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by

Ruth Elaine Taylor-Piliae

To my husband, Malama Lafaele Leilua Piliae [Puipuifatu]

for your support, loyalty, and patience.

To my sons, Ryan, Nicholas and Derrek

學而不厭, 誨而不倦.

Never tire to study, and to teach others.
Confucius, 551-479 B.C.

Just as the value of a house lies in its location,
The value of a mind lies in its depth,
The value of giving lies in the presence of a generous spirit,
The value of words lies in their reliability.
-Lao Tzu, 570-490 B.C.

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This dissertation contains multiple published papers. The publications represent research or scholarship comparable in scope and contribution to the portion of the dissertation it replaces, and are the product of my work while a doctoral student at UCSF. Paper 1 is a reprint of the material as it appears in the *Journal of Cardiopulmonary Rehabilitation.* I wish to thank Lippincott, Williams and Wilkins who granted permission to reprint the entire article. Paper 2 is a reprint of the material as it appears in the *Journal of Cardiovascular Nursing.* I wish to thank Lippincott, Williams and Wilkins who granted permission to reprint the entire article. The co-author listed in this publication directed and supervised the research that forms the basis for the dissertation. Paper 3 is a reprint of the material as it appears in the *European Journal of Cardiovascular Nursing.* I wish to thank Elsevier Science and the European Society of Cardiology who granted permission to reprint the entire article. The co-author listed in this publication directed and supervised the research that forms the basis for the dissertation. Papers 4, 5, and 6 are currently in review.

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Tai Chi as an Alternative Exercise for Ethnic Chinese with Cardiovascular Disease Risk Factors

Ruth Elaine Taylor-Piliae
Doctor of Philosophy
University of California, San Francisco, 2005

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality in the United States (US), including ethnic Chinese living in the US. Regular participation in physical activity is associated with protection against CVD, and improvements in physical and psychological health. However, the majority of adults in the US are not meeting recommended physical activity levels. Since participation in physical activity is often influenced by social experiences and cultural values, it is an important consideration when planning exercise programs for specific ethnic groups. Tai Chi (TC) is a traditional form of exercise among Chinese populations, which has been shown to produce some health and performance benefits similar to Western style exercise training.

The overall aim of this dissertation was to examine physiological and psychosocial status after 12-weeks of TC exercise in ethnic Chinese adults with CVD risk factors. This was a repeated measures intervention study. Subjects attended a 60-minute TC exercise class 3 times per week for 12 weeks, with data collected at baseline, 6 and 12-weeks following the TC exercise intervention.

A total of 39 subjects, on average 66 (± 8.3) years old, married (85%), Cantonese-speaking (97%), immigrants participated. The majority were women (69%), with ≤ 12 years education (87%) reported. At baseline, the average BP at rest was 150/86, and subjects were below the 50th percentile of fitness, compared to age and gender-specific US normative data. A significant reduction in resting blood pressure, and improvements

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in: aerobic endurance, balance, muscular strength and endurance, flexibility, and psychosocial status were found ($p \leq 0.05$). Adherence (87%) to the TC exercise intervention was high, with very high follow-up (97%) of subjects on completion of the study achieved.

TC has the potential to reduce expenditures associated with CVD by facilitating a lifestyle that promotes physical activity, while remaining a low-tech, low-cost alternative to exercise. These findings provide important information for future community-based TC exercise programs, and support current public health initiatives to reduce disability from chronic health conditions.

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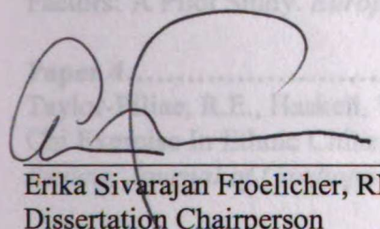

Erika Sivarajan Froelicher, RN, MA, MPH, PhD
Dissertation Chairperson

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Introduction

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Cardiovascular disease (CVD) is the leading cause of morbidity and mortality in the United States (AHA 2003; CDC 2004). Ethnic Chinese are the largest group of Asian immigrants in the United States (US), with heart disease listed as the leading cause of mortality (Hoyert & Kung 1997), affecting mainly middle to older age adults. Prevention and treatment of cardiovascular disease (CVD) among Chinese immigrants in the US has not been widely studied, though the incidence of CVD and CVD risk factors among Chinese are increasing (WHO 1998; Yusuf *et al.* 2001).

Regular participation in physical activity is associated with protection against cardiovascular disease (CVD), and improvements in physiologic and psychosocial health and well-being (Miller *et al.* 1997; Thompson *et al.* 2003; Wenger *et al.* 1999). However, recruitment and retention of persons with CVD or CVD risk factors in exercise programs is problematic with high drop-out rates reported, (Gallagher *et al.* 2003; Moore *et al.* 1998), a reflection of the complexities and difficulties associated with personal behavioral changes (Bandura 1997). Moreover, as physical activity is strongly determined by social experiences, cultural background and health status (Shih 1996; Spector 1996), research that is specifically aimed at Chinese with CVD or those with CVD risk factors is needed, in order to achieve the greatest health benefits for these persons.

Tai Chi (TC) is a traditional form of exercise in China, and has been shown to produce some health benefits similar to Western style exercise. The goal of this dissertation was to determine whether TC exercise, a culturally appropriate form of exercise among ethnic Chinese, is effective in improving physiologic and psychosocial

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status in middle-aged and older Chinese adults with at least one major CVD risk factor, including hypertension, hypercholesteremia, diabetes or smoking.

Given the difficulties surrounding traditional exercise programs to improve health and well-being among persons with CVD or CVD risk factors, such as the costs associated with expensive equipment and personnel when utilizing a treadmill or cycle ergometry, adherence to exercise programs, and barriers to access, including language, or transportation issues; this dissertation explores a novel approach to exercise participation by introducing Tai Chi exercise as a potential alternative form of exercise among ethnic Chinese with CVD risk factors. This dissertation consists of six papers: papers 1, 2, and 3 were published, and papers 4, 5, and 6 are in review.

In paper 1, a review of the literature on TC, up to December 2001, explores whether there are potential benefits to performing TC exercise as an adjunct to existing cardiac rehabilitation exercise training. In paper 2, a meta-analysis was conducted to estimate the extent to which TC exercise affects aerobic capacity. The effect of Tai Chi exercise on aerobic capacity is important to know, if clinicians would like to recommend Tai Chi as an alternative form of aerobic exercise for persons with CVD risk factors. However, people often struggle to change their behavior, and experience both failures and successes.

Self-efficacy beliefs help determine how much effort individuals will spend on an activity, such as Tai Chi exercise, how long they will persevere with the activity when facing barriers or other obstacles, and how resilient they are in the face of impossible situations (Bandura 1997; Pajares 2002). In paper 3, a pilot study was conducted to

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assess the utility and appropriateness of existing tools measuring aspects of TC exercise Self-Efficacy in a new population, ethnic Chinese with CVD risk factors.

Papers 4, 5 and 6 report the findings from a repeated-measures intervention study among self-identified ethnic Chinese middle-aged and older adults residing in the San Francisco Bay Area with at least one major CVD risk factor (current smoker, high blood pressure, high cholesterol, diabetes). Subjects attended a 60-minute TC exercise class 3 times per week for 12 weeks. Change in hemodynamic responses, performance-based physical functioning (balance, muscular strength & endurance, and flexibility), and psychosocial status following a 12-week TC exercise intervention among ethnic Chinese with CVD risk factors are reported.

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Paper 1

Tai Chi as an Adjunct to Cardiac Rehabilitation Exercise Training

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Tai Chi as an Adjunct to Cardiac Rehabilitation Exercise Training

Abstract

Heart disease is a chronic condition needing lifetime secondary prevention measures to decrease morbidity and mortality, and improve quality of life. Cardiac rehabilitation exercise training, one aspect of cardiac recovery, traditionally includes some form of aerobic fitness and more recently muscle strength training to improve exercise tolerance. Tai Chi has been widely practiced in China for centuries, is a popular form of exercise among older Chinese persons, and is associated with enhanced well-being and health among traditional Chinese practitioners. Recent research has reported improvements in cardiorespiratory function, balance and postural stability, fall prevention, and stress reduction. A review of the literature suggests potential benefits of performing Tai Chi exercise as an adjunct to cardiac rehabilitation exercise training. Tai Chi is cost-effective and facilitates a life-style of health-related behavior practices.

Key Words: Tai Chi, cardiac rehabilitation, exercise training, secondary prevention, integrative medicine

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Introduction

Despite advances in medicine and clinical care, heart disease continues to be the leading cause of morbidity and mortality in the USA.[1-3] Global cardiovascular disease (CVD) mortality accounts for one-third of all deaths, with two-thirds of those deaths coming from developing countries.[4, 5] Projected global CVD deaths are expected to rise significantly, increasing CVD burden in developing countries over the next two decades. In developing countries alone, CVD mortality currently represents 24.5% of all deaths and is predicted to increase to 34% by 2020.[2] In China, death attributable to CVD rose from 12.1% in 1957 to 35.8% in 1990.[2] Cigarette smoking among males in China is reported to be over 60% and is expected to increase.[6] In Hong Kong, diseases of the circulatory system accounted for 25% of all deaths in 1998, with heart disease listed as the second leading cause of death, representing 61% of that mortality.[7] There is concern that the prevalence of heart disease will continue to rise due to an increase in affluence and an adoption of a 'westernized' lifestyle with increased levels of smoking, high cholesterol intake, stress, and a sedentary lifestyle among Chinese persons living in Hong Kong, as well as other affluent cities around the world.[8] Moreover, ethnic Chinese are the largest group of Asian immigrants in the United States, with heart disease listed as the leading cause of mortality, representing 29.4% of all deaths.[9] Secondary prevention through cardiac rehabilitation can make a significant contribution to improving the functional status of known cardiac patients, modifying coronary risk factors, and improving quality of life, while reducing mortality and morbidity.[10] Secondary prevention has been found effective for a variety of cardiac conditions including, angina pectoris (stable), myocardial infarction, coronary bypass surgery, intracoronary

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revascularization (angioplasty, stenting, rotablator, laser angioplasty), valve replacement, or heart failure.[10-12] Cardiac rehabilitation exercise training, one element of cardiac recovery, has been shown to decrease cardiac risk factors by improving blood lipid profile, symptoms associated with angina and heart failure, and psychosocial well-being; reducing stress, blood pressure, and mortality; and aiding weight control.[10, 11] Research evidence has also found that cardiac rehabilitation exercise training leads to improvements in various measures of psychological status and functioning.[10, 13] Moreover, physical fitness among persons qualifying for cardiac rehabilitation has been shown to serve as an independent predictor for mortality.[12, 14]

The most common forms of exercise training have included some form of aerobic fitness and more recently muscle strength training to improve exercise tolerance.[14, 15] Exercise intensity of 50% to 70% of predicted maximum heart rate is safe and appropriate for coronary patients.[11] Light to moderate intensity physical activity has been reported to reduce coronary heart disease mortality.[16] Tai Chi, a traditional Chinese exercise originated in China hundreds of years ago, and is based upon principles found in the ancient Chinese philosophies of Confucianism, Taoism, and Buddhism. As a healing art, it is widely used by Chinese doctors to treat conditions of hypertension, stress, depression, mental strain, chronic indigestion, insomnia, and arthritis. Tai Chi is associated with enhanced well-being and health among traditional Chinese practitioners[17, 18] and only recently has attention been given by the West to its potential health benefits.[19-21] Recent research has reported improvements in cardiorespiratory function, balance and postural stability, fall prevention, and stress reduction.[22] Tai Chi requires no special facility or expensive equipment and can be performed either individually or in

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groups. Tai Chi movements are ideally suited for persons of all ages, regardless of previous exercise experience and aerobic capacity.[17]

Theoretical Framework

The scientific foundations of exercise physiology and psychoneuroimmunology serve as the theoretical framework for understanding how Tai Chi may function as an adjunct to cardiac rehabilitation exercise training. Psychoneuroimmunology is the study of how psychological variables, such as anxiety, stress, or depression; the nervous, endocrine and immune systems communicate. This mind-body communication is thought to occur through two distinct pathways (the sympathetic-adrenal-medullary axis and the hypothalamic-pituitary-adrenal-cortex axis) via neurotransmitters, neuropeptides, hormones, and immunomodualtors. The pathways connecting the mind and body enable an integrated response to behavioral, physiological, or immunological threats, in order to maintain homeostasis.[23, 24] Substantial evidence suggests that exercise is also related to improvements in mental health, neuroendocrine, and immune functioning.[23, 25]

Review of Literature

Tai Chi has been widely practiced in China for thousands of years as a method of meditation, exercise and self-defense. The art and philosophy of Tai Chi is based on the collective philosophies of Taoism, Confucianism, Buddhism and the study of nature. The various forms of the exercise called movements, come from animals and birds. The function of these movements is to guide breathing and circulation to help the vital energy flow through the body and have beneficial effects.[18, 22] Slow, controlled graceful movements characterize Tai Chi, integrating mental concentration and breathing control.

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Movements flow from one to another, without excess energy expenditure from unnecessary muscle contraction.[19] Each posture is performed evenly from beginning to end with the same continuous rhythm and is thought to improve circulation, breathing and strengthen internal organs. Masters of Tai Chi have reported benefits of health, vigor and longevity, which are thought to be due to the relationship between the movements, breathing and meditation.[18, 26]

The philosophy behind Tai Chi is based on the Tao, as a coming together of opposites, called yin and yang. While performing Tai Chi, these principles of movement and rest while breathing in and out, are direct applications of the yin and yang principle of opposites. This dualism has been the basis of the Chinese understanding of health and illness since ancient times. Chinese believe that good health requires a balance of yin and yang forces within the body.[27, 28] Heaven, day, male, arteries, exhalation and movement are thought to be *yang*; while earth, night, female, veins, inhalation and rest are viewed as *yin*.

The basic physiological foundation of Tai Chi involves circulation of *chi* or energy throughout the body, through channels or meridians. These concepts of physiology are important to Chinese though quite different from Western models of physiology, as they do not refer to any physical entity that can be seen or measured scientifically.[18, 28] Tai Chi integrates both body and mind. The mind is used to direct the chi and move the limbs. The movement is thought to facilitate blood circulation, which in turn aids functioning of the internal organs. Traditional Chinese medical practitioners claim health benefits may be gained for the heart and lungs through the breathing techniques and improvement of circulation that results from free-flowing chi within the

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body. Tai Chi is presumed to aid in the removal of toxins in the liver, help the kidney to function properly, improve balance, prevent backaches and improve joint stiffness associated with arthritis. Finally, Tai Chi is thought to develop calm, peace, relaxation and clarity of mind, which in turn aids an individual to control daily mental and emotional distress such as tension, anxiety, fear, depression and anger.[18, 26-28]

There are several styles of Tai Chi, which are currently practiced. The Chen style has quick and slow large movements; the Yang style, the most popular, has slow large movements; the Wu style is mid-paced with compact movements; while the Sun style has quick, compact movements.[22] In addition, there are a few simplified or modified forms of Tai Chi. One modified version of Tai Chi, called Tai Chi Chih, is easily learned and consists of only 20 simple movements.[29] Unlike other forms of Tai Chi, the entire routine does not have to be mastered before benefiting from exercise training.[29] Tai Chi Chih is best learned from a certified instructor in a group setting and takes approximately 30 minutes to perform the whole routine. Once movements are learned, they can be performed alone. The feasibility of using Tai Chi Chih among elderly persons and those with heart failure has been demonstrated in prior research.[30, 31] Though there are several styles of Tai Chi currently being practiced, they all share common beliefs and philosophies.

Tai Chi is suitable for people of all ages, though is very popular with older Chinese persons. These movements are ideal for elderly people, of whom high percentages are likely to require cardiac rehabilitation exercise training, regardless of previous exercise experience and aerobic capacity.[17] Tai Chi requires only moderate work intensity with estimated energy costs ranging between 4.1 to 4.6 metabolic

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equivalents (METs),[32, 33] with work intensity not exceeding 50% of an individual's maximum oxygen uptake.[33] Recently, the exercise intensity during performance of the classical Yang style among experienced Tai Chi practitioners, was reported by Lan and colleagues[34] to be at 55% of the subjects peak oxygen uptake and 58% of their heart rate range. Zhou and colleagues[33] have reported energy cost for a simplified form of Tai Chi requiring an average of 2.9 METs with a maximum oxygen uptake at less than 40%, suggesting Tai Chi is an appropriate exercise for older adults and those with cardiovascular disease. Energy requirements for Tai Chi Chih movements are estimated at 1.5-2.6 METs,[35] depending on whether the subject was sitting or standing, while energy costs for the breathing component for Tai Chi Chih, were estimated at 3.0 to 3.6 METs.[35] Fontana[35] reported mean maximum heart rate was 43% to 49% of the predicted maximum heart rate, no differences were reported in response to this exercise by gender. Thus, the exercise intensity of Tai Chi is not fixed, and it can easily be adjusted by the height of the postures and the duration of the practice session, to accommodate sedentary individuals or those with a chronic condition.[34]

Tai Chi facilitates a life-style that practices health-related behavior among people of all ages. A recent cross-sectional study by Chen and colleagues[36] examined various facilitators and barriers to practicing Tai Chi among elders in Taiwan. Participants matched on age and gender, were compared as Tai Chi practitioners versus non-practitioners. Both groups reported similar chronic illnesses, with heart disease and hypertension accounting for 46% of these. Positive attitudes towards Tai Chi exercise included encouragement from others with perceived health benefits of feeling relaxed and peaceful, more energetic and having the ability to think more clearly. Other factors that

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facilitated Tai Chi practice were convenience, manageability, and a better social life developed by new friendships acquired through practicing Tai Chi in a group setting. However, many older Chinese adults in Taiwan have never even considered Tai Chi as a form of exercise, while others stated that they had no time to perform it. Other difficulties that Chinese elders reported include: feeling too weak physically, being too old, too fat or not knowing where to go and learn Tai Chi. Further, perceived barriers reported were that Tai Chi was too complicated to learn, having no patience to learn the movements or no interest in learning. Similar barriers to exercise participation among elders in the United States have been reported.[36]

Clinicians may need to emphasize not only the health benefits associated with exercise, but also the social and recreational aspects of exercise when performed in a group setting, such as Tai Chi. Further, clinicians may like to emphasize Tai Chi's portability, thus overcoming barriers such as transportation and costs associated with exercise facilities. Tai Chi may be individually tailored for elderly persons, so that only a few movements are taught and mastered, before new movements are introduced. This gradual learning with small attainable goals, promotes self-confidence and fosters long-term adherence to physical activity.

Tai Chi and Cardiorespiratory Function

An early study examining the cardiorespiratory responses of Tai Chi, reported a more efficient use of ventilatory volume among long-term Tai Chi practitioners.[37] Among elderly populations practicing Tai Chi, significantly better cardiorespiratory function has been reported, with continued improvements documented after two years.[38,

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[39] Research among older adults considered as long-term Tai Chi practitioners has demonstrated a significantly higher peak oxygen uptake during exercise than their sedentary counterparts, matched on gender, age, height, weight and body mass index. There were no significant baseline differences in blood pressure or smoking status between the groups.[40, 41] Tai Chi has been shown to be just as effective as aerobic exercise in reducing blood pressure among older adults.[42, 43] Recent research found similar results among older adults regularly practicing Tai Chi, suggesting Tai Chi might improve cardiovascular function.[17] Tai Chi was reported to be as effective as formal aerobic exercise for reducing blood pressure among post–myocardial infarction patients participating in a cardiac rehabilitation program.[21] Previous research has shown improvements in cardiorespiratory function among coronary artery bypass surgery patients deemed to be at low-risk, while participating in a Tai Chi exercise program.[20] Tai Chi Chih was recently utilized among persons with heart failure.[31] Initial support for this intervention among individuals with severely compromised energy reserves was positive, though the sample size was small. No adverse effects have been reported.

Tai Chi, Balance, Postural Stability and Fall Prevention

Research among long-term Tai Chi practitioners demonstrated greater flexibility and muscle strength, with a reduction in body fat, as compared to their sedentary counterparts, matched on age, gender and body size.[40, 41, 44] Among older adults participating in a Tai Chi exercise program, significantly better balance, postural stability, arm movement control and flexibility have been reported, than among those in a control group, matched on age and gender.[17, 30, 45-49] However, Wolf and colleagues[50] reported

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that Tai Chi among elders did not significantly improve postural stability, when compared to a balance-training group. Tai Chi was estimated to reduce the risk of multiple falls among older persons by 47.5%,[43] and a recent economic analysis of the implementation of Tai Chi in a typical nursing home for the prevention of hip fractures, reported significant cost-savings of $1274.43 per person per year.[51] Among persons with rheumatoid arthritis, no deterioration in joint tenderness, joint swelling or handgrip strength was found following participation in a Tai Chi exercise group.[52] Findings from a pilot study among persons with chronic arthritis reported a significant reduction in pain for the Tai Chi group as compared with the control group.[53] Significant improvements in walking speed and flexibility were reported following a Tai Chi exercise program among persons with multiple sclerosis.[54]

Tai Chi, Mood, Stress Reduction and Well-Being

Previous research examining the effect of Tai Chi on physiological and psychological changes associated with stress and mood disturbance, reported improvements in mood and reductions in stress, tension, depression, anger, fatigue, confusion and anxiety, among both beginners and seasoned Tai Chi practitioners.[55] Following exposure to a stressful situation among Tai Chi practitioners, Tai Chi was found to elicit a stress-reduction effect with an improvement in mood state.[56] Among older adults in the community, a sense of enhanced well-being, increased alertness, relaxation, better mental outlook, sense of achievement and greater confidence has been reported following completion of a Tai Chi exercise program.[19] Healthy women participating in a Tai Chi exercise group reported an improvement in overall mood with

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reductions in tension-anxiety, depression-dejection, anger-hostility and confusion-bewilderment.[57] Recent research demonstrated reductions in anxiety among older adults[45] and improvement in health-related quality of life among persons with multiple sclerosis[54] and those with lower-extremity osteoarthritis.[58] Tai Chi was recently used as an intervention among older adults to improve self-efficacy and exercise behavior with positive results reported.[59] Tai Chi is thought to encourage exercise self-efficacy and improve long-term adherence, due to the integration of mind and body while performing this form of exercise.[60] Thus, psychological improvements are thought to coincide with physical improvements.[61]

Discussion

Physiological and psychological improvements following cardiac rehabilitation have been documented and cardiac rehabilitation may be helpful in decreasing morbidity and mortality.[10, 11] Cardiac rehabilitation exercise-training improves functioning of the cardiovascular system with evidence of coronary heart disease risk factor reduction. Research evidence suggests that exercise is related to enhanced mood with reductions in anxiety, stress, and mood disturbance. Self-efficacy has been found to be a significant predictor of exercise behavior. Tai Chi has been reported to enhance self-efficacy, leading to exercise adherence.

Tai Chi facilitates a life-style that practices health-related behavior among people of all ages. However, learning Tai Chi may initially be a daunting task, due to a prior sedentary lifestyle, a lack of knowledge about exercise or potential health benefits, motivation to commence, finding an instructor and the financial costs associated with learning Tai Chi. Information regarding potential health benefits and encouragement

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from others including healthcare practitioners, family and friends may aid in developing a positive attitude towards Tai Chi exercise. Strategies need to be developed to overcome negative perceptions associated with exercise and Tai Chi such as a lack of time, being too complicated to learn, having no patience or interest to learn the movements.

The majority of research focusing on Tai Chi as an intervention has focused mainly on the elderly population.[17, 30, 40-42, 44-47, 53, 58] In particular, improvements in flexibility, balance, control, muscular strength and fall risk reduction have been documented. Research studies using Tai Chi as a low to moderate-intensity exercise are limited among persons with heart disease,[20, 21, 31] though the evidence suggests that it is safe and effective, able to improve cardiovascular and respiratory function. However, the long-term safety and efficacy of Tai Chi as an exercise for persons with heart disease has not been established. Future research using Tai Chi as an adjunct to other secondary prevention measures is needed among a variety of cardiac conditions including, angina pectoris, myocardial infarction, coronary bypass surgery, intracoronary revascularization, valve replacement and heart failure, to establish the effectiveness of this intervention for persons participating in cardiac rehabilitation exercise training. Limited research has found that persons enrolled in a Tai Chi exercise program had a reduction in blood pressure,[42, 43] though further studies may like to examine how Tai Chi impacts the atherosclerotic process. Finally, future research among persons with heart disease, comparing the efficacy of a Tai Chi exercise intervention with traditional cardiac rehabilitation exercise training, may be warranted. Additional forms of cardiac rehabilitation exercise training may aid with patient participation and program adherence,

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as previous research found that exercise options other than the treadmill or cycle were desired.[62]

Application to practice

In developing countries, cardiac rehabilitation exercise training utilizing equipment-based exercise is likely to encounter financial difficulties when implementing these programs. It is an unrealistic expectation for developing countries with large rural areas to have so many easily accessible facilities or to require patients to travel long-distances to participate in them. Non-equipment based programs using Tai Chi offers alternative strategies in promoting cardiovascular fitness aiding cardiac risk factor reduction and leading to improvements in health and outcomes.

Tai Chi is a suitable exercise for people of all ages, regardless of previous exercise experience or aerobic capacity. Tai Chi is low to moderate-intensity exercise with work intensity not exceeding 50% of an individual's maximum oxygen uptake.[33] However, as with all cardiac rehabilitation exercise training programs individuals should first be evaluated for exercise tolerance, dysrhythmias, ventricular function and angina. Tai Chi exercise may then be individually tailored to their exercise tolerance and aerobic capacity, which could include sitting versions of Tai Chi Chih, having low energy requirements (1.5-2.6 METs).[35]

Tai Chi Chih is a relatively simple form of Tai Chi to learn and may be taught in eight to ten lessons, taking approximately 30 minutes to perform the whole sequence. However, individual progress needs to be monitored and evaluated on a regular basis among novice performers to ensure that no untoward effects of performing this exercise occur. Areas to be monitored include, but are not limited to: cardiovascular responses to

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exercise, cognitive and psychological responses, including depression, stress, and/or anxiety levels; muscular strength, balance, flexibility, and control.

The slow and graceful movements of Tai Chi have several advantages over other forms of exercise, as it does not require any special clothing or equipment, making it a cost-effective and affordable form of exercise. Tai Chi may also foster adherence due to its portability (may be performed anytime and anyplace), lower exercise intensity and impact. Moreover, Tai Chi is an enjoyable form of exercise.

Summary

The literature provides evidence of the potential effect that Tai Chi has on improving exercise capacity and self-efficacy for exercise, while reducing anxiety, depression, and improving mood state. Tai Chi has the potential to reduce expenditures associated with chronic disease management by facilitating a lifestyle that promotes wellness among people of all ages. The exercise intensity of Tai Chi varies among the different styles performed. Simplified forms of Tai Chi, such as Tai Chi Chih, have a lower intensity, fewer movements and are shorter in duration. These simplified forms of Tai Chi are ideal for deconditioned persons, including those with heart disease and the elderly. Once the initial movements are learned and mastered, new movements can be added, to increase the exercise intensity and duration of the Tai Chi exercise session, thus increasing the aerobic effect.

Tai Chi is usually performed in a group setting, which also enhances exercise participation.[20] Moreover, persons who feel safe and confident to perform Tai Chi are more likely to continue long-term, achieving the greatest benefits of cardiac rehabilitation. Tai Chi is a self-paced, noncompetitive exercise, which can be performed

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at any time or place without the need for large space requirements[17, 20] easily implemented in any community setting.

The creation of novel approaches to enhance the well-being of people with chronic disease or disabilities and needing long-term rehabilitation could include the use of Tai Chi exercise. Given the increased financial burden placed on the current health care systems, Tai Chi has the potential to be an affordable and cost-effective form of exercise. Tai Chi may be an excellent compliment to a traditionally supervised aerobic exercise program for secondary prevention. Future research studies examining the long-term safety and efficacy of Tai Chi, and how it impacts the atherosclerotic process are suggested.

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Paper 2

The Effectiveness of Tai Chi Exercise in Improving Aerobic Capacity: A Meta-Analysis

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The Effectiveness of Tai Chi Exercise in Improving Aerobic Capacity: A Meta-Analysis

Abstract

Purpose: A meta-analysis involves the integration of several studies with small sample sizes, enabling the investigator to summarize research results into useful clinical information. Tai Chi exercise, though practiced in China for hundreds of years, has recently gained the attention of researchers in Western countries as a potential form of aerobic exercise. A goal of the meta-analysis was to estimate the effect of Tai Chi exercise on aerobic capacity.

Methods: A computerized search of seven databases was done using keywords and all languages. A total of 16 study elements were critically appraised to determine a study quality score. D-STAT software was used to calculate the standardized mean differences (ES_{sm}) and the 95% confidence intervals (CI), using means and standard deviations (SD) reported on the outcome measure aerobic capacity, expressed as peak oxygen uptake (VO_2 peak) ($mL \cdot kg^{-1} \cdot min\text{-}^{1}$).

Results: A total of 441 citations were obtained, only 7 studies focused on Tai Chi exercise with aerobic capacity as an outcome variable (4 experimental & 3 cross-sectional). Older adults including subjects with heart disease participated (n=344 subjects); on average men were 55.7 years old (SD=12.7) and women were 60.7 years old (SD= 6.2). Study quality scores ranged from 22 to 28 (mean= 25.1, SD=2.0). The average effect size for the cross-sectional studies was large and statistically significant (ES_{sm} =1.01, CI= +0.37, +1.66), while in the experimental studies the average effect size was small and not significant (ES_{sm} =0.33, CI=-0.41, +1.07). Effect sizes of aerobic capacity in women (ES_{sm} =0.83, CI=-0.43, +2.09) were greater than those for men (ES_{sm}

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=0.65, CI=-0.04, +1.34), though not statistically significant. Aerobic capacity was higher in subjects performing classical Yang style (108 postures) of Tai Chi exercise (ES_{sm} =1.10, CI= +0.82, +1.38), a 52-week Tai Chi exercise intervention (ES_{sm} =0.94, CI=+0.06, +1.81), and with sedentary subjects as comparisons (ES_{sm} =0.80, CI= +0.19, +1.41).

Conclusions: There is considerable scientific and clinical interest in Tai Chi exercise. This meta-analysis suggests that Tai Chi may be an additional form of aerobic exercise and provides information for sample size calculations. The greatest benefit was seen when the classical Yang style of Tai Chi exercise was performed for one-year, and practiced by sedentary adults with an initial low level of physical activity habits. Future research studies examining the effect of Tai Chi on aerobic capacity, should consider using the same frequency, duration and intensity of Tai Chi exercise, with a sufficient sample to answer the question of efficacy. It is recommended to use an established style of Tai Chi, such as the classical Yang style, rather than unspecified or modified forms, in order to be able to provide a comparison to published findings. Finally, randomized clinical trials in diverse populations and populations with chronic diseases, would expand the current knowledge about the effect the Tai Chi on aerobic capacity.

Keywords: Tai Chi, meta-analysis, aerobic capacity, oxygen consumption

NB: In this paper, V [dot] O_2 max = VO_2 max (symbol not included)

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Introduction

Tai Chi exercise, though practiced in China for hundreds of years, has only recently gained the interest of researchers in Western countries as an alternative form of exercise.[1-3] Recently improvements in cardiorespiratory function,[4-6] balance,[7-9] muscular strength,[10-12] flexibility,[5, 13, 14] relaxation[15, 16] and mood state[15, 17-19] have been associated with Tai Chi. Additionally, reduction in blood pressure,[3, 20] and improvement in aerobic capacity[2] in patients with heart disease have been reported. Tai Chi requires no special facility or expensive equipment and can be performed either individually or in groups. Tai Chi movements are suited for persons of all ages, regardless of previous exercise experience and aerobic capacity.[14, 21] Tai Chi is a low impact, low to moderate intensity exercise incorporating elements of balance, strength, flexibility, relaxation, and body alignment. Features of Tai Chi exercise include weight-shifting between right and left legs, knee flexion, straight and extended head and trunk, rotation, asymmetrical diagonal arm and leg movements with bent knees.[22, 23] The exercise intensity of Tai Chi is variable and can be adjusted by the height of the postures, duration of the practice session, and training style.[22, 23] Tai Chi is performed in a semi-squat position. A high-squat posture and short-training session are well suited for deconditioned persons, including those with heart disease and older adults.[22, 23] The exercise intensity of Tai Chi, height of the postures and duration are all likely to affect overall improvements in aerobic capacity. However, there is a paucity of literature on the aerobic benefits of Tai Chi exercise.

Lan and colleagues[22] reported the exercise intensity during performance of the classical Yang style among experienced Tai Chi practitioners to be at 55% of the subjects

peak oxygen uptake. Zhou and colleagues[24] reported the estimated energy costs of performing the classical Yang style of Tai Chi to be 4.1 metabolic equivalents (METs), with work intensity not exceeding 50% of an individual's maximum oxygen uptake. Schneider and Leung[25] reported that the exercise intensity of performing Tai Chi was 4.6 METs. Zhou and colleagues[24] have also reported the energy cost for performing a simplified form of Tai Chi requires an average of 2.9 METs with a maximum oxygen uptake at less than 40%. Energy requirements for Tai Chi Chih, a simplified form of Tai Chi, were reported by Fontana[26] to range from 1.5-2.6 METs,[26] depending on whether the subject was sitting or standing. There seems to be a wide range of exercise intensities associated with Tai Chi performance, ranging from 1.5 to 4.6 METs.

