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Tai Chi Exercise in Medicine and Health Promotion

Guest Editors: Ching Lan, Steven L. Wolf, and William W. N. Tsang

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Editorial Board

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Editorial

Tai Chi Exercise in Medicine and Health Promotion

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1. Physical Activity and Health

The three major factors that influence our health and longevity are genetics, the environment, and behavior [1]. From the 1980s, the fast development of computer technology has significantly changed human's working environment, behavior, and lifestyle. Physical inactivity and obesity are prevalent worldwide, thus causing a major public health problem. According to the Global Health Observatory Report from the World Health Organization [2], insufficient physical activity is the 4th leading risk factor for mortality. People who are insufficiently physically active have an increased risk of 20% to 30% in all-cause mortality compared to people who engage in moderate intensity physical activity ≧30 minutes for most days of the week. Participation in 150 minutes of moderate physical activity a week or its equivalent is estimated to reduce the risk of ischemic heart disease by approximately 30%, the risk of diabetes by 27%, and the risk of breast and colon cancer by 21%–25% [2].

Traditional exercise training mainly focuses on the younger population and pursuing significant improvement of physical fitness. In the "graying" world, however, new exercise recommendations are needed for the senior population and many "apparently healthy" individuals who may have chronic diseases. Before the mid-1990s, physical activity guidelines recommended vigorous intensity exercise for at least 20 minutes continuously, 3 days a week, with the goal of improving physical fitness and body composition [3]. In 1995, the American College of Sports Medicine (ACSM) and US Centers for Disease Control and Prevention (CDC) [4] issued a landmark report on physical activity and health. The New guidelines recommended that "every adult should accumulate 30 minutes or more of moderate physical activity on most, preferably all, days of the week." Subsequently, the National Institute of Health [5] and the US Surgeon General [6] issued similar recommendations for physical activity and public health in 1996. These publications called attention to the health-related fitness of regular physical activity, and even moderate exercise intensity that did not meet traditional criteria for improving fitness may significantly improve health [5].

2. Principle of Exercise Prescription

A program of regular exercise that includes cardiorespiratory, resistance, flexibility, and neuromotor exercise training beyond activities of daily living to improve and maintain physical fitness and health is essential for most adults [7]. The ACSM recommends that most adults engage in moderate-intensity cardiorespiratory exercise training for ≥30 minutes per day on ≥5 days per week for a total of ≥150 minutes per week [8]. Additionally, adults should also perform resistance exercises for each of the major muscle groups and neuromotor exercise involving balance, agility, and coordination on 2-3 days per week [8]. Crucial to maintaining joint range of movement, completing a series of flexibility exercises for each of the major muscle-tendon groups on ≥2 days per week is also recommended [8]. The exercise program should be modified according to an individual's habitual physical activity, physical function, health status, exercise responses, and stated goals. Behaviorally based exercise interventions and exercise that is pleasant and enjoyable can improve adoption and adherence to prescribed exercise programs.

3. Ancient Wisdom of Exercise

The beneficial health effect of physical exercise has been known dating back to the 5th century BC, when Hippocrates said that "Even when all is known, the care of a man is not yet complete, because eating alone will not keep a man well, he must also take exercise. For food and exercise, while possessing opposite qualities, yet work together to produce health" [9]. In ancient China, the earliest medical book Huangdi Neijing (*Yellow Emperor's Book of Internal Medicine*) described the principle that human harmony with nature was important to prevent disease and was the key to longevity [10]. The ideas in the book have a basis in Chinese Taoist philosophy, and the key to a healthy life is to follow the Tao (e.g., the natural way of the universe). In 1974, the oldest diagram of Taoist exercise (Tao Yin) was excavated from the archeological site of Mawangdui (King Ma's tomb) of the Han Dynasty (206 BC–AD 220) in Changsha, China. Tao Yin is a series of exercises practiced by Taoists to cultivate the internal energy. Tai Chi Chuan is deeply rooted in Taoist philosophy and is well known for its slow and graceful movement. Tai Chi exercise has been practiced for centuries in the East for health promotion and longevity, and it has gained popularity in Western societies recently. During the practice, Tai Chi integrates deep diaphragmatic breathing into continuous body motions to achieve a harmonious balance between body and mind [11]. Tai Chi is performed in a semi squat posture, and the exercise intensity can be easily adjusted by controlling the postural height. The exercise intensity of Tai Chi appears low owing to the slow speed and gentle movements during exercise. The slow exercise speed associated with Tai Chi actually increases the load on the lower limbs in crouching posture, since the poses are held for a comparatively long time. Tai Chi participants with different ages thus can adjust the postural height and duration to achieve similar relative exercise intensity [12].

