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Original Article

Adhering to a Tai Chi Chuan Exercise Program Improves Vascular Resistance and Cardiac Function☆

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SUMMARY

Background: Cardiac function is an important predictor for life expectancy in elderly subjects. Tai Chi Chuan (TCC) is a generalized tolerable exercise for the aged population. The current study evaluated the effects of TCC on the vascular compliance and resistance as well as cardiac function of a general healthy elderly population.

Materials and methods: A total of 122 consecutive subjects were enrolled from the general population. Yang style TCC was practiced three times a week for 1 hour each session for a duration of 5 months. Subjects were categorized as "adherents" ($n = 33$) if they participated in >48 (80%) sessions, or as "non-adherents" ($n = 34$). Biochemistry data, including fasting glucose, serum cholesterol, triglycerides, uric acid, were recorded before and after the 5-month intervention. Hemodynamic variables, including vascular compliance, resistance, cardiac output, stroke volume, and left ventricular ejection fraction, were obtained before and after the program using a Dynapulse 200 M monitor.

Results: Serum triglyceride levels declined after TCC practice (the changes in triglycerides were −3.12 mg/dL and 18.8 mg/dL for the adherent and non-adherent groups, respectively; $p = 0.03$). Significant differences between the adherent and non-adherent groups existed in left ventricular contractility, cardiac output, cardiac index, stroke volume, and brachial artery compliance ($p < 0.01$; $p = 0.01$; $p < 0.01$; $p < 0.01$; $p = 0.02$, respectively).

Conclusion: A 5-month TCC intervention can have a favorable impact on some biochemical indices of cardiovascular risk. This intervention can also have favorable effects upon hemodynamic parameters. These findings indicate that TCC intervention may offer enhanced cardioprotective effects in the aged population.

1. Introduction

Tai Chi Chuan (TCC) is a unique exercise that has been practiced in China, Japan, Korea and other Asian countries for several hundred of years, particularly for the elderly population. However, its importance and benefits have been recognized only in recent years after a number of case–control studies and clinical trials[1,2]. TCC emphasizes the balance of the body and the mind, and is performed in a variety of ways, including the Chen, the Yang, the Wu, and the Sun styles[3]. The Yang style is the most popular, according to various studies. TCC is practiced in a semi-squat posture with a series of continual motions, balances, relaxations and slow deep breaths[4]. Despite its slow motion, it is considered to be a moderately intense form of aerobic exercise because it does not demand >55% of maximum oxygen intake[5], but equivalent in intensity to those recommended for the prevention of cardiovascular disease[6].

Cardiovascular disease (CVD) is clearly an important public health problem. Mortality due to CVD can be striking and unbearable to the family and relatives of the deceased person. Since 1992, mortality related to CVD has slightly decreased in Taiwan thanks to improved cardiac care, but hospitalization rates for CVD have significantly increased from 1996 to 2001[7]. In China, a recent study has reported that the rates of CVD mortality in Beijing increased by >50% in men and >27% in women from 1984 to 1999. These

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increases may be attributed to changes in lifestyle, including a substantial rise in cholesterol levels, dramatically less exercise, and even genetic factors[8–13].

Of all preventive methods, exercise is the core component for the cardiac rehabilitation of patients with CVD and is a major factor in improving one's well-being. Mind–body interventions, such as TCC, are complementary therapies that are frequently used. TCC is a reliable and tolerable exercise for all ages of patients and may offer some benefits for preventing or treating CVD. According to a recent review of the effects of TCC on CVD[14], it may lower blood pressure in patients with hypertension and prevent the incidence of stroke or congestive heart failure. However, the evidence about TCC for CVD is still scarce and there are no studies about TCC and its influence on cardiac function in a general population. A noninvasive technique has recently been developed that can measure isolated pressure and rates of pressure change (Dyna-Pulset, Pulse Metric, San Diego, CA, USA). The technology has the potential to measure not only arterial pressure, but also structural properties, such as vascular compliance, cardiac output, and stroke volume[15].

In the current study, we applied the new technology for noninvasive measurements of changes in cardiac structural properties before and after TCC intervention. We also investigated whether adherence to the exercise had any influence on various cardiac performance parameters.

