The Beneficial Effects of *Tai Chi Chuan* on Blood Pressure and Lipid Profile and Anxiety Status in a Randomized Controlled Trial

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**ABSTRACT**

**Objectives:** To evaluate the effects on blood pressure, lipid profile, and anxiety status on subjects received a 12-week *Tai Chi Chuan* exercise program.

**Design:** Randomized controlled study of a *Tai Chi Chuan* group and a group of sedentary life controls.

**Setting:** Taipei Medical University Hospitals and University campus in the Taipei, Taiwan, area.

**Subjects:** Two (2) selected groups of 76 healthy subjects with blood pressure at high–normal or stage I hypertension.

**Intervention:** A 12-week *Tai Chi Chuan* exercise training program was practiced regularly with a frequency of 3 times per week. Each session included 10-minute warm-up, 30-minute *Tai Chi* exercise, 10-minute cool-down. Exercise intensity was estimated to be approximately 64% of maximal heart rate.

**Outcome measures:** Blood pressure, lipid profile and anxiety status (State-Trait Anxiety Inventory; STAI) were evaluated.

**Results:** After 12-weeks of *Tai Chi* training, the treatment group showed significant decrease in systolic blood pressure of 15.6 mm Hg and diastolic blood pressure 8.8 mm Hg. The serum total cholesterol level decreased 15.2 mg/dL and high-density lipoprotein cholesterol increased 4.7 mg/dL. By using STAI evaluation, both trait anxiety and state anxiety were decreased.

**Conclusions:** This study shows that under well-designed conditions, *Tai Chi* exercise training could decrease blood pressure and results in favorable lipid profile changes and improve subjects’ anxiety status. Therefore, *Tai Chi* could be used as an alternative modality in treating patients with mild hypertension, with a promising economic effect.

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INTRODUCTION

Coronary heart disease remains the leading cause of death in the United States (American Heart Association, 2000). One of the major risk factors is hypertension. Hypertension is an important risk factor for cardiovascular mortality and morbidity in epidemiologic studies (Kannel et al., 1993; Taylor et al., 1991). Improvements in identification and treatment of hypertension have contributed to a major reduction in the incidence of cardiovascular disease in many countries (Collins et al., 1990). Despite these major advancements in detection and pharmacologic treatment of hypertension, inadequate blood pressure control persists as a major public health problem (Joint National Committee on Detection, Evaluation and Treatment of High Blood Pressure, 1997). Compliance of patients to hypotensive therapy may be an important barrier to optimal blood pressure control as some antihypertensive drug treatment may have a negative impact on the quality of life (Bulpitt et al., 1982).

Regular physical activity is associated with multiple health benefits, including a reduced incidence of cardiovascular disease (Paffenbarger et al., 1986) and stroke (Abbott et al., 1994). It is also generally accepted that physical exercise reduces blood pressure and prevents hypertension (Paffenbarger et al., 1983, 1991). In cross-sectional studies, physically fit or physically active individuals tend to have lower blood pressure than their unfit or sedentary counterparts (Eaton et al., 1995). Population-based cohort studies suggest that being physically fit or active is associated with a reduced incidence of developing hypertension (Paffenbarger et al., 1986). Similarly, clinical trials tend to demonstrate a significant blood pressure-lowering effect of exercise (Tsai et al., 2002a, 2002b). However, it is well recognized that many of the trials had major design limitations (e.g., no control group, small sample size, inadequate blood pressure measurement procedures) (Arroll et al., 1992; Kelley and McClellan, 1994).

The intensity of physical activity necessary to reduce blood pressure remains uncertain. The instruments that assessed physical activity in the population-based studies are sufficient to rank groups of individuals according to physical activity status but are inadequate to characterize the actual intensity of habitual physical activity. Most intervention trials have tested the effects of vigorous exercise on blood pressure (Cononie et al., 1991). In the trials that compared vigorous and moderate-intensity exercise, moderate-intensity activity seems to lower blood pressure as much as higher intensity exercise training in middle-aged and older adults (Rogers et al., 1996).