Tai Chi has several unique characteristics. First, the motions of Tai Chi are slow, harmonious, and relaxing. Second, Tai Chi is performed in a semi squatting posture at extremely slow speed. During the performance, various degrees of concentric and eccentric contraction are demanded for lower extremities [13]. Third, Tai Chi is an exercise with low impact, low velocity, and minimal orthopedic complications [14].

4. Tai Chi in Medicine and Health Promotion

In recent years, Tai Chi has become a popular exercise worldwide and research studies are flourishing. Research shows that Tai Chi may be helpful for health-related fitness and can be prescribed safely as a therapeutic exercise for patients with neurological disease, rheumatological disease, orthopedic disease, cardiopulmonary disease, and certain cancer. In this special issue, new evidence is provided by researchers in this field. W. W. N. Tsang and associates measured the reaction time and movement time during performing finger-pointing tasks for older individuals. The findings suggest that Tai Chi may slow down the aging effect on eye-hand coordination tasks involving choices that require more cognitive progressing. There are two studies that evaluated the effect of Tai Chi on breast cancer survivors. S. S. M. Fong and associates applied Tai Chi Qigong to breast cancer survivors and measured the isokinetic peak torques of the shoulder rotator muscles and quality of life. The result showed that greater shoulder muscular strength was significantly associated with better functional well-being in breast cancer survivors with TC Qigong training. In another study, J. L. W. Robins and associates used two stress management interventions (Tai Chi and spiritual growth) for women with breast cancer undergoing adjuvant chemotherapy. The results found that both interventions had insufficient power to overcome the psychosocial or physiological stress experienced during the chemotherapy treatment period. There are three articles that review the clinical applications of Tai Chi. B. Oh and associates reviewed the effect of Qigong on depression, and J. Wang and associates reviewed the effect of Tai Chi on hypertension. C. Lan and associates reviewed the health-promotion effect of Tai Chi and its applications in medicine.

From the perspective of exercise prescription, Tai Chi is a suitable conditioning exercise because the training characteristics fulfill the recommendations of the ACSM regarding exercise to develop and maintain cardiorespiratory function, muscular fitness, neuromotor agility, and flexibility [8]. Moreover, Tai Chi is a low technology approach to conditioning, which can be easily implemented in the community at a minimal cost. Although previous research suggested that Tai Chi has potential benefits for many clinical conditions, large randomized controlled trials with standardized Tai Chi training protocols are needed in future research.

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Ching Lan
Steven L. Wolf
William W. N. Tsang

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Review Article

Tai Chi Chuan in Medicine and Health Promotion

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Tai Chi Chuan (Tai Chi) is a Chinese traditional mind-body exercise and recently, it becomes popular worldwide. During the practice of Tai Chi, deep diaphragmatic breathing is integrated into body motions to achieve a harmonious balance between body and mind and to facilitate the flow of internal energy (Qi). Participants can choose to perform a complete set of Tai Chi or selected movements according to their needs. Previous research substantiates that Tai Chi has significant benefits to health promotion, and regularly practicing Tai Chi improves aerobic capacity, muscular strength, balance, health-related quality of life, and psychological well-being. Recent studies also prove that Tai Chi is safe and effective for patients with neurological diseases (e.g., stroke, Parkinson's disease, traumatic brain injury, multiple sclerosis, cognitive dysfunction), rheumatological disease (e.g., rheumatoid arthritis, ankylosing spondylitis, and fibromyalgia), orthopedic diseases (e.g., osteoarthritis, osteoporosis, low-back pain, and musculoskeletal disorder), cardiovascular diseases (e.g., acute myocardial infarction, coronary artery bypass grafting surgery, and heart failure), chronic obstructive pulmonary diseases, and breast cancers. Tai Chi is an aerobic exercise with mild-to-moderate intensity and is appropriate for implementation in the community. This paper reviews the existing literature on Tai Chi and introduces its health-promotion effect and the potential clinical applications.

