ELECTROMYOGRAPHIC ANALYSIS OF TAI CHI

ICHIRO KAWANO1), SHIN-ICHIRO TAKASUGI1), TETSURO NEJIME1), TAKEHIDE KAMISHIMA1), KENJI MASUMOTO2) and YUKIHIDE IWAMOTO2)

Abstract

The purpose of this study was to analyse electromyographic characteristics of Tai Chi. The subjects, six healthy men, performed: (1) the maximum voluntary contraction (MVC) of each tested muscle; (2) three forms in 24-style Tai Chi; (3) on a bicycle ergometer (100 w) and jogging (120 m/s). For each muscle, the maximum integrated EMG for one second was computed and standardized by MVC (%MVC). The results were as follows: (1) High muscle activity was observed during Tai Chi. In five muscles, the %MVC exceeded 60%. (2) In the rectus femoris m., the %MVC of Tai Chi was 6.8 times that of the bicycle ergometer and 10.3 times that of jogging (p < 0.01). In a similar way, in the biceps anterior m., the %MVC was 7.1 and 4.8 times (p < 0.01) and in the rectus abdominis m., the %MVC was 6.3 and 4.9 times (p < 0.01). We conclude that Tai Chi might be useful as an exercise in muscle strength training.


key word : Tai Chi, surface electromyography, muscle strength, health-promotion exercise

Introduction

The decline of muscle strength in elderly people may hinder activities of daily living and contribute to falls. It has become increasingly clear that exercise training can mitigate or even reverse many adverse changes of aging that reduce quality of life1). We think that for the elderly, low-velocity and low-impact exercises are preferable for reducing cardiovascular and orthopedic complications.

Tai Chi (TC) is a Chinese traditional martial art. However, today Tai Chi has become more famous as a health-promotion exercise than as a martial art. TC has low-impact and slow movement. During the performance of TC, mind concentration and breathing control are integrated with graceful body movements. According to previous studies, TC training is beneficial to cardio-respiratory function2~4), balance5~6) and body composition7). However, few studies have reported on the activity of muscles during the performance of Tai Chi.

The purpose of this study was twofold: first, to analyse the electromyographic characteristics of trunk and lower extremity muscles during Tai Chi and, second, to compare these with the peak integrated electromyography (iEMG) measured during generic health-promotion exercises, using a bicycle ergometer and jogging.

Methods

Subjects

Six healthy males (age, 37.5 +/- 8.0 years; height, 168.1 +/- 8.7 cm; weight 62.0 +/- 6.9 kg; mean +/- SD, respectively) were volunteer participants. All were beginners at TC. They were informed about this study and consented to participate.

Experimental protocol

The subjects performed three kinds of health-promotion exercise, TC, bicycle ergometer and jogging. Representative high muscle activity, and three forms in 24-style TC were selected as follows: (1) No. 3 Form in which a white crane extends feather, (2) No. 7 Form which makes and prevents the formation of the tail of a peafowl, (3) No. 13 Form which kicks and steps toward a leg. These were performed after instruction by a skilled player of TC. The other two exercises were performed on the strength of generic health-promotion, that is, the

1) Department of Rehabilitation Medicine, Kyushu University Hospital, 3-1-1 Maidashi Higashiku Fukuokashi Fukuoka, Japan
2) Department of Orthopaedic Surgery, Graduate School of Medical Sciences, Kyushu University
bicycle ergometer (BE) was set at 100 w and jogging on a treadmill (Jog) was at 120 m/min. Each exercise was measured for 3 minutes.