Tai Chi Chuan (also known as Tai Chi Quan, Tai Chi or Shadow Boxing) has been used for centuries as a martial arts form in Oriental cultures and has also been used in this country as a form of exercise, performed predominantly by older individuals of Asian heritage, to enhance balance and body awareness. Most previous studies (Lai et al., 1995; Lan et al., 1996) were designed to evaluate the effects of Tai Chi training program on the cardiorespiratory system, flexibility, muscle strength, and body fat composition in the elderly (Lai et al., 1995; Lan et al., 1996). Reports from the Chinese literature (En et al., 1984) indicate substantial psychologic as well as physiologic benefits from the practice of Tai Chi (TC). Because people in this country traditionally viewed TC exercise as a useful pathway to their mind–body health, we felt that there was a need to explore the beneficial effects of the TC training for people with hypertension.

The purpose of this randomized trial was to evaluate the effects over 12 weeks of a training program of TC as a means to reduce blood pressure in previously sedentary subjects with high-normal blood pressure or stage I hypertension; the effect on lipid profile and subjects’ anxiety status were also evaluated.

MATERIALS AND METHODS

Subjects

Subjects with documented borderline hypertension (resting systolic blood pressure 130–159 mm Hg or diastolic blood pressure 85–99 mm Hg) were recruited from the campus and two teaching hospitals of Taipei Medical University, Taipei, Taiwan. Subjects were not receiving any medication and were not engaged in
an exercise program prior to the study. Subjects gave their written consents to participate in the study after the risks and benefits of the study had been explained to them verbally and in writing. Subjects were asked to maintain their dietary intake throughout the study. Each subject completed a medical history questionnaire and received a complete physical check-up by a physician. Any subject having a personal history of coronary artery disease, strokes, limiting orthopedic problems, or any other major health problems (American College of Sports Medicine [ACSM] guidelines) were excluded from the study (American College of Sports Medicine, 2000). After completion of the medical history questionnaire, the subjects’ height and body weight were determined. Descriptive data for the subjects are presented in Table 1. The study was approved by the Human Investigation and Studies Committee at the Taipei Medical University.

Baseline blood pressure

All patients had three blood pressures taken in a clinic setting by a research assistant who was blinded to grouping assignment of the subjects. Blood pressure measurements were taken for each subject 5 minutes apart on three separate occasions with a random zero sphygmomanometer. Patients were included if either their mean systolic blood pressure was between 130 and 159 mm Hg or their mean diastolic blood pressure was between 85 and 99 mm Hg. All patients underwent a physical examination by a physician to rule out obvious secondary causes of hypertension and contraindications to exercise.

Experimental grouping and trials

A total of 88 subjects were selected after the screening process and then randomly assigned by drawing to either a TC group or a sedentary life control group. None of them had practiced TC before. The TC group included 44 subjects. Prior to participation in this program, the TC subjects practice the Yang TC exercise by following instructions and movements provided by a qualified master. Then, subjects of the TC group performed this exercise 3 times each week as a maintenance program. Each session included 10 minutes of warm-up exercises, 30 minutes of TC practice, and 10 minutes of cool-down exercise. Each set of TC included 108 postures; some popular TC postures have been published in English (Wolf et al., 1997). During the exercise, the group was led by a Tai Chi instructor and imitated the motions at same speed. In addition, subjects performed each posture according to a prerecorded form sequence on tape to ensure the same time course.

During the performance of TC, heart rates of the subjects were monitored by an electrocardiogram (ECG) telemeter (Hewlett-Parkard model 78100A and 78101A system, Waltham, MA). Table 1. Baseline Parameters of the Subjects in the Tai Chi (TC) and Control Group