The weak can overpower the strong; the flexible can overcome the rigid, the whole world can perceive this, but does not put it into practice. Tao Te Ching (Lao Tze).

1. Introduction

Tai Chi Chuan is a branch of Chinese martial arts and has developed since the 17th century in China. The slow, supple, and graceful movement of Tai Chi is rooted in Taoism. Taoism is an ancient Chinese philosophy and has been taught by Lao Tze in the 5th-4th century B.C. The Taoist doctrine is focused on mind tranquility, and its goal is to achieve longevity by meditation and lifestyle modification. In the process of development, Tai Chi differentiated into five main styles: Chen, Yang, Wu (Hao), Wu, and Sun [1]. Among them, Chen style is the oldest, while Yang style is the most popular. The classical Tai Chi styles consisted of complex forms, and they take long time to learn and practice. Therefore, many simplified Tai Chi forms were developed to shorten the learning period. Variations in training approaches result in significant differences in exercise intensity and training effect. Tai Chi is performed in a semisquat position (Figure 1), and the exercise intensity can be easily adjusted by controlling the speed and postural height. The characteristics of Tai Chi include (1) mind concentration with breathing control, (2) whole-body exercise in a semisquat posture, and (3) continuous, curved, and spiral body movements [1]. Tai Chi can be practiced alone or as a group exercise, and it has significant benefits for physical, emotional, and social functions. Participants may practice several Tai Chi movements instead of a whole set to achieve specific health benefits, such as flexibility and balance. However, if they want to enhance aerobic capacity or muscular strength, a complete set of classical Tai Chi is recommended. In the recent years, Tai Chi has become a

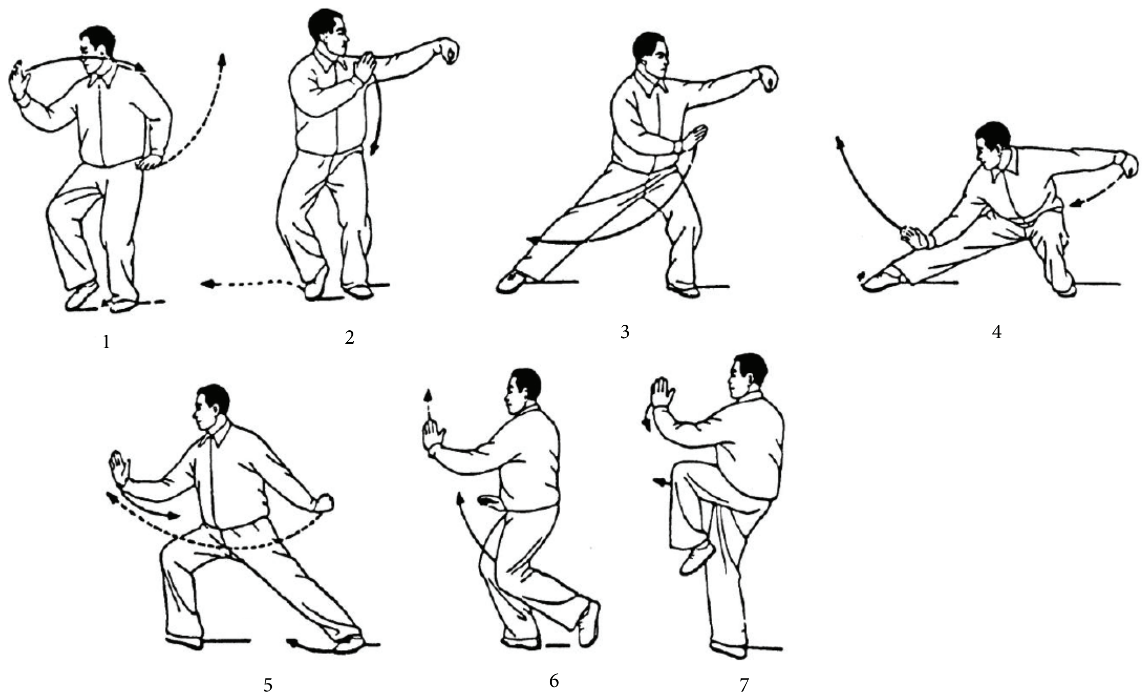

FIGURE 1: An example of a typical form of Tai Chi (push down and stand on one leg). The sequential motions are performed in a semi-squat posture. (From [1], with permission).