Maximum oxygen consumption (V [dot] O_2 max) is considered the best measure of aerobic capacity and provides important information about cardiorespiratory function.[27, 28] VO_2 max is the greatest amount of oxygen a person can take in from inspired air while performing dynamic exercise involving a large part of total muscle mass.[27] VO_2 max is considered the gold standard for determining aerobic capacity,[27, 28] though may not be feasible or appropriate for some patient populations. Aerobic capacity is derived from gas exchange during exercise testing, and is difficult to obtain in older populations and those with compromised cardiopulmonary functioning. In high risk or diseased populations it may be more appropriate to obtain VO_2 peak if symptoms such as angina, deconditioning or other factors prevent subjects from achieving maximum oxygen consumption levels.[27, 28] Oxygen consumption derived from VO_2 peak during exercise testing is most accurate when measured directly from expired gases.[27, 28] Another term to express oxygen consumption is metabolic equivalents.[27, 28] One

metabolic equivalent (MET) is a unit of resting oxygen uptake (~ 3.5 ml of O_2 per kilogram of body weight per minute [$mL \cdot kg^{-1} \cdot min^{-1}$]).[29] In this meta-analysis, VO_2 peak in $mL \cdot kg^{-1} \cdot min^{-1}$, is used as the measure of aerobic capacity.

The effect of Tai Chi exercise on aerobic capacity is important to know, if clinicians would like to recommend Tai Chi as an alternative form of aerobic exercise. The majority of the published studies examining cardiorespiratory responses to Tai Chi exercise by measuring aerobic capacity have small sample sizes. A meta-analysis involves the integration of several studies with small or large sample sizes, enabling the investigator to summarize the research results into useful clinical information. Therefore, the purpose of this meta-analysis was to estimate the extent to which Tai Chi exercise affects aerobic capacity.

Methods

Literature search and study selection

A computerized search of seven databases (PubMed, CINAHL, Current Contents, Cochrane Library, Digital Dissertations, PsychINFO and SocAbstracts) was done using keywords for the various English language spellings of Tai Chi (e.g. Tai Chi, Tai Chi Chuan, Tai Chi Quan, Tai Ji, and Tai Ji Quan). All languages were accepted. A total of 441 citations were obtained. Abstracts of all research studies were reviewed using a study selection form to determine if subjects were randomly assigned to a Tai Chi exercise intervention or if a Tai Chi exercise group was compared with another group; and if aerobic capacity was an outcome measure. The following types of articles were rejected: review, commentary, case-report, research methodology paper, a re-analysis of data, a meta-analysis, an overview, qualitative research, not-related to the meta-analysis topic, or

if aerobic capacity was not included as an outcome variable. Several articles appeared in more than one database.

Following initial selection criteria, 14 studies and one doctoral dissertation were examined in-depth, to determine if they met the selection criteria. A total of 8 studies investigated Tai Chi and aerobic capacity, and met the inclusion criteria. Four of the articles were experimental studies (2 randomized clinical trials,[19, 20] 2 quasi-experimental[2, 4]), there were three cross-sectional studies[5, 25, 30] and one prospective cohort study.[6] In the cross-sectional studies, 2 groups of different subjects were matched on age, gender and body composition, allowing for adequate group comparisons. The prospective cohort study examined age-related deterioration in aerobic capacity and how Tai Chi may slow progressive decline. Subjects in the Tai Chi exercise and control groups in the prospective cohort study had statistically significant different baseline VO_2 scores, thus group comparisons at the end of the study were not feasible,[6] and the study was not included in the analysis. A total of seven studies were included in this meta-analysis. Characteristics of the subjects in these studies can be found in Table 1 (experimental) and Table 2 (cross-sectional).

Development of Study Quality Scoring Tool

A study quality scoring tool was developed, based on previous work from Chan and Bartlett.[31] A total of 16 study elements were critically appraised to determine a study quality score. Elements reviewed included study design, sample selection, description of the independent variable (Tai Chi), description of the outcome measure (aerobic capacity), data analyses and results. The highest possible study quality score was 32, each item had a possible score of 0-2 (0=absent, 1=partially defined, 2=clearly defined),

with possible scores ranging from 0-32. The methodological quality of both experimental and cross-sectional studies could be assessed using this tool. Any study with a quality score below 67% (<21) of the total possible score,[31] was set as the criteria for elimination from this analysis.

Measurements of Effects of Tai Chi Exercise Assessed

In order to measure the benefits of exercise, consideration of the frequency, intensity, duration, type of exercise and preference need consideration.[27, 28] Current recommendations by the American College of Sport Medicine[27, 28] include exercise frequency of 3-5 days per week, an intensity of either 65-90% of maximum heart rate or 50-85% of maximal oxygen uptake, duration of 20-60 minutes per session, aerobic type activity, and participation in an enjoyable aerobic activity. In very unfit individuals, the exercise intensity based on 55-64% of an individual's predicted maximum heart rate may be most suitable .[27, 28] Aerobic capacity is influenced by age, weight, gender, exercise habits, genetic factors and cardiovascular clinical status. Effects of Tai Chi exercise on aerobic capacity in this meta-analysis included study design, gender, physical activity habits, style of Tai Chi exercise and the duration of the Tai Chi exercise intervention-training period.

Data Abstraction and Calculation of Effect Size

Using the data abstraction form developed for this meta-analysis, information from the seven studies was abstracted (by RTP) to record study sample characteristics, the independent variable (Tai Chi), the outcome variable (aerobic capacity, expressed as VO_2 peak in $mL \cdot kg^{-1} \cdot min\text{-}^{1}$), results and statistical methods. The effect sizes were

calculated from the standardized mean differences using means and standard deviations reported on the outcome measure (aerobic capacity).

The standardized mean difference effect size (ES_{sm}), also called **d**, is a scale-free measure that can contrast results for two groups, with continuous underlying distributions.[32, 33] Effect sizes are important for power calculations when designing research studies, and help clinicians and researchers understand the magnitude and direction of a relationship.[33, 34]

The following formula[34] was used: $$ES_{sm} = \frac{Mean_{Rx} - Mean_{C}}{S_{pool}}$$

Rx=Tai Chi exercise group, C=control or comparison group, $S_{pool} = \sqrt{\frac{(n_1 - 1)\, s_1^2 + (n_2 - 1)\, s_2^2}{n_1 + n_2 - 2}}$
n=sample size, s=standard deviation

D-STAT*[1] software was used to calculate the ES_{sm} and the 95% confidence intervals. The ES_{sm} for each study was weighted by the sample size and pooled variance. The post-intervention mean aerobic capacity (VO_2 peak) was used to contrast the experimental and control group in the experimental studies, as there was no difference in the baseline mean scores in these studies. The ES_{sm} for one of the experimental studies[20] was calculated by D-STAT using the mean change in aerobic capacity , due to incomplete descriptive data. The ES_{sm} in the cross-sectional studies were derived from group contrasts between the Tai Chi exercise and the comparison groups. All relevant data derived from the studies were coded and entered into SPSS (10.0)[35] for analysis.

*[1] Johnson, BT (1989) D-STAT: Software for the Meta-Analytic Review of Research Literature. Lawrence Erlbaum Associates, Inc.

Interpretation of Effect Sizes

Cohen[33] has previously presented guidelines for assessing effect sizes. An effect size (ES) of 0.20 is judged to be a small effect, 0.50 as a medium effect and 0.80 as a large effect.[33] In addition, a proportion of variance (eta^2) can be calculated. Analysis of variance is a t-test statistic for > 2 means. The analysis of variance ES is called f; and f = d / 2. Using the following formula, eta^2 (η^2) = [d^2 / d^2 + 4]; the percentage of variance between 2 groups can be calculated.[33] Finally, interpretation of the ES can be expanded by transforming the ES into a percentile. The percentile is obtained by referring to a normal distribution table and identifying the area under the curve associated with the ES, referred to as the measure of non-overlap, (U_3).[33] U_3 is the percentage of the control distribution exceeded by the upper 50% of the treatment population.[36] U_3 readily provides the clinician with information regarding the success or failure, of a treatment or intervention. For example, if the ES = 0.85, then 80% of the control group is below the average person in the treatment group. Also it is important to note, when 50% of the control group is below the average person in the treatment group, then the ES = 0 (e.g. no non-overlap).[32, 33, 36]

Results

Descriptive Data from Studies in Meta-Analysis

A quality score was given for each of the studies included in this meta-analysis. Scores ranged from 22 to 28 (mean= 25.1, SD=2.0) and no studies were excluded on the basis of their quality. The purpose of each study was clearly defined in all of the studies included in the meta-analysis. All but one of the studies had a complete and comprehensive description of subject characteristics. All of the studies had the

dependent variable (aerobic capacity) clearly defined. However, only one of the seven studies had the rater blinded to group assignment, when collecting the data on aerobic capacity.

Within these studies, a total of 344 subjects participated; 166 subjects were in Tai Chi exercise groups. There were 82 males and 57 females, and no gender was specified for the remaining 27 subjects practicing Tai Chi. There were 178 subjects in either control or comparison groups. Sample sizes ranged from 7-27 subjects per group. Mainly healthy older adults participated in these studies (n=6 studies). In the Tai Chi exercise groups, on average men were 56.0 years old (SD=12.3) and women were 60.4 years old (SD= 7.0). Control/comparison groups were similar with regard to age and health status (men=55.5 years, SD=14.2; women=60.9 years, SD=6.4).

Four of the seven studies had subjects perform the classical Yang style of Tai Chi, which constitutes 108 postures, one study had a modified 13-movement Yang style of Tai Chi, while Tai Chi styles were unspecified in two of the studies. In the four experimental studies, the duration of the Tai Chi exercise sessions ranged from 45–60 minutes, 3-5 times per week. The length of the Tai Chi intervention-training period ranged from 12 to 52 weeks. The workload of the outcome variable, aerobic capacity, was provided either by treadmill or cycle ergometer in all of the studies.

In six of the studies,[2, 4, 5, 19, 25, 30] aerobic capacity was derived from VO_2 peak through estimations obtained from subjects' expired air. One study[20] used predicted maximal workload using published equations by plotting heart rate and estimating workload at the predicted maximal heart rate. Thus, VO_2 max is not likely to have been achieved in these studies. Though use of VO_2 peak and established equations for

estimating oxygen consumption during exercise testing are common, aerobic capacity may have been overestimated due to wide variance inherent with multi-stage testing.[27, 28]

Effects of Tai Chi on Aerobic Capacity

The effect size and the 95% confidence interval were calculated for each study, weighted by the sample size and pooled variance. Effects of Tai Chi exercise on aerobic capacity in this meta-analysis also included study design, gender, physical activity habits, style of Tai Chi exercise and the length of the Tai Chi exercise intervention-training period. The percent of variance between groups (η^2) and the measure of non-overlap (U_3), was only calculated for effects found to be statistically significant (Table 3).

The average effect size for the cross-sectional studies was large (ES_{sm}=1.01, CI= +0.37, +1.66) (Figure 1), while in the experimental studies the average effect size was small (ES_{sm}=0.33, CI=-0.41, +1.07) (Figure 2). In the cross-sectional studies, approximately 20% (η^2 = 0.20) of the variance in aerobic capacity could be explained by group. Aerobic capacity for the average subject in a Tai Chi exercise group was higher than 84% of the subjects in the comparison groups in the cross-sectional studies.

Six of the seven studies[2, 4, 5, 19, 25, 30] reported gender-specific descriptive statistics and enabled gender-specific effects to be calculated. Effect sizes of aerobic capacity in women (ES_{sm} =0.83, CI=-0.43, +2.09) were somewhat higher than those for men (ES_{sm} =0.65, CI=-0.04, +1.34), though not statistically significant.

Effect sizes examining aerobic capacity based on the physical activity habits of subjects in the control and comparison groups were also calculated. Four of the studies[4, 5, 19, 30] had sedentary subjects as comparisons, while the other three studies[2, 20, 25] involved subjects doing other exercise, such as walking. Approximately 14% (η^2 = 0.14) of the

variance in aerobic capacity could be explained by physical activity habits. Aerobic capacity for the subjects in a Tai Chi exercise group was higher than 79% of the sedentary subjects (average ES_{sm}=0.80, CI=+0.19, +1.41).

Dose-treatment effects of Tai Chi exercise were calculated by the style of Tai Chi exercise performed. Four of the seven studies[2, 4, 5, 30] utilized the longest form of the Yang style of Tai Chi with 108 postures. The other three studies had subjects perform a simplified Yang style form (13 movements)[20] or the style of Tai Chi was not specified in two of the studies.[19, 25] Approximately 23% (η^2 = 0.23) of the variance in aerobic capacity could be explained by style of Tai Chi exercise. Aerobic capacity for the average subject performing the classical Yang style form of Tai Chi exercise was higher than 86% of the subjects in the control or comparison groups (average ES_{sm}=1.10, CI= +0.82, +1.38).

In the four experimental studies,[2, 4, 19, 20] Tai Chi exercise session ranged from 45–60 minutes (mean=56 minutes, SD=7.5), 3-5 times per week (mean=4 times per week, SD=0.8). The length of Tai Chi intervention training period ranged from 12 to 52 weeks (mean=33 weeks, SD=22). Only effect sizes examining aerobic capacity based on length of the Tai Chi intervention were calculated. Approximately 18% (η^2 = 0.18) of the variance in aerobic capacity could be explained by length of the Tai Chi exercise-training period . Aerobic capacity for the average subject participating in a 52-week Tai Chi exercise group was higher than 83% of the subjects in the control group (average ES_{sm}=0.94, CI=+0.06, +1.18). On the other hand, the improvement in aerobic capacity for the average subject in the 12 or 16-week control group was better than 61% of the subjects in the Tai Chi exercise group (average ES_{sm}= -0.28, CI=-0.53, -0.02). However,

this result is not likely to be clinically relevant, only 2% ($\eta^2 = 0.02$) of the variance in aerobic capacity could be explained by the number of weeks subjects remained in the control condition.

Discussion

Given the limited number of studies pertaining to the effects of Tai Chi exercise on aerobic capacity in women (n=126) these results need to be interpreted with caution. However, this early review appears to indicate potential gender differences in the effectiveness of Tai Chi exercise on aerobic capacity. Effect sizes of Tai Chi exercise on aerobic capacity in women were greater than those for men, though not statistically significant. This finding suggests that it may be important to consider, and future studies could clarify if there are gender differences by designing stratified randomization (based on gender). The development of alternative exercise programs for women including Tai Chi exercise could be of value, as previous research has reported that women desired exercise options other than using the treadmill or cycle.[37] Further, one of the experimental studies[20] did not provide gender information for the subjects completing the study. It is unknown if an effect based on gender would have resulted in different findings.

The degree of improvement in aerobic capacity depends on the exercise intensity, duration and frequency, as well as the subject's initial level of physical activity. Subjects that were sedentary before beginning Tai Chi exercise, made greater gains with a more favorable effect. This finding is consistent with the traditional western exercise literature wherein the most sedentary persons demonstrate the greatest benefit when they initiate a regular program of exercise.[38] However, consideration needs to be given to possible

selection bias, as Tai Chi masters were compared with sedentary subjects (>5 years), matched on age and gender, in two of the cross-sectional studies.[5, 30] This selection of subjects with distinctly different exercise proficiencies, is likely to influence the large effect sizes obtained. Further, the extent to which diet and other lifestyle practices influenced the results was not measured.

Tai Chi exercise styles varied among the studies reviewed. The classical Yang style comprises 108 postures and is more difficult to learn. [5, 30] Simpler forms have fewer postures and exclude some of the more strenuous movements, such as deep squatting or vigorous kicking. While the simplified forms of Tai Chi are shorter and easier to learn, they may have a reduced training benefit. Results from four studies[2, 4, 5, 30] utilized the classical Yang style of Tai Chi and had larger effect sizes. The findings are likely due to the inclusion of more strenuous movements and the longer time needed to complete the entire set of postures.

In the four experimental studies, the Tai Chi exercise intervention ranged from 45–60 minutes, 3-5 times per week and is consistent with the current recommendations for Western-style exercise.[27, 28] However, the length of the Tai Chi intervention training period varied, ranging from 12 to 52 weeks. Subjects in two of the four experimental studies[2, 4] had longer intervention times (52 weeks), than the other two experimental studies (12 or 16 weeks).[19, 20] The largest effect was seen in the studies with the 52-week intervention time. However, the improvement in aerobic capacity for the average subject in the 12 or 16-week control group was significantly better than subjects in the Tai Chi exercise groups. This finding may partially be attributed to a threshold effect when performing Tai Chi exercise or a dropout effect.

Subjects in the 12 or 16-week Tai Chi exercise groups participated in either a simplified or unspecified form of Tai Chi and may have had a reduced training benefit. In the study by Young and colleagues[20] moderate-intensity aerobic exercise, instead of sedentary controls, may partially explain why the improvement in aerobic capacity for the average 12-week control subject was greater than the average subject in the Tai Chi exercise group. Further, the mean change in aerobic capacity within and between the 12 or 16-week control and Tai Chi exercise groups was small in these two studies.

Finally, the dropout rate for subjects participating in a 52-week intervention was approximately 26.5 %; while the 12-week and 16-week intervention studies reported dropout rates of 17% and 8%, respectively. Future research could help in providing an answer to these findings, by examining dose-response effects of Tai Chi exercise.

Conclusion

The findings of this meta-analysis fill a gap in the literature and highlight a potential benefit in aerobic capacity when performing Tai Chi. This meta-analysis included a total of seven studies, four had experimental designs, while the other three were cross-sectional. The small samples in these studies, likely had insufficient power for the researchers to detect significant differences between groups, assuming an alpha=0.05 and power=0.80 were utilized.

Tai Chi may be an additional form of aerobic exercise, suitable for sedentary older adults and those with heart disease[2, 3, 20]. The slow and graceful movements of Tai Chi have several advantages over other forms of exercise, as Tai Chi does not require any special clothing or equipment, making Tai Chi a cost-effective and affordable form of exercise. Tai Chi may also foster adherence due to its practical utility (may be performed

any time and any place). Moreover, Tai Chi might be an enjoyable and preferred form of exercise for some.[1]

Finally, future research studies examining the effect the Tai Chi on aerobic capacity, may like to consider using the same frequency, duration and intensity of Tai Chi exercise as an intervention, using the current exercise recommendations of the American College of Sports Medicine.[27, 28] This is necessary in order to have valid comparisons of the effect of Tai Chi exercise to traditional forms of exercise, such as walking.

Further, it is recommended that an established style of Tai Chi be used, such as the classical Yang style, rather than unspecified or modified forms, in order to be able to provide a comparison to published findings. Research among diverse populations including persons with chronic diseases, would help to expand current knowledge about the effect the Tai Chi on aerobic capacity. However, aerobic capacity is only one potential outcome and improvements in balance,[7-9] muscular strength,[10-12] flexibility,[5, 13, 14] relaxation[15, 16] and mood state[15, 17-19] may be achieved, as benefits of doing Tai Chi.

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Table 1
Experimental Studies

Author/ Year	Study Design	Size	Gender	Mean Age in Years (SD)	Tai Chi Style	Length of Intervention	Group	Baseline Mean VO_2 peak ($mL \cdot kg^{-1} \cdot min^{-1}$) (SD)	Follow-up Mean VO_2 peak ($mL \cdot kg^{-1} \cdot min^{-1}$) (SD)	**Effect Size**	LBCI	UBCI
Brown, et al 1995	RCT	**11**	**Males**	**50.4 (5.7)**	Not specified	16 weeks	**Tai Chi**	**31.7 (5.1)**	**30.8 (4.1)**	**-.3580**	-1.154	+.4379
		14	Males	50.5 (7.4)			Control (sedentary)	31.9 (5.4)	32.7 (5.8)			
		7	**Females**	**51.5 (8.3)**		16 weeks	**Tai Chi**	**25.0 (4.4)**	**23.8 (4.7)**	**-.3101**	-1.1857	+.5830
		17	Females	53.6 (9.4)			Control (sedentary)	26.7 (6.0)	25.2 (4.4)			
Lan, et al 1998	Quasi-exper.	**9**	**Males**	**65.2 (4.2)**	Yang, 108 postures	52 weeks	**Tai Chi**	**24.2 (5.2)**	**28.1 (5.4)**	**+.8176**	-.1442	+1.779
		9	Males	66.6 (3.9)			Control (sedentary)	24.0 (4.8)	23.6 (5.0)			
		11	**Females**	**64.9 (4.7)**		52 weeks	**Tai Chi**	**16.0 (2.5)**	**19.4 (2.8)**	**+1.334**	+.3609	+2.307
		9	Females	65.4 (3.8)			Control (sedentary)	15.8 (2.5)	15.6 (2.6)			
Lan, et al 1999	Quasi-exper.	**9**	**Males**	**55.7 (7.1)**	Yang, 108 postures	52 weeks	**Tai Chi**	**26.2 (4.4)**	**28.9 (5.0)**	**+.6572**	-.2469	+1.561
		11	Males	57.2 (7.6)			Control (walking program)	26.0 (3.9)	25.6 (4.6)			
Young, et al 1999	RCT	**27**	**Not specified**	**Not specified**	Yang, 13 movements	12 weeks	**Tai Chi**	**Not specified**	**.97* (4.1)**	**-.1598**	-.7105	+.3909
		24	Not specified	Not specified			Control (aerobic exercise)	Not specified	1.64* (4.1)			

*mean change in aerobic capacity, RCT= randomized clinical trial, Quasi-exper. = quasi-experimental study, LBCI= lower bound confidence interval, UBCI= upper bound confidence interval.
Effect size is not significant if zero is included in the confidence interval

Table 2
Cross-sectional Studies*

Author/ Year	Study Design	Size	Gender	Mean Age in Years (SD)	Group	Tai Chi Style	Mean VO_2 peak ($mL \cdot kg^{-1} \cdot min^{-1}$) (SD)	**Effect Size**	LBCI	UBCI
Schneider, et al 1991	Cross-Sectional	**10**	**Males**	**35.5 (3.9)**	**Tai Chi**	**Not specified**	**44.3 (6.6)**	**+.1571**	-.7208	+1.035
		10	Males	30.0 (5.0)	Wing Chun	--------	43.4 (4.0)			
Lai, et al 1993	Cross-Sectional	**21**	**Males**	**58.7 (3.9)**	**Tai Chi**	**Yang, 108 postures**	**33.9 (6.3)**	**+1.3836**	+.7252	+2.0421
		23	Males	59.1 (4.0)	sedentary	--------	26.3 (4.4)			
		20	**Females**	**58.3 (4.8)**	**Tai Chi**	**Yang, 108 postures**	**21.8 (2.2)**	**+.8943**	+.2834	+1.5052
		26	Females	57.5 (4.7)	sedentary	-------	19.0 (3.6)			
Lan, et al 1996	Cross-Sectional	**22**	**Males**	**70.4 (4.1)**	**Tai Chi**	**Yang, 108 postures**	**26.9 (4.7)**	**+1.2289**	+.5503	+1.9076
		18	Males	69.5 (4.2)	sedentary	-------	21.8 (3.1)			
		19	**Females**	**66.9 (2.7)**	**Tai Chi**	**Yang, 108 postures**	**20.1 (2.9)**	**+1.3965**	+.6670	+2.1260
		17	Females	67.1 (2.8)	sedentary	--------	16.5 (2.0)			

* matched on gender, age and body composition; LBCI= lower bound confidence interval, UBCI= upper bound confidence interval.
Effect size is not significant if zero is included in the confidence interval.

Table 3: Aerobic Capacity Effects sizes and 95% Confidence Intervals (n=344)

Selected Group for Analysis	n	ES	LBCI	UBCI	η^2	U_3
Study Design						
Cross-sectional	186	1.01*	+0.37	+1.66	0.20	0.84
Experimental	158	0.33	-0.41	+1.07		
Gender#						
Women	126	0.83	-0.43	+2.09		
Men	167	0.65	-0.04	+1.34		
Physical Activity Level						
Sedentary comparisons	253	0.80*	+0.19	+1.41	0.14	0.79
Other exercise	91	0.22	-0.81	+1.24		
Style of Tai Chi						
Classical Yang style	224	1.10*	+0.82	+1.38	0.23	0.86
Modified or unspecified	120	-0.17	-0.54	+0.20		
Length of Tai Chi Intervention†						
52-weeks	58	0.94*	+0.06	+1.81	0.18	0.83
12 or 16 weeks‡	100	-0.28*	-0.53	-0.02	0.02	0.61

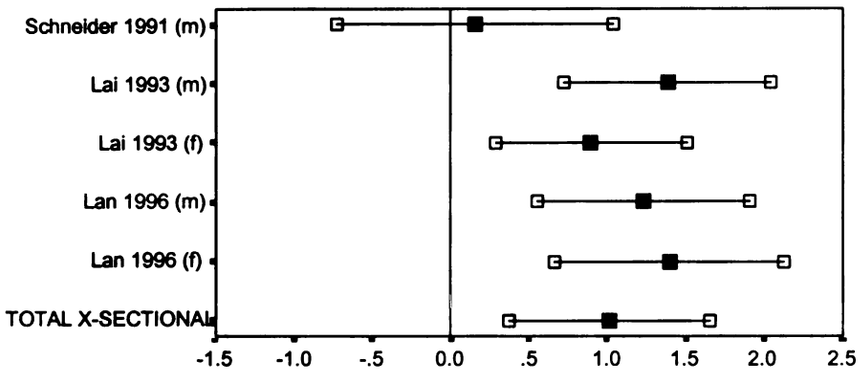
n= sample size, ES= effect size, LBCI= lower bound confidence interval, UBCI= upper bound confidence interval, η^2 = percent of explained variance between groups (eta^2), U_3= percentage of the treatment group above the control group mean.
The effect size is not significant if zero is included in the confidence interval; η^2 and U_3 reported only for significant ES; * = significant ES.
= 51 subjects not included due incomplete descriptive data; †= sample of 158 subjects; ‡= control group better than 61% of the subjects in treatment group.

Figures

Figure 1

Cross-sectional Studies, n=3

Tai Chi & Aerobic Capacity ES (95% C.I.)



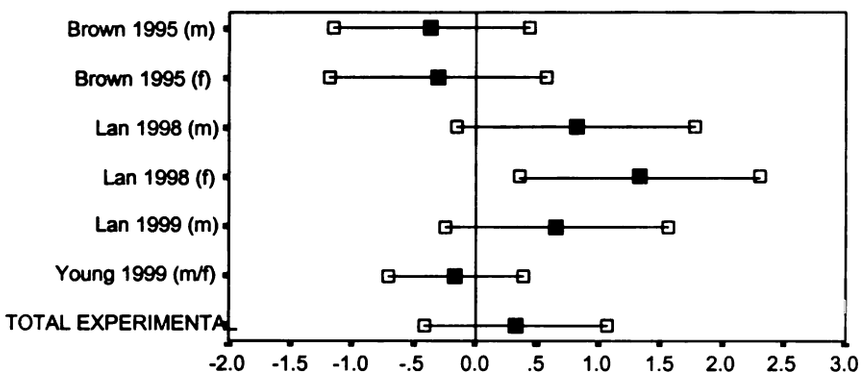
ES=effect size, C.I.=confidence interval, m=males, f=females

All studies listed by 1st Author and year; ES not significant if 0 in CI

Figure 2

Experimental Studies, n=4

Tai Chi & Aerobic Capacity ES (95% C.I.)



ES=effect size, C.I.=confidence interval, m=males, f=females

All studies listed by 1st Author and year; ES not significant if 0 in CI

Paper 3

Measurement Properties of Tai Chi Exercise Self-Efficacy among Ethnic Chinese with Coronary Heart Disease Risk Factors: A Pilot Study

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Measurement Properties of Tai Chi Exercise Self-Efficacy among Ethnic Chinese with Coronary Heart Disease Risk Factors: A Pilot Study

Abstract

Background: Improvement in aerobic capacity and reduction in blood pressure after Tai Chi exercise programs in persons with coronary heart disease (CHD) or with CHD risk factors have been reported. Self-efficacy has been shown to be a consistent predictor of behavioral outcomes, now being applied to Tai Chi exercise.

Aim: To assess the utility and appropriateness of existing tools measuring aspects of Tai Chi exercise Self-Efficacy (TCSE) in a new population, ethnic Chinese with CHD risk factors. Specific objectives were: 1) examine acceptability and feasibility; 2) determine score distributions; 3) assess the reliability and known-groups validity; 4) translate tool into an equivalent Chinese version and determine if there were any differences between ethnic Chinese and non-Chinese.

Methods: Following a review of the literature, two existing tools used with Caucasians were found and modified; a 9-item exercise self-efficacy tool developed by Resnick & Jenkins (2000), and a 3-item tool developed by Li and colleagues (2001) to assess gradations of the challenge to perform Tai Chi among elderly populations. The modified TCSE tool was translated into Chinese and back-translated. A pilot study was conducted to pre-test the modified 14-item TCSE tool in ethnic Chinese and non-Chinese.

Results: A total of eighteen subjects (mean age=60 years, SD=18.4) participated. Seven subjects (39%) identified themselves as ethnic Chinese. Ten subjects (56%) had experience performing Tai Chi, ranging from 3 months to 17 years (mean=5.0 years, SD=5.0). Half of the subjects reported having a history of hypertension (n=9, 50%),

while nearly one-third reported having high cholesterol (n=5, 28%). No significant difference in TCSE mean scores was found between ethnic Chinese and non-Chinese ($p>0.05$). Internal consistency estimates were very high (TCSE Barriers, $r=0.95$; TCSE Performance, $r=0.97$). A statistically significant difference was found in the TCSE mean scores between Tai Chi practitioners and non-practitioners (TCSE Barriers, $t=-3.3$, $p=0.01$; TCSE Performance, $t=-2.7$, $p=0.03$), with Tai Chi practitioners reporting higher self-efficacy; thus providing initial evidence of known-groups validity.

Conclusions: Measurement of self-efficacy to overcome barriers to Tai Chi exercise (TCSE Barriers) and self-efficacy to perform Tai Chi (TCSE Performance) functioned well in this sample. The acceptability and feasibility of this tool was established and known-groups validity was confirmed. Further research using this tool among ethnic Chinese with CHD or CHD risk factors, including those with less than high school education or low literacy, is recommended as the next step in development of TCSE.

Keywords: Tai Chi, self-efficacy, Chinese, measurement, validity

Introduction

Despite advances in medicine and clinical care, heart disease continues to be the leading cause of mortality and morbidity in the USA [1-3]. Major risk factors for coronary heart disease (CHD) include cigarette smoking, diabetes, hypertension and hyperlipidemia. A recent meta-analysis of 14 international randomized clinical trials of CHD, reported that 80-90% of persons diagnosed with CHD had at least 1 of these 4 major risk factors [4]. Before a CHD event, Greenland and colleagues [5] reported that at least 1 of these risk factors is prevalent (87-100%).

Ethnic Chinese are the largest group of Asian immigrants in the United States, with heart disease listed as the leading cause of mortality, representing 29.4% of all deaths [6], affecting mainly middle to older age adults. Prevention and treatment of CHD among ethnic Chinese has not been widely studied, though the incidence of heart disease among Chinese populations is increasing [2, 7].

Physical activity has been shown to reduce atherosclerotic risk factors by improving blood lipid profile, insulin resistance and glucose intolerance, and psychosocial well-being; reducing stress, blood pressure, and mortality; and aiding weight loss [8-11]. The recent American Heart Association Scientific Statement on "*Exercise and Physical Activity in the Prevention and Treatment of Atherosclerotic Cardiovascular Disease*" [11] reported that the exercise component of a cardiac rehabilitation program is a critical element in reducing cardiac mortality. However, a pattern of increasing attrition in the first 3-6 months of rehabilitation among persons with CHD has been documented and reported [8, 12, 13], a reflection of the complexities and difficulties associated with personal behavioral changes [14]. Moreover, as physical

activity is strongly determined by social experiences, cultural background and health status [15, 16]; research that is specifically aimed at Chinese populations with CHD or those with CHD risk factors is needed, in order to achieve the greatest health benefits for these persons.

Theoretical Framework

Human behavior is multifaceted and multidimensional [14]. People often struggle to change their behavior, and experience both failures and successes. Social Cognitive Theory (SCT) emphasizes reciprocal relationships between personal factors, environmental factors and behavior. SCT provides a parsimonious conceptual framework from which to examine human behavior, considers the multifaceted complexities of human beings, and has been shown empirically to be consistently useful in aiding the development of programs dealing with behavioral change [14].

Self-efficacy, at the heart of Social Cognitive Theory, represents the confidence that one has to perform a certain behavior [14]. Self-efficacy beliefs help determine how much effort individuals will spend on an activity, such as Tai Chi exercise, how long they will persevere with the activity when facing barriers or other obstacles, and how resilient they are in the face of impossible situations [14, 17]. Several investigators consistently report that efficacy beliefs significantly predict exercise behavior [18-23].

Review of Literature

Tai Chi Exercise

Tai Chi is a low impact, moderate-intensity exercise [24] and has been practiced in China for hundreds of years. Recently, Tai Chi has gained considerable popularity as an alternative form of exercise [25-27]. Tai Chi exercise has been associated with improvements in cardiorespiratory function [28-30], balance [31-33], muscular strength and endurance [34-36], flexibility [29, 37, 38], relaxation [39, 40] and mood state [39, 41-43]. In addition, lower blood pressure [25, 44], and improvement in aerobic capacity [27] have been reported in persons with CHD. However, little research has examined the aerobic benefits of Tai Chi exercise for persons with CHD or CHD risk factors [45].

Tai Chi is relatively inexpensive, as it requires no special facility or equipment, and can be performed either indoors or outdoors. Tai Chi can be performed by persons of all ages, regardless of previous exercise experience or ability [37, 46]. Features of Tai Chi exercise include slow and gentle movements, shifting body weight between right and left legs with knees slightly bent, keeping body straight and upright, rotation from the hips, and moving arms and legs simultaneously [24, 47].