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 39)</th>
<th>TC (n = 37)</th>
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</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>50.5 ± 9.8</td>
<td>51.6 ± 16.3</td>
</tr>
<tr>
<td>Male/female</td>
<td>19/20</td>
<td>19/18</td>
</tr>
<tr>
<td>BMI</td>
<td>24.1 ± 1.8</td>
<td>23.8 ± 2.4</td>
</tr>
<tr>
<td>SBP (mm Hg)</td>
<td>148.2 ± 8.8</td>
<td>142.4 ± 8.6</td>
</tr>
<tr>
<td>DBP (mm Hg)</td>
<td>86.2 ± 8.4</td>
<td>87.4 ± 8.7</td>
</tr>
<tr>
<td>Heart rate (beats per minute)</td>
<td>78.2 ± 6.8</td>
<td>77.8 ± 7.4</td>
</tr>
<tr>
<td>Cholesterol (mg/dL)</td>
<td>212.6 ± 22.8</td>
<td>205.2 ± 18.8</td>
</tr>
<tr>
<td>Triglyceride (mg/dL)</td>
<td>174.2 ± 55.8</td>
<td>172.4 ± 68.8</td>
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<tr>
<td>HDL-C (mg/dL)</td>
<td>49.8 ± 8.9</td>
<td>51.2 ± 13.8</td>
</tr>
<tr>
<td>LDL-C (mg/dL)</td>
<td>131.6 ± 20.8</td>
<td>130.1 ± 15.8</td>
</tr>
<tr>
<td>Trait anxiety</td>
<td>40.8 ± 7.2</td>
<td>42.8 ± 6.4</td>
</tr>
<tr>
<td>State anxiety</td>
<td>39.8 ± 6.9</td>
<td>41.2 ± 7.8</td>
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Values are mean ± standard deviation (SD). BMI, body-mass index[(weight, kg)/(height, m)²]; SBP, systolic blood pressure; DBP, diastolic blood pressure. HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.
RFA). Resting blood pressure was calculated by averaging the blood pressure measurements following at least 10 minutes seated rest by the subject before each of the TC training monitored by a staff member to ensure compliance with the TC exercise. In addition, subjects’ blood pressures were taken every 15 minutes during TC exercise to ensure the safety of the subjects. The control group maintained their usual lifestyle behaviors, including eating habits and previous sedentary life pattern. Regular follow-up through outpatient department or by telephone interview were arranged every 4 weeks for the control group.

Blood lipid measurement

Biochemical blood tests were performed for each subject at the baseline and the 12th week during the study period. Plasma cholesterol and triglycerides were measured by conventional assays and high-density lipoprotein (HDL) cholesterol was determined after sodium phosphotungstate-magnesium chloride precipitation (LaRosa et al., 1990). Low-density lipoprotein (LDL) cholesterol was calculated by a modified version of the Friedewald formula: LDL cholesterol = total cholesterol – (0.16 × triglycerides + HDL-cholesterol) (Chan et al., 1995).

State and trait anxiety measures

State and trait anxiety of the subject was assessed by the State and Trait Anxiety Inventory (Spielberger at al., 1983). This inventory contains 20 items each on trait and state anxiety. Each item is scored from 1 (not at all) to 4 (very anxiety). The psychologic properties of this inventory have been examined and support its validity and reliability (Spielberger at al., 1983). The internal consistency reliability of this scale was also evaluated in our present study. The Cronbach α values were 0.84 for trait anxiety and 0.89 for state anxiety, respectively.

Statistical analysis

All data are presented as mean ± standard deviations. Unpaired t tests were performed to analyze the differences among baseline data between groups. The paired t test was used to compare variables within each group. A p value of < 0.05 was considered to be statistically significant.

RESULTS

Of the 88 enrolled subjects, 76 (73.1%) completed this study. The age range of the subjects was 35 to 65 years with a mean age of 52 years. The TC group (n = 37) included 19 men and 18 women; the sedentary control group (n = 39) included 19 men and 20 women. There was no statistical difference in demographic data between the two groups. There were 2 male smokers (1 in the TC group and 1 in the control group). None of the female subjects were smokers. Because rigorous medical screening had been performed, only a small percentage of subjects had chronic disease. For the TC groups, 5 men and 4 women had stage I hypertension. For the control group, 5 men and 5 women had stage I hypertension. Because almost all the hypertensive subjects had had their hypertension diagnosed recently, most of them were not undergoing pharmacologic treatment. None of the subjects experienced angina, major ventricular arrhythmias, or significant myocardial ischemia during the TC exercise. Baseline data of the TC group and the control group are shown in Table 1.