popular exercise worldwide, and researches are flourishing. The objective of this paper is to review the existing literature on Tai Chi and to introduce the characteristics of training (exercise intensity and biomechanical aspects), the effect on health promotion (aerobic capacity, muscular strength, balance, health-related quality of life and psychological well-being), and potential applications in medicine (e.g., neurological diseases, rheumatological diseases, orthopedic diseases, cardiopumonary diseases, and cancers).

2. Training Characteristics of Tai Chi

2.1. Exercise Intensity. The exercise intensity of Tai Chi depends on its training style, posture, and duration. Variations in training approaches result in substantial differences in exercise intensity. Lan and colleagues [2] have measured heart rate (HR) responses and oxygen uptake while performing classical Yang Tai Chi in middle-aged subjects. Figure 2 illustrates the heart rate response, and oxygen uptake ($\dot{V}O_2$) during the practice of Tai Chi. In the 24 minutes of practice, subjects' HR increased rapidly in the first 12 minutes and then increased slowly towards the end of the exercise. By contrast, subjects' $\dot{V}O_2$ showed a sharp increase in the first three minutes, and then it achieved a steady state towards the end of the exercise. In the steady state of Tai Chi practice, the average HR was 58% of the heart rate reserve (HRR), and the oxygen uptake was 55% of the peak oxygen uptake ($\dot{V}O_{2peak}$). HRR is the difference between maximum heart rate and resting heart rate. HRR is typically utilized to establish HR-based training zones according to the heart rate reserve method. The HRR method is demonstrated as follows: Target HR = $[(HR_{max} - HR_{rest}) \times \%$ intensity desired$] + HR_{rest}$. According to the recommendations of American College of Sports Medicine, moderate-intensity (40%–59% of HRR) aerobic exercise is recommended for most of the adults [3]. The HR during Tai Chi practice is 50%–58% of HRR in subjects aging from 25 to 80 years (Figure 3), which indicates that the exercise intensity is similar across different ages [4]. Previous studies reported that the energy cost during Tai Chi practice was between 3 and 6 metabolic equivalents (METs) depending on different styles and training requirements. Therefore, a suitable style of Tai Chi and selected movements can be chosen to fit participants' needs.

2.2. Biomechanical Aspects. Wu and Hitt [5] have examined the kinematics of Tai Chi gait (TCG) and normal gait by using a motion analysis system and biomechanical force plates. TCG had a low-impact force, an evenly distributed body weight between the fore-foot and the rear-foot, and a large medial-lateral displacement of the foot center of pressure (COP). The low-impact force may be attributed to the slow speed of Tai Chi and the coordinated muscular activities of the lower extremities. The activation duration of leg muscles, especially the knee extensors, is significantly affected by the speed of Tai Chi movement. Practicing Tai Chi at a different speed may alter the role of muscular function in movement control [6]. Additionally, the spatial, temporal, and neuromuscular activation patterns of TCG were different with normal gait. Compared with normal gait, Tai Chi gait had (1) a longer cycle duration, and duration of single-leg stance; (2) a larger joint motion in ankle dorsi/plantar flexion, knee flexion, hip flexion, and hip abduction; (3) a larger lateral body shift; and (4) a significant involvement of ankle