Tai Chi exercise was reported to be positively associated with perceived self-efficacy and physical function among older adults [48], suggesting that Tai Chi exercise may promote exercise adherence [48]. Tai Chi may be individually tailored for elderly persons, so that only a few movements are taught and mastered before new movements are introduced. This gradual learning with small attainable goals promotes self-confidence, encourages long-term adherence to Tai Chi, and fosters Self-Efficacy. However, little research to date has focused on Tai Chi exercise Self-Efficacy (TCSE).

Moreover, no prior intervention study has examined TCSE among ethnic Chinese living in the USA with CHD risk factors.

Measurement of Tai Chi Exercise Self-Efficacy

Tai Chi exercise Self-Efficacy (TCSE) must have its own measure tailored to the specific domain of functioning and representing gradations of task demands [14, 49]. An individual's assessment of their perceived capabilities representing the various dimensions of efficacy beliefs is vital [14, 49]. Building a gradation of challenges into a scale can assess the level of Tai Chi exercise performance. Questions about an individual's perceived capability to move their body in a slow, rhythmical fashion continuously ranging from 2 to 30 minutes [48, 50], would ensure that a ceiling effect is avoided [49]. Allowing individuals to respond to questions on a 0-100 percentage scale (0=not at all confident, 100=very confident), would ensure that the strength of efficacy beliefs were adequately captured [49]. Finally, assessment of situations known to impede exercise participation, would aid in identifying potential barriers to performing Tai Chi exercise [51].

Measuring concepts, such as TCSE, is a complex task. Reliance on a measure's reliability and validity is inadequate, particularly when application across diverse populations, including different cultures is desired. Information obtained through cognitive interviews, regarding the appropriateness of the measures, the meaning of the questions or response patterns, may reveal inherent problems. Pre-testing questions in a specific population can disclose important information about how the measure is likely to function or can identify problems that may occur.

Aim and Objectives

A pilot study was conducted to assess the utility and appropriateness of existing tools measuring TCSE in a new population, ethnic Chinese with CHD risk factors. Specific objectives were to:

1. Examine the acceptability and feasibility of the tool.
2. Determine score distributions and measurement properties.
3. Assess the reliability and known-groups validity.
4. Translate the TCSE into an equivalent Chinese version and determine any differences between ethnic Chinese and non-Chinese.

Pre-test Methods

Subjects

A purposive, convenience sample of subjects were recruited to pretest the questionnaire and included ethnic Chinese, Tai Chi practitioners, and persons with CHD risk factors. Subjects from a community senior center volunteered, including adults participating in a Tai Chi exercise class. A script for the initial contact was prepared and all persons contacted, agreed to participate.

Procedures

Pre-testing of the TCSE tool included questions regarding self-efficacy to overcome barriers to Tai Chi exercise (TCSE Barriers) and self-efficacy to perform Tai Chi (TCSE Performance). TCSE Barriers questions were derived from a 9-item exercise self-efficacy tool developed by Resnick & Jenkins (2000). The response options range from 0-100 (0=not at all confident, 100=very confident). Psychometric testing of the

scale developed by Resnick & Jenkins (2000) among older adults, reported strong internal consistency estimates (r=0.92), and construct validity (F=78.8, p=0.05, n=187) accounting for 30% of the variance in exercise [51]. Minor modifications to the original tool included the following: questions were changed from 2nd person 'you' to 1st person 'I', and the words 'exercise' were changed to 'Tai Chi exercise' throughout. The conceptual context of the tool was retained.

TCSE Performance questions were derived from a new 3-item tool to assess gradations of the challenge to perform Tai Chi among elderly populations [50]. Responses are on a 0 to100 percentage scale (0=not at all confident, 100=very confident). Psychometric testing of this tool reported high internal consistency estimates (r=0.81 & 0.92) [50]. However, two additional questions were added to assess TCSE performance at 20 and 30 minutes, ensuring a wide range of response choices in the scale and avoiding ceiling effects [49].

Permission to use and modify these tools was obtained from the respective copyright owners. Following the minor modifications of these two pre-existing tools (TCSE Barriers and TCSE Performance), translation and independent back-translation of the TCSE (Confidence Scale) into Chinese by two bilingual and bicultural persons with translation experience and graduate level education was done, according to the methods described by Bracken and Barona [52]. Content equivalence included independent assessment of each item in the tool for cultural relevance. Next, semantic equivalence included translation and independent back-translation of the tool. Finally, the modified and the back-translated tools were compared. In this study, the back-translated tool had a

100% agreement with the modified tool [52], establishing content and semantic equivalence.

Scoring of the TCSE Barriers and the TCSE Performance scales is done by summing the confidence ratings and then dividing by the total number of items in the respective scale. The revised TCSE Barriers scale had 9 items, while the revised TCSE Performance scale has 5 items. Scores range from 0 to 100, a higher score indicates more confidence or perceived TCSE (0=not at all confident, 100=very confident). In this pilot study, the questionnaire was formatted using a 14-point font size for all questions and instructions, to avoid potential response error due to reading problems [53], as the majority of subjects invited to participate were older adults.

Questions posed in the TCSE tool were reviewed in detail by the first author (RTP), with consideration given to potential problem questions for older adults, including ethnic Chinese or those with CHD risk factors [54]. Cognitive interview questions were developed and included questions regarding the meaning of words or phrases used, difficulty in understanding specific questions or patterns of answering questions, acceptability of questions, and utilization of the response scales or missing values [54].

Ethical Issues

The Committee on Human Research at the University of California, San Francisco provided approval for this study, with the investigation carried out according to the principles outlined in the Declaration of Helsinki. Participation was on a voluntary basis. Each participant was assured of confidentiality and the ability to withdraw from the study at any time.

Data Analysis

All tools were checked for completeness at the time of data collection. Frequencies distributions were checked for extreme or logically inconsistent values. Data was analyzed using the Statistical Package for Social Sciences (SPSS 10.0) [55]. Descriptive statistics were used for all variables.

Basic psychometric evaluation includes not only previously reported reliability and validity of established tools, but also variability to determine how the tool is likely to function in a new population of interest. The information on variability helps determine if the tool is detecting important differences in the concept at each end of the continuum. Further, the degree of variability in scores can affect the internal consistency (reliability) of the tool [56]. Skewness and kurtosis scores closer to zero, but $< \pm 2$, represent a more normal distribution [56]. TCSE score distributions examined included the mean, standard deviation, standard error of the mean, median, skewness, kurtosis, observed range of scores, floor & ceiling effects, and the inter-quartile percentage values.

Internal consistency was assessed by Cronbach's alpha coefficient, and reflects the extent to which all items in the scale measures the same concept. Internal consistency scores of at least 0.70 are considered acceptable [56]. Item analysis is another method of checking reliability of a tool. Pearson's product moment correlations were used between the items in TCSE Barriers and TCSE Performance scales with overall mean scores for the respective scales. Evidence of the scale's homogeneity was defined as correlations higher than 0.40 [56].

Finally, known-groups validity, a type of construct validity was examined. Known-groups validity tests for mean differences between groups, known to differ on the

concept being measured. We hypothesized that TCSE mean scores (TCSE Barriers and TCSE Performance) between Tai Chi practitioners and non-practitioners would differ significantly, and that the mean score of the Tai Chi practitioners would be significantly higher than the non-practitioners. Validity is supported if results obtained confirm the *a priori* hypothesis [56].

Pre-test Results

Study Sample

A total of 18 subjects aged between 27-86 (mean=60 years, SD=18.4) years old, volunteered to participate. Seven of the subjects (39%) identified themselves as ethnic Chinese. Ten of the subjects had experience performing Tai Chi exercise, ranging in length from 3 months to 17 years (mean=5.0 years, SD=5.0) (Table 1). All but one subject perceived their personal health to be good, very good or excellent (n=17, 94%). Half of the subjects reported having a history of hypertension (n=9, 50%), while nearly one-third reported having high cholesterol (n=5, 28%). No persons reported being a current smoker or diabetic. The following medical histories were reported: irregular heart beat (n=4, 22%), asthma (n=1, 6%), major depression (n=1, 6%), rheumatoid arthritis (n=2, 11%), severe back pain (n=2, 11%), degenerative disc or joint disease (n=1, 6%), and cancer (n=3, 17%).

Feasibility

In general, subjects understood the questions and had no difficulty answering any of them. However, several respondents (n=7, 39%) commented that an additional instruction sentence be added to the TCSE tool, to help clarify how respondents should

answer the questions in the tool. The questionnaire was reported to be about the right length, with subjects requiring 10 to 20 minutes of time to complete the whole questionnaire, which included the TSCE tool as well as personal and medical information (mean=13.9 minutes, SD=3.6). None of the subjects found that the questionnaire was too long. No differences were found between ethnic Chinese and non-Chinese in response to the interview questions.

None of the respondents found any of the questions to be offensive and thought that others would answer the questions honestly. Interestingly, 17% (n=3) of the subjects thought that other people might have difficulty answering some of the questions, if others did not know some of the medical terms used. None of the subjects had a problem determining their response level, though one commented that their response choice could vary depending on whether they were doing Tai Chi alone or with others in the Tai Chi class, perceiving themselves to be more confident to perform Tai Chi in a group, than alone. One subject commented that the larger font size (14-point) aided in the readability of questionnaire for older adults.

Variability

The distribution for the TCSE Barriers scale was approximately normal, while the TCSE Performance scale was negatively skewed. However, there was a wide range of responses (TCSE Barriers 0-93; TCSE Performance 0-100), providing preliminary evidence of good variability in both scales in the TCSE tool. Descriptive data (n=18) of the TCSE tool are included in Table 2. TCSE Barriers mean scores (mean=47.7, SD=29.7) were lower than the TCSE Performance mean scores (mean=72.2, SD=34.4) (0=not at all confident, 100=very confident). The item with the lowest mean score was,

"I believe I can perform Tai Chi exercise 3 times per week if I feel pain or discomfort when doing Tai Chi"(mean=39.7, SD=33), in the TSCE Barriers scale. While the item with the highest mean score was, *"I believe I can move my whole body in a slow, rhythmical fashion continuously for 2 minutes"* (mean=80.3, SD=32.7), representing the lowest level of challenge in TCSE performance.

Reliability

Internal consistency estimates were very high is this population (TCSE Barriers, alpha=0.95; TCSE Performance, alpha =0.97) (Table 2). Internal consistency is a function of the number of items, the average correlation among items and the variability of the items in the study sample [56]. In this sample, the wide dispersion in scores reported, likely contributed to the high reliability. Item analysis using Pearson's product moment correlations between the items in TCSE Barriers and TCSE Performance scales with overall mean scores for the respective scales was done. Items in the TCSE Barriers scale correlated significantly with the overall TCSE Barriers mean score (r=0.86-0.95, p=0.01), except for the item about performing Tai Chi alone (r=0.41, p> 0.05). All items in the TCSE Performance scale correlated significantly with the overall TCSE Performance mean score (r=0.91-0.97, p=0.01). Further, a significant positive correlation between the TCSE Barriers and TCSE Performance was found (r=0.66, p=0.01).

Known-Groups Validity

Among Tai Chi practitioners higher TCSE mean scores were reported, than in the non-practitioners (Table 3). As expected, a statistically significant difference was found in the TCSE mean scores between Tai Chi practitioners and non-practitioners, with Tai

Chi practitioners reporting higher self-efficacy; thus providing initial evidence of known-groups validity. No significant difference in TCSE mean scores was found between ethnic Chinese and non-Chinese persons (all p-values > 0.05).

Discussion

In this pilot study, the overall aim was to assess the utility and appropriateness of existing tools measuring aspects of TCSE (TCSE Barriers and TCSE Performance) in a new population, ethnic Chinese with CHD risk factors. According to Bandura [14, 49], measures must be tailored to the specific domain of functioning and represent gradations of the specific task demands. Minor modifications to the original exercise self-efficacy tool developed by Resnick & Jenkins (2000) (TCSE Barriers) included changing questions to 1st person, and made specific to Tai Chi. Two additional time questions were added to the original TCSE performance tool, developed by Li and colleagues (2001). These minor modifications were done in accordance with recommendations and guidelines presented by Bandura[14, 49], for assessing self-efficacy. The face, content and construct validity and test-retest reliability of the previously established tools as reported by the original authors, were accepted [50, 51].

In this study, approximately 39% of the subjects were ethnic Chinese older adults, having at least one major risk factor (hypertension) for CHD. Further, these subjects reported a wide range of Tai Chi exercise experiences, ranging from none to 17 years. The modified TCSE tool was feasible to use in this sample, as no difficulties or differences between ethnic Chinese and non-Chinese were reported. The only suggestion from the participants was that an additional sentence be added to the instructions to help

clarify how subjects should respond to the questions. This comment was similar with both the Chinese and English versions of the tool. Therefore, an additional instruction sentence was added to the tool, between the title and the response options, in an attempt to aid with clarification and minimize measurement error with future use (see Appendix).

Internal consistency of this tool was very high in this sample. The modifications made to the original tools for use in this study, did not negatively affect the internal consistency of the scale, but resulted in slightly higher Cronbach's alpha scores. This is likely due to the wide dispersion of TCSE scores obtained (TCSE Barriers, 0-93; TCSE Performance, 0-100). However, scales with high internal consistency may have difficulty discriminating well in studies with repeated measures. Thus, consideration needs to be given to tools with high reliability, when measuring change in an attribute is desired.

The non-significant correlation between the item, "*I believe I can perform Tai Chi exercise 3 times per week if I have to perform Tai Chi alone,*" and the overall TCSE Barriers mean score, cannot be explained. However, it does not appear to have negatively affected the internal consistency of the scale. In the original tool [51], an item analysis of the exercise self-efficacy tool to overcome barriers to exercise with the overall exercise efficacy mean score was not reported.

Validity accumulates with evidence derived from different samples. There was a significant difference in the TCSE mean scores between Tai Chi practitioners and non-practitioners, confirming known-groups validity. This tool functioned well to identify differences in the groups known to differ on level of perceived confidence to perform Tai Chi exercise. Further, the non-significant difference in the TCSE mean scores between

ethnic Chinese and non-Chinese suggests that the tool is adequate for measuring the construct of TCSE, regardless of ethnicity.

Conclusion

Social Cognitive Theory, in particular self-efficacy, provides a framework for measuring perceived confidence to perform a specific task, such as TCSE. Measurement of self-efficacy to overcome barriers to Tai Chi exercise (TCSE Barriers) and self-efficacy to perform Tai Chi (TCSE performance) functioned well in this group of subjects. Initial feasibility of this tool was established and known-groups validity was confirmed.

The extent to which this modified measure of TCSE in Chinese populations performs in the future is unknown, though additional studies may help answer this question and contribute to knowledge building on this phenomenon from a cross-cultural perspective. Further research using this tool among ethnic Chinese with CHD or CHD risk factors, including those with less than high school education or low literacy is needed. Additional questions regarding other features of Tai Chi exercise, such as weight-shifting between legs, is recommended as the next step in development of a tool to measure TCSE.

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TABLE 1: PRE-TEST SUBJECT DEMOGRAPHICS, N=18

Age [mean (SD)], years	60.3 (18.4)
	% (n)
Gender	
Men	28% (5)
Women	72% (13)
Marital Status	
Never married	11% (2)
Married/ Domestic partner	61% (11)
Divorced/Separated/ Widowed	28% (5)
Education	
Secondary (7-12 years)	22% (4)
Tertiary (13+ years)	78% (14)
Employment Status	
Retired	56% (10)
Full or Part-time	44% (8)
Income (in US dollars per year)	
< 24,999	39% (7)
25,000-49,999	17% (3)
>50,000	44% (8)
Ethnicity	
Non-Chinese	61% (11)
Chinese	39% (7)
Language Spoken	
English	61% (11)
Cantonese	33% (6)
Mandarin	6% (1)
Previous Tai Chi experience	56% (10)
mean years Tai Chi (SD)	5.0 (5.0)
range (years)	0.25-17.0

TABLE 2: TAI CHI EXERCISE SELF-EFFICACY PRE-TEST RESULTS, N=18

Statistic	TCSE Barriers	TCSE Performance
Number of items	9	5
mean	47.7	72.2
SD	29.7	34.4
SE mean	7.0	8.1
Median	46.7	91.0
Skewness	-0.03	-1.17
Kurtosis	-1.06	0.16
Possible range	0 to 100	0 to 100
Observed range	0 to 92.8	0 to 100
Floor effects % (n)	11(2)	11(2)
Ceiling effects % (n)	0 (0)	22 (4)
Inter-quartile Percentile Values		
25%	23.3	56
50%	46.7	91
75%	75.6	99
Direction of high score	↑ self-efficacy to overcome barriers	↑ self-efficacy to perform Tai Chi
Cronbach's alpha	0.95	0.97

TCSE=Tai Chi Exercise Self-Efficacy, SD=standard deviation, SE=standard error

TABLE 3: KNOWN-GROUPS VALIDITY, N=18

	TCSE Barriers mean (SD)	TCSE Performance mean (SD)
Tai Chi Practitioners, n=10	64.1 (25.5)	89.8 (16.3)
Non-Practitioners, n=8	27.2 (20.8)	50.1 (39.1)
t-test	-3.3	-2.7
p-value	0.01	0.03

Appendix

Confidence Scale

Using the scale below, please answer each question and indicate how ***confident*** you are ***right now*** to perform Tai Chi exercise.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
not at all confident					moderately confident					very confident

1. I *believe* I can perform Tai Chi exercise three times per week, even if[1] .....

Confidence rating (0-100%)

a. the weather is bothering me?..... _____

b. I am bored by Tai Chi?..... _____

c. I feel pain or discomfort when doing Tai Chi?..... _____

d. I have to perform Tai Chi alone?..... _____

e. I do not enjoy Tai Chi?..... _____

f. I am too busy with other activities?..... _____

g. I feel tired?..... _____

h. I feel stressed?..... _____

i. I feel depressed?..... _____

2. I *believe* I can move my whole body in a slow, rhythmical fashion continuously[2] .....

Confidence rating (0-100%)

a. for 2 minutes..... _____

b. for 5 minutes..... _____

c. for 10 minutes..... _____

d. for 20 minutes..... _____

e. for 30 minutes..... _____

[1] Derived from Resnick, B., & Jenkins, L. S. (2000). Testing the reliability and validity of the Self-Efficacy for Exercise scale. *Nurs Res, 49*(3), 154-159; used with permission

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Paper 4

Hemodynamic Responses To Tai Chi Exercise In Ethnic Chinese Adults With Cardiovascular Disease Risk Factors

Taylor-Piliae, R.E., Haskell, W.L., & Froelicher, E.S. Hemodynamic Responses To Tai Chi Exercise In Ethnic Chinese Adults With Cardiovascular Disease Risk Factors. *In Review, Journal of Cardiopulmonary Rehabilitation*

Hemodynamic Responses To Tai Chi Exercise In Ethnic Chinese Adults With Cardiovascular Disease Risk Factors

Abstract

Purpose: Cardiovascular disease (CVD) is the leading cause of death in the United States (US) among Asian-Americans. Tai Chi (TC) is a traditional form of exercise among Chinese, and has been shown to produce some health benefits similar to Western style exercise. Hemodynamic responses to a 12-week TC exercise intervention among ethnic Chinese with CVD risk factors were examined.

Methods: Blood pressure (BP), heart rate, and a two-minute step-in-place test to assess aerobic endurance were measured at baseline, 6 & 12-weeks following the TC exercise intervention.

Results: A total of 39 subjects, 66 ± 8.3 years old, attended a 60-minute TC exercise class 3 times per week for 12 weeks, at a community center in the San Francisco Bay Area. At baseline, the average BP at rest was 150/86. Clinically and statistically significant reductions in systolic BP (-18.9 mmHg), and diastolic BP (-8.9 mmHg) at rest were found after 12 weeks of TC (BP=131/77). Improvement in aerobic endurance was statistically significant over-time (eta^2=0.39). Adherence (87%) to the TC exercise intervention was high, with very high follow-up (97%) of subjects on completion of the study achieved.

Conclusions: A 12-week TC exercise intervention in ethnic Chinese older adults with CVD risk factors was able to significantly reduce BP and improve aerobic endurance. Given the rise in hypertension (HTN) among adults in the US and the associated public

health burden of HTN, this is an important finding. This innovative exercise program, utilized a culturally appropriate, traditional exercise from China.

Key Words: exercise, risk factors, hemodynamics, blood pressure, Chinese, Tai Chi

Introduction

Coronary heart disease (CHD) has been the leading cause of death in the United States (US) for over 5 decades.[1, 2] Though the incidence of CHD has declined over the past 50 years, hypertension (HTN) has been steadily rising.[3-5] The National Health and Nutrition Examination Survey study between 1999-2000 suggest that HTN is prevalent in approximately 30% of the adult population in the United States (US).[4, 5] This is an increase from the previously reported HTN prevalence of 23% in the adult US population during 1989-1994.[6] Moreover, the incidence of HTN is increasing among all ethnic groups, including Asian-Americans.[4, 5, 7] The largest group of Asian-Americans are ethnic Chinese, although limited cardiovascular disease (CVD) prevention research has focused on ethnic Chinese.[8]

HTN is defined as having a systolic blood pressure (SBP) ≥ 140 mmHg, diastolic blood pressure (DBP) ≥ 90 mmHg, or taking prescribed anti-hypertensive medications.[3, 4] HTN is a major independent risk factor for CVD[3, 7, 9] and is associated with increased risks for heart attacks, heart failure, kidney disease and especially stroke.[3] Stroke is 3rd leading cause of death in the US.[7] Together CHD and stroke represent the principal causes for CVD and account for approximately 40% of all deaths in the US.[7, 9]

Among adults with HTN, only 34% are taking anti-hypertensives and have their blood pressure (BP) under control.[5, 7] Approximately 30% are not aware of having HTN, 11% are not on any anti-hypertensives, while 25% are taking anti-hypertensives yet their BP is not under control.[5, 7] HTN is a major public health challenge. In 2004, the costs (direct and indirect) of HTN are estimated at $55.5 billion.[7, 9] Therefore, it is vital that

steps be taken to reduce HTN in adults in the US, and thus decrease health risks associated with CVD.

Physical activity has been shown to reduce BP,[10] however, the majority of adults in the US are not meeting recommended physical activity levels.[7, 11] Since participation in physical activity is often influenced by social experiences and cultural values,[12, 13] it is an important consideration when planning exercise programs for specific ethnic groups, such as Chinese adults. Tai Chi (TC) is a traditional form of exercise among Chinese populations, that has been shown to produce some health and performance benefits similar to Western style exercise training, such as walking.[14-17]

Literature Review

TC is a low-impact moderate-intensity exercise that has been practiced in China for hundreds of years.[18, 19] Slow, controlled graceful movements characterize TC, integrating mind and body. TC is popular among older adults, and is suitable for persons with CVD risk factors, including persons with HTN.[14, 17, 20, 21]

TC exercise programs are inexpensive, requiring no special facility or equipment. TC can be learned and performed by persons of all ages, regardless of previous exercise experience or ability.[20, 22] The whole body is relaxed while practicing TC, integrating mental concentration and breathing control.[23] Movements flow from one posture to another.[18, 23] Essential techniques for practicing TC exercise include shifting body weight between the right and left leg, keeping the head up with trunk straight and extended, flexing knees, turning from the hips, and asymmetrical arm and leg movements.[18, 19]

The majority of research on TC exercise has focused on the elderly population.[17, 22, 24-32] Improvements in flexibility, balance, control, muscular strength and fall risk reduction have been documented.[20] Upon completion of a TC exercise program, community-dwelling older adults have reported a sense of enhanced well-being, increased alertness, relaxation, and a better mental outlook.[27, 33] However, research among persons with CVD is limited, though the evidence suggests that it is safe,[20, 34] able to reduce BP and improve cardiorespiratory functioning.[17, 21, 35, 36]

Only a handful of intervention studies have examined the effect of TC exercise on BP in persons with HTN or normotensives.[17, 35-38] In prior studies, the average length of each TC intervention study was 12 weeks, ranging from 8-15 weeks (Table 1). However, the number of TC exercise sessions held during each intervention study varied greatly, ranging from 11 to 36 sessions, resulting in unequal doses of TC exercise across the studies.[17, 35-38] All of these studies utilized different styles of TC, which can represent different exercise intensities.[14, 19, 34] These studies reported dissimilar follow-up visits completed (8-97%), making comparisons difficult and limiting generalizability to other populations. No prior TC exercise intervention study has been conducted in ethnic Chinese living in the US, with HTN or other CVD risk factors.

The overall aim of this study was to examine hemodynamic responses to a 12-week TC exercise intervention among ethnic Chinese with CVD risk factors. Specific objectives were to determine if a TC exercise intervention: 1) was feasible and acceptable among Chinese living in the San Francisco Bay Area; 2) lowered blood pressure, heart rate, or pressure-rate product; and 3) improved aerobic endurance.

Methods

Setting and Subjects

This was a repeated measures intervention study, conducted at a community center in the San Francisco Bay Area with a high density of ethnic Chinese living nearby. Information about the study was distributed through flyers, posters, brochures and newspaper advertisements. Interested persons contacted the study investigator for further information and to determine eligibility. If the eligibility criteria were met, subjects were invited for a baseline evaluation.

Inclusion criteria for participation were: 1) ethnic Chinese; 2) aged ≥ 45 years old; 3) speaks Cantonese or English; 4) ≥ 1 CVD risk factor (current smoker, high blood pressure, high cholesterol, diabetes); 5) has not practiced TC on a regular basis in the past 6 months; 6) willing to sign a written informed consent. Exclusion criteria included persons diagnosed with cognitive impairments, severe debilitating arthritis, or unstable cardiac condition such as ventricular dysrhythmias, pulmonary edema, chest pain, or uncontrolled atrial fibrillation.[21, 35]

Sample Size

N-Query 4.0[39] statistical software was used to calculate the effect size for an univariate one-factor repeated measures analysis of variance (ANOVA). Experimental studies have reported an average attrition rate of 25%.[17, 21, 30, 40] Sample size calculations using univariate one-factor repeated measures ANOVA to examine significant differences in means at baseline, 6 weeks and 12-weeks; and alpha=.05 and power=.80, with a conservative delta^2 effect size of 0.15 (delta^2=f^2), required a sample size of 28

subjects.[41] However, when considering a potential attrition rate of 25%, 39 subjects were required.

Measures

Self-reported personal and medical history was obtained from all subjects. Information obtained included age, gender, marital status, education, employment status, income, birthplace, and primary language spoken. Self-reported medical history included previous hospitalizations, myocardial infarction, HTN, high cholesterol, diabetes, smoking status, major medical conditions, surgical procedures, major depression or musculoskeletal conditions. Subjects were asked to bring all of their medications for review at the baseline appointment.

Hemodynamics

Subjects were instructed to relax, and to avoid exercise, smoking or caffeine 4 hours prior to measuring BP. Resting BP was measured according to the recommended guidelines.[3] All BP readings were taken in the left arm by an automatic digital BP monitor from the American Diagnostic Corporation, Model 6008. The BP device measures SBP, DBP and HR, with accuracy reported as ± 3mmHg or 2% of the reading. The BP cuff size used was determined individually, based on arm circumference.

Pressure-rate product (PRP) was calculated as the product of the SBP and HR/ 1000. PRP at rest and after the step-test were calculated, as an indication of cardiovascular response to exercise.[42]

Two-Minute Step-in-Place

A 2-minute step-in-place test was used to assess aerobic endurance. The test involves having the subject raise their knees one at a time, to a height halfway between

the middle of the patella and the iliac crest, as many times as possible within 2 minutes.[43] The score is the number of times the right knee reaches the minimum height. Normative data for the 2-minute step-in-place test among older adults (n= 7,183) has been reported.[44] On average, men between 65-69 years old should be able to complete 101 steps in 2 minutes, while women the same age complete an average of 90 steps. The 2-minute step-in-place test was reported to correlate significantly with a 1-mile timed walk (r=0.73, n=24), and with time on treadmill to 85% predicted maximum heart rate (r=0.74, n=25).[43] Known-groups validity was established by the test's ability to discriminate between age groups (p=0.01) and between exercisers and non-exercisers (p=0.01).[43] BP was taken immediately after a 2-minute step-in-place test.

Adherence

Monitoring the process of change in exercise behavior is vital.[45] Having subjects sign an attendance sheet at each TC exercise session assessed adherence to the intervention.

Procedures

All of the data were collected at baseline, 6 and 12-weeks following the TC exercise intervention. Subjects were recruited in cohorts, limited to 20 per group, to ensure individual attention. Subjects attended a 60-minute TC exercise class 3 times per week for 12 weeks, located at the community center. An experienced TC Instructor proficient in the Yang Style 24-posture short-form[23] taught all sessions. The form is easier to learn and remember than the classical Yang style 108-posture long-form, though still contains the essential TC principles. Older adults and those with chronic illnesses can practice this form safely.[23]

During class, subjects were asked to replicate the motions, postures, and movement speed of the instructor. Subjects were monitored for safety with corrections given as needed. A registered nurse (RTP) experienced in exercise testing/supervision and possessing advanced cardiac life support certification, was in attendance at all sessions. Each session consisted of a 20-minute warm-up period, 30-minutes of TC exercise, and a 10-minute cool-down period. The 24-posture short-form was taught gradually and subjects were able to learn the entire sequence by the end of 12 weeks. The entire sequence takes 8-10 minutes to perform and was repeated several times, to provide an aerobic benefit.[14, 15, 46]

Subjects were encouraged to practice at home at least two other days, though was not monitored. Upon completion of the 12-week intervention, each subject received a CD-Rom of the TC Master performing the form taught.[23]

Data Analysis

All forms were reviewed for accuracy and completeness at the time of data collection. Frequencies were run on each variable to check for extreme values. Data were analyzed using the Statistical Package for Social Sciences (version 10.0).[47] Descriptive statistics were calculated on all variables. Univariate repeated measures ANOVA was used to test for changes in the outcomes variables over-time. Maulchy's test of sphericity (≥ 0.05)[48] was done before the analysis. If the compound symmetry criterion was not met, then the data were analyzed using the Greenhouse-Geisser adjusted univariate approach. If the overall ANOVA was significant, then Bonferroni's adjusted paired-samples confidence intervals[48] were done for all 3 possible comparisons (0-12 weeks, 0-6 weeks, 6-12 weeks) to identify mean differences.

Protection of Human Subjects

Approval to conduct the study was obtained from the Institutional Review Board at the University of California San Francisco, with the investigation carried out according to the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all subjects in either English (n=1) or Cantonese (n=38). All subjects were assured of confidentially and the ability to decline participation or withdraw from the study at any time.

Results

Baseline Characteristics

A total of 39 subjects agreed to participate, and were on average 66 (± 8.3) years old, married, Cantonese-speaking immigrants (Table 2). The majority of subjects reported ≤ 12 years education, and an income < $35,000 US per year.

HTN was present in 92% of subjects, however only 54% were taking one or more anti-hypertensive medications (Table 3). Hypercholesteremia was reported in 49% of the subjects, though only 28% were taking statins. Approximately 21% of the subjects were diabetics, and only one subject was a current smoker. Few subjects used Chinese medicine for maintaining their health. The majority of subjects perceived their health to be good, very good or excellent (56%) (Table 3), despite self-reported rheumatoid arthritis (46%) or chronic back pain (41%).

Adherence

Subjects were asked to attend a total of 36 TC exercise classes during the study. Adherence to the intervention was very high (87% ± 0.18). Follow-up at 6 weeks was 100%. Only one woman dropped out of the study after completing the 6-week evaluation,

due to health problems. There were no further dropouts, thus very high follow-up of subjects was achieved on completion of the study (97%).

Hemodynamics

At rest, the baseline mean BP was 150/86, with a heart rate of 76 beats per minute. After the baseline 2-minute step-in-place test, the mean BP was 178/99, with a heart rate of 92 beats per minute (Table 4). Hemodynamic responses assessed at 6-weeks and 12-weeks showed significant reductions in SBP (Figure 1) and DBP (Figure 2) at rest and after the 2-minute step-in-place test. Pairwise contrasts of the mean differences comparing baseline to 6-weeks and baseline to 12-weeks were statistically significant (Table 5). Following 12-weeks of TC exercise the mean BP at rest was 131/77, a significant SBP reduction of 19 mmHg and DBP reduction of 9 mmHg.

Univariate repeated measures ANOVA examining changes in resting SBP, DBP, and PRP were statistically significant over-time (Table 4). Approximately 43% (eta^2=0.43) of the variance in resting SBP, and 39% (eta^2=0.39) of the variance in resting DBP over time could be explained. Univariate repeated measures ANOVA examining changes in SBP and DBP after the 2-minute step-in-place test were statistically significant over-time. Approximately 21% (eta^2=0.21) of the variance in SBP and 30% (eta^2=0.30) of the variance in DBP after the 2-minute step-in-place test over time could be explained.

Aerobic Endurance

A two-minute step-in-place test was used to assess aerobic endurance. At baseline, subjects were able to complete an average of 73 steps in 2 minutes (Table 4). At the 6-week and 12-week assessments, the number of steps subjects completed in 2-

minutes increased and were statistically significant (Figure 3). All 3 pairwise contrasts of the mean differences were significant (Table 5). On average, subjects were able to complete 88 steps in 2-minutes, after 12-weeks of TC exercise, indicating better aerobic endurance. Univariate repeated measures ANOVA examining change in aerobic endurance was statistically significant over-time (Table 4). Approximately 39% (eta^2=0.39) of the variance in aerobic endurance over-time could be explained.