Of the 12 subjects (13.6%) who dropped out, losses were equally divided between the TC and the control group. The reasons included quitting because of TC training (n = 4), changed residence (n = 4), and refusal of follow-up testing (n = 4). For the subjects who quit TC training, the main reason was lack of interest. No one was forced to stop training because of medical problems.

Table 2 presents the changes of variables obtained by the TC and the control groups. After 12 weeks of training, the TC group showed a significant decrease in blood pressure with mean systolic pressure decreased from 142.4 to 126.8 mm Hg (−15.6 mm Hg) and mean diastolic pressure decreased from 87.4 to 78.6 mm Hg (−8.8 mm Hg). However, the control group blood pressure revealed increase with systolic pressure increased from 148.2 to 154.6 mm Hg (+6.4 mm Hg) and diastolic pressure increased from 86.2 to 89.6 mm Hg (+3.4 mm Hg).
One distinct finding of this study is the favorable changes of lipid profile (Table 2). The mean total cholesterol level of the TC group decreased significantly from 205.2 to 190.0 mg/dL (−15.2 mg/dL, −7.4%); mean triglyceride level decreased from 172.4 to 148.6 mg/dL (−23.8 mg/dL, −13.8%) and LDL cholesterol decreased from 130 to 110 mg/dL (−20 mg/dL, −15.4%), whereas the HDL cholesterol increased from 51.2 to 55.9 mg/dL (+4.7 mg/dL or +9.2%).

The TC group also reported lower scores on both state and trait anxiety compared to the baseline (Table 2). On the contrary, no improvements in blood lipid profile and anxiety level were observed in the control group (Table 2).

**DISCUSSION**

TC practice has been used for centuries as an exercise for health in a wide age range, particularly in the elderly. The present study is the first to evaluate about the impact of TC exercise on the blood pressure, lipid profile, and anxiety status in hypertensive individuals.

High blood pressure and hyperlipidemia are two major important risk factors for coronary heart disease, and anxiety status represents a portion of life quality.

The current practice of TC has evolved into relaxed, smooth, and graceful movements. Cardiovascular responses to TC exercise have been reported in a variety of publications. The first paper in English was published in 1981 (Gong et al., 1981). A total of 100 healthy regular TC practitioners participated in that study. The TC experience of those subjects varied from 6 months to 30 years. The results showed that the mean heart rate of the subject was 74 beats per minute before exercise, rose to 92 beats per minute after 2 minutes of exercise, and then stabilized at 95–98 beats per minute throughout the exercise. The mean peak heart rate was 104 beats per minute, and the mean maximal increase in the heart rate was 30 beats per minute at 12–14 minutes of exercise. When the subjects were divided into three groups according to their years of TC experience, age, and resting heart rate before exercise, there was no significant difference in the changes in heart rate among the groups. In our hypertensive subjects, the mean exercise heart rate was approx-
 aproximadamente 63.7% predeterminado ritmo cardíaco máximo. El tipo de intensidad de ejercicio es comparable a la experiencia de los sujetos durante el entrenamiento submáximo por tapis roulant (Tsai et al., 2002a).

Nuestra presente evidencia muestra que el uso de ejercicios de TC puede reducir la presión arterial en sujetos con etapa I o hipertensión alta normal y que esta reducción de presión arterial es equivalente a muchos tipos de drogas antihipertensivas. Significa que el uso de este método no farmacológico de reducción de la presión arterial puede evitar los efectos secundarios de medicamentos y también tiene beneficios económicos. Hay varias razones para recomendar TC como una alternativa de ejercicio para sujetos con hipertensión leve. Primero, el TC no requiere un espacio especial o equipo costoso como una máquina de tapis roulant y puede practicarse en cualquier momento y en cualquier lugar. Segundo, el TC es efectivo para mejorar la función cardiorespiratoria y otros rasgos de fitness. Tercero, el practicar TC es bajo en tecnología y puede ser fácilmente implementado en la comunidad.