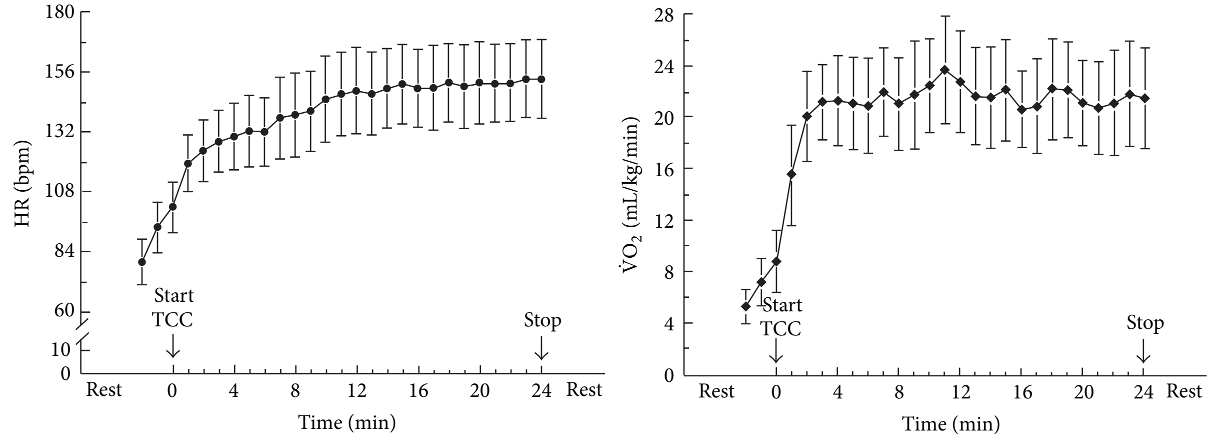

Figure 2: Heart rate response and oxygen uptake during the practice of classical Yang Tai Chi in middle-aged men (values are mean ± SD) [2].

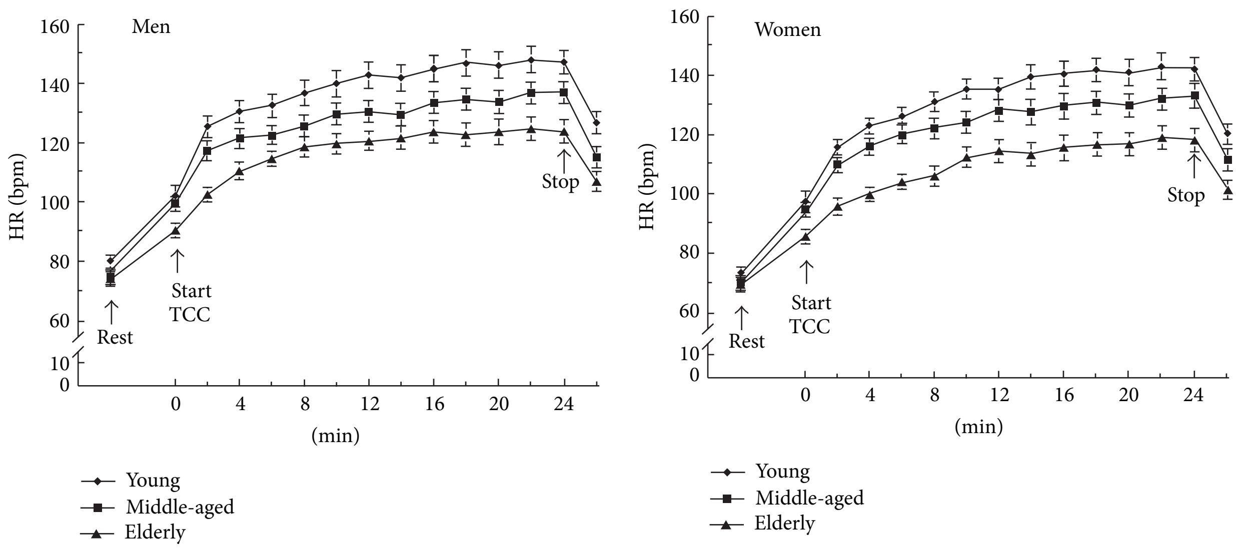

Figure 3: Heart rate responses of men and women during the practice of classical Yang Tai Chi in different age groups (⧫ young group, ■ middle-aged group, and ▲ elderly group; values are mean ± SE) [4].

dorsiflexors, knee extensors, hip flexors and abductors, longer isometric and eccentric actions, and longer coactivations of muscles [7]. Normal muscle activation patterns are characterized by activation and relaxation related to the agonist and antagonist muscle groups during a specific activity. Coactivation of muscle groups is a common strategy adopted to reduce strain and shear forces at the joint [8].