Discussion

This was the first TC exercise intervention study conducted in ethnic Chinese living in the US with CVD risk factors, such as HTN. This was an innovative exercise program, utilizing a culturally appropriate, traditional exercise from China, while eliminating any linguistic barriers. The principal investigator (RTP) is fluent in Cantonese, and worked with a translator fluent in Cantonese, to assist in obtaining informed consent, data collection and providing detailed explanations in the TC classes. All aspects of the study, assessments and TC classes, were conducted at a local community center providing easy, convenient access and familiarity to the setting, where a large number of Cantonese-speaking senior citizens gather daily for lunch and other activities such as mahjong, haircuts, buying vegetables, and health talks.

The high adherence rate (87%) to the TC exercise intervention with 97% of subjects completing the study reflects the high acceptability of TC exercise in these subjects. This is in contrast to previous exercise intervention studies to reduce CVD risk factors, reporting low adherence (28%) to a 3 times-per-week exercise prescription.[49, 50] In addition, drop-out rates in exercise programs tend to be high, averaging 44% after 12 weeks.[49, 50] Attrition in most prior studies (Table 1) examining the effect of TC on BP

was relatively low (15%), when compared to other exercise intervention studies. In the study by Channer and colleagues,[35] attrition in the control group was very high (92%), while the TC group experienced a 18% attrition rate, threatening internal validity and severely limiting generalizability of the study findings.[35] The extent to which selection bias affected attrition in these studies also needs consideration.[17, 35-38]

Most subjects in this study were married, Cantonese-speaking immigrant women. This is generally an underrepresented group in research studies, often due to financial and language barriers,[7, 8] and their inclusion in this study provides valuable new information. Relative to the median income and education level of persons in the San Francisco Bay area, subjects in this study were poor and had limited education. The income level of women reported in this study is similar to findings reported by Froelicher and colleagues (2002) among women in the San Francisco Bay area with CVD, participating in a smoking cessation study.[51]

HTN was the most prevalent CVD risk factor (92%). Hypercholesteremia was also common (49%). High BP and high cholesterol are major CVD risk factors with established effective treatments, and CVD can be prevented through assessment, adherence to medication, and other lifestyle changes such as exercise and diet.[9] Subjects in this study may have been unaware of personal CVD risk, were under-treated or unwilling to take medications to lower CVD risk factors. The awareness, treatment and control of these CVD risk factors warrants further investigation among ethnic Chinese to determine if language, cost, or other factors may be contributing to the prevalence of HTN and other CVD risk factors, such as hypercholesteremia.

A clinically and statistically significant reduction in BP was found in this study. At baseline, the average BP was 150/86, considered Stage-1 HTN.[3] After 12-weeks of TC exercise the average BP was 131/77, with a decrease of 18.9 mmHg in SBP, and a decrease of 8.9 mmHg in DBP. On average, subjects started the TC exercise intervention at Stage-1 HTN and completed the study at the pre-HTN stage.[3] No subject in the study began any new anti-hypertensive medications. Findings in this study are similar to other intervention studies that have examined the effect of TC on BP (Table 1). Previous studies have reported reductions in mean SBP from 7 to16 mmHg, and in DBP from 2 to 9 mmHg, among subjects in Tai Chi exercise groups.[17, 35-38] However, it is not known if TC exercise alone or other lifestyle factors may have contributed to the reduction in BP in this study, without a comparison group.

Subjects enrolled in studies examining the effect of TC on BP, had either HTN,[17, 35, 36, 38] or were normotensive at baseline.[37] Significant within-group reductions in BP were reported for the subjects enrolled in TC intervention groups.[17, 35-37] However, only the study by Wolf and colleagues[38] reported a significant between-group reduction in SBP, with subjects in the TC exercise group experiencing a greater reduction in BP than subjects in the control group.

In the study conducted by Young and colleagues,[17] the controls were assigned to aerobic exercise. Significant reductions in SBP and DBP were found within each group after 12-weeks, but not between groups.[17] It is likely that both the experimental and control conditions had similar exercise intensities. Moreover, conclusions that TC is as effective as aerobic exercise cannot be made, given the lack of a sedentary control group to serve as a comparison.[52]

In this study, TC exercise had no effect on heart rate, and is similar to findings reported by Tsai and colleagues.[36] Approximately 13% (n=5) of subjects in this study were taking beta-blockers. Post-hoc analysis examining change on heart rate overtime, comparing subjects taking beta-blockers with other subjects in the study was not statistically significant ($p>0.05$), likely due to the small sample size. However, it is not known if other factors such as the breathing and relaxation components of TC may have contributed to this finding.

A two-minute step-in-place test was used to assess aerobic endurance. Content, convergent, discriminant and criterion validity have been reported for this test as an adequate measure of aerobic endurance in older adults.[43, 44, 53] From a public health perspective, this test is affordable as no expensive equipment is required, can be done with greater ease in a non-clinical setting, and has the potential to be utilized in large epidemiological studies to assess the effectiveness of exercise interventions among older adults.

Subjects in this study were less fit than community-residing older adults in the US, when compared to reported normative data.[44] Among US community-residing older adults aged 65-69 years, the 50th percentile for women is 90 steps, while for men it is 101 steps in 2-minutes. Subjects were only able to complete 73 steps in 2-minutes at baseline (women = 72.4 steps ± 14.2, men=74.1 steps ± 12.7), which is less than the 50th percentile of women and men aged 65-69 years. After the 12-weeks TC exercise intervention, a clinically and statistically significant improvement in aerobic endurance was observed (Table 4). Subjects were able to complete on average 88 steps in 2-minutes

(women = 88.6 steps ± 20.0, men=87.8 steps ± 21.7), nearly reaching the 50th percentile among community-residing older adults aged 65-69 years in the US.

The degree of improvement in aerobic endurance depends on the TC exercise intensity, duration and frequency, as well as the subject's initial level of physical activity. Cross-sectional studies have reported that TC practitioners have higher aerobic capacity than sedentary persons, matched on age and gender.[34] However, experimental studies examining the effect of TC exercise on aerobic capacity have reported mixed results.[34] Additional randomized controlled trials examining the short and long-term effects of TC exercise on cardiorespiratory responses are needed.

Limitations and Strengths

It was initially important to determine if the TC exercise intervention study was feasible and acceptable in this population, before conducting a large randomized clinical trial. However, without a control group to serve as a comparison, improvement unrelated to TC is possible. Furthermore, the generalizability of the findings obtained may be limited, as only subjects uniquely interested in TC may have volunteered as study participants. However, the information obtained in this study provides data useful for effect size calculations, and culture-specific information needed for conducting future intervention studies.

This study examined only hemodynamic responses to TC exercise. Future studies may like to examine the effect of TC exercise programs on the reduction of other CVD risk factors, such as lipid levels, weight reduction, or smoking cessation.

There were several strengths in this study. This was the first reported study among ethnic Chinese in the US, tailored for Cantonese-speaking persons with CVD risk

factors. A very high follow-up of subjects (97%) was achieved on completion of the study. In addition, very high adherence to the TC exercise intervention suggests this was a convenient and acceptable, culturally appropriate form of exercise for these subjects. Finally, a high proportion of women volunteered (69%) to participate in this TC exercise intervention, unlike other aerobic exercise studies.[54]

Conclusion

A 12-week TC exercise intervention in ethnic Chinese adults with CVD risk factors was able to significantly reduce BP and improve aerobic endurance. Given the number of persons estimated to have HTN and other CVD risk factors, the identification of new approaches to improve health, combined with risk factor reduction is needed. This is particularly important, given the rise in HTN among adults in the US and the associated public health burden of HTN. TC has the potential to reduce expenditures associated with CVD by facilitating a lifestyle that promotes physical activity, while remaining a low-tech, low-cost alternative to exercise.

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TABLE 1: TAI CHI INTERVENTION STUDIES EXAMINING EFFECT ON BLOOD PRESSURE

Author/Year	Channer, et al. 1996[35]		Wolf, et al. 1996[38]		Young, et al. 1999[17]		Tsai, et al. 2003[36]		Thornton, et al. 2004[37]	
Study Design	RCT		RCT		RCT		RCT		Quasi-exper.	
Tai Chi Style	Wu, 47 postures		Yang, 10 movements		Yang, 13 movements		Yang, 108 postures		Yang, 108 postures	
Length of Intervention	8 weeks		15 weeks		12 weeks		12 weeks		12 weeks	
Number of Sessions	11		15		24		36		36	
Location of Study	England, UK		Georgia, USA		Maryland, USA		Taiwan, ROC		Hong Kong, SAR	
Group	**Tai Chi**	Control (sedentary)	**Tai Chi†**	Control† (education)	**Tai Chi†**	Control† (aerobics)	**Tai Chi**	Control (sedentary)	**Tai Chi**	Control (sedentary)
Size	**38**	47	**61**	53	**31**	31	**37**	39	**17**	17
% Women	**0**	0	**81**	84	**77**	81	**51**	49	**100**	100
Mean Age in Years	**56***	56*	**76.9 ± 4.8**	75.4 ± 4.1	**66.4 ± 5.1**	67.0 ± 7.9	**51.6 ± 16.3**	50.5 ± 9.8	**47.2 ± 4.1**	48.4 ± 4.3
% Attrition	**18**	92	**15**	17	**3**	3	**16**	11	**15**	15
Baseline Mean SBP± SD	**135***	---	**172.1 ±27.7**	164.0 ± 26.8	**141.7±10.2**	138.2 ± 8.1	**142.4 ± 8.4**	148.2 ± 8.8	**122.4 ± 6.6**	122.6 ± 6.0
Δ Mean SBP ± SD	**-3 ± 3.3**	---	**-13.2 ±27.4**	-1.7 ± 27.1	**-7.0 ± 8.6**	- 8.4 ± 8.6	**-15.6 ± 7.9**	6.4 ± 10.5	**-9.7***	0*
p-value within group	**0.05**	---	**—**	---	**0.001**	0.001	**0.001**	---	**0.001**	---
p-value between groups	**—**	---	**0.05**	---	**0.56**	---	**—**	---	**—**	---
Baseline Mean DBP±SD	**83***	---	**—**	**—**	**76.6 ± 7.2**	75.4 ± 7.5	**87.4 ± 8.7**	86.2 ± 8.4	**80.8 ± 4.2**	79.2 ± 3.6
Δ Mean DBP ± SD	**-2 ± 2.7**	---	**—**	**—**	**-2.4 ± 5.4**	- 3.2 ± 5.4	**-8.8 ± 7.4**	3.4 ± 8.1	**-7.5***	0*
p-value within group	**0.05**	---	**—**	---	**0.02**	0.002	**0.05**	---	**0.001**	---
p-value between groups	**—**	---	**—**	---	**0.54**	---	**—**	---	**—**	---

RCT= randomized clinical trial, Quasi-exper. = quasi-experimental study, SBP=Systolic Blood Pressure, DBP=Diastolic Blood Pressure, SD=Standard Deviation, Δ = change from baseline, * = no SD reported, † = baseline values includes dropouts.

TABLE 2: BASELINE SUBJECT DEMOGRAPHICS, N=39

	Mean ± SD
Age in years	65.7 ± 8.3
Body Weight (pounds)	131.7 ± 16.7
Height (inches)	62.2 ± 2.7
Body Mass Index*	23.9 ± 2.7
	% (n)
Gender	
Men	30.8 (12)
Women	69.2 (27)
Marital Status	
Married/ Domestic partner	84.6 (33)
Divorced/Separated/ Widowed/Single	15.4 (6)
Education	
Primary (1-6 years)	41.0 (16)
Secondary (7-12 years)	46.2 (18)
Tertiary (13+ years)	12.8 (5)
Employment Status	
Retired/unemployed	84.6 (33)
Full or Part-time	15.4 (6)
Income (in US dollars per year)	
< 15,999	46.2 (18)
16,000-34,999	20.6 (8)
> 35,000	12.8 (5)
refused to answer	20.5 (8)
Birthplace	
Mainland China	87.2 (34)
Hong Kong	12.8 (5)
Language Spoken at home	
Cantonese	97.4 (38)
Mandarin	2.6 (1)

*Body Mass Index= (pounds x 703)/inches^2

TABLE 3: SELF-REPORTED CLINICAL HISTORY AND HEALTH STATUS, N=39

	%	n
CVD Risk Factors		
Hypertension	92.3	36
Hypercholesteremia	48.7	19
Diabetic	20.5	8
Current Smoker	2.6	1
CVD Medication Use		
Antihypertensives	53.8	21
Beta-blockers	12.8	5
ACE Inhibitors	12.8	5
Calcium Channel Blockers	17.9	7
Angiotension Receptor Blockers	17.9	7
Diuretics	20.5	8
Alpha-Blockers	2.6	1
Statins	28.2	11
Oral Hypoglycemics	17.9	7
Aspirin	33.3	13
Chinese Medicine	10.3	4
Self-reported Medical History		
Angina	5.1	2
Mild congestive heart failure	5.1	2
Irregular heart rhythm	17.9	7
Heart Block	5.1	2
Heart Valve	5.1	2
Angioplasty/ Stent	2.6	1
Stroke	7.7	3
Peripheral Vascular Disease	7.7	3
Asthma	2.6	1
Depression	5.1	2
Rheumatoid Arthritis	46.2	18
Reiter's Disease/ Lupus	5.2	2
Anemia	12.8	5
Stomach Ulcers	12.8	5
Chronic Back Pain/ Degenerative disc	41.0	16
General Health Perception		
Good/ Very good/ Excellent	56.4	22
Fair	43.6	17

CVD= Cardiovascular Disease

TABLE 4: CHANGE IN HEMODYNAMIC RESPONSE OVER 12 WEEKS OF TAI CHI EXERCISE, N=38

Hemodynamic Response	Baseline Mean ± SD	6-Weeks Mean ± SD	12-Weeks Mean ± SD	Change from Baseline Mean ± SD	Univariate Repeated Measures ANOVA F [$df_{2,36}$]	p-value	eta^2
At Rest							
Systolic Blood Pressure	150.0 ± 20.0	134.6 ± 17.8	131.1 ± 15.1	-18.9 ± 2.8	28.09	0.001*	0.43
Diastolic Blood Pressure	85.8 ± 9.3	77.6 ± 9.1	76.9 ± 8.4	- 8.9 ± 1.3	23.85	0.001*	0.39
Heart Rate	75.9 ± 14.6	74.5 ± 12.8	73.6 ± 11.7	-2.4 ± 1.6	0.97	0.384	0.03
Pressure Rate Product†	11.4 ± 2.9	10.0 ± 2.1	9.6 ± 1.9	-1.8 ± 0.4	15.39	0.001*	0.29
After 2-Minute Step-in-Place Test							
Systolic Blood Pressure	178.3 ± 23.7	167.6 ± 25.2	164.3 ± 22.3	-14.0 ± 4.0	10.08	0.001*	0.21
Diastolic Blood Pressure	98.8 ± 22.7	83.2 ± 12.6	81.6 ± 11.2	-17.2 ± 3.5	15.78	0.001*	0.30
Heart Rate	92.2 ± 23.5	94.0 ± 21.9	91.1 ± 20.4	-1.2 ± 2.9	0.49	0.614	0.01
Pressure Rate Product†	16.6 ± 5.3	15.7 ± 4.0	15.0 ± 4.0	-1.6 ± 0.7	2.69	0.086	0.07
Aerobic Endurance							
Number of steps in 2-minutes	73.0 ± 13.8	83.0 ± 18.3	88.3 ± 20.2	+15.3 ± 2.7	23.72	0.001*	0.39

*significant if p-value ≤ 0.05, †Pressure Rate Product= Systolic Blood Pressure x Heart Rate / 1000

TABLE 5: PAIRWISE CONTRASTS OF MEAN DIFFERENCES IN HEMODYNAMIC RESPONSES OVER 12 WEEKS OF TAI CHI EXERCISE, N=38

Contrasts	Baseline to 6-Weeks				7 to 12-Weeks				Baseline to 12-Weeks			
Hemodynamic Responses	F $[df_{1,36}]$	eta^2	LBCI	UBCI	F $[df_{1,36}]$	eta^2	LBCI	UBCI	F $[df_{1,36}]$	eta^2	LBCI	UBCI
Systolic Blood Pressure												
Resting	26.25	0.42	**7.89**	**23.01**	2.64	0.07	-1.90	8.90	44.95	0.55	**11.86**	**26.03**
Post 2-minute step-in-place	8.76	0.19	**1.64**	**19.78**	1.54	0.04	-3.32	9.85	16.55	0.31	**5.36**	**22.59**
Diastolic Blood Pressure												
Resting	26.04	0.41	**4.19**	**12.28**	0.25	0.01	-2.87	4.29	50.66	0.58	**5.80**	**12.10**
Post 2-minute step-in-place	14.99	0.29	**5.47**	**25.58**	0.49	0.01	-4.22	7.48	23.41	0.39	**8.27**	**26.05**
Heart Rate												
Resting	0.71	0.02	-2.81	5.65	0.28	0.01	-3.57	5.46	2.07	0.05	-1.75	6.49
Post 2-minute step-in-place	0.32	0.01	-9.85	6.22	1.01	0.03	-4.43	10.38	0.16	0.00	-6.13	8.45
Pressure Rate Product*												
Resting	16.90	0.31	**0.55**	**2.28**	1.82	0.05	-0.34	1.12	21.87	0.37	**0.84**	**2.78**
Post 2-minute step-in-place	5.92	0.14	-1.07	2.91	1.66	0.04	-0.63	1.97	4.86	0.12	-0.22	3.39
Aerobic Endurance												
Number of steps in 2-minutes	18.67	0.34	**4.21**	**15.84**	10.83	0.23	**1.27**	**9.37**	32.00	0.46	**8.54**	**22.14**

Bold=$p \leq 0.0167$, LBCI= Lower Bound Confidence Interval with Bonferroni adjusted pairwise contrasts, UBCI= Upper Bound Confidence Interval with Bonferroni adjusted pairwise contrasts, *Pressure Rate Product= Systolic Blood Pressure x Heart Rate / 1000

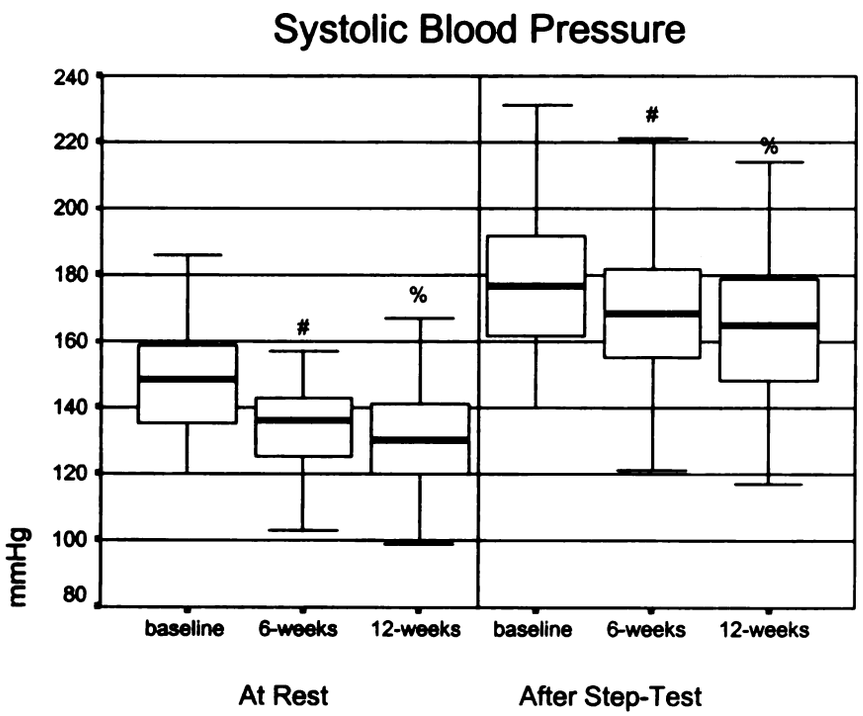
Figure Legends

Figure 1: Mean scores and 95% Confidence Intervals of Systolic Blood Pressure mmhg at Rest and After Step-Test at Baseline, 6-Weeks and 12-Weeks

Figure 2: Mean scores and 95% Confidence Intervals of Diastolic Blood Pressure mmhg at Rest and After Step-Test at Baseline, 6-Weeks and 12-Weeks

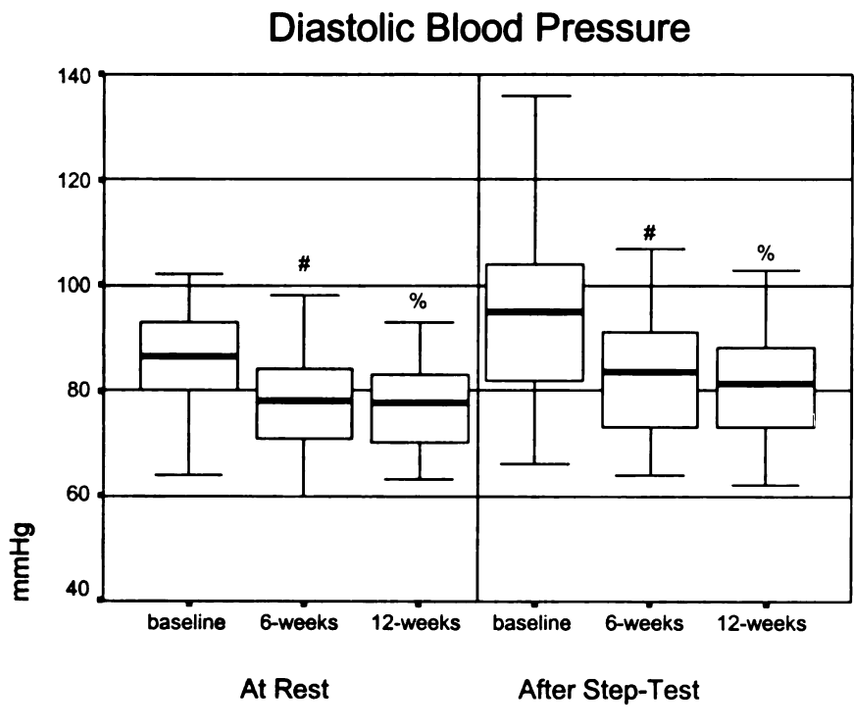
Figure 3: Mean scores and 95% Confidence Intervals of Aerobic Endurance, Number of Steps in Two-Minutes at Baseline, 6-Weeks and 12-Weeks

FIGURE 1: MEAN SCORES AND 95% CONFIDENCE INTERVALS OF SYSTOLIC BLOOD PRESSURE MMHG AT REST AND AFTER STEP-TEST AT BASELINE, 6-WEEKS AND 12-WEEKS



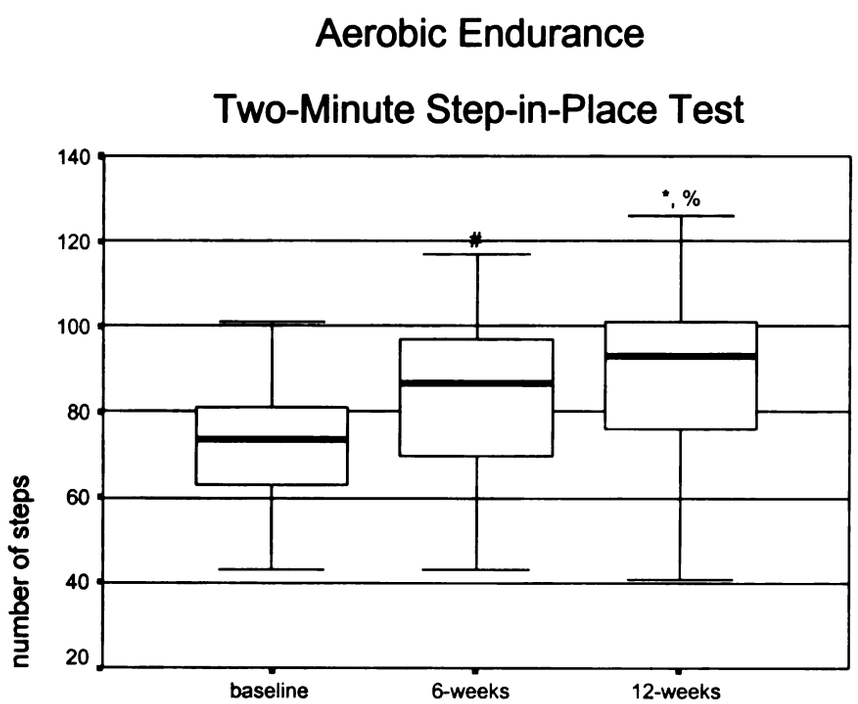
#Baseline vs. 6-weeks, p<0.01, %Baseline vs.12-weeks, p<0.01

FIGURE 2: MEAN SCORES AND 95% CONFIDENCE INTERVALS OF DIASTOLIC BLOOD PRESSURE MMHG AT REST AND AFTER STEP-TEST AT BASELINE, 6-WEEKS AND 12-WEEKS



#Baseline vs. 6-weeks, $p<0.01$, %Baseline vs.12-weeks, $p<0.01$

FIGURE 3: MEAN SCORES AND 95% CONFIDENCE INTERVALS OF AEROBIC ENDURANCE, NUMBER OF STEPS IN TWO-MINUTES AT BASELINE, 6-WEEKS AND 12-WEEKS



#Baseline vs. 6-weeks, $p<0.01$, *6-weeks vs. 12-weeks, $p<0.01$, %Baseline vs.12-weeks, $p<0.01$

Paper 5

Improvement in Balance, Strength and Flexibility after 12-Weeks of Tai Chi Exercise in Ethnic Chinese Adults with Cardiovascular Disease Risk Factors

Taylor-Piliae, R.E., Haskell, W.L., Stotts, N.A. & Froelicher, E.S. Improvements in Balance, Strength and Flexibility after 12-Weeks of Tai Chi Exercise in Ethnic Chinese Adults with Cardiovascular Disease Risk Factors. *In Review, Alternative Therapies in Health and Medicine*

Improvement in Balance, Strength and Flexibility after 12-Weeks of Tai Chi Exercise in Ethnic Chinese Adults with Cardiovascular Disease Risk Factors

Abstract

Context: Declines in physical performance are associated with aging and chronic health conditions. Appropriate physical activity interventions are able to reverse functional limitations, and help maintain independent living. Tai Chi (TC) exercise is a popular form of exercise in China among older adults.

Objective: To determine if TC exercise improves balance, muscular strength & endurance, and flexibility over-time.

Design: Repeated measures intervention, data collected at baseline, 6 and 12-weeks.

Setting: Community center in the San Francisco Bay Area.

Participants: Thirty-nine Chinese adults with ≥ 1 cardiovascular disease (CVD) risk factor.

Interventions: A 60-minute TC exercise class 3 times per week for 12 weeks.

Main Outcome Measures: A battery of physical fitness measures specifically developed for older adults assessed balance, muscular strength & endurance, and flexibility.

Results: Subjects were 65.7(± 8.3) years old, Cantonese-speaking (97%) immigrants, with little education (87%) and very low income (67%). Reported CVD risk factors were hypertension (92%), hypercholesteremia (49%), diabetes (21%), and 1 current smoker. Subjects were below the 50th percentile of fitness at baseline, compared to age and gender-specific normative US data. Statistically significant improvements were observed in all balance, muscular strength & endurance, and flexibility measures over 12-weeks.

Conclusions: TC is a potent intervention that improved balance, upper and lower body muscular strength & endurance, and upper and lower body flexibility in these older Chinese adults. These findings provide important information for future community-based TC exercise programs, and support current public health initiatives to reduce disability from chronic health conditions, and enhance physical functioning in older adults.

Key words: Tai Chi, balance, strength, flexibility, Chinese, community-based exercise program

Background

Worldwide there are a growing number of adults ≥ 65 years old. In addition, longer life expectancy is projected and the proportion of persons ≥ 65 years old in the population is increasing.[1] This places great demands on the current and future healthcare services, with potential increased costs for chronic conditions. Physical disability, hospitalizations and death in older adults are associated with several common chronic diseases,[1, 2] including coronary heart disease, stroke, respiratory diseases, Alzheimer's, arthritis, and diabetes.[3] However, decline in functional status is not solely dependent on chronological age, but is related to female gender, sedentary or unfit individuals, low income, little education, and concomitant chronic disease.[4-6] Regular physical activity is beneficial among middle-aged and older adults for preventing several chronic diseases, as well as improving physical functioning, vital for performance of the activities of daily living (ADL), and aiding in rehabilitation.[3, 5, 7-9]

Functional ability and safe performance of ADLs for older adults is dependent on good balance, muscular strength & endurance, and flexibility, with these physiologic parameters working in concert to reduce the risk of falling, while maintaining independent living.[10-12] Among persons with cardiovascular disease (CVD), improvement in exercise capacity, as well as activities that promote balance, muscular strength & endurance, and flexibility are important to incorporate into a regular exercise program. Appropriate physical activity interventions are able to reverse functional limitations, improve declines in physical performance associated with age and chronic conditions in older adults.[13, 14] Tai Chi (TC) exercise, a low-impact moderate-intensity

exercise, has been practiced in China for hundreds of years, and is a popular form of exercise among older adults.[15]

Over the past decade, the number of studies examining the effectiveness of TC exercise for improving balance,[16-37] muscular strength & endurance,[17, 20, 21, 26, 33, 37-43] and flexibility[19, 21, 25, 26, 38, 41, 44-48] has increased exponentially, though conflicting results on the effectiveness of TC have been reported.[16, 17, 25, 27, 38, 39] Different research designs, a wide variety of measures, and diverse study populations including young healthy adults, persons with arthritis, multiple sclerosis, middle aged women, and frail older adults, may have contributed to variability in the results.[18, 24, 26, 27, 31]

Few studies have examined upper body strength, which is important for performance of some ADLs in older adults, like carrying groceries.[38, 42, 43] In addition, a wide range of TC styles were used in these studies, ranging from a simplified 6-posture form[49] to the classical Yang style of TC, which has 108-postures,[41] likely resulting in unequal amounts of TC exercise intensity, making comparisons difficult and limiting generalizability.

Chronic disease, such as CVD, is the primary cause of disability in middle-aged and older adults.[12, 50] Maintaining functional ability and preventing injuries are potential benefits of physical activity among older adults, reducing disability among persons in community settings. Until recently, there was no common measure to assess physical performance or functional mobility in older adults living independently.[14, 51] No studies have examined the effectiveness of TC on balance, muscular strength & endurance, and flexibility in Chinese immigrants with CVD risk factors. Therefore, the overall aim of this study was to examine performance-based physical functioning after 12-weeks of TC

exercise in ethnic Chinese men and women with CVD risk factors. Specific objectives were to determine if TC exercise improves upper and lower body: 1) balance, 2) strength, and 3) flexibility; overtime.

Methods

Design

This was a repeated-measures intervention study. Subjects attended a 60-minute TC exercise class 3 times per week for 12 weeks. Data were collected at baseline, 6 and 12-weeks.

Setting and Subjects

This study was conducted at a community center in the San Francisco Bay Area (SFBA) having a high density of Chinese immigrants living in the neighborhood. Information about the study was distributed through flyers, brochures and newspaper advertisements. Interested persons contacted the study investigator for further information and to determine eligibility. If the eligibility criteria were met, subjects were invited for a baseline evaluation.

Inclusion criteria for participation were: 1) ethnic Chinese and residing in the SFBA; 2) ≥ 45 years; 3) speaks Cantonese or English; 4) has at least one major CVD risk factor (current smoker, high blood pressure, high cholesterol, diabetes); 5) has not practiced TC on a regular basis in the past 6 months; 6) willing to sign a written informed consent. Exclusion criteria included persons diagnosed with cognitive impairments, severe debilitating arthritis, or unstable cardiac condition such as ventricular dysrhythmias, pulmonary edema, chest pain, or uncontrolled atrial fibrillation.[52]

Sample Size

N-Query 4.0[53] statistical software was used to calculate the effect size for an univariate one-factor repeated measures analysis of variance (ANOVA). Effect sizes were derived from prior research using TC exercise as an intervention, and examining balance, muscular strength and flexibility.[16, 17, 20, 21, 36, 40-43, 45] Experimental studies have reported an average attrition rate of 25%.[40, 41, 43] Sample size calculations using univariate one-factor repeated measures ANOVA to examine significant differences in means at baseline, 6 weeks and 12-weeks, alpha=.05, power=.80, with a conservative delta^2 [delta^2=f^2] effect size of 0.15 required a sample size of 28 subjects.[54] However, when considering a potential attrition rate of 25%, 39 subjects were required.

Main Outcome Measures

Balance Measures

Functional reach

Functional reach (FR) assesses dynamic balance by measuring the maximal distance a subject can reach forward beyond one's own arm length, while maintaining a fixed base of support in the standing position.[55] A yardstick is mounted on the wall at shoulder height, and reported in inches. Subjects are asked to reach as far forward as possible in a plane parallel with the measuring device, without taking a step forward. The better of the two trials is recorded.

FR is a precise (coefficient of variation = 2.5%), and stable measure (ICC = 0.92),[55] with established sensitivity to change (responsiveness index = 0.97).[56] Criterion-related validity for FR was established using the center of pressure excursion platform (r=0.71).[55] FR was used as an outcome measure among persons (n=22) with balance

disorders, participating in a TC exercise intervention.[16] Before the TC intervention reported scores were 11.69 ± 4.15 inches, while after the intervention reported scores were 12.15 ± 4.66 inches, though not statistically significant ($p>0.05$). The results are likely due the small sample or wide variation in subject age (20 to >76 years old).

