibrium and balance in various postures. In the art of TCC, some movement like single leg kicking and twisting need a good balance to maintain the posture. The balance of the master was good as shown in the "reaching arm forward while standing" test. From the neurophysiologic point of view, balance involves an interaction of sensory information between vestibular, somatosensory information and visual systems. The observed benefits of reinforcement of balance possibly attributed through vision in the present study. When the vision component was cut off as in the single-leg stand test, the ability to maintain balance became poor. This may due to the fact that during practice, TCC emphasis on mind concentration. The usual practice was to keep the eyes open to concentrate on the target hitting. The vision seems quite dominate the control in balance in the present study. Future study should involve more subjects to confirm the findings.

CONCLUSION: It is conclude that most of the large muscle groups were used during the TCC while the muscle work of the TCC is quite low in both modes in most of the time. On the other hand, the practitioner can suddenly produce a forceful muscle work by a high IEMG when necessary during martial combat. In TCC, the muscles of trunk and lower limbs involvement are greater than the upper limbs

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Table 2A Percentage of Time Duration of MVC, Peak Voltage, and Percentage of MVC of Different Muscle Groups in The “Gentle Practising Mode” and The “Strenuous Defense Mode”

	Percentage of time duration		Peak (V)	MVC	% MVC
	Below 10% MVC	Over 50% MVC			
Left Pectoralis Major					
Gentle practising mode	90.4	0.01	0.249	0.495	50.303
Strenuous defense mode	83.22	2.02	0.591	0.495	119.394
Right Pectoralis Major					
Gentle practising mode	92.72	0	0.093	0.368	25.272
Strenuous defense mode	79.64	6.25	1.157	0.368	314.402
Left Biceps					
Gentle practising mode	92.28	0	0.303	1.042	29.079
Strenuous defense mode	87.5	1.44	2.192	1.042	210.365
Right Biceps					
Gentle practising mode	98.08	0	0.225	1.079	20.853
Strenuous defense mode	87.84	1.23	1.899	1.079	175.996
Left Triceps					
Gentle practising mode	100	0	0.059	0.685	8.613
Strenuous defense mode	92.97	2.57	1.348	0.685	196.788
Right Triceps					
Gentle practising mode	99.97	0	0.078	0.674	11.573
Strenuous defense mode	92.73	1.95	1.499	0.674	222.404
Left External Oblique					
Gentle practising mode	76.11	0	0.063	0.176	35.795
Strenuous defense mode	75.37	3.44	0.791	0.176	449.432
Right External Oblique					
Gentle practising mode	96.4	0	0.054	0.285	18.947
Strenuous defense mode	86.6	2.14	0.547	0.285	191.903

Table 2B Percentage of Time Duration of MVC, Peak Voltage, and Percentage of MVC of Different Muscle Groups in The “Gentle Practising Mode” and The “Strenuous Defense Mode” (Continuing)

	Percentage of time duration		Peak (V)	MVC	% MVC
	Below 10% MVC	Over 50% MVC			
Left Erector Spinae					
Gentle practising mode	37.29	4.61	0.269	0.223	120.628
Strenuous defense mode	46.83	4.18	0.913	0.223	409.417
Right Erector Spinae					
Gentle practising mode	63.73	0.31	0.171	0.252	67.85
Strenuous defense mode	67.64	5.23	1.143	0.252	453.571
Left Rectus Femoris					
Gentle practising mode	37.85	18.27	0.767	0.352	217.898
Strenuous defense mode	15.26	41.61	1.499	0.352	425.852
Right Rectus Femoris					
Gentle practising mode	67.45	0.12	0.21	0.308	68.182
Strenuous defense mode	72.31	2.42	0.625	0.308	202.922
Left Hamstrings					
Gentle practising mode	86.74	0	0.093	0.293	31.741
Strenuous defense mode	62.56	2.67	0.796	0.293	271.672
Right Hamstrings					
Gentle practising mode	84.45	0.21	0.278	0.388	71.649
Strenuous defense mode	41.45	8.82	1.367	0.388	352.320
Left Gastrocnemius					
Gentle practising mode	72.62	0.09	0.156	0.258	60.465
Strenuous defense mode	56.9	4.03	0.439	0.258	170.155
Right Gastrocnemius					
Gentle practising mode	84.32	0.01	0.083	0.165	50.303
Strenuous defense mode	76.56	6.85	0.605	0.165	366.667