Age may affect the characteristics of Tai Chi performance. The elderly people practice Tai Chi in a higher posture because of muscle weakness or degeneration of knee joints [9]. Tai Chi gait has an increased shear force and frontal plane torque at lower extremity joints than normal gait, but the shear force at lower extremity joints during TCG is lower in the elderly subjects than in the young adults [10].

2.3. Cost. Tai Chi is a low-cost exercise because equipment and facility are not needed. In the Chinese community, most of the instructors are volunteer, and participants only need to pay minimum tuition fees. In the United States, a study [11] reported that the direct cost of a Tai Chi program was about $3.5 per person per session, and the cost was affordable for most participants. In Taiwan, a formal Tai Chi training course for novice participants usually costs $20–40 per month. In a recent review to evaluate the strategies to prevent falls among older people [12], Tai Chi was the most cost-effectiveness strategy to prevent falls.

3. Tai Chi for Health Promotion

3.1. Aerobic Capacity. The peak oxygen uptake is the best indicator for aerobic capacity and is the strongest predictor of the risk of death among normal subjects and patients with cardiovascular diseases [13]. In cross-sectional studies, Lan and colleagues [14] have reported that elderly Tai Chi practitioners showed 18%-19% higher in $\dot{V}O_{2peak}$ than their sedentary counterparts. Furthermore, long-term Tai Chi practitioners displayed slower age-related decline of aerobic capacity than sedentary individuals. In a five-year follow up study [15], the annual decrease of $\dot{V}O_{2peak}$ in the Tai Chi group was about 40% slower than in the sedentary control group. Lan and colleagues [16] also reported that the $\dot{V}O_{2peak}$ increased 16.1% and 21.3% after one year of Tai Chi training in older men and women, respectively. According to a recent meta-analysis [17], practice of Tai Chi may significantly improve aerobic capacity. Middle-aged and older women and men benefit the most, with greater gains seen among those initially sedentary.

3.2. Muscular Strength. Tai Chi is performed in the semisquat position, and various degrees of concentric and eccentric contractions are demanded in this unique posture. In the Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT) study [18], Tai Chi program might preserve the strength gains from a 3-month strength training program using instruments, and significant gains persisted after 6 months of Tai Chi.

Twelve to 24 weeks of Tai Chi exercise appears to be beneficial to muscular strength of lower extremities. Jacobson and colleagues [19] reported that the 12 subjects aging 20–45 years who performed 108-form Tai Chi three times per week for 12 weeks significantly increased the muscular strength of their knee extensors. Lan and colleagues [20] found that Tai Chi exercise enhanced strength of knee extensors at various angles. After 6 months of Yang Tai Chi training, men increased 13.5–24.2% of isokinetic strength in concentric contractions and increased 15.1%–23.8% in eccentric contractions. Wu and colleagues [21] also reported that Tai Chi participants had higher concentric and eccentric strengths of knee extensors and smaller foot center of pressure excursions in both eyes-open and eyes-closed conditions than the controls. The degree of knee flexion during single-leg stance of Tai Chi may be a key element for improving leg muscle strength [22]. In a recent study, Lu and colleagues [23] measured muscular strength of knee by isokinetic testing at 30°/s. The Tai Chi group demonstrated greater eccentric muscular strength in both knee extensors and flexors than the control group.

In elderly individuals, Li and colleagues [24] reported that a 16-week Tai Chi program increased 19.9% of muscular strength of the knee flexors, and there was a significant decrease in latency of semitendinosus muscle in the Tai Chi group. The prevention of falls depends on the timely initiation of an appropriate postural response. Tai Chi intervention significantly hastened the reaction time of the semitendinosus muscle, which may help older people maintain postural control. In a recent randomized trial, a 16-week Tai Chi program three sessions per week also induced a significant increase in eccentric knee extensor strength in senior female subjects [25].