Single-leg stance

The single-leg stance (SLS) assesses balance and is a frequently used measure in studies evaluating health-related fitness among adults, including the elderly participating in a TC exercise intervention.[32, 33, 57, 58] Subjects are timed on their ability to stand on a single leg with their eyes open. Subjects are instructed to lift one foot just off the floor, focus on a point on a nearby wall in front of them, and stand that way for as long as they are able, up to a one minute maximum.[32, 57] The better of the two trials for each leg is recorded.

The inter-rater reliability reported by Suni and colleagues[57] ranged from fair (study A, ICC=0.76) to high in (study B, ICC=0.99). One-week test-retest reproducibility of the single leg stance in men and women aged 37-57 years old, had a moderate amount of variability (coefficient of variation = 3.7%).[57] Known-groups validity among older Chinese adults (n=18) was demonstrated by the test's ability to distinguish between TC practitioners and non- practitioners ($F_{1,7}=5.57$, $p=0.05$ right leg; $F_{1,7}=6.36$, $p=0.05$ left leg), as well as differences between men and women ($F_{1,7}=10.0$, $p=0.01$ right leg; $F_{1,7}=14.42$, $p=0.01$ left leg).[32]

Muscular Strength and Endurance Measures

Arm Curl

The arm curl assesses upper body strength and endurance.[14, 51, 59] Subjects are instructed to execute as many arm curls as possible within the 30-second time limit, using controlled movements during both the concentric (flexion) and eccentric (extension) phases, to perform a full range of motion.[14, 51, 59] The number of arm curls completed is recorded.

Normative data on men and women aged 60-94 years old (n=7,183) has been reported.[51] ICC and 95% confidence intervals between two trials performed the same day among older adults (n=78) was good (R=0.81, CI=0.72, 0.88).[14] Convergent and known-groups validity based on age, gender and physical activity level have been reported.[14, 51] Men, younger age and high-active adults, scored significantly better than women, older age and low-active adults on number of arm curls within 30 seconds (p=0.01).[14, 51]

Chair stand

The chair stand assess lower body strength and endurance, and is important in evaluating the functional performance of older adults.[60] Subjects are instructed to rise to a full standing position and then return to seated position, with arms folded across their body, as many times as possible within the 30-second time limit. The number of stands completed within the time limit is recorded. Among older adults, test-retest ICC of 0.84 for men and 0.92 for women have been reported.[60]

Normative data on men and women aged 60-94 years old (n=7,183) has been reported.[51] ICC and 95% confidence intervals between two trials performed the same day among older adults (n=76) was good (R=0.89, CI=0.79, 0.93).[14] Convergent and known-

groups validity have been reported. Known-groups validity was demonstrated by the test's ability to detect differences between gender, age and physical activity level groups. Men, younger age and highly active adults, scored significantly better than women, older age and low active adults on number of chair stands within 30 seconds (p=0.01).[14, 51, 60]

Flexibility Measures

Back Scratch

The back scratch is used to test upper body flexibility.[14, 59] Subjects are instructed to stand and then raise one arm above their head, bend the elbow and reach down across their back as far as possible. Simultaneously, the opposite arm is extended up along the back as far as possible to meet or overlap the fingers of both hands. The distance of overlap (plus score) or the distance between (minus score) the tips of the middle finger is measured in centimeters.[14, 59] The better of the two trials is recorded.

Normative data on men and women aged 60-94 years old (n=7,183) has been reported.[51] ICC and 95% confidence intervals between two trials performed the same day among older adults (n=77) was good (R=0.96, CI=0.94, 0.98).[14] This test was found to significantly discriminate between exercisers and non-exercisers (p=0.01), across various age groups (p=0.01), and between gender (p=0.01).[14, 51] Women, high-active adults, and adults less than 80 years old performed significantly better than men, low-active adults and adults older than 80 years old.[14, 51]

Chair Sit-and-Reach

The chair sit-and-reach (CSR) assesses lower body flexibility, primarily the hamstring. The test was developed primarily to decrease the risk of injury among older adults and those with back pain or limited range of motion.[61] Subjects are instructed to

sit on a chair and then move forward in the chair until they are sitting on the front edge. Keeping one leg bent and the foot flat on the floor, the other leg (preferred) is extended straight in front of the hip, with the heel on the floor and foot flexed at approximately 90°. With their leg extended and without locking their knee, the subject is instructed to extend their arms forward. The subject should slowly bend forward and slide the hands down the extended leg in an attempt to touch the toes, with their hands placed on top of each other and fingertips perfectly even. The best of two trials is recorded.[62] Normative data on men and women aged 60-94 years old (n=7,183) has been reported.[51]

High test-retest reliability (ICC=0.95, CI= 0.92-0.97) was reported among older adults (n=76), with testing done on 2 different days, 2-5 days apart.[61] Criterion validity was established by the good correlation between goniometric-measured flexibility and the CSR (r=0.76 for men, r=0.81 for women).[61] Convergent validity between the CSR and the traditional sit-and-reach test (r=0.23, p=0.05) has been reported in female university students, regardless of preferred leg utilized.[63] Known-groups validity was established by the tests' ability to discriminate between age groups (p=0.02) and between exercisers and non-exercisers (p=0.01).[14]

Intervention

Subjects were recruited in cohorts limited to 20 per group, to ensure individual attention during class instruction. Subjects attended a 60-minute TC exercise class 3 times per week for 12 weeks, located at the community center. An experienced TC Instructor proficient in the Yang Style 24-posture short-form[64] taught all sessions. The form is easier to learn and remember than the classical Yang style 108-posture long-form,

though still contains the essential TC principles. Older adults and those with chronic illnesses, can practice this form safely.[64]

During class, subjects were asked to replicate the motions, postures, and movement speed of the instructor. Subjects were monitored for safety with corrections given as needed. A registered nurse (RTP) experienced in exercise testing/supervision and possessing advanced cardiac life support certification, was in attendance at all sessions. Each session consisted of a 20-minute warm-up period, 30-minutes of TC exercise and a 10-minute cool-down period. The 24-posture short-form was taught gradually, and subjects were able to learn the entire sequence by the end of 12 weeks. The entire sequence takes 8-10 minutes to perform, and was repeated several times to provide an aerobic benefit.[65-67]

Subjects were encouraged to practice the same routine at home at least two other days, though this was not monitored. Upon completion of the 12-week intervention, each subject received a CD-Rom of the TC Master performing the form taught.[64]

Protection of Human Subjects

Approval to conduct the study was obtained from the Institutional Review Board at the University of California San Francisco, with the investigation carried out according to the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all subjects. All subjects were assured of confidentially and the ability to decline participation or withdraw from the study at any time.

Data Analysis

All forms were reviewed for accuracy and completeness at the time of data collection. Frequencies were run on every variable to check for extreme values. Data was

analyzed using the Statistical Package for Social Sciences (version 10.0),[68] following data cleaning. Descriptive statistics were calculated on all variables. Univariate repeated measures ANOVA was used to test for changes in the outcome variables over-time. Maulchy's test of sphericity (≥ 0.05)[69] was done before the analysis. If the compound symmetry criteria were not met, then the data were analyzed using the Greenhouse-Geisser adjusted univariate approach. If the overall ANOVA was significant, Bonferroni's adjusted paired-samples confidence intervals[69] were done for all 3 possible comparisons (0-12 weeks, 0-6 weeks, 6-12 weeks) to determine where the mean difference was.

Results

Baseline Characteristics

A total of 39 subjects with CVD risk factors agreed to participate in this TC exercise intervention study. Subjects were on average 66 ($\pm$ 8.3) years old, mean body mass index (23.9 $\pm$ 2.7) was normal, and 62% (n=24) were $\geq$ 65 years old. The majority of subjects were married, Cantonese-speaking, immigrant women (Table 1), reporting $\leq$ 12 years education and an income < $35,000 US per year.

All subjects had at least one major risk factor for CVD. Reported CVD risk factors were hypertension (92%), hypercholesteremia (49%), diabetes (21%) and smoking (3%). Subjects reported several concomitant chronic health conditions (Table 2), including rheumatoid arthritis (46%), and chronic back pain or degenerative disc problems (41%). However, the majority of subjects perceived their health to be good, very good or excellent (56%) (Table 2).

Adherence

Subjects were asked to attend a total of 36 TC exercise classes during the 12-week study. Adherence to the intervention was very high (87% ± 0.18). Follow-up at 6 weeks was 100%. One woman dropped out of the study after completing the 6-week evaluation, due to recurring health problems. There were no further dropouts, thus very high retention of subjects was achieved on completion of the study (97%).

Balance

At baseline, subjects were able to reach forward on average 12 ± 2.7 inches without losing balance (Table 3), assessed by the FR test. Univariate repeated measures ANOVA examining change in FR was statistically significant over-time. Approximately 12% of the variance (eta^2=0.12) in FR over-time could be explained (Table 3). Pairwise contrasts of the mean differences (Table 4) were statistically significant between baseline and 12-weeks (Figure 1).

Right and left single-leg stances (SLS) were used to assess balance. Subjects were able to stand on their right leg longer than their left leg at baseline, before losing balance (Table 3). Univariate repeated measures ANOVA examining change in right and left SLS was statistically significant over-time (Table 3). Approximately 8% of the variance (eta^2=0.08) in right SLS, and 23% (eta^2=0.23) of the variance in left SLS over-time could be explained. Pairwise contrasts examining the mean differences were statistically significant between baseline and 12 weeks for both right and left SLS (Figure 2), with statistically significant improvements in left SLS found following the 2nd 6 weeks of the TC intervention (Table 4).

Muscular Strength & Endurance

The number of arm curls done in 30 seconds assessed upper body strength, while lower body strength was assessed by the number of chair stands completed in 30 seconds (Table 3). At 6-weeks and 12-weeks statistically significant improvements in upper and lower body strength (Figure 3) were found. Univariate repeated measures ANOVA examining change in upper and lower body strength were statistically significant over-time (Table 3). Approximately 49% (eta^2=0.49) of the variance in upper body strength, and 42% (eta^2=0.42) of the variance in lower body strength over-time could be explained. All 3 pairwise contrasts of the mean differences in upper and lower body strength were statistically significant (Table 4).

Flexibility

The back scratch test was used to assess upper body flexibility. Univariate repeated measures ANOVA examining change in upper body flexibility was statistically significant over-time (Table 3). Approximately 22% (eta^2=0.22) of the variance in upper body flexibility over-time could be explained. Pairwise contrasts of the mean differences found statistically significant improvements between baseline and 12 weeks (Figure 4) and following the 2nd 6-weeks of the TC intervention (Table 4).

Lower body flexibility was assessed by the chair sit-and-reach test. Univariate repeated measures ANOVA examining change in lower body flexibility was statistically significant over-time (Table 3). Approximately 19% (eta^2=0.19) of the variance in lower body flexibility over-time could be explained. Pairwise contrasts of the mean differences found statistically significant improvements between baseline and 12 weeks (Figure 4) and following the 1st 6-weeks of the TC intervention (Table 4).

Discussion

This was the first study to examine the effect of TC exercise on balance, muscular strength & endurance, and flexibility in older Chinese adults living in the US, and having CVD risk factors. TC exercise is an appropriate intervention for older adults, and may help delay declines in physical performance associated with age and chronic health conditions, such as CVD. Findings in this study substantiate previously reported findings by Huang and colleagues,[5] that physical activity improves physical functioning and prevents functional limitations in middle-aged and older adults.

TC exercise likely facilitates improvements in balance, muscular strength and endurance, and flexibility through the development of proprioceptive awareness and kinesthetic sense.[20, 31, 35] Subjects in this study were continually reminded about correct foot placement, and properly shifting their weight between their legs, and thus learned to be aware of their body position, while learning the entire sequence of the Yang Style 24-posture short-form.[64]

Several TC movements are directly related to elements of balance, muscular strength and endurance, and flexibility, with improvements readily observed in de-conditioned persons. For example, the TC movement called 'Twin Dragons Play the Pearl Game' involves shifting the weight forward and standing on the left leg, while lifting the right foot an inch off the floor, demanding adequate balance to perform this safely. The end of the movement called 'Single Whip' involves standing in a semi-squat position, requiring lower body muscular strength and endurance, while 'Carry Tiger Back to Mountain' demands lower body flexibility to safely complete the 160° step to the opposite corner.[64, 70]

The majority of subjects in this study were ≥ 65 years old, married, retired/unemployed, Cantonese-speaking, immigrant women. However, chronological age is only one consideration for exercise programs aimed at preventing chronic health conditions. Other important factors to consider include: level of fitness, access to health care, language barriers, limited income, low level of education, or presence of chronic disease, including major risk factors, such as hypertension.[4, 6] In this sample, concomitant chronic diseases in addition to ≥ 1 CVD risk factor were prevalent. Self-reported hypertension, hypercholesteremia and rheumatoid arthritis were common (Table 2). However, over half of the subjects in the study perceived their health to be good, very good or excellent (56%), despite the prevalence of CVD risk factors and other chronic illnesses. TC exercise was an appropriate and acceptable form of exercise for these older adults. Chronic illnesses, such as arthritis, did not affect their participation in the study. This finding is similar to previously reported research findings among persons with arthritis, that TC was safe without aggravating joint pain.[17, 26, 43]

Subjects in this study were less fit than other US community-residing older adults, when compared to reported normative data for balance, strength and flexibility measures (Table 5).[51] After the 12-week TC exercise intervention, statistically significant improvements were observed in all measures (Table 3). Interestingly, improvement in single-leg stance balance was greater in the non-dominant left leg (12.7 ± 19.6), than the dominant right leg (7.2 ± 15.6) over 12-weeks.

When comparing functional fitness measures of upper and lower body strength, and flexibility in older adults entering an outpatient cardiac rehabilitation program,[11] subjects in this TC intervention study had higher percentile scores for these measures,

though were only approaching the 50th percentile on the age and gender-specific normative data for community-residing older adults in the US.[51]

It is not known if the further improvements in balance, muscular strength and endurance, and flexibility would continue over a longer intervention time period. Nevertheless, the importance of exercise programs aimed at enhancing performance-based physical functioning and independent living among older adults with chronic health conditions in the community was evident in this TC intervention study.

Limitations and Strengths

The generalizability of the findings obtained may be limited, as only subjects uniquely interested in TC may have volunteered as study participants. Furthermore, without a control group to serve as a comparison, improvement unrelated to TC is possible. Improvements in balance, muscular strength and endurance, and flexibility among subjects in this study may have occurred as a result of a learning effect, associated with repeated use of the study measures to assess changes during the 12-weeks. However, the information obtained in this study provides data useful for effect size calculations, and culture-specific information needed for conducting future TC intervention studies.

. This was an innovative, culturally appropriate exercise program appealing to ethnic Chinese seniors, with potential linguistic barriers eliminated. All aspects of the study were conducted at a local community center providing easy, convenient access and familiarity to the setting. The principal investigator (RTP) is fluent in Cantonese, and worked with a translator to assist in obtaining informed consent, data collection and providing detailed explanations in the TC classes. Additional factors contributing to the

success of the study were the availability of subjects, and their willingness to regularly attend the TC exercise classes (87%).

Conclusions

TC is a potent intervention that improves balance, upper and lower body muscular strength & endurance, and upper and lower body flexibility in this sample of ethnic Chinese older adults with CVD risk factors. TC exercise is a non-pharmacologic approach for managing chronic illnesses. Exercise programs, such as TC, aimed at enhancing performance-based physical functioning and independent living among community-dwelling older adults with chronic health conditions are vital. These findings provide important information for future community-based TC exercise programs, and support current public health initiatives to reduce disability and death from chronic diseases.

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Figure Legends

Figure 1: Mean scores and 95% confidence intervals of Functional Reach in inches, at baseline, 6-weeks and 12-weeks

Figure 2: Mean scores and 95% confidence intervals of Single-Leg Stance in seconds, at baseline, 6-weeks and 12-weeks

Figure 3: Mean scores and 95% confidence intervals of Strength Measures, number of repetitions in 30 seconds, at baseline, 6-weeks and 12-weeks

Figure 4: Mean scores and 95% confidence intervals of Flexibility Measures in inches, at baseline, 6-weeks and 12-weeks

TABLE 1: BASELINE SUBJECT DEMOGRAPHICS, N=39

	Mean ± SD
Age in years	65.7 ± 8.3
Body Weight (pounds)	131.7 ± 16.7
Height (inches)	62.2 ± 2.7
Body Mass Index#	23.9 ± 2.7
	% (n)
≥ 65 years old	62 (24)
Gender	
Men	30.8 (12)
Women	69.2 (27)
Marital Status	
Married/ Domestic partner	84.6 (33)
Divorced/Separated/ Widowed/Single	15.4 (6)
Education	
Primary (1-6 years)	41.0 (16)
Secondary (7-12 years)	46.2 (18)
Tertiary (13+ years)	12.8 (5)
Employment Status	
Retired/unemployed	84.6 (33)
Full or Part-time	15.4 (6)
Income (in US dollars per year)	
< 15,999	46.2 (18)
16,000-34,999	20.6 (8)
> 35,000	12.8 (5)
refused to answer	20.5 (8)
Birthplace	
Mainland China	87.2 (34)
Hong Kong	12.8 (5)
Language Spoken at home	
Cantonese	97.4 (38)
Mandarin/English	2.6 (1)

#Body Mass Index= (pounds x 703)/inches^2

TABLE 2: SELF-REPORTED MEDICAL HISTORY AND HEALTH STATUS, N=39

	%	n
CVD Risk Factors		
Hypertension	92.3	36
Hypercholesteremia	48.7	19
Diabetic	20.5	8
Current Smoker	2.6	1
Self-reported Medical History		
Rheumatoid Arthritis	46.2	18
Chronic Back Pain/ Degenerative disc	41.0	16
Irregular heart rhythm	17.9	7
Anemia	12.8	5
Stomach Ulcers	12.8	5
Stroke	7.7	3
Peripheral Vascular Disease	7.7	3
Angina	5.1	2
Mild congestive heart failure	5.1	2
Heart Block	5.1	2
Heart Valve	5.1	2
Depression	5.1	2
Reiter's Disease/ Lupus	5.1	2
Angioplasty/ Stent	2.6	1
Asthma	2.6	1
General Health Perception		
Good/ Very good/ Excellent	56.4	22
Fair	43.6	17

CVD= Cardiovascular Disease

TABLE 3: CHANGE IN BALANCE, STRENGTH AND FLEXIBILITY OVER 12 WEEKS OF TAI CHI EXERCISE, N=38

					Univariate Repeated Measures ANOVA		
Measure	Baseline Mean ± SD	6-Weeks Mean ± SD	12-Weeks Mean ± SD	Change from Baseline Mean ± SD	F [$df_{2,36}$]	p-value	eta^2
Balance							
Functional Reach (inches)	12.0 ± 2.7	12.4 ± 2.3	13.1 ± 2.2	1.1 ± 2.1	5.11	0.00*	0.12
Right Single-Leg Stance (seconds)	40.1 ± 23.1	43.9 ± 21.5	47.3 ± 20.2	7.2 ± 15.6	3.06	0.05*	0.08
Left Single-Leg Stance (seconds)	32.4 ± 23.8	36.1 ± 23.7	45.1 ± 21.9	12.7 ± 19.6	10.98	0.00*	0.23
Strength							
Arm Curl (reps in 30 seconds)	14.7 ±3 .7	17.2 ± 3.3	18.6 ± 3.6	3.9 ± 3.1	35.37	0.00*	0.49
Chair Stand (number in 30 seconds)	12.3 ± 2.7	14.3 ± 3.8	16.5 ± 5.2	4.2 ± 4.1	26.70	0.00*	0.42
Flexibility							
Back Scratch (inches)	-2.2 ± 4.1	-1.7 ± 4.6	-0.9 ± 3.8	1.3 ± 1.5	10.53	0.00*	0.22
Chair-sit-and-reach (inches)	-5.1 ± 6.1	-3.6 ± 5.9	-3.1 ± 6.0	2.0 ± 3.5	8.45	0.00*	0.19

*significant if p-value ≤0.05

TABLE 4: PAIRWISE CONTRASTS OF MEAN DIFFERENCES IN BALANCE, STRENGTH AND FLEXIBILITY OVER 12 WEEKS OF TAI CHI EXERCISE, N=38

Contrasts	Baseline to 6-Weeks				7 to 12-Weeks				Baseline to 12-Weeks			
Measure	$F[df_{1,36}]$	eta^2	LBCI	UBCI	$F[df_{1,36}]$	eta^2	LBCI	UBCI	$F[df_{1,36}]$	eta^2	LBCI	UBCI
Balance												
Functional Reach (inches)	1.45	0.04	-0.43	1.22	4.71	0.11	-0.10	1.33	8.76	0.19	**0.16**	**1.87**
Right Single-Leg Stance (seconds)	1.22	0.03	-4.84	12.47	1.57	0.04	-3.42	10.26	8.20	0.18	**0.90**	**13.57**
Left Single-Leg Stance (seconds)	2.52	0.06	-2.18	9.70	10.64	0.22	**2.07**	**15.78**	15.94	0.30	**4.72**	**20.65**
Strength												
Arm Curl (reps in 30 seconds)	27.80	0.42	**1.30**	**3.65**	10.85	0.23	**0.35**	**2.55**	60.59	0.62	**2.66**	**5.18**
Chair Stand (number in 30 seconds)	18.95	0.34	**0.84**	**3.11**	14.69	0.28	**0.77**	**3.70**	32.30	0.51	**2.53**	**5.90**
Flexibility												
Back Scratch (inches)	3.42	0.09	-0.19	1.27	6.65	0.15	**0.02**	**1.40**	24.86	0.40	**0.62**	**1.88**
Chair-sit-and-reach (inches)	11.16	0.23	**0.38**	**2.67**	0.89	0.02	-0.73	1.63	11.88	0.24	**0.54**	**3.41**

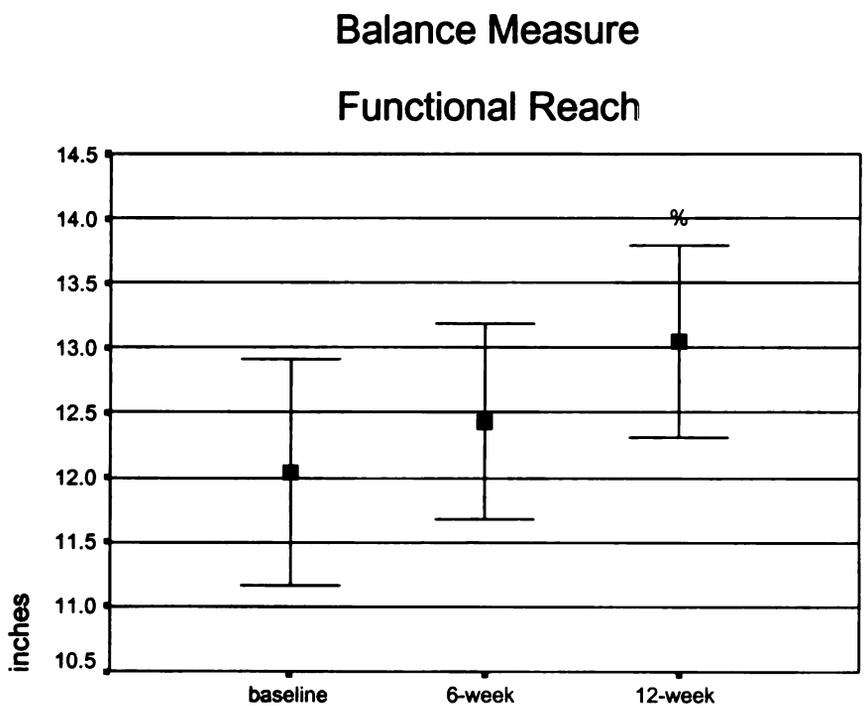
Bold=$p \leq 0.0167$, LBCI= Lower Bound Confidence Interval with Bonferroni adjusted pairwise contrasts, UBCI= Upper Bound Confidence Interval with Bonferroni adjusted pairwise contrasts

TABLE 5: AGE AND GENDER-SPECIFIC BALANCE, STRENGTH AND FLEXIBILITY NORMATIVE DATA[1]

Average Score or 50th percentile	**Women, 65-69 years old**	**Men, 65-69 years old**
Balance		
Functional Reach (inches)[2]	14	14
Right Single-Leg Stance (seconds)[3]	44	44
Left Single-Leg Stance (seconds)[3]	44	44
Strength		
Arm Curl (reps in 30 seconds)	15	18
Chair Stand (number in 30 seconds)	14	15
Flexibility		
Back Scratch (inches)	-1.0	-4.0
Chair-sit-and-reach (inches)	2.0	0

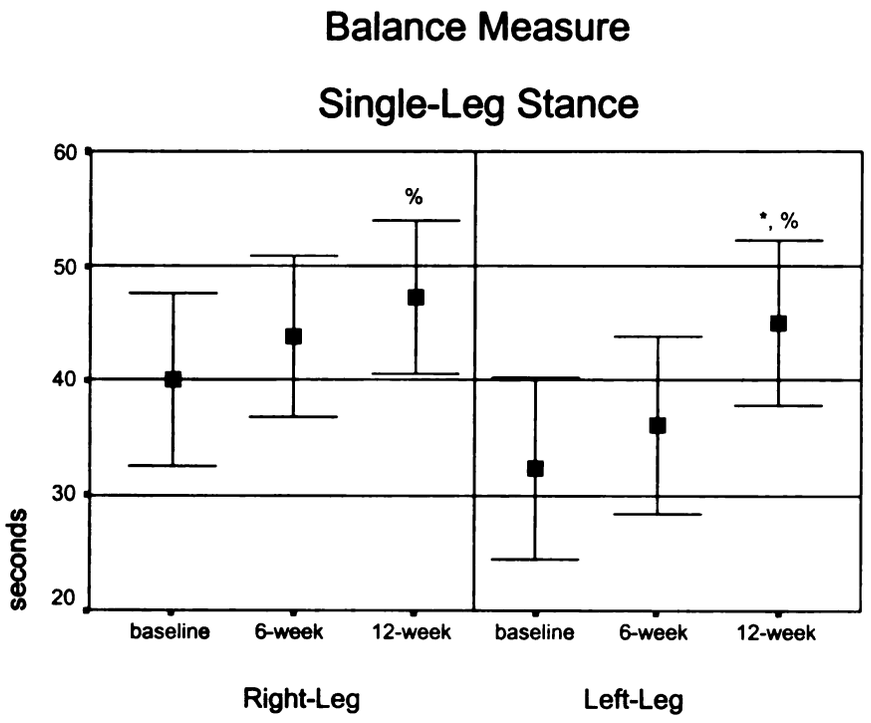
[1] Rikli RE, Jones CJ. Functional fitness normative scores for community-residing older adults, ages 60-94. *J Aging Phys Act* 1999;7:162-181.
[2] Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. *J Gerontol* 1990;45:M192-197.
[3] Suni JH, Oja P, Laukkanen RT, Miilunpalo SI, Pasanen ME, Vuori IM, Vartiainen TM, Bos K. Health-related fitness test battery for adults: aspects of reliability. *Arch Phys Med Rehabil* 1996;77:399-405.

FIGURE 1: MEAN SCORES AND 95% CONFIDENCE INTERVALS OF FUNCTIONAL REACH BALANCE IN INCHES, AT BASELINE, 6-WEEKS AND 12-WEEKS



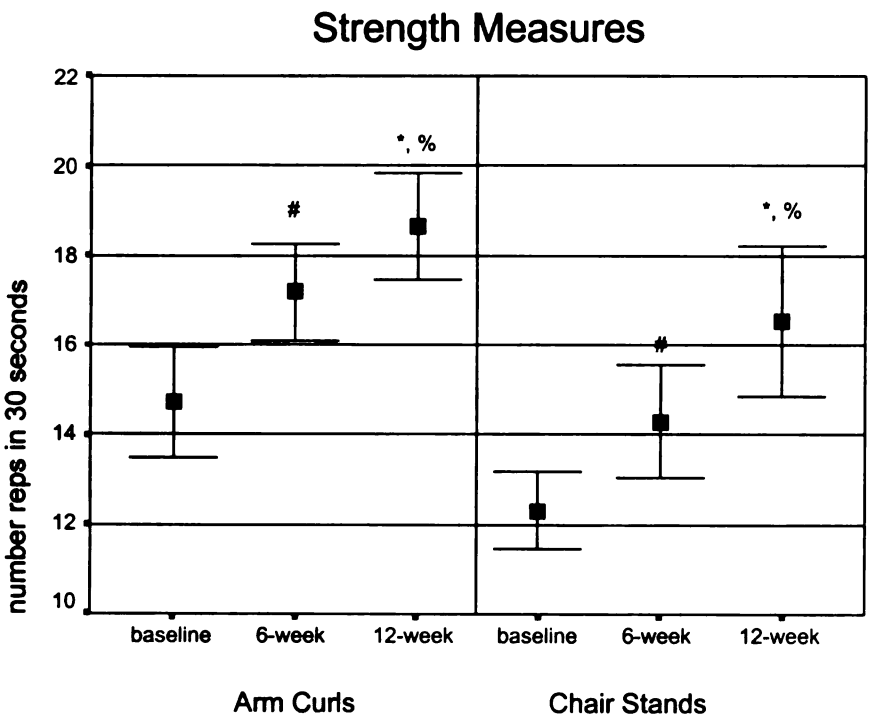
%Baseline vs. 12-weeks, $p<0.01$

FIGURE 2: MEAN SCORES AND 95% CONFIDENCE INTERVALS OF SINGLE-LEG STANCE BALANCE IN SECONDS, AT BASELINE, 6-WEEKS AND 12-WEEKS



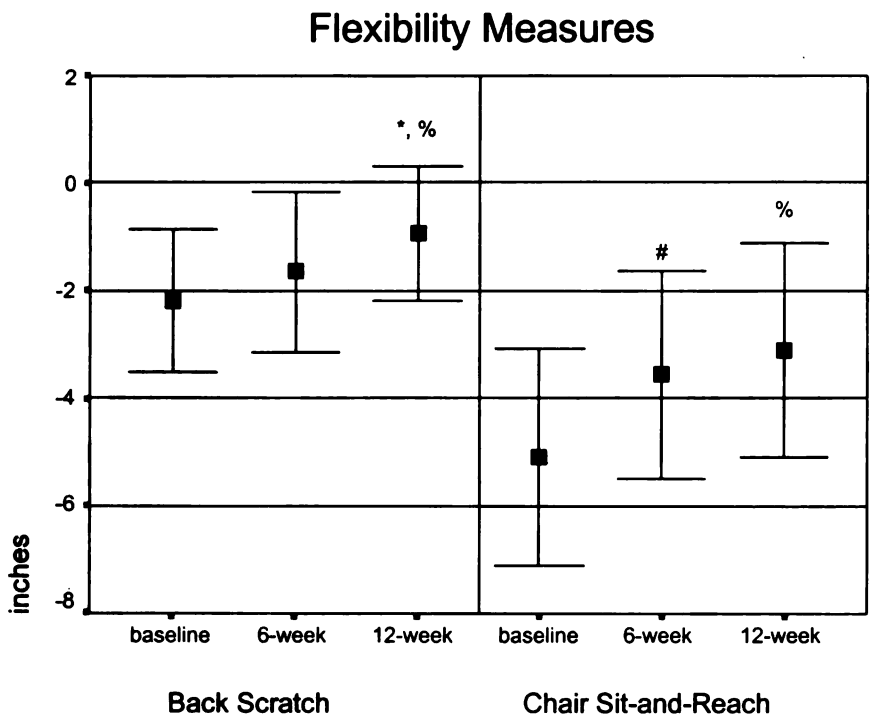
*6-weeks vs. 12-weeks, $p<0.01$, %Baseline vs. 12-weeks, $p<0.01$

FIGURE 3: MEAN SCORES AND 95% CONFIDENCE INTERVALS OF STRENGTH MEASURES, NUMBER OF REPETITIONS IN 30 SECONDS, AT BASELINE, 6-WEEKS AND 12-WEEKS



#Baseline vs. 6-weeks, $p<0.01$, *6-weeks vs. 12-weeks, $p<0.01$, %Baseline vs. 12-weeks, $p<0.01$

FIGURE 4: MEAN SCORES AND 95% CONFIDENCE INTERVALS OF FLEXIBILITY MEASURES IN INCHES, AT BASELINE, 6-WEEKS AND 12-WEEKS



#Baseline vs. 6-weeks, p<0.01, *6-weeks vs. 12-weeks, p<0.01, %Baseline vs. 12-weeks, p<0.01

Paper 6

Change in Perceived Psychosocial Status following a 12-Week Tai Chi Exercise Program in Ethnic Chinese adults with Cardiovascular Disease Risk Factors

Taylor-Piliae, R.E., Haskell, W.L. Waters, C.M. & Froelicher, E.S. Change in Perceived Psychosocial Status following a 12-Week Tai Chi Exercise Program in Ethnic Chinese adults with Cardiovascular Disease Risk Factors. *In Review, Journal of Advanced Nursing*

Change in Perceived Psychosocial Status following a 12-Week Tai Chi Exercise Program in Ethnic Chinese adults with Cardiovascular Disease Risk Factors

Abstract

Background: Regular participation in physical activity is associated with protection against cardioavascular disease (CVD), and improvements in physical and psychological health. Increasing amounts of scientific evidence suggests that mind-body exercise, such as Tai Chi (TC), are related to improvements in mental health, emotional well-being, and stress reduction. No prior study has examined the effect of a TC exercise intervention on psychosocial status among persons with CVD risk factors.

Aims: To examine change in psychosocial status following a 12-week TC exercise intervention among ethnic Chinese with CVD risk factors living in the United States (US).