Durante el programa de 12 semanas de TC, no se observaron cambios significativos del índice de masa corporal en estos sujetos de TC. También se informó que la pérdida de grasa corporal inducida por entrenamiento físico no ha estado asociada con la reducción de la presión arterial (Ishikawa et al., 1999). El mecanismo de cambio de la presión arterial puede contribuir a la pérdida de sodio durante la condición sudoratoria. Además, la hipertensión arterial puede ser considerada como uno de los mecanismos involucrados en la atenuación de la hipertensión arterial. El reducción de la actividad nerviosa simpática producida por el entrenamiento puede ser considerada como uno de los mecanismos implicados en la atenuación de la hipertensión arterial. Las reducciones en la actividad simpática que siguen al entrenamiento son más pronunciadas en pacientes con hipertensión esencial que en individuos normotensivos y son más propensos a la hiperinsulinemia. Otro tipo de evidencia también sugiere que el ejercicio puede activar la lipoproteína lipasa (LPL) que es crítica en el formado de HDL y que aumenta con el entrenamiento de resistencia. La LPL está también correlacionada con el gasto máximo de oxígeno (VO2max) y mejora la utilización de la grasa en los músculos en individuos entrenados. En el otro lado, la actividad de la lipasa hepática está asociada con el tratamiento de la hipertensión arterial. La actividad de la lipasa hepática es un factor que promueve la formación de HDL y es aumentada con el entrenamiento de resistencia. Los estudios previos también sugieren que el ejercicio puede activar la lipasa muscular y disminuir el gasto de triglicéridos y aumentar el nivel de HDL. Aunque el ejercicio puede reducir el gasto de triglicéridos, también puede aumentar el nivel de HDL. Los estudios previos también sugieren que el ejercicio puede activar la lipasa muscular y disminuir el gasto de triglicéridos y aumentar el nivel de HDL. La actividad de la lipasa hepática está asociada con el tratamiento de la hipertensión arterial. La actividad de la lipasa hepática es un factor que promueve la formación de HDL y es aumentada con el entrenamiento de resistencia. Los estudios previos también sugieren que el ejercicio puede activar la lipasa muscular y disminuir el gasto de triglicéridos y aumentar el nivel de HDL. La actividad de la lipasa hepática está asociada con el tratamiento de la hipertensión arterial. La actividad de la lipasa hepática es un factor que promueve la formación de HDL y es aumentada con el entrenamiento de resistencia.
production of LDL, which is reduced in fit adults (Rowland et al., 1996).

In addition, the practice of TC has viewed as a mind–body approach to achieving complete relaxation and wellness. The somatic elements of TC activity include slow hand, arm, leg, and waist movement. The mindful elements of this activity were accompanied by relaxation and deep breathing exercises (Lan et al., 1999). In our study, significant reduction in anxiety level was observed in the TC group. Some investigators (Young et al., 1998) reported that high trait anxiety is associated with increased smoking behavior, decreased routine exercise, and lifestyle variables that are associated with high cardiovascular risk. TC intervention can impact favorably on anxiety status and may also have a subsequent favorable effect on cardiovascular risk modification.

Limitations of the current study are recognized. Some confounding hidden factor, such as the interaction among the subjects and/or the influence of the instructor, could have an impact on anxiety of the subjects. Additional clinical research is needed to validate the reported positive health outcome of TC exercise in hypertensive individuals. For example, a comparable control group participating in other physical activity program, meeting the same number of times per week as the TC group.

In conclusion, the present data show that TC exercise program has the potential to play an important role in lowering blood pressure and also result in favorable lipid profile changes among people with hypertension. Subjects’ anxiety status also improved. These results probably implicate that TC is good for hypertensive individuals physically and mentally. In addition, TC is a low-technology exercise, and hence it may be easily implemented in the community with potential economic benefit to the health care system.

REFERENCES


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