3.3. Balance and Motor Control. Standing balance is a complex process that depends on the integration of mechanical, sensory, and motor processing strategies. The visual, proprioceptive, and vestibular systems are three sources of afferent information to influence the control of balance, which is termed "sensory organization" [26]. The sensory organization testing (SOT) can be used to identify problems with postural control by assessing the subject's ability to make effective use of visual, vestibular, and proprioceptive information.

During the performance of Tai Chi, weight shifting, body rotation, and single-leg standing in different positions are frequently practiced. Delicate joint control with muscle coordination is required during motions, and hence balance function may benefit from long-term practice of Tai Chi. In studies using simple balance tests (e.g., time duration in single-leg standing with eyes open or closed), older Tai Chi practitioners showed better postural control than sedentary subjects [27, 28]. In a study using computerized balance system, Tai Chi practitioners showed no difference compared to control group in simple conditions (such as postural sway in standing with eyes open or close) [29]. By contrast, Tai Chi participants showed better performance in complex conditions, such as eyes closed with sway surface, sway vision with sway surface, and forward-backward weight shifting test [29]. Many studies have demonstrated the advantages of Tai Chi on visual, proprioceptive, and vestibular functions, and they are described briefly below.

3.3.1. Visual System. In elderly people, Tai Chi participants had better postural stability at the more challenging condition of sway-referenced vision and support than the control group [29]. Tsang and colleagues [30] investigated elderly Tai Chi practitioners using the SOT and found that their visual ratio was higher than that of nonpractitioners, and even comparable with that of the young subjects. The results implied that long-term practice of Tai Chi improved balance control in the elderly population, and there was an increased reliance on the visual system during stance. Additionally, elderly Tai Chi practitioners attained the same level of balance control as young subjects when standing in reduced or conflicting sensory conditions. In a recent study, Chen and colleagues [31] investigated the effects of Tai Chi for elderly persons with visual impairment and found that the Tai Chi group showed significant improvements in visual and vestibular ratios compared with the control group.

3.3.2. Proprioceptive System. Tai Chi training puts a great emphasis on exact joint positions, and it may improve the sense of position of lower extremities. Wong et al. [32] and Tsang and Hui-Chan [33] examined the knee proprioception in elderly subjects by using the passive knee joint reposition test and found that Tai Chi practitioners had better knee joint proprioceptive acuity than control subjects. In another study, Tsang and Hui-Chan [34] reported that both Tai Chi practitioners and golfers had better knee joint proprioceptive acuity than the elderly control subjects, and it was similar to that of the young subjects. Similarly, Xu and colleagues [35] reported that Tai Chi participants not only showed better proprioception at the ankle and knee joints than the controls, but they also showed better ankle kinesthesis than swimmers/runners.

Training duration of Tai Chi may influence the accuracy of joint position sense. Fong and Ng [27] have compared long-term (practice for 1–3 years) and short-term (practice for 3 months) Tai Chi training for middle-aged and older individuals. The results showed that both long-term and short-term Tai Chi training improved joint position sense, but only long-term practice could enhance dynamic standing balance.

Tai Chi also improves proprioceptive function of upper extremities. Tai Chi practitioners focus specific mental attention on the body and upper extremities, which may facilitate tactile acuity and perceptual function. Previous study showed that Tai Chi training could increase shoulder kinesthetic sense and reduce movement force variability in manual aiming tasks. Recent study also found that Tai Chi practitioners attained significantly better eye-hand coordination in finger pointing than control subjects [36].

3.3.3. Vestibular System. Elderly Tai Chi practitioners had better maximal stability and average velocity than the controls under the condition of eyes closed and sway-referenced support (ECSS), which indicated improvement of balance function through vestibular mechanism [32, 37]. Practicing Tai Chi involves head movements and thus stimulates the vestibular system. Therefore, the elderly Tai Chi practitioners could attain a higher vestibular ratio than the controls under the condition of ECSS.