Methods: This was a repeated measures intervention study. Subjects attended a 60-minute TC exercise class 3 times per week for 12 weeks. Data were collected at baseline, 6 and 12-weeks following the TC exercise intervention. Psychosocial status was assessed using Chinese versions of Cohen's Perceived Stress Scale, Profile of Mood States, Multidimensional Scale of Perceived Social Support, and Tai Chi exercise Self-efficacy.

Results: A total of 39 subjects, on average 66 (± 8.3) years old, married (85%), Cantonese-speaking (97%), immigrants participated. The majority were women (69%), with ≤ 12 years education (87%) reported. Statistically significant improvements in all measures of psychosocial status were found ($p \leq 0.05$), following a 12-week TC exercise intervention in these subjects. Improvement in mood state ($eta^2=0.12$), and reduction in perceived stress ($eta^2=0.13$) were found. In addition, TC exercise significantly increased

self-efficacy to overcome barriers to TC (eta^2=0.19), confidence to perform TC (eta^2=0.27), and perceived social support (eta^2=0.12) in these subjects.

Conclusions: This was the first study to examine change in psychosocial status following a TC exercise intervention among ethnic Chinese adults with CVD risk factors, living in the US. TC was a culturally appropriate mind-body exercise for these older adults, with statistically significant psychosocial benefits observed over 12-weeks.

Key Words: Tai Chi exercise, Self-efficacy, Stress, Mood, Social Support, Chinese

Introduction

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality in the United States(AHA 2003; CDC 2004). Regular participation in physical activity is associated with protection against CVD, and improvements in physical and psychological health (Miller *et al.* 1997; Thompson *et al.* 2003; Wenger *et al.* 1999). Negative psychosocial factors such as major depression, social isolation, or chronic stress can adversely affect pathophysiological mechanisms associated with CVD, and also contribute to poor health behavior (Astin *et al.* 2003; Mendes de Leon *et al.* 2001; Rozanski *et al.* 1999; Ziegelstein *et al.* 2000).

Thoughts, feelings and personal exercise behavior can impact health outcomes, and psychological well-being (Baum & Posluszny 1999). Mind-body communication is thought to occur through two distinct pathways, the sympathetic-adrenal-medullary axis and the hypothalamic-pituitary-adrenal-cortex axis. The communication between the mind and body is very complex, though enables an integrated response to behavioral, physiological, or immunological threats, with the goal of maintaining homeostasis (Watkins & Jonas 1997).

Increasing amounts of scientific evidence suggests that mind-body exercise, such as Tai Chi (TC), are related to improvements in mental health, emotional well-being, and stress reduction (Arent *et al.* 2000; La Forge 1997; LaPerriere *et al.* 1994). Some individuals, particularly older adults and those with chronic illnesses, experience social, psychological, and health-related barriers to exercise, making exercise adoption and maintenance a great challenge. Careful attention to psychological variables, including

perceived self-efficacy, are important for understanding physical activity and exercise behavior (Nies & Kershaw 2002).

TC exercise, an ancient Chinese martial art, is popular among Chinese immigrants, gaining interest in older adults, and is suitable for persons with CVD (Taylor-Piliae 2003; Taylor-Piliae & Froelicher 2004a). TC is a low-impact, moderate-intensity aerobic exercise, incorporating relaxed breathing and mental concentration (Luskin *et al.* 1998). TC movements were originally derived from watching animals and birds over 500 years ago (Cheng & Smith 1967; Lan *et al.* 2002). During the performance of TC exercise, individuals are taught to be mindful of what their body is doing, and how it feels. The mindful movements and body awareness characterize TC as a 'meditation in motion', evoking a mind-body connection (La Forge 1997).

Theoretical Framework

Several behavioral theories have been conceptualized and tested empirically in the past 25 years to address the complexities associated with human behavior, particularly as it relates to exercise behavior (Bandura 1997a; Dzewaltowski 1994). Social Cognitive Theory (SCT) is based on an interactional model of human behavior, useful for understanding the complex and dynamic nature of health behavior (Bandura 1997b). Behavior, when applied to exercise, involves the mode, intensity, duration and frequency of the activity (Bandura 1997b; Dzewaltowski 1994). Personal factors include cognitive, affective and biological events. Environmental factors include socioeconomic status, education and family structures. Bandura emphasizes the reciprocal relationships between personal factors, environmental factors and behavior, which are constantly interacting and influence one another bi-directionally (Bandura 1997b) (see Figure 1).

Basic tenets inherent in SCT can readily be applied to TC exercise. TC is thought to foster self-efficacy beliefs through enactive mastery, modeling, verbal or social persuasion, and physiological and affective status. Inherent with an enactive mastery experience, TC is taught at a slow progressive pace, with various levels and periods of refinement built in. Thus, these small steps of success help develop the belief in personal efficacy to perform the entire TC sequence.

Modeling of TC exercise by the instructor serves to build this source of self-efficacy, combined with the group environment as the mode of instruction. Subjects can appraise their capabilities in relation to others in the class through social comparison. The instructor shows them exactly how to do it, modeling the behavior, and at the same time helps them find better ways of doing TC, to avoid pain or fatigue.

Verbal or social persuasion occurs through the instructor and peers in the TC class. TC self-efficacy beliefs are strengthened with messages from a credible and knowledgeable source, such as a TC instructor, that they are capable of performing TC. In addition, TC is frequently taught to a group of persons. Social connectedness or group support frequently accompanies this type of a group-based learning, and serves to further strengthen performance capabilities (Bandura 1997b).

Finally, physiological and affective status, are further sources of strengthening efficacy beliefs. A review of recent research reported improvements in cardiorespiratory function, balance and postural stability, fall prevention, and stress reduction through practicing TC (Taylor-Piliae 2003). It is likely that a cyclical process of performing TC enhances physical functioning, a better physical state reduces stress, and improvement in

mood encourages one to continue to perform TC. The model operationalised for this study is based on Bandura's SCT (see Figure 2).

Literature Review

Translated versions of the *Tai Chi Classics* from the 13th Century, teach both mental and physical aspects of TC exercise, as mind and body must be aligned so that they become inseparable, and work in harmony (Cheng 1999; Cheng & Smith 1967; Galante 1981). Only nine studies have examined the effect of TC exercise on affective status (Bond *et al.* 2002; Brown *et al.* 1995; Chen *et al.* 2001; Chen & Sun 1997; Jin 1989, 1992; Ross *et al.* 1999; Sun *et al.* 1996; Tsai *et al.* 2003). Published studies have recruited mainly healthy women (58%), with ages ranging from 16 to 92 years old, to examine this phenomena. Some studies report significant between-group improvements in mood, with TC participants reporting less mood disturbance than those in comparison groups (Bond *et al.* 2002; Brown *et al.* 1995; Chen *et al.* 2001). Conversely, other studies have reported null findings when evaluating the effect of TC on mood, comparing TC participants with sedentary controls (Chen & Sun 1997; Jin 1992; Tsai *et al.* 2003) (Table 1).

In prior studies, the style of TC was generally not specified. Currently, there is no standard style of TC, and some styles have both short and long forms (e.g. 24 to 108 postures) varying in duration, likely representing different exercise intensities of TC (Chen & Sun 1997; Ross *et al.* 1999; Taylor-Piliae & Froelicher 2004a; Tsai *et al.* 2003). In addition, the length of the intervention studies ranged from 8-16 weeks (Chen & Sun 1997; Ross *et al.* 1999; Tsai *et al.* 2003), while the number of TC exercise sessions held during each intervention study differed greatly, ranging from 12 to 48 sessions (Brown *et*

al. 1995; Sun *et al.* 1996). This likely resulted in unequal doses of TC exercise across the studies, making comparisons difficult and limiting generalizability to other populations. Only one published study has examined the effect of TC exercise on perceived stress (Sun *et al.* 1996), though chronic stress is associated with negative CVD health outcomes. No prior study has examined the effect of a TC exercise intervention on psychosocial status among persons with CVD risk factors.

The Study

Aim

The overall aim of this study was to examine change in psychosocial status following a 12-week TC exercise intervention among ethnic Chinese with CVD risk factors. Specific objectives were to determine if TC exercise: 1) improves affective status (mood state, and stress reduction); 2) increases TC exercise Self-efficacy (TCSE); and 3) if social support, TCSE, or previous TC exercise experience are predictive of TC exercise behavior, defined as class attendance.

Design

This was a repeated measures intervention study. Subjects attended a 60-minute TC exercise class 3 times per week for 12 weeks, with data collected at baseline, 6 and 12-weeks following the TC exercise intervention. Data were collected from February to June 2004, and analyzed from July to October 2004.

Setting and Subjects

This study was conducted at a community center in the San Francisco Bay Area (SFBA) having a high density of ethnic Chinese living in the neighborhood. Information about the study was distributed through flyers, brochures and newspaper advertisements.

Interested persons contacted the study investigator for further information and to determine eligibility. If the eligibility criteria were met, subjects were invited for a baseline evaluation.

Inclusion criteria for participation were: 1) self-identified ethnic Chinese and residing in the SFBA; 2) ≥ 45 years; 3) speaks Cantonese or English; 4) has at least one major CVD risk factor (current smoker, high blood pressure, high cholesterol, diabetes); 5) has not practiced TC on a regular basis in the past 6 months; and 6) willing to sign a written informed consent. Exclusion criteria included persons diagnosed with cognitive impairments, severe debilitating arthritis, or unstable cardiac condition such as ventricular dysrhythmias, pulmonary edema, chest pain, or uncontrolled atrial fibrillation (Lan *et al.* 1999).

Sample Size

N-Query 4.0 (Elashoff 2000) statistical software was used to calculate the effect size for an univariate one-factor repeated measures analysis of variance (ANOVA). Effect sizes were derived from prior research using TC exercise as an intervention, and examining affective status (Brown *et al.* 1995; Sun *et al.* 1996; Tsai *et al.* 2003). Sample size calculations using univariate one-factor repeated measures ANOVA to examine significant differences in means at baseline, 6 weeks and 12-weeks, alpha=.05, power=.80, with a conservative delta^2 effect size of 0.15 [delta^2=f^2] required a sample size of 28 subjects (Cohen 1988). However, when considering a potential attrition rate of 25% (Brown *et al.* 1995; Ross *et al.* 1999; Sun *et al.* 1996; Tsai *et al.* 2003), 39 subjects were required.

Study Procedures

Subjects were recruited in cohorts limited to 20 per group, ensuring individual attention during class instruction. Subjects attended a 60-minute TC exercise class 3 times per week for 12 weeks, located at the community center. An experienced TC Instructor proficient in the Yang Style 24-posture short-form (Fei 2001) taught all sessions. The form is easier to learn and remember than the classical Yang style 108-posture long-form, though still contains the essential TC principles. The exercise intensity of performing Tai Chi is 4.0 metabolic equivalents (METs), similar in intensity to brisk walking (Ainsworth *et al.* 2000). Older adults and those with chronic illnesses, can practice this form safely (Fei 2001).

During class, subjects were asked to replicate the motions, postures, and movement speed of the instructor. Subjects were monitored for safety with corrections given as needed. A registered nurse (RTP) experienced in exercise testing/supervision and possessing advanced cardiac life support certification, was in attendance at all sessions. Each session consisted of a 20-minute warm-up period, 30-minutes of TC exercise and a 10-minute cool-down period. The 24-posture short-form was taught gradually, and subjects were able to learn the entire sequence by the end of 12 weeks. The entire sequence takes 8-10 minutes to perform and was repeated several times, to provide an aerobic benefit (Lan *et al.* 2004).

Subjects were encouraged to practice the same routine at home at least two other days, though this was not monitored. Upon completion of the 12-week intervention, each subject received a CD-Rom of the TC Master performing the form taught (Fei 2001).

Instruments

All instruments used in this study were available in Chinese. Translation and independent back-translation of these tools into Chinese by bilingual and/or bicultural persons with translation experience and graduate level education was done, establishing content and semantic equivalence (Chen *et al.* 2000; Molassiotis *et al.* 1999; Short & Johnston 1997; Taylor-Piliae & Froelicher 2004b; Zhang & Norvilitis 2002).

Mood State

Mood is conceptualized as transient, fluctuating affective states,(McNair *et al.* 1992) important for understanding emotions that result from the effect of an illness or chronic disease on an individual's life, such as CVD. The Profile of Mood States (POMS) is a widely used instrument with established psychometric properties to assess mood state (McNair *et al.* 1992; Molassiotis *et al.* 1999).

The POMS is a 65-item adjective checklist using a five-point Likert format (0=not at all, 4=extremely). The POMS measures six emotional dimensions (tension-anxiety, depression-dejection, anger-hostility, vigor-activity, fatigue-inertia, confusion-bewilderment) and total mood disturbance (McNair *et al.* 1992). Scores can be calculated for each of the six subscales and for overall mood state. The total mood disturbance score is obtained after subtracting the vigor-activity subscale from the sum of the remaining five subscales (58 items). The remaining seven items in the POMS are not calculated into the mood disturbance score. Possible scores range from –32 to 200, with higher scores indicating greater mood disturbance.

Psychometric testing of the Chinese version has established content, convergent (anxiety, r=0.65, p=0.01; uncertainty, r=0.57, p=0.01) and divergent validity (self-esteem

r=0.01, p-value not-significant; POMS subscales r=0.01, p-values not-significant) with strong test-retest reliability reported (r=0.86) (Molassiotis *et al.* 1999; Taylor-Piliae & Molassiotis 2001). Strong internal consistency using Cronbach's alpha coefficient was reported (r= 0.90 to 0.92), among Chinese populations with heart disease (Taylor-Piliae & Chair 2002; Taylor-Piliae & Molassiotis 2001). The utility of the POMS to measure mood state among older adults performing TC, and TC practitioners was reported (Brown *et al.* 1995; Jin 1992).

Stress

Stressful events are thought to increase risk of disease when these events are viewed as threatening or when coping resources are perceived as insufficient (Cohen *et al.* 1983; Cohen & Williamson 1988). The Perceived Stress Scale (PSS) designed by Cohen and colleagues (Cohen *et al.* 1983; Cohen & Williamson 1988) is the most commonly used tool to measure appraised stress. Perceived stress is defined as the degree to which situations in one's life are appraised as stressful (Cohen *et al.* 1983), with the original scale containing 14 items. The PSS was modified by Cohen and colleagues (Cohen & Williamson 1988) to a 10-item, 5-point Likert scale (0=never, 4=very often) with possible scores ranging from 0 to 40 (Cohen & Williamson 1988). A higher score indicates more perceived stress. Cohen and colleagues (Cohen & Williamson 1988) argue that the PSS-10 (r=0.78) has somewhat better psychometric properties than the PSS-14 (r=0.75) , and recommend using the PSS-10 in research (Cohen & Williamson 1988).

The items in the PSS were designed to assess an individual's cognitive evaluation of stress. The central components of perceived stress include situations that individuals perceive as unpredictable, uncontrollable, and overloaded (Cohen *et al.* 1983; Cohen &

Williamson 1988). The PSS is a self-administered tool, designed for community samples with limited education (Cohen *et al.* 1983; Cohen & Williamson 1988). Strong reliability (r=0.85) with good test-retest reliability (r=0.85 & 0.55) as well as concurrent and predictive validity have been reported (Cohen *et al.* 1983). Known-groups validity was demonstrated by the tool's ability to detect differences between age groups (p=0.01), income (p=0.01) and education levels (low versus high) (p=0.01)(Cohen & Williamson 1988).

High internal consistency of the Chinese PSS was reported (r=0.90) (Lee & Crockett 1994). Chen and colleagues (Chen *et al.* 2000) reported adequate test-retest reliability and construct validity of the PSS among Chinese women (n=60). Following a 4-week intervention to decrease postpartum distress, the PSS demonstrated responsiveness to change in women with postpartum distress (t= -3.75, p=0.01) (Chen *et al.* 2000).

Tai Chi Exercise Self-Efficacy

Several investigators have reported that efficacy beliefs significantly predicted exercise behavior and that exercise efficacy increased overtime, even among cardiac populations (Blanchard *et al.* 2002; Li, McAuley *et al.* 2001; McAuley 1993; Perkins & Jenkins 1998). Tai Chi exercise Self-Efficacy (TCSE) refers to the beliefs in one's capability to perform TC exercise (Bandura 1997b, 2001). TCSE must have its own measure tailored to the specific domain of functioning and representing gradations of task demands (Bandura 1997b, 2001). An individual's perceived confidence to perform TC exercise can be assessed by the TCSE scale (Taylor-Piliae & Froelicher 2004b). This

scale assess perceived self-efficacy to overcome barriers to TC exercise (TCSE Barriers) and self-efficacy to perform TC (TCSE Performance) (Taylor-Piliae & Froelicher 2004b).

Subjects respond to nine items regarding their perceived confidence to exercise five times per week for 30 minutes (0=not at all confident, 100=very confident), when faced with situations known to impede exercise participation (TCSE Barriers) (Bandura 2001; Katula *et al.* 1999; Resnick & Jenkins 2000). TCSE Performance contains five questions, regarding an individual's perceived capability to move their body in a slow, rhythmical continuous fashion (0=not at all confident, 100=very confident), ranging from 2 to 30 minutes (Li, Harmer *et al.* 2001; Li, McAuley *et al.* 2001). Confidence scores for TCSE Barriers, and TCSE Performance are summed separately, and then divided by the total number of items in each scale. A higher score indicates more confidence or perceived self-efficacy.

Reported internal consistency estimates were very high (TCSE Barriers, r=0.95; TCSE Performance, r=0.97) (Taylor-Piliae & Froelicher 2004b). Known-groups validity was demonstrated by the tool's ability to detect differences between TC practitioners and non-practitioners (TCSE Barriers, t=-3.3, p=0.01; TCSE Performance, t=-2.7, p=0.03), with TC practitioners reporting higher self-efficacy (Taylor-Piliae & Froelicher 2004b).

Previous Tai Chi experience

A mastery experience is one of the most influential ways to cultivate perceived efficacy, particularly when one's personal capability to perform an activity is perceived to be successful (Bandura 1997b). A positive mastery experience is likely to foster increased personal efficacy, while failures often result in negative perceptions of personal capability. A single dichotomous item was used to ascertain if subjects had previous TC

experience. However, subjects that practiced TC regularly in the last 6 months (at least once a week) were excluded from participation in this study, in accordance with the study criteria.

Social Support

Verbal persuasion through social support and encouragement from experts aids in the cultivation of efficacy beliefs (Bandura 1997b). Personal change occurs within a network of social influences and there is no single social network that is all encompassing and solely able to effect behavioral change. Social support is likely to influence perceived self-efficacy and thus TC exercise behavior (Bandura 1997b). In addition, TC is usually performed in a group setting, which in turn is likely to enhance exercise participation. Thus, social support adequacy or the actual connection that persons have in their environment is important to assess.

The Multidimensional Scale of Perceived Social Support (MSPSS) (Blumenthal *et al.* 1987; Zimet *et al.* 1988) is a 12-item tool, used to assess perceptions of social support adequacy available from family members, friends and a significant other. The MSPSS is a self-administered tool, on a 7-point Likert Scale (1=very strongly disagree, 7=very strongly agree), requiring approximately 5-10 minutes to complete. This response format was devised to avoid possible ceiling effects and increase response variability following initial psychometric testing (Blumenthal *et al.* 1987; Zimet *et al.* 1988). Possible scores range from 1 to 7, as the total score is the sum of the item responses, divided by the number of items. A higher score indicates greater level of perceived support. In addition, scores can be calculated for the three subscales (family, friends, and significant others) by summing the item responses of each subscale and

dividing by the number of items contained in subscale. Reliability in the original sample of college students was high (Cronbach's alpha= 0.88), with good test-retest reliability at 2-3 months reported (r= 0.85) (Zimet *et al.* 1988). Confirmatory factor analysis has consistently reported a 3-factor solution (family, friends, others) with all items loading at 0.74 or greater (Dahlem *et al.* 1991; Zimet *et al.* 1990).

Internal consistency of the Chinese version is good, ranging from 0.82 to 0.94 (Short & Johnston 1997; Zhang & Norvilitis 2002). Content validity has been reported in both the original and Chinese populations (Short & Johnston 1997; Zhang & Norvilitis 2002; Zimet *et al.* 1988). In the original population (college students), anxiety and depression correlated negatively (r=-0.18, p=0.01; r=-0.24, p=0.01; respectively), as hypothesized, with perceived social support demonstrating convergent validity (Zimet *et al.* 1988). Among Chinese college students convergent validity was demonstrated by significant associations (r=0.34,p=0.01 self-esteem; r=-0.41, p=0.01 depression; r=-0.21, p=0.01 suicidal ideation) between hypothesized relationships to perceived social support (Zhang & Norvilitis 2002). Among Hong Kong Chinese mothers, additional evidence of convergent validity was reported (r=0.38, p=0.01 parenting support; r=-0.54, p=0.01 depression; r=-0.46, p=0.01 somatization and anxiety) (Short & Johnston 1997).

Instrument Reliability

Internal consistency estimates for the instruments used in this study were found to be high at all data collection time periods (Table 5). Internal consistency estimates for the tools measuring affective status (PSS and POMS) ranged from 0.87-0.96. The tool assessing social support, MSPSS, demonstrated strong reliability over time, with internal

consistency estimates ranging from 0.86-0.95. Internal consistency estimates of the tools examining self-efficacy (TCSE Barriers and TCSE Performance) ranged from 0.92-0.96.

Ethical Considerations

Approval to conduct the study was obtained from the Institutional Review Board at the University of California San Francisco, with the investigation carried out according to the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all subjects in either English or Chinese (Cantonese). All subjects were assured of confidentially and the ability to decline participation or withdraw from the study at any time. Permission to use the instruments in this study, were obtained from the respective copyright holders.

Data Analysis

All data forms were reviewed for accuracy and completeness at the time of data collection. Frequencies were run on every variable to check for extreme and inconsistent values. Data was analyzed using the Statistical Package for Social Sciences (version 10.0) (Norusis 2000). Descriptive statistics were calculated on all variables. Univariate repeated measures ANOVA was used to test for changes in the outcomes variables over-time. Maulchy's test of sphericity (≥ 0.05) (Shott 1990) was done before proceeding with the analysis. If the compound symmetry criteria were not met, then the data were analyzed using the Greenhouse-Geisser adjusted univariate approach. If the overall ANOVA was significant, then Bonferroni's adjusted paired-samples confidence intervals (Shott 1990) were done for all 3 possible comparisons (0-12 weeks, 0-6 weeks, 6-12 weeks) to determine where the mean difference was.

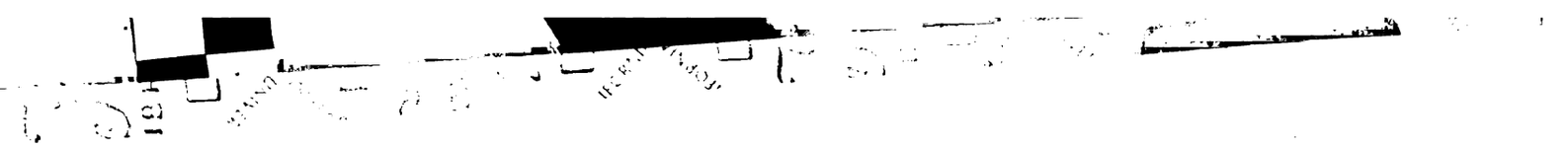
Results

Baseline Characteristics

A total of 39 subjects agreed to participate in this TC exercise intervention study. Subjects were on average 66 (± 8.3) years old, married, Cantonese-speaking, immigrant women (Table 2). The majority of subjects were retired or unemployed (85%), with ≤ 12 years education, approximately half reported an income < $16,000 US per year.

Self-reported musculoskeletal conditions, such as arthritis or chronic back pain, were common (Table 3). However, the majority of subjects perceived their health to be good, very good or excellent (56%). Only 41% of subjects reported having a history of cardiovascular problems, though 92% of subjects were found to have hypertension, and/or other CVD risk factors. CVD medication use for hypertension, and hypercholesteremia was lower than reported risk factors. Only a few subjects (n=4) reported using Chinese medicine for health benefits. Approximately one-fourth of the subjects had prior TC experience, though none had performed TC regularly in the past 6 months, according to the inclusion criteria (Table 4).

Subjects were asked to attend a total of 36 TC exercise classes during the 12-week study. Adherence to the intervention was very high (87% ± 0.18). Follow-up at 6 weeks was 100%. However, after the 6-week evaluation, one woman dropped out of the study due to recurring health problems. A total of 97% of subjects completed the study, with data from these subjects used in the analyses (n=38).



Outcomes

Affective Status

Stress and mood state were assessed using the PSS and the POMS, respectively. At baseline, subjects reported little stress (15.6 ± 6.9) and very low mood disturbance (19.3 ± 29.6) (Table 4). Univariate repeated measures ANOVA examining change in perceived stress was statistically significant over-time(Table 6). Approximately 13% of the variance (eta^2=0.13) in perceived stress over-time could be explained (Table 6). A pairwise contrast of the mean differences (Table 7) was statistically significant between baseline and 12-weeks (Figure 3), with less stress following the 12-week TC intervention.

Univariate repeated measures ANOVA examining change in total mood disturbance, and two subscales, tension-anxiety and confusion-bewilderment, were statistically significant over-time (Table 6). Approximately 12% of the variance (eta^2=0.12) in total mood disturbance, 15% (eta^2=0.15) of the variance in tension-anxiety, and 10% (eta^2=0.10) of the variance in the confusion-bewilderment subscale over-time could be explained. Pairwise contrasts examining mean differences found statistically significant reductions in total mood disturbance (Figure 3), and the two subscales, tension-anxiety and confusion-bewilderment, between baseline and 12 weeks. In addition, a statistically significant reduction in tension-anxiety was found following the 2^{nd} 6 weeks of the TC intervention (Table 7).

Tai Chi exercise Self-Efficacy

Perceived self-efficacy to overcome barriers to TC exercise (TCSE Barriers) was assessed at baseline, 6 and 12-weeks after the intervention. At baseline, subjects perceived themselves to be moderately confident to overcome barriers to TC exercise

(TCSE Barriers=50.3± 33.0) (Table 4). At 12-weeks a statistically significant improvement in TCSE Barriers (Figure 4) was found, with subjects reporting more confidence to overcome barriers to TC exercise. Univariate repeated measures ANOVA examining change in TCSE Barriers was statistically significant over-time (Table 6). Approximately 19% (eta^2=0.19) of the variance in TCSE Barriers over-time could be explained. Pairwise contrasts of the mean differences in TCSE Barriers found statistically significant increases between baseline and 12 weeks, and following the 2nd 6-weeks of the TC intervention (Table 7).

TCSE Performance was used to assess self-efficacy to perform TC. At baseline, subjects were fairly confident that they could perform TC (72.5 ± 28.0) (Table 4). As expected, subjects were more confident that they could perform TC continuously for 2-minutes (84.2 ± 27.0), than continuously for 30-minutes (56.9 ± 33.9), at baseline. At 6-weeks and 12-weeks statistically significant improvements in TCSE Performance (Figure 4) were found, with subjects very confident that could perform TC continuously for 30-minutes. Univariate repeated measures ANOVA examining change in TCSE Performance at all time levels, were statistically significant over-time (Table 6). Approximately 27% (eta^2=0.27) of the variance in TCSE Performance over-time could be explained. Pairwise contrasts of the mean differences in TCSE Performance at all time levels were statistically significant between baseline and 12 weeks, and following the 1st 6-weeks of the TC intervention (Table 7).

Social Support

The MSPSS was used to assess social support. At baseline, subjects reported a moderate amount of social support (4.9 ± 0.8) (Table 4). At 12-weeks, a statistically

significant improvement in the MSPSS score (Figure 5) was found. Univariate repeated measures ANOVA examining change in overall social support, perceived support from family, and significant others were statistically significant over-time (Table 6). Approximately 12% (eta^2=0.12) of the variance in overall social support over-time could be explained. Pairwise contrasts of the mean differences found statistically significant improvements in overall social support, perceived support from family, and significant others between baseline and 12 weeks (Table 7).

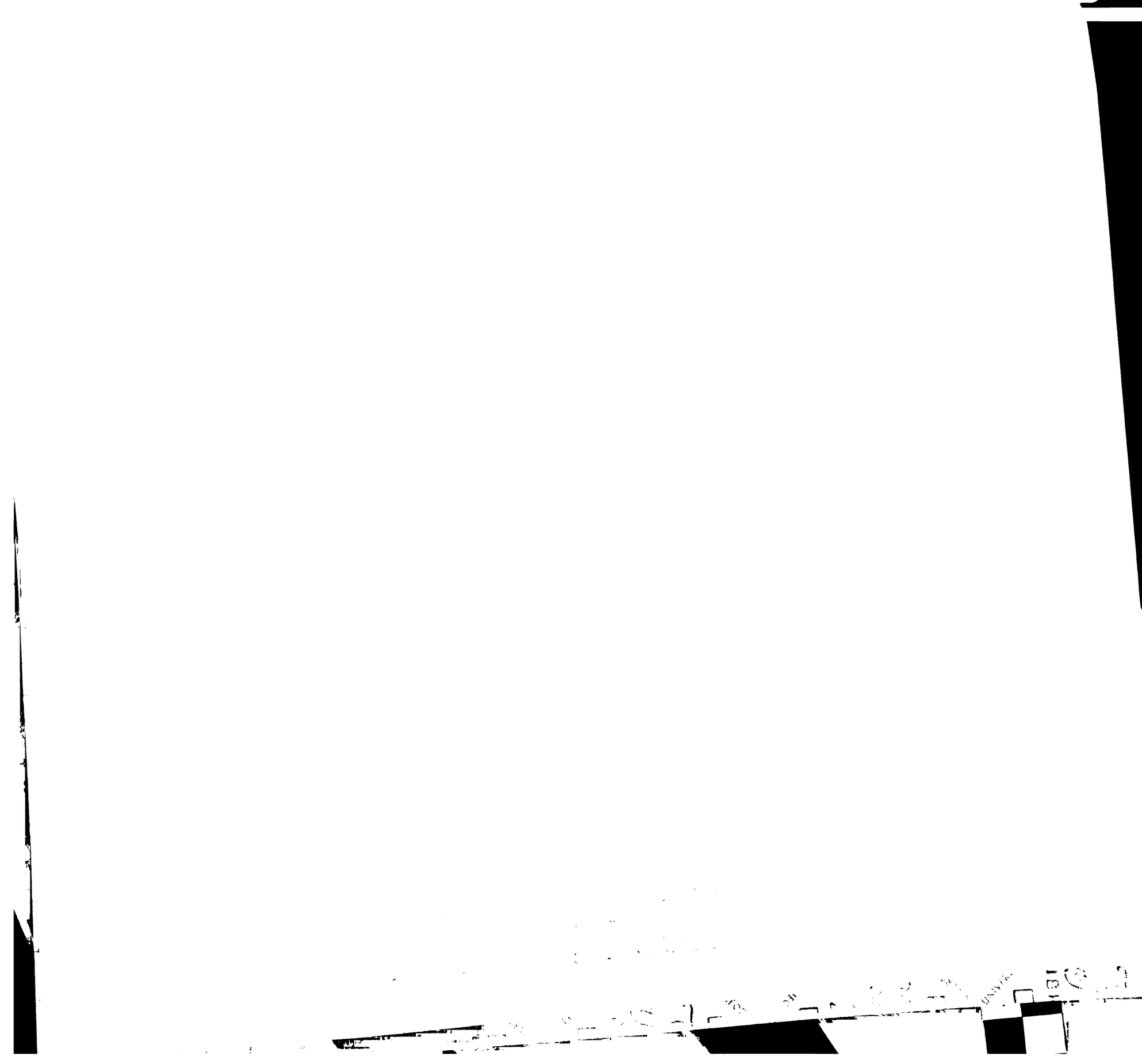
Predictors

Social support, TCSE, and previous Tai Chi exercise experience were not predictive of TC exercise behavior, defined as class attendance ($p > 0.05$ for all variables). High adherence to the intervention (87%), and a small sample, likely contributed to these findings.