2. Materials and methods

2.1. Study population and design

One hundred and twenty-two consecutive elderly participants (age >50 years) free from hypertension, diabetes and hyperlipidemia were recruited from a Tai Chi club at Taipei City Hospital, Renai branch. All were community dwellers and led active lifestyles that consisted of regular exercise at least three times a week. Subjects were excluded if they had a history of significant cardiovascular, pulmonary, metabolic, musculoskeletal (e.g., joint fracture, or artificial joint replacement), renal or neurological (e.g., stroke, Parkinson's disease, dementia, or poor vision) disease. Eighty-three subjects completed both pre- and post-test measurements in a 5-month intervention program and were finally recruited. The subjects were predominantly female (70%), with a mean age of 62.3 years [standard deviation (SD) = 9.0]. The mean body mass index (BMI) of the subjects was 23.4 kg/m^2 and none of the participants was overweight. The participants were asked to take food ordinarily during the 5-month course.

Based on the recommendations of the American College of Sports Medicine that 80% of exercise attendance is required for significant outcomes to be found[16], 16 participants did not sign in regularly during the program and were dropped from the adherence analysis. Subjects were categorized as "adherent" ($n = 33$) if they participated in >48 sessions or as "non-adherent" ($n = 34$) if otherwise. The study was approved by the local institution committee, and the subjects gave their informed consent.

2.2. TCC Intervention

The TCC program consisted of 24 movements from the Yang styles (http://www.egreenway.com/taichichuan/short.htm#List), which are distinguished primarily as deep breathing accompanying the opening and closing of hands and the stepping forward and backward with weight transference[17]. Each session began with a warm-up exercise to prepare the body, and sessions ended with a cool-down exercise to release muscle tension and stiffness. Subjects in the program practiced at least three times a week for 1 hour each time. The entire intervention length was 5 months. Before starting the TCC program, certified TCC instructors trained with and ensured that each subject was familiar with a standard TCC program.

2.3. Baseline risk factor records

Data were collected by trained personnel according to standardized procedures. Blood pressure (BP) was measured in the right arm unless otherwise specified. Average systolic BP (SBP) and diastolic BP (DBP) were obtained. Sex was self-reported and age was calculated according to birth date. BMI was calculated as weight (kg) divided by height (m^2).

2.4. Laboratory assays

After fasting for 10–14 hours, subjects underwent venous blood sampling from an antecubital vein. Blood glucose and lipid profile, including total cholesterol, triglycerides, and low-density lipoprotein-cholesterol were measured using the autoanalyzer provided by Taipei Institute of Pathology. Biochemistry data, including C-reactive protein and uric acid levels, were also measured.

2.5. Measurements of vascular resistance and cardiac function

Our current study used the Dynapulse 200 M monitor (Pulse Metric, San Diego, CA, USA) to measure vascular resistance and compliance along with left ventricular (LV) contractility and stroke volume. The Dynapulse system used a noninvasive procedure to record and display oscillometric pressure waveform signals from the brachial artery (BA) using a conventional BP cuff wrapped around the upper arm. The procedure was similar to conventional BP measurement. A detailed description of the method has already been published[18,19]. In brief, this instrument employed pulse dynamic pattern recognition technology, whereby integration of the pulsation signal with measurements of isolated pressure and the rate of pressure change at the BA over time (dP/dt max) was used to determine the hemodynamic properties of the BA using a proprietary algorithm. Previous validation studies of the Dyna-Pulse instrument have demonstrated a high correlation between compliance (from which distensibility was calculated) measured with cardiac catheterization and compliance derived by noninvasive means[18–20]. Hemodynamic measurements were taken in triplicate both before and after TCC intervention. Subjects rested for at least 5 minutes before measurements were taken. Waveforms for each patient were downloaded to a personal computer with device-specific software and then uploaded to a web-based analysis center (Dynapulse Analysis Center: http://www.dynapulse.com) for analysis of the tracings and the provision of a table with values for the hemodynamic parameters.

2.6. Statistical methods

SAS version 9.1 software (SAS Institute, Cary, NC, USA) was used for data analysis. Baseline characteristics, biochemistry data and cardiovascular parameters were calculated and presented with means and SD. Effects of all data after the 5-month TCC program were compared by Student's paired t test. Between-group (adherent and non-adherent group) data were compared using Student's unpaired t test for continuous data and a χ^2 test for categorical data. A value of $p < 0.05$ was considered to be statistically significant.