Measurements and processing materials

Activities of the trunk and lower extremity muscles during each exercise were measured using surface electromyography (EMG) (Myosystem 1200, Noraxon Co. Ltd., USA). Miniature silver-silver chloride surface electrodes (BLUE SENSOR, Ambu Inc., Denmark) were arranged in a bipolar configuration (3 cm inter-electrode distance) directly over the muscle bellies and parallel to the lines of action of the muscle fibres of the rectus abdominis m. (Abd), the erector spinae m. at the level of L4 (ES), the gluteus maximus m. (GMax), the gluteus medius m. (GMed), the rectus femoris m. (RF), the long head of the biceps femoris m. (BF), the tibialis anterior m. (TA), and the lateral head of the gastrocnemius m. (Gas). Each electrode site was prepared by abrading the skin using a skin preparation gel (Skinpure, YZ-0019, Nihon Kohden Co. Ltd., Japan) so that the impedance of the skin was below 5 kohms. The raw EMG signals were recorded at a sampling rate of 1000 Hz and then analyzed using the software, Myo Research 2.11.11 (Noraxon Co. Ltd., USA).

The integrated electromyography (iEMG) was computed every second from the EMG during each exercise and the highest iEMG (iEMGmax) of each muscle in each exercise was recorded. In order to normalize, the EMG during the maximum isometric voluntary contraction (MVC) of each tested muscle was measured essentially following the muscle testing method of Daniel and Worthingham. The iEMGmax during MVC was also calculated. To calculate the percentage of MVC (%MVC) for normalization, the iEMGmax of each tested muscle for each exercise was divided by the iEMGmax of the MVC.

Electroencephalography was monitored (Life Scope 6, Nihon Kohden Co. Ltd., Japan) during each exercise and the peak heart rate (HR) of each performance was recorded.

Statistical analysis

One-way factorial analyses of variance (ANOVA) were performed to compare the mean %MVC of each muscle and HR during each exercise. A value of p < 0.05 was considered significant.

Result

Figure 1 represents typical raw EMG data from

Figure 1. Typical EMG data from the tested muscles during three exercises. Muscles are TA, Gas, BF, RF, ABD, GMax, GMid and ES sequentially from a top. Exercises are TC, BE and Jog sequentially from the left.
the tested muscles during three exercises. During TC, high and continuous muscle activities were observed. During BE and Jog, muscle activities were rhythmic but low.

The %MVC from each muscle during each performance is presented in Figure 2. During TC, in GMax, GMed, RF, TA and GA, %MVC exceeded 60%. In RF, %MVC during TC was 6.8 times that during BE and 10.3 times that during Jog. In a similar way, in TA, %MVC was 7.1 times and 4.8 times, in ABD, %MVC was 6.3 times and 4.9 times.

In Abd, ES, GMax, GMed, RF, TA and Gas, %MVC during TC were significantly higher than that during BE (p < 0.01). In Abd, ES, GMax, GMed, RF and TA, %MVCs during TC were significantly higher than those during Jog (p < 0.01, 0.05).

The peak of HR during TC was 122.2+/−8.7, BE was 130.5+/−14.1 and Jog was 132.3+/−5.6 (beat/min). There were no significant differences between the HR during TC, BE and Jog.

**Discussion**

Tai Chi is a weight bearing and mild intensity exercise, which consists of slow continuous motions of the low center of gravity with extremely long breathing. In No. 3 and 7, the ankle joints repeated plant–dorsi flexion with weighting on the heel and progressive flexion of the knees was performed to varying degrees with most of body weight on one leg, then shifting to the other leg. For this motion, high muscle activities were needed. In No. 13, this form is just single leg standing. To keep body balance and raise the other leg to the outside requires greater muscle contraction.

Hettinger reported that muscle strength is reinforced by training with 40% or more of the maximum muscle strength. In this study, %MVC in five muscles during TC exceeded 60%. The results suggest that muscle strength may be enhanced by TC exercise.

TC is a time-honored martial art form that has gained recognition as an exercise for older people. The literature reveals ample reason why TC offers multiple cardiopulmonary, postural, and body composition benefits to its practitioners. In addition, improved muscle strength can be expected. We consider that determining the effects of TC as a health-promotion exercise for elderly individuals necessitates controlled clinical studies.

**Conclusion**

During TC, the %MVC of five muscles in the lower extremities exceeded 60%. The results suggest that Tai Chi may be a good exercise for muscle
strength training.

References