Discussion

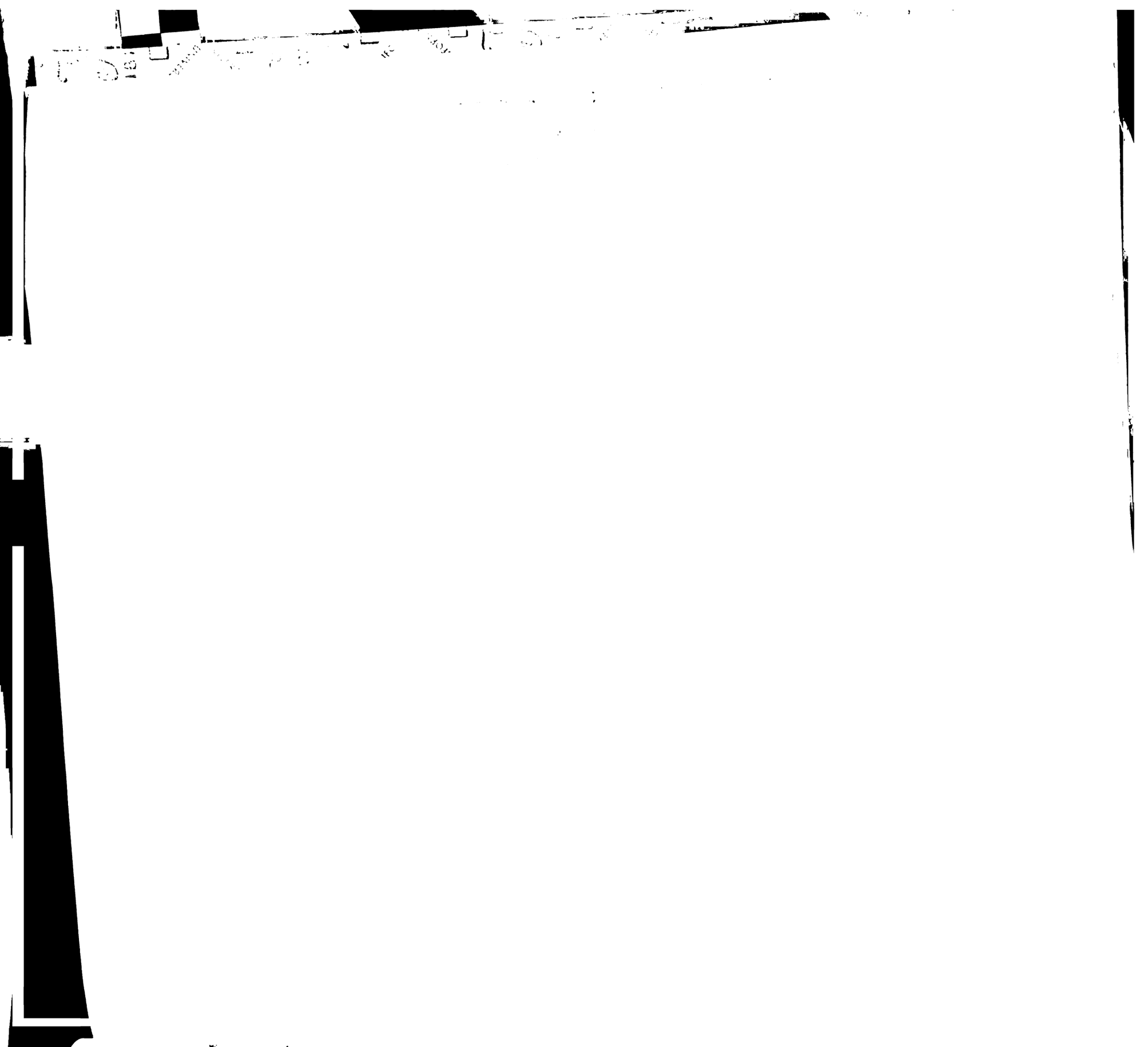
This was the first study to examine change in psychosocial status following a TC exercise intervention among ethnic Chinese adults with CVD risk factors, living in the SFBA in the US. TC was a culturally appropriate mind-body exercise for these older adults, with statistically significant psychosocial benefits observed over 12-weeks. Using Bandura's SCT, sources of information for cultivation of self-efficacy were examined (Figure 2), including affective status, previous TC experience, and social support, as well as change in TCSE.

Subjects in this study reported very little mood disturbance, which is similar to previously reported mean scores among ethnic Chinese (Chen *et al.* 2001; Taylor-Piliae



& Chair 2002). However, prior research examining the effect of TC on mood among non-Chinese populations have reported much higher mean scores at baseline, and after a TC exercise intervention (Brown *et al.* 1995; Jin 1989, 1992). Among Chinese persons, the expression of negative emotions or strong personal feelings are controlled in order to maintain internal balance, and conform to social norms for expected public behavior (Holroyd *et al.* 1998; Taylor-Piliae & Molassiotis 2001). Negative emotions, such as anxiety, fear, or worry, are thought to cause internal disharmony, and allow illnesses to occur (Taylor-Piliae & Chair 2002; Taylor-Piliae & Molassiotis 2001; Torsch & Ma 2000). This may partially explain the findings obtained, as subjects in this study were mainly immigrants from mainland China, and more likely to have been influenced by the pervasive cultural and social norms, reluctant to express their emotions or feelings. In addition, the low level of education reported by the majority of subjects (87% ≤ high school) may have limited the understanding of some of the words in the POMS. Utilization of alternative tools to assess mood in ethnic Chinese, such as the Positive and Negative Affective Schedule (Watson *et al.* 1988) or the Chinese Stress Symptoms checklist (Cheng & Hamid 1996), may be warranted in future studies.

Only one prior study among recent immigrants of older Hmong adults to the USA, has examined the effect of TC on perceived stress (Sun *et al.* 1996), with a statistically significant reduction ($Z=3.79$, $p=0.01$) in perceived stress reported following a 12-week TC intervention. However, further comparisons to this study cannot be made, as information on the instrument used to measure perceived stress was not reported (Sun *et al.* 1996).



Two scales were used to assess TCSE. Findings obtained in this study are similar to those reported in prior studies examining TCSE Barriers and TCSE Performance among older adults, with statistically significant improvements reported over-time (Li, Harmer *et al.* 2001; Resnick & Jenkins 2000; Taylor-Piliae & Froelicher 2004b). Interestingly, improvement in self-efficacy to overcome barriers to TC (TCSE Barriers) was statistically significant following the 2nd 6-weeks of TC exercise, while self-efficacy to perform TC (TCSE Performance) was statistically significant following the 1st 6-weeks of TC exercise. Perceived self-efficacy to overcome barriers to TC confirms similar reports from the literature on exercise behavior (Bandura 1997b), and is important information for researchers to be aware of. Initially, frequent reminders and extra time may be needed to encourage regular participation in an exercise program, such as TC. TC may be individually tailored for elderly persons, so that only a few movements are taught and mastered, before new movements are introduced, and may have contributed to perceived TCSE Performance in these subjects.

No prior study has examined the effect to TC on social support over-time, though social support is likely to occur during exercise classes performed in groups, and also serves as a vital source to cultivate self-efficacy and further encourage exercise behavior. Findings in this study are similar to previous research using the MSPSS to assess perceptions of social support adequacy among Chinese and persons with CVD, with increased perceptions of social support reported over-time (Carels *et al.* 1999; Daly *et al.* 2000; Short & Johnston 1997; White & Frasure-Smith 1995; Zhang & Norvilitis 2002).

Future research may like to explore the effect of TC on different domains of social support, such as the perceived availability of functional support. Functional support

includes specific behaviors or actions performed by others as expressions of support, including material aid, tangible assistance, information or guidance, positive social interaction and affection (Barrera & Ainlay 1983; Sherbourne & Stewart 1991). In addition, different or additional measures to assess TC mastery, modeling, or social persuasion may be needed, to comprehensively explore TC information sources for cultivating self-efficacy.

Subjects in this study reported having a major CVD risk factor (current smoker, high blood pressure, high cholesterol, diabetes) in accordance with the inclusion criteria. However, given the high percentage of CVD risk factors reported in these subjects (Table 2), it apparent that interventions are needed to address several health concerns to reduce hypertension and hypercholesteremia in this population.

Limitations and Strengths

The generalizability of the findings obtained may be limited, as only subjects uniquely interested in TC with perceived good health, may have volunteered as study participants. No subjects in this study reported perceived poor health, and may not be representative of all Chinese seniors living in the community. Furthermore, without a control group to serve as a comparison, improvement unrelated to TC is possible.

Readability of the English version of the questionnaire was at the 6^{th} to 7^{th} grade reading level, based on the Flesch-Kincaid Grade Level analysis. However, readability of the Chinese version was not ascertained. It is possible that readability of the Chinese version was more difficult than the English version. In addition, the majority of subjects reported a limited education. The use of unfamiliar vocabulary, or complex sentences

may have limited the understanding of some of the concepts examined in this study and contributed to the results obtained. Further, feelings or expectations about answering a questionnaire may be influenced by personal beliefs or socially desirable answers.

This was an innovative, culturally appropriate exercise program appealing to ethnic Chinese seniors, with potential linguistic barriers eliminated. The very high adherence to the Tai Chi exercise intervention (87%) suggests this was a convenient and acceptable form of exercise for these subjects. Additional factors contributing to the success of the study were the availability of subjects, and their willingness to complete the study (97%).

Conclusions

Statistically significant changes in psychosocial status were observed following a 12-week TC exercise intervention among ethnic Chinese with CVD risk factors. Improvement in mood state, and reduction in perceived stress were found. In addition, TC exercise significantly increased self-efficacy to overcome barriers to TC, confidence to perform TC, and perceived social support in these subjects. Social support, TCSE, and previous TC exercise experience were not predictive of adherence to the TC intervention, likely due to the small sample and high adherence to the TC exercise behavior observed in this study (87%).

Summary Statement

'What is already known about this topic'

- Negative psychosocial factors such as major depression, social isolation, or chronic stress can adversely affect pathophysiological mechanisms associated with cardiovascular disease.
- Expressions of negative emotions or strong personal feelings among ethnic Chinese are generally controlled.
- Tai Chi exercise is a low-impact, moderate-intensity aerobic exercise, incorporating relaxed breathing and mental concentration.

'What this paper adds'

- Tai Chi is culturally appropriate mind-body exercise appealing to ethnic Chinese older adults.
- 12-weeks of Tai Chi was adequate for observing a significant reduction in perceived stress, improvement in mood state, and an increase in perceived social support.
- Longer time was needed to observe significant improvements in perceived confidence to overcome barriers to Tai Chi exercise, than in perceived confidence to perform Tai Chi.

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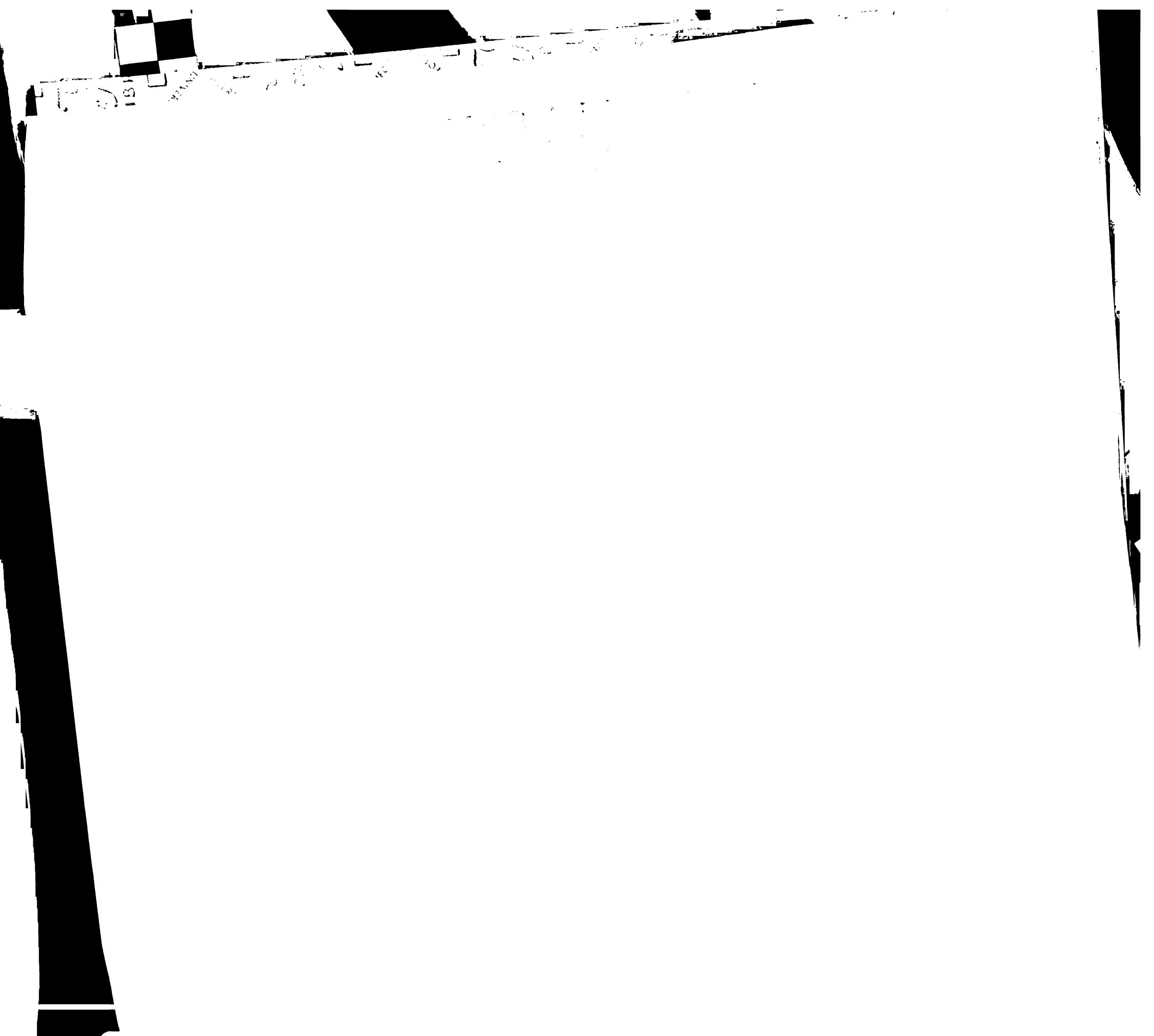

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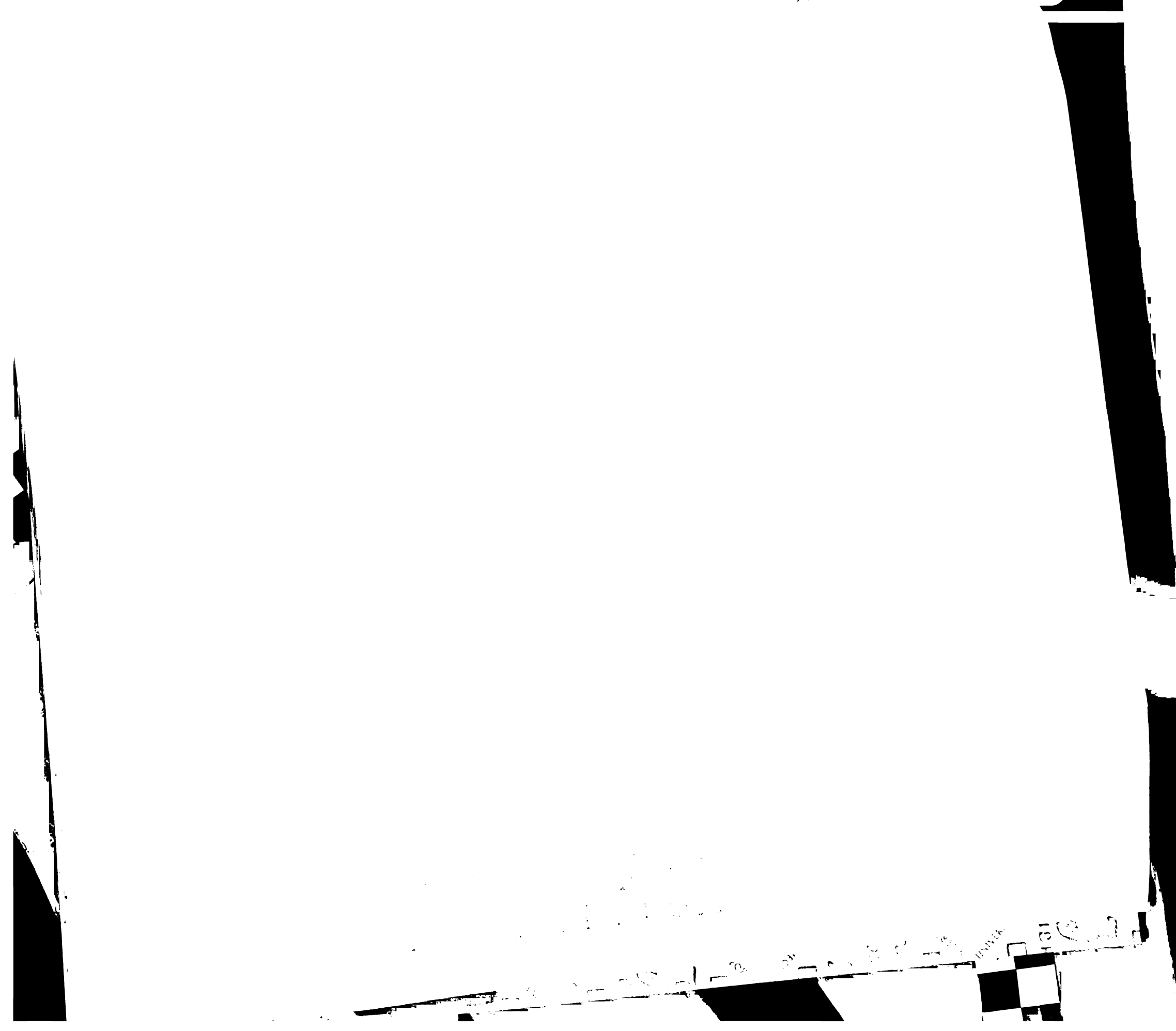

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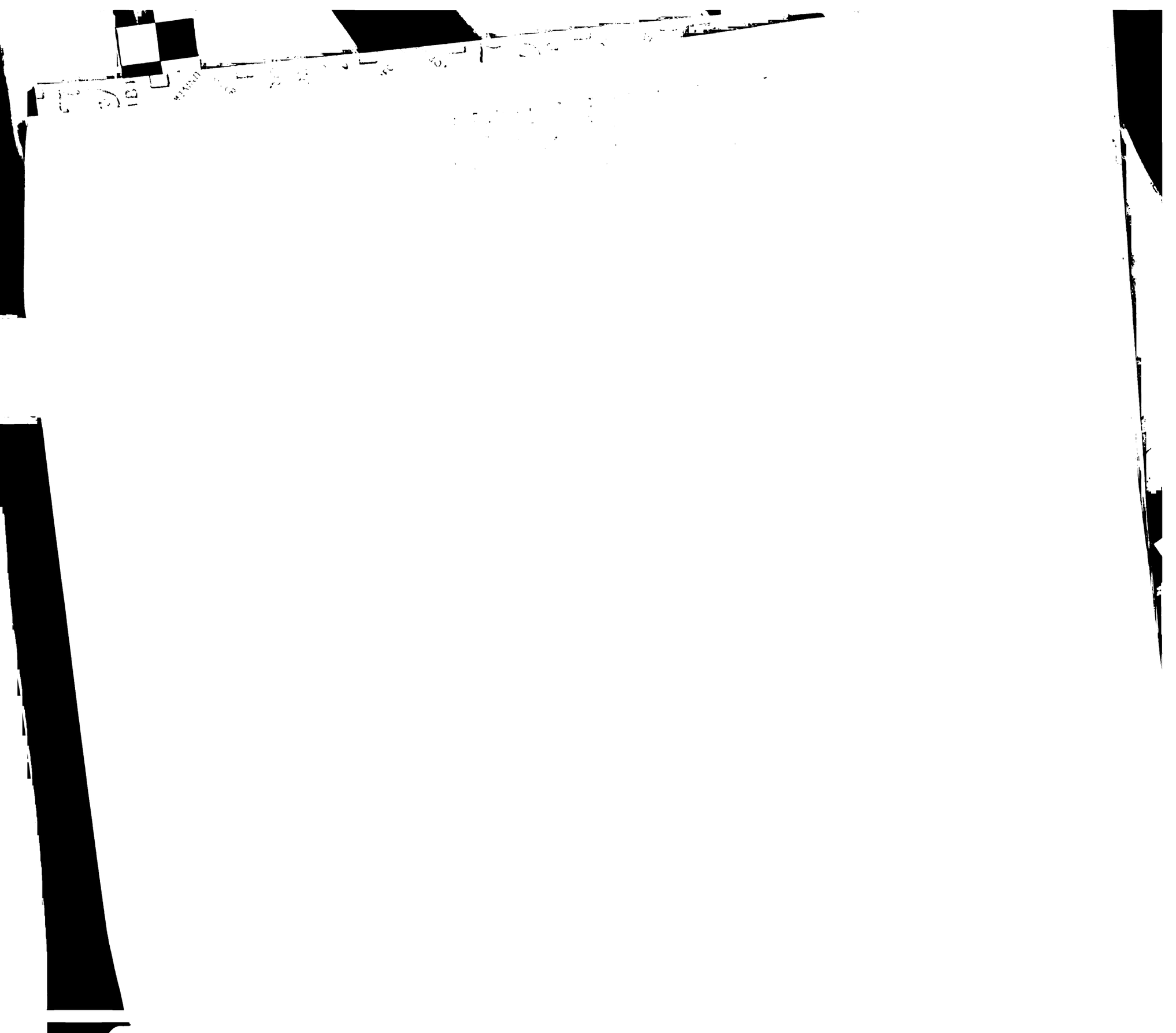
TABLE 1: PRIOR STUDIES EXAMINING TAI CHI AND AFFECTIVE STATUS

Author/Year	Study Design/ Location	Tai Chi Style	Sample	Intervention Length or Years of Practice	Measure	Findings
Jin 1989	Quasi-experimental Australia	Yang 108 or Wu variation of Yang	TC skilled (>1 yr), n=33 TC novice (<1yr), n=33 Age range=16-75 yrs. 45% females	TC skilled (>1 yr), TC novice (<1yr)	*Mood* POMS-65 items Measured-before, during & after TC	During and after TC ↓ in mood disturbance than before TC, in both skilled and novice TC groups, p=0.01 0% drop-outs
Jin 1992	RCT Australia	Yang 108 or Wu variation of Yang	All TC practitioners Treatment Conditions: TC, n=24 Brisk walking, n=24 Meditation, n=24 Reading, n=24; after exposure to mental and emotional stress Age=36 yrs. 50% females	> 3 years	*Anxiety* SAI-20 items *Mood* POMS-65 items	TC treatment condition ↓ anxiety than reading condition, p=0.00 Mood between groups-NS 0% drop-outs
Brown *et al*, 1995	RCT USA	unspecified style	Moderate-intensity walking, n=24 Low-intensity walking, n=34 Low-intensity walking + relaxation response, n=28 Tai Chi, n=18 Sedentary Control, n=31 Age=53 yrs. 51% females	16 weeks (48 sessions)	*Anxiety* STAI-40 items *Mood* POMS-65 items PANAS-not specified STAXI-not specified	TC group [women only] less mood disturbance than other groups, p=0.04 Anxiety, affect, anger between groups-NS 25% drop-outs
Sun *et al*, 1996	RCT USA	unspecified style	TC intervention, n=10 Control, n=10 Hmong immigrants Age range=60-79 yrs. 65% females	12 weeks (12 sessions)	Stress Not specified	TC group ↓ stress than controls, p=0.00 0% drop-outs



Author/Year	Study Design/ Location	Tai Chi Style	Sample	Intervention Length or Years of Practice	Measure	Findings
Chen & Sun 1997	Quasi-experimental USA	24 movements unspecified style	TC intervention, n=18 Control, n=10 Age range=50-74 yrs. 50% females	16 weeks (32 sessions)	*Anxiety* TMAS-50 items SAI-20 items	Between groups-NS 22% drop-outs
Ross *et al*, 1999	Quasi-experimental USA	unspecified style	TC intervention, n=17 Age range=68-92 yrs. 88% females	8 weeks (18 sessions)	*Mood* MAACL-R-132 items	Post-intervention ↓ mood disturbance, p=0.05 % drop-outs-not reported
Chen *et al*, 2001	Cross-sectional Taiwan	unspecified style	TC practitioners, n=40 Sedentary comparisons, n=40 Age=74 yrs. 63% females	> 20 years	*Mood* POMS-SF-30 items	TC group ↓ mood disturbance than sedentary, p=0.05 % drop-outs-not reported
Bond *et al*, 2002	Cross-sectional USA	unspecified style	TC practitioners, n=71 Aerobic exercise, n=86 Sedentary comparisons, n=94 Age=37 yrs. 59% females	≥ 6 months	*Anxiety* STAI-40 items	TC & aerobic exercise groups ↓ anxiety than sedentary, p=0.05 % drop-outs-not reported
Tsai *et al*, 2003	RCT/ Taiwan	Yang, 108 postures	TC intervention, n=37 Sedentary Control, n=39 Age=51 yrs. 50% females	12 weeks (36 sessions)	*Anxiety* STAI-40 items	Within TC group ↓ in anxiety, p=0.01; between groups-NS 14% drop-outs

RCT=randomized clinical trial, TC=Tai Chi, STAI=State Trait Anxiety Inventory, POMS=Profile of Mood States, POMS-SF= Profile of Mood States Short Form, MAACL-R=Multiple Affect Adjective Check List Revised, TMAS=Taylor Manifest Anxiety Scale, SAI=State Anxiety Inventory, PANAS=Positive Affect/Negative Affect Scale, STAXI=State-Trait Anger Expression Inventory

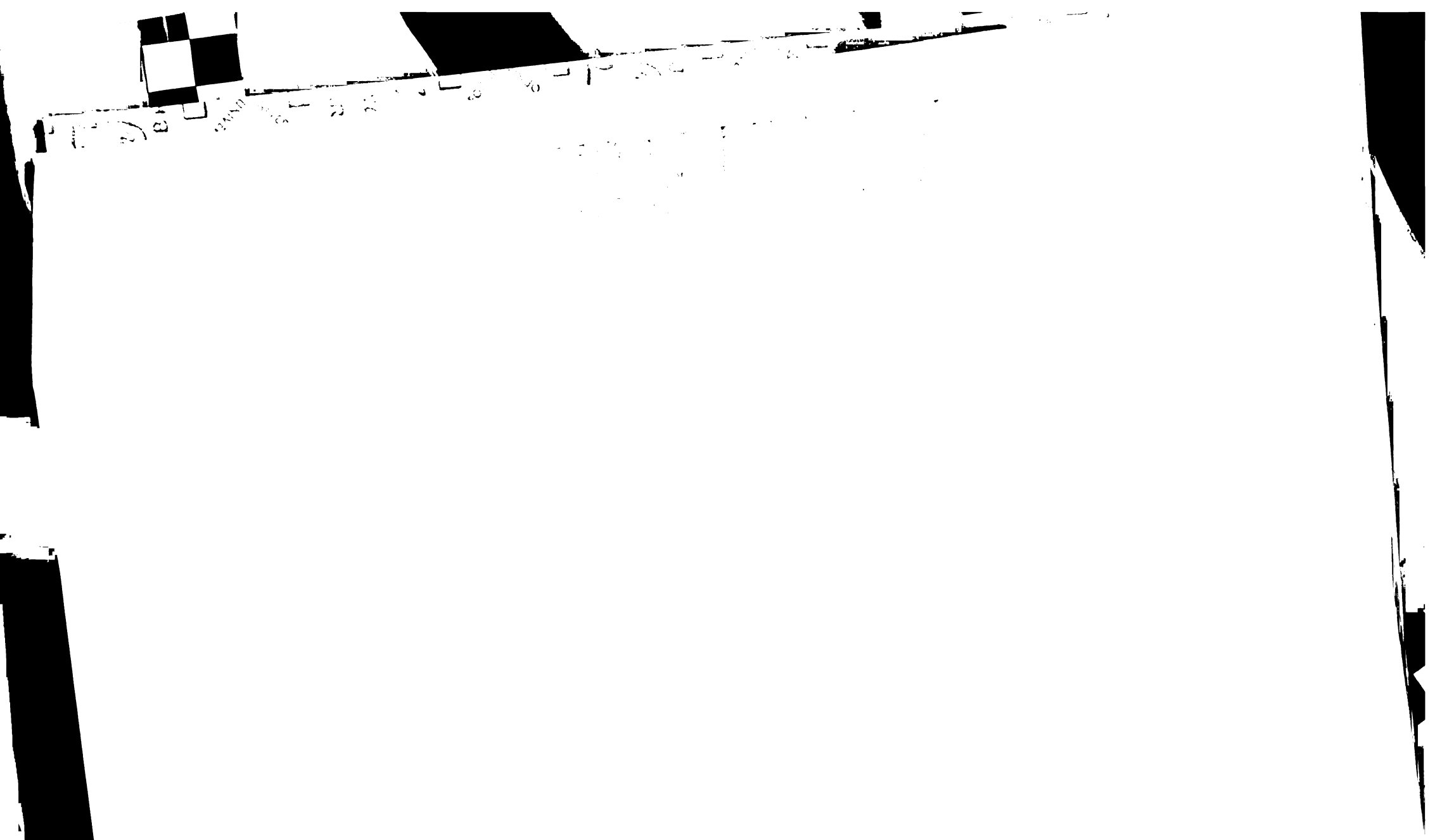


TABLE 2: BASELINE SUBJECT CHARACTERISTICS, N=39

	%	n
Gender		
Men	30.8	12
Women	69.2	27
Marital Status		
Married/Domestic partner	84.6	33
Divorced/Separated/Widowed/Single	15.4	6
Education		
Primary (1-6 years)	41.0	16
Secondary (7-12 years)	46.2	18
Tertiary (13+ years)	12.8	5
Employment Status		
Retired/unemployed	84.6	33
Full or Part-time	15.4	6
Income (in US dollars per year)		
< 15,999	46.2	18
16,000-34,999	20.6	8
> 35,000	12.8	5
refused to answer	20.5	8
Birthplace		
Mainland China	87.2	34
Hong Kong	12.8	5
Language Spoken at home		
Cantonese	97.4	38
Mandarin	2.6	1

TABLE 3: SELF-REPORTED CLINICAL HISTORY AND HEALTH STATUS, N=39

	%	n
Cardiovascular Risk Factors		
Hypertension	92.3	36
Hypercholesteremia	48.7	19
Diabetic	20.5	8
Current Smoker	2.6	1
Medication Use		
Antihypertensives	53.8	21
Statins	28.2	11
Oral Hypoglycemics	17.9	7
Aspirin	33.3	13
Chinese Medicine	10.3	4
Self-reported Medical Disorders		
Cardiovascular	41.0	16
Musculoskeletal	53.8	21
Gastrointestinal	12.8	5
Hematological	12.8	5
Immunological	5.1	2
Respiratory	2.6	1
Psychological	5.1	2
General Health Perception		
Excellent	7.7	3
Very good	20.5	8
Good	28.2	11
Fair	43.6	17
Poor	0	0

TABLE 4: PSYCHOSOCIAL STATUS DESCRIPTIVE STATISTICS, N=38

	Possible range of scores	Baseline	6-weeks	12-weeks	Change from Baseline	Desired direction of change in score
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Perceived Stress	0-40	15.6 (6.9)	14.3 (7.2)	13.1 (6.3)	-2.5 (5.0)	↓
Total Mood Disturbance	-32 to 200	19.3 (29.6)	14.0 (32.0)	8.9 (26.8)	-10.4 (21.6)	↓
Tension-Anxiety	0-36	7.7 (6.1)	7.4 (6.2)	5.5 (5.3)	-2.2 (4.3)	↓
Confusion-Bewilderment	0-28	7.2 (4.5)	6.2 (4.6)	5.7 (3.7)	-1.5 (3.4)	↓
Depression-Dejection	0-60	8.1 (9.0)	7.6 (9.5)	6.4 (8.1)	-1.7 (5.5)	↓
Anger-Hostility	0-48	6.2 (6.3)	5.3 (5.8)	4.6 (5.7)	-1.6 (5.1)	↓
Fatigue-Inertia	0-28	5.8 (5.3)	5.1 (5.2)	4.4 (4.1)	-1.3 (4.2)	↓
Vigor-Activity	0-32	15.6 (5.3)	17.6 (5.7)	17.7 (5.4)	2.1 (6.3)	↑
Overall Social Support	1-7	4.9 (0.8)	5.1 (1.1)	5.4 (0.9)	0.4 (0.7)	↑
Family	1-7	5.3 (1.0)	5.5 (1.2)	5.7 (1.1)	0.4 (1.1)	↑
Friends	1-7	4.6 (1.1)	4.7 (1.2)	4.9 (1.0)	0.3 (1.1)	↑
Significant Other	1-7	4.9 (0.8)	5.1 (1.2)	5.4 (1.1)	0.5 (0.9)	↑
TCSE Barriers	0-100	50.3 (33.0)	53.1 (33.9)	75.3 (29.5)	25.0 (37.1)	↑
TCSE Performance	0-100	72.5 (28.0)	88.5 (18.8)	91.3 (16.1)	18.8 (26.3)	↑
2 minutes	0-100	84.2 (27.0)	93.2 (16.6)	95.8 (13.9)	11.6 (27.6)	↑
5 minutes	0-100	78.7 (30.1)	92.4 (16.7)	93.4 (15.6)	14.7 (28.7)	↑
10 minutes	0-100	75.5 (30.7)	87.6 (21.9)	92.0 (18.1)	16.4 (28.8)	↑
20 minutes	0-100	67.1 (32.8)	85.8 (22.9)	90.5 (19.2)	23.3 (28.4)	↑
30 minutes	0-100	56.9 (33.9)	83.4 (24.6)	85.0 (24.1)	28.1 (32.5)	↑
Previous Tai Chi experience, % (n)	Yes/No	25.6% (10)	---	---	---	---

TCSE Barriers= Self-Efficacy to overcome barriers to Tai Chi, TCSE Performance= Self-Efficacy to Perform Tai Chi, SD=standard deviation

TABLE 5: INTERNAL CONSISTENCY OF THE STUDY INSTRUMENTS OVER 12-WEEKS

Instrument/ Cronbach's Alpha	Baseline	6-weeks	12-weeks
PSS	0.88	0.89	0.87
POMS	0.96	0.95	0.95
MSPSS	0.86	0.95	0.93
TCSE Barriers	0.95	0.94	0.96
TCSE Performance	0.95	0.94	0.92

PSS=Perceived Stress Scale, POMS=Profile of Mood States, MSPSS= Multidimensional Scale of Perceived Social Support, TCSE Barriers= Self-Efficacy to overcome barriers to Tai Chi, TCSE Performance= Self-Efficacy to Perform Tai Chi

TABLE 6: CHANGE IN PSYCHOSOCIAL STATUS OVER 12 WEEKS OF TAI CHI EXERCISE, N=38

Univariate Repeated Measures ANOVA	F $[df_{2,36}]$	p-value	eta^2
Perceived Stress	5.46	0.009*	0.13
Total Mood Disturbance	5.23	0.008*	0.12
Tension-Anxiety	6.61	0.002*	0.15
Confusion-Bewilderment	4.16	0.019*	0.10
Depression-Dejection	2.10	0.138	0.05
Anger-Hostility	2.64	0.087	0.07
Fatigue-Inertia	1.85	0.165	0.05
Vigor-Activity	2.88	0.063	0.07
Overall Social Support	5.12	0.008*	0.12
Family	3.38	0.039*	0.08
Friends	1.14	0.324	0.03
Significant Other	6.08	0.004*	0.14
TCSE Barriers	8.89	0.001*	0.19
TCSE Performance	13.66	0.001*	0.27
2 minutes	5.57	0.010*	0.13
5 minutes	8.44	0.001*	0.19
10 minutes	7.62	0.001*	0.17
20 minutes	13.90	0.001*	0.27
30 minutes	18.94	0.001*	0.34

TCSE Barriers= Self-Efficacy to overcome barriers to Tai Chi, TCSE Performance= Self-Efficacy to Perform Tai Chi
*significant if p-value ≤ 0.05

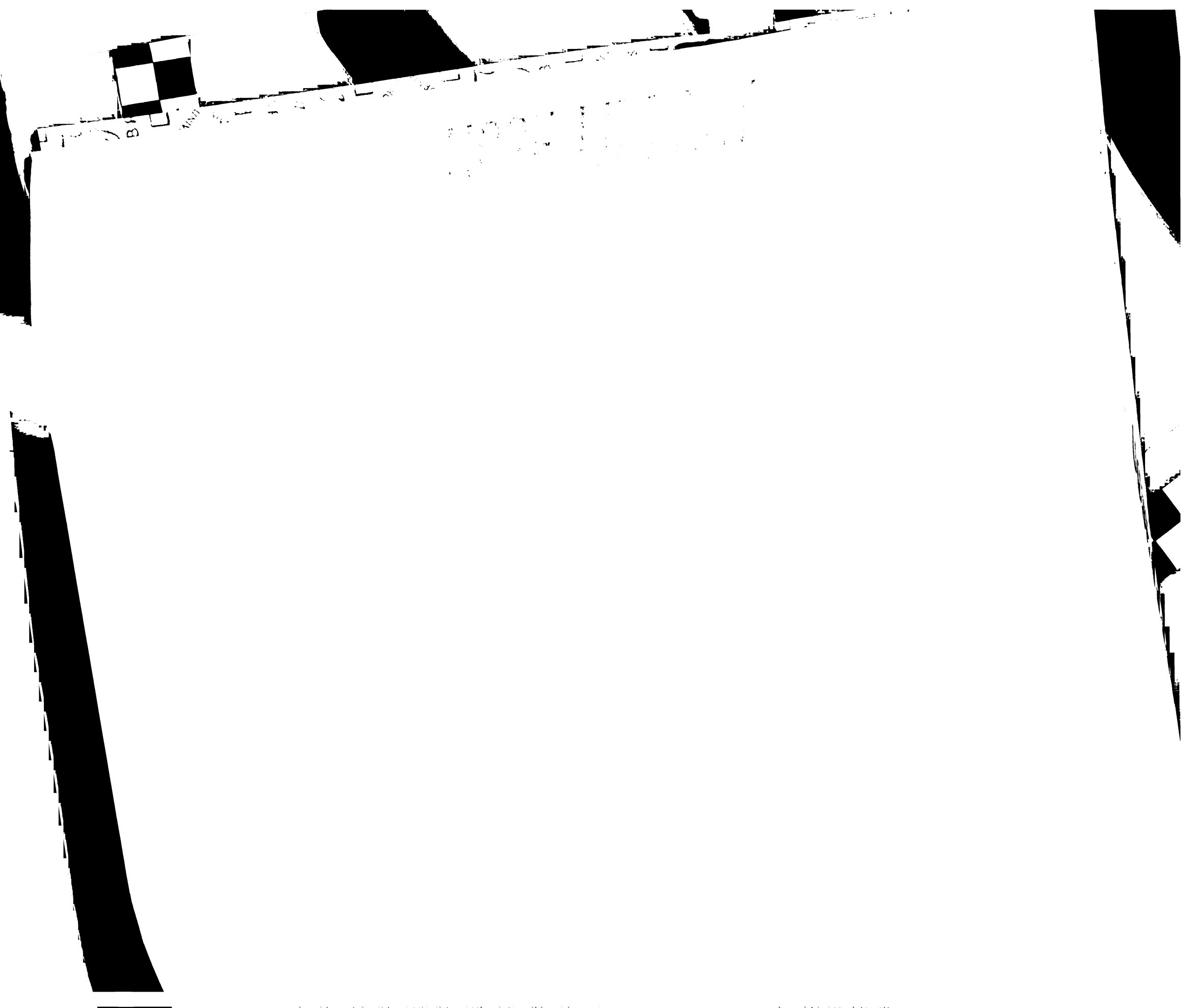
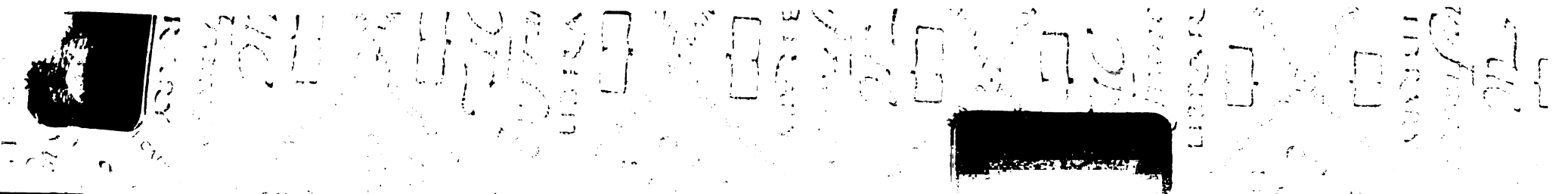


TABLE 7: PAIRWISE CONTRASTS OF MEAN DIFFERENCES IN PSYCHOSOCIAL STATUS OVER 12 WEEKS OF TAI CHI EXERCISE, N=38

Contrasts	Baseline to 6-weeks				7 to 12-weeks				Baseline to 12-weeks			
	F $[df_{1,36}]$	eta^2	LBCI	UBCI	F $[df_{1,36}]$	eta^2	LBCI	UBCI	F $[df_{1,36}]$	eta^2	LBCI	UBCI
Perceived Stress	2.32	0.06	-0.85	3.48	4.09	0.10	-0.29	2.71	9.85	0.21	**0.51**	**4.55**
Total Mood Disturbance	3.87	0.10	-1.46	12.09	2.25	0.06	-3.41	13.57	8.82	0.19	**1.62**	**19.17**
Tension-Anxiety	0.16	0.00	-1.40	1.93	9.52	0.21	**0.37**	**3.53**	10.07	0.21	**0.46**	**3.96**
Confusion-Bewilderment	4.63	0.11	-0.17	2.17	0.80	0.02	-0.90	1.90	7.20	0.16	**0.10**	**2.90**
Depression-Dejection	0.67	0.02	-1.08	2.14	1.50	0.04	-1.19	3.45	3.49	0.09	-0.57	3.88
Anger-Hostility	1.96	0.05	-0.67	2.35	1.37	0.04	-0.87	2.40	3.79	0.09	-0.46	3.67
Fatigue-Inertia	1.04	0.03	-0.96	2.28	0.81	0.02	-1.22	2.59	3.86	0.09	-0.37	3.06
Vigor-Activity	3.97	0.09	-4.58	0.50	0.00	0.00	-2.35	2.24	4.09	0.10	-4.66	0.50
Overall Social Support	2.03	0.05	-0.14	0.49	2.67	0.07	-0.13	0.61	12.13	0.25	**0.12**	**0.72**
Family	2.38	0.06	-0.14	0.57	1.57	0.04	-0.20	0.59	5.42	0.13	**0.03**	**0.86**
Friends	0.38	0.01	-0.38	0.63	0.76	0.02	-0.31	0.64	2.47	0.06	-0.17	0.75
Significant Other	1.23	0.03	-0.24	0.62	4.69	0.11	-0.06	0.77	15.40	0.29	**0.20**	**0.90**
TCSE Barriers	0.17	0.00	-14.09	19.68	10.94	0.23	**5.37**	**39.02**	17.27	0.32	**9.91**	**40.07**
TCSE Performance	16.34	0.31	**6.07**	**25.91**	0.71	0.02	-5.62	11.34	19.49	0.35	**8.14**	**29.55**
2 minutes	7.24	0.16	**0.61**	**17.29**	0.80	0.02	-4.73	10.00	6.71	0.15	**0.37**	**22.79**
5 minutes	11.21	0.23	**3.44**	**23.93**	0.12	0.00	-6.73	8.84	10.00	0.21	**3.05**	**26.42**
10 minutes	7.25	0.11	**0.83**	**23.38**	1.24	0.03	-5.44	14.12	12.41	0.25	**4.74**	**28.15**
20 minutes	12.71	0.26	**5.54**	**31.78**	1.28	0.03	-5.72	15.14	25.72	0.41	**11.82**	**34.92**
30 minutes	25.84	0.41	**13.46**	**39.65**	0.10	0.00	-10.72	13.82	28.39	0.43	**14.88**	**41.33**

Bold=$p \leq 0.0167$, LBCI= Lower Bound Confidence Interval with Bonferroni adjusted pairwise contrasts, UBCI= Upper Bound Confidence Interval with Bonferroni adjusted pairwise contrasts, TCSE Barriers= Self-Efficacy to overcome barriers to Tai Chi, TCSE Performance= Self-Efficacy to Perform Tai Chi



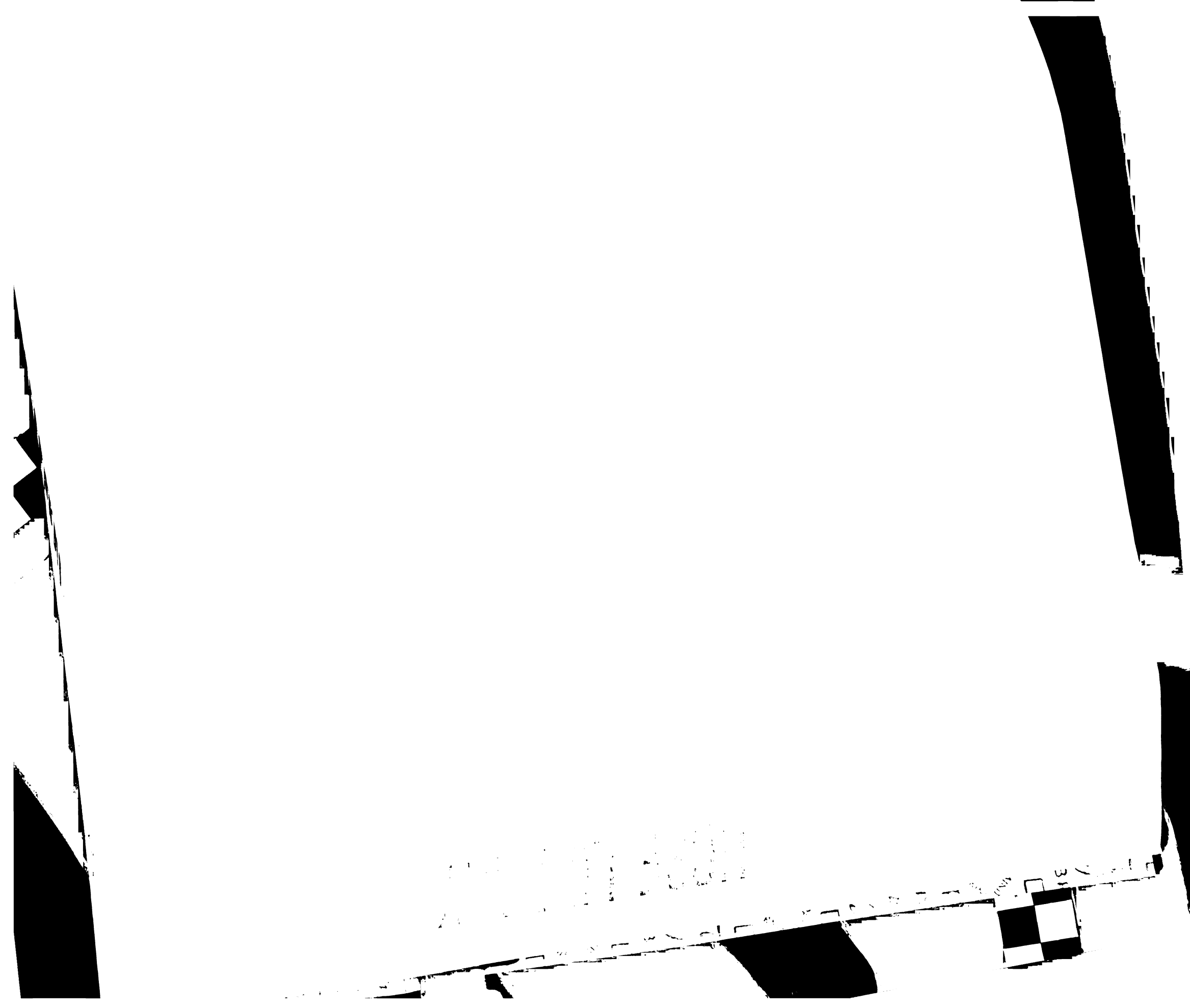
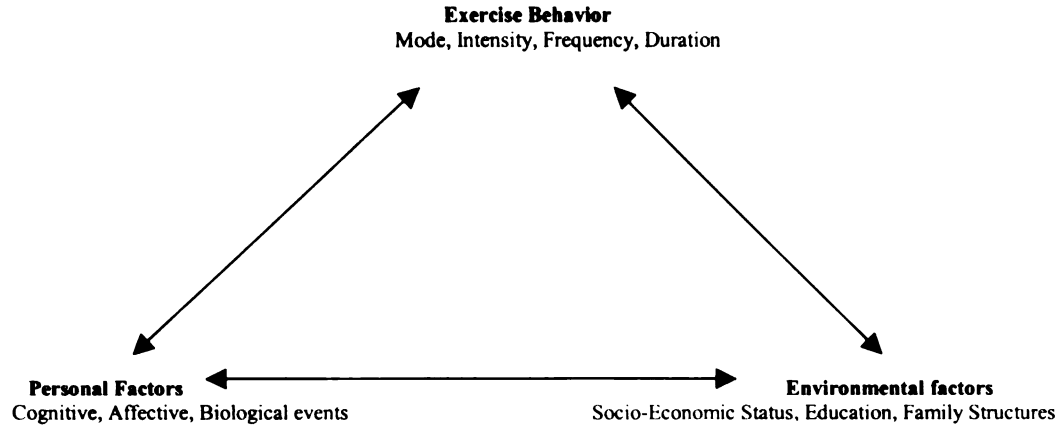


FIGURE 1: RECIPROCAL DETERMINISM IN SOCIAL COGNITIVE THEORY [1]



[1] derived from Bandura, A. (1997b). *Self-efficacy: The exercise of control*. New York: W. H. Freeman & Co., p. 6, used with permission

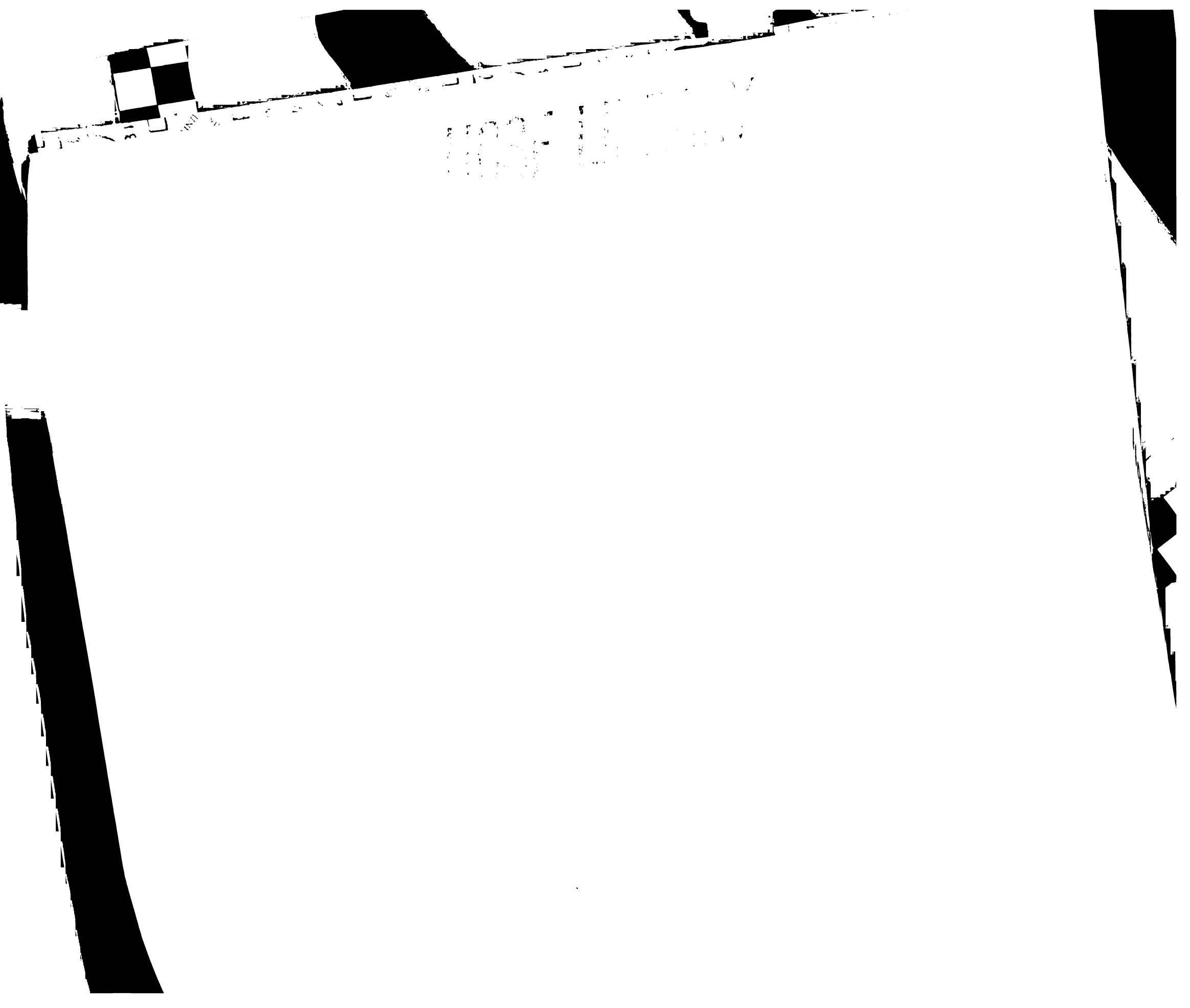
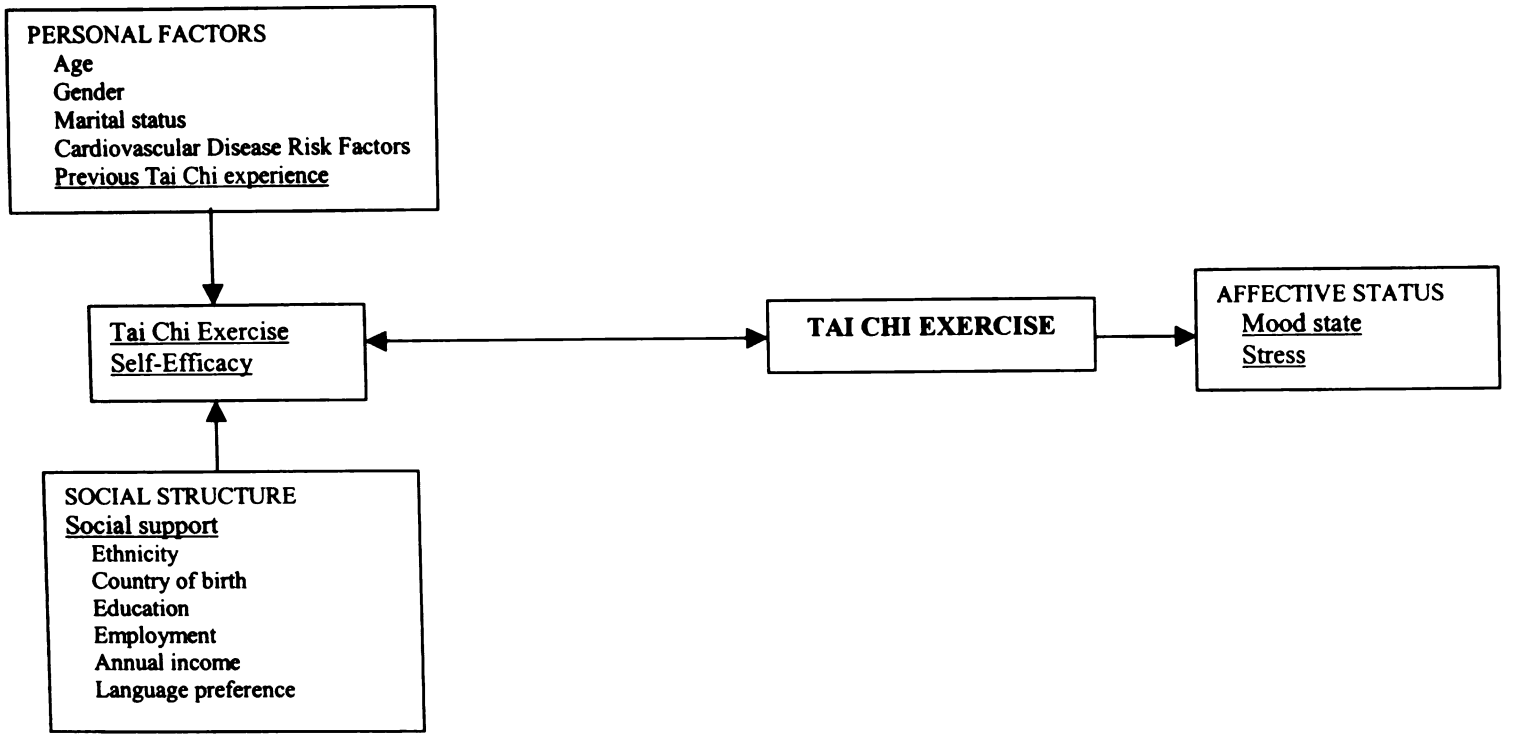


FIGURE 2: OUTCOMES AND PREDICTORS OF TAI CHI EXERCISE IN ADULTS WITH CARDIOVASCULAR DISEASE RISK FACTORS*



* only underlined variables examined

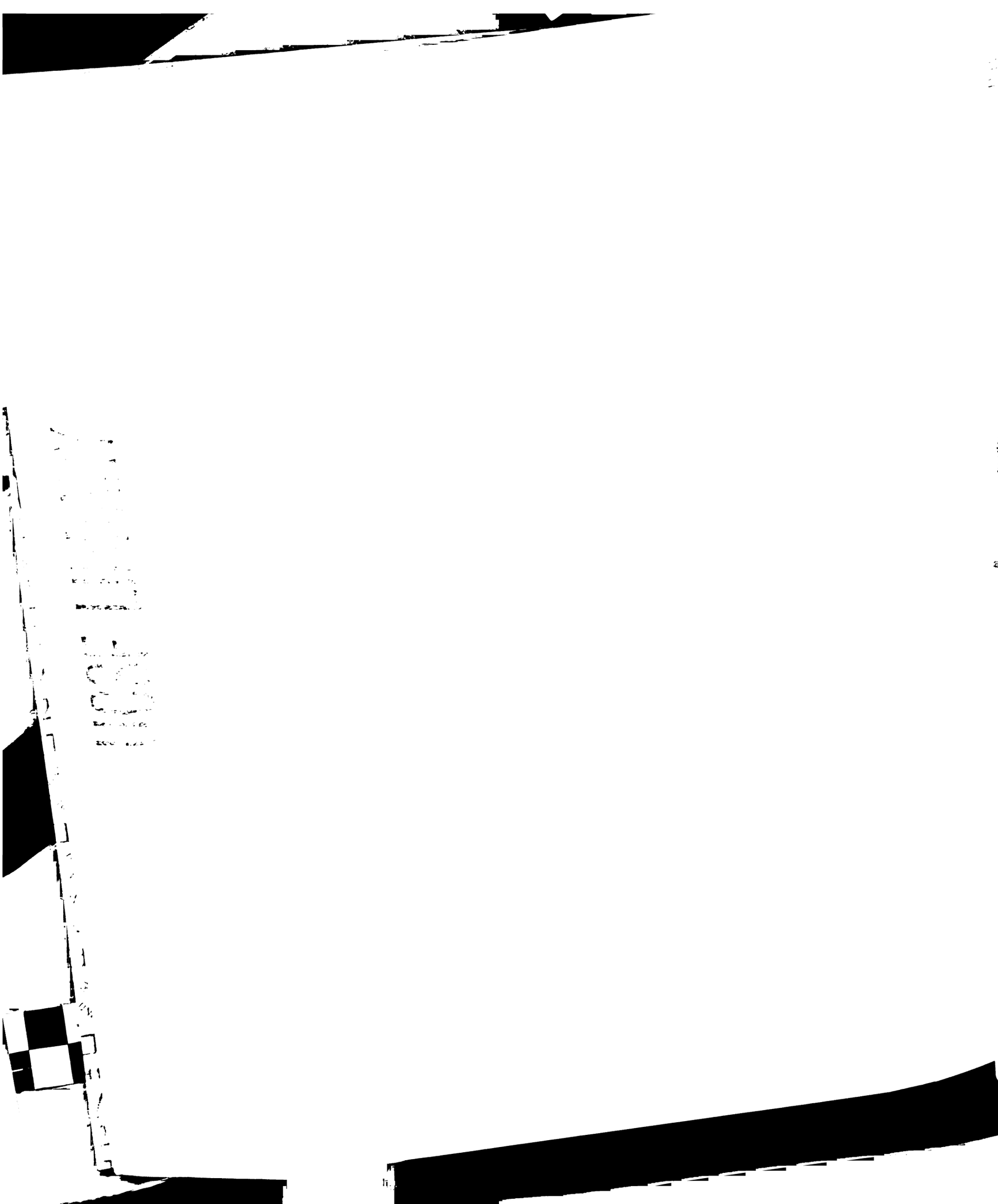
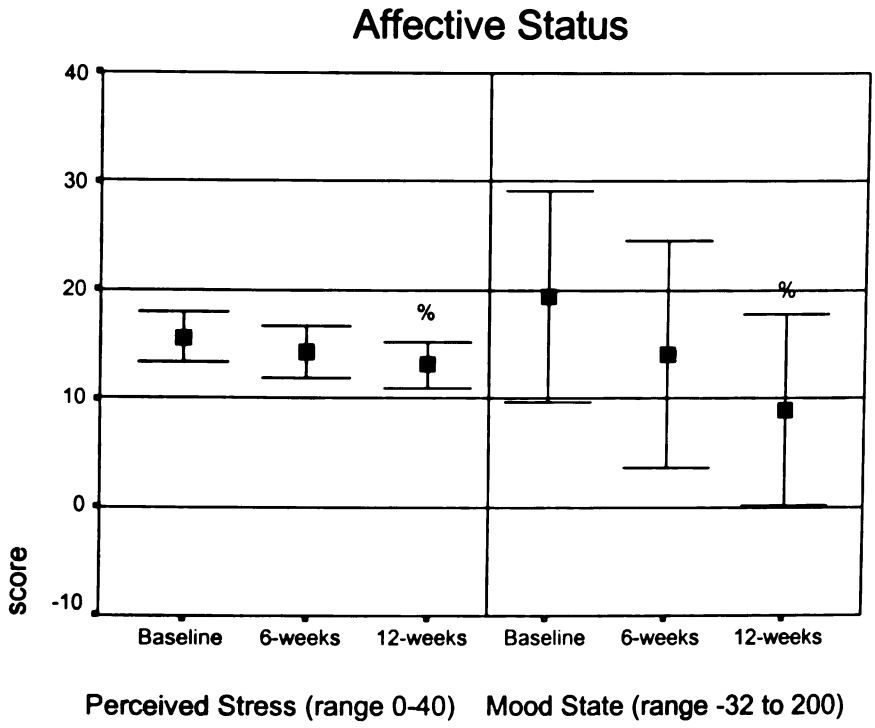
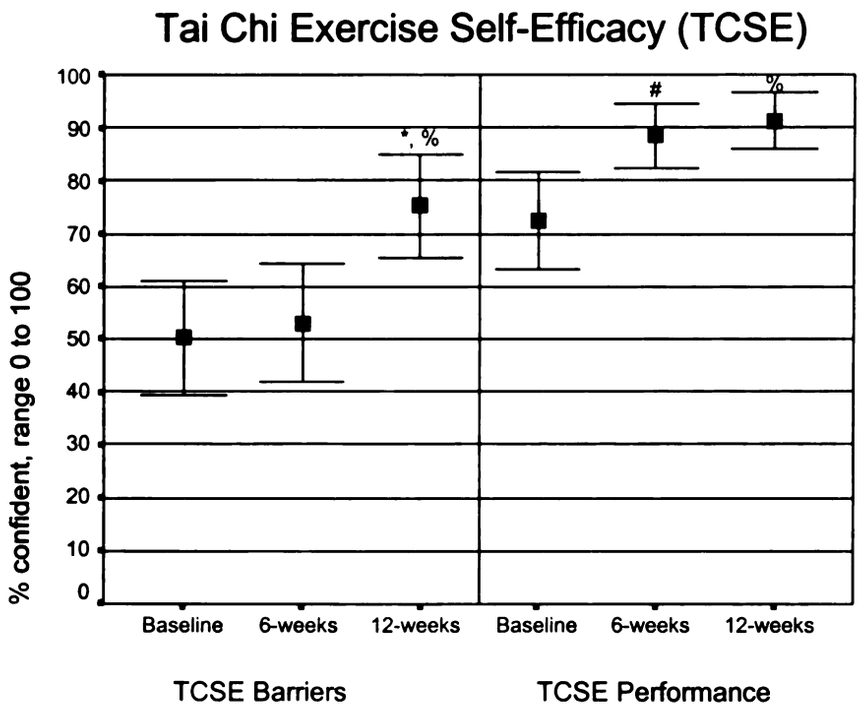


FIGURE 3: MEAN SCORES AND 95% CONFIDENCE INTERVALS OF PERCEIVED STRESS AND MOOD STATE, AT BASELINE, 6 AND 12-WEEKS



%Baseline vs. 12-weeks, $p<0.01$

FIGURE 4: MEAN SCORES AND 95% CONFIDENCE INTERVALS OF SELF-EFFICACY TO OVERCOME BARRIERS TO TAI CHI, AND SELF-EFFICACY TO PERFORM TAI CHI, AT BASELINE, 6 AND 12-WEEKS



TCSE Barriers= Self-Efficacy to overcome barriers to Tai Chi, TCSE Performance= Self-Efficacy to Perform Tai Chi , #Baseline vs. 6-weeks, $p<0.01$, *6-weeks vs. 12-weeks, $p<0.01$, %Baseline vs. 12-weeks, $p<0.01$

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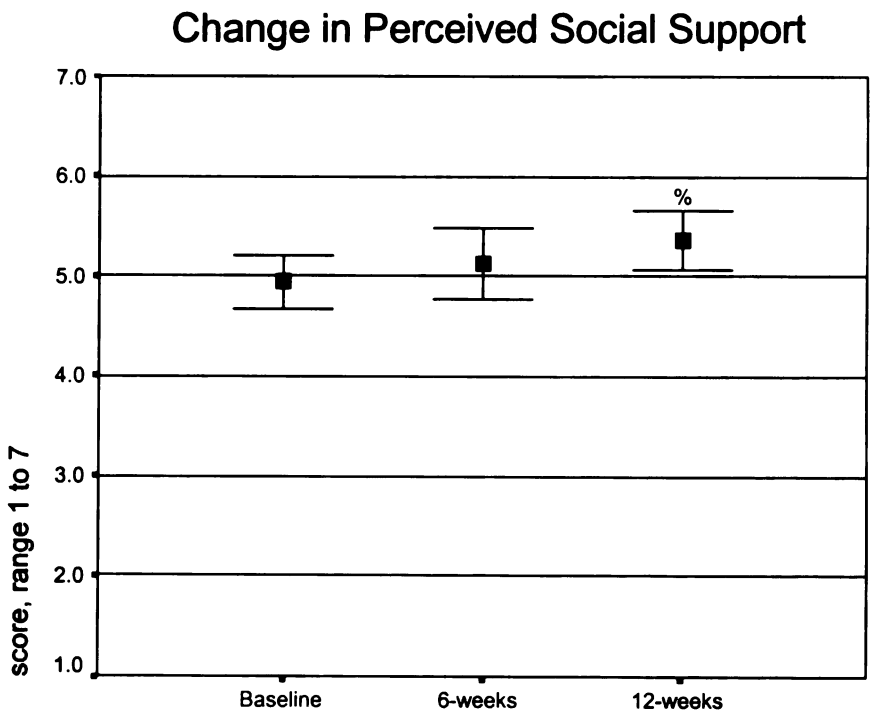
FIGURE 5: MEAN SCORES AND 95% CONFIDENCE INTERVALS OF PERCEIVED SOCIAL SUPPORT, AT BASELINE, 6 AND 12-WEEKS



%Baseline vs. 12-weeks, $p<0.01$

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