Patients with dizziness and balance disorders may get benefits from Tai Chi training. Hain and colleagues [38] reported that patients with dizziness who practiced 8 Tai Chi movements every day for at least 30 min showed significant improvements in the SOT and the Dizziness Handicap Inventory scores. McGibbon and colleagues [39] found that both Tai Chi and vestibular rehabilitation improved balance in patients with vestibulopathy, but through different mechanisms. Gaze stability is most improved in those who receive vestibular rehabilitation, but Tai Chi training improves whole-body stability and footfall stability without improving gaze stability. In a subsequent study [40], 36 older adults with vestibulopathy were assigned to a 10-week program of vestibular rehabilitation or Tai Chi exercise. The improvements of the Tai Chi group were associated with reorganized neuromuscular pattern in lower extremities, while the vestibular rehabilitation group only had better control of upper body motion to minimize loss of balance. In a recent study, MacIaszek and Osinski [41] assigned 42 older people with dizziness to either a Tai Chi group or a control group. The Tai Chi group practiced a 45-minute exercise twice weekly for 18 weeks and showed significant improvement in up to and go test, forward deflection, backward deflection, and the maximum sway area.

3.3.4. Prevention of Falls. Balance function begins to decline from middle age, deteriorates in older age, and increases the risk of fall and injury. Suitable exercise training may improve balance function and prevent accidental falls. Recent studies found that Tai Chi has favorable effects on balance function and falls prevention in the elderly. In the Atlanta subgroup of the clinical trial of FICSIT [42], a total of 200 participants were divided into three groups: Tai Chi, balance training, and education. After 15 weeks of training, the fear of falling responses were reduced in the Tai Chi group compared with the education group, and the Tai Chi group reduced the risk of multiple falls by 47.5%.

Li and colleagues [43] randomly assigned 256 sedentary community-dwelling elderly people to a Tai Chi group or a stretching control group. After 6 months of training, the Tai Chi group showed significantly fewer falls, lower proportions of fallers, and fewer injurious falls than the control group. The risk for multiple falls in the Tai Chi group was 55% lower than that in the control group. In another study, Voukelatos and colleagues [44] reported that 702 community-dwelling older people participated in a Tai Chi class for 16 weeks. The Tai Chi group showed less falls than the control group, and the hazard ratios of falls for the Tai Chi group were 0.72 and 0.67 at 16 weeks and 24 weeks, respectively.

Tai Chi and conventional balance training appear to have similar effects in falls prevention. Huang and colleagues [45] assigned 163 older adults to three interventions groups (education, Tai Chi, and education plus Tai Chi) and one control group. Over a five-month intervention, the education plus Tai Chi group showed a significant reduction in falls and the risk factors of falls. After a one-year follow up, participants who were receiving any one of the interventions showed a reduction in falls compared with the control group. In a recent study, Tousignant and colleagues [46] randomly assigned 152 elderly subjects to a 15-week Tai Chi exercise or conventional physical therapy, and the results showed that both interventions were effective in falls prevention, but Tai Chi showed a better protective effect compared with physical therapy. In a recent randomized trial [47], 684 community-dwelling older adults were assigned to 3 groups: Tai Chi once a week, Tai Chi twice a week, or a low-level exercise program control group for 20 weeks. Over the 17-month period, the rate of falls reduced similarly among the 3 groups (mean reduction of 58%). The results implied that multiple interventions could be used to prevent falls among older adults.

Although many studies have reported favorable effects of Tai Chi on balance and falls prevention, some studies did not find positive evidence. Woo and colleagues [48] randomized 90 men and 90 women into 3 groups (Tai Chi, resistance training, and control), and found no significant changes in balance, muscle strength, and flexibility for either exercise group compared with controls. Logghe and colleagues [49] applied Tai Chi to 269 community-dwelling elderly people with a high risk of falling. The intervention group received Tai Chi training one hour twice weekly for 13 weeks; the control group received usual care. After 12 months, the Tai Chi group did not display lower risk of falls than the control group.

A meta-analysis including 9 trials (2203 participants) reported that Tai Chi participants had significant improvements in fall rates (2 trials included) and static balance (2 trials included) compared with exercise controls [50]. Compared with nonexercise controls, however, no improvement was found for Tai Chi participants in fall rates (5 trials) or static balance (2 trials), but a significant improvement was found for fear of falling. In a recent meta-analysis, Leung and colleagues [51] reported that Tai Chi was effective in improving balance of older adults, but it may not be superior to other interventions. Although many Tai Chi studies reported positive effects on balance function, the training protocols varied among these studies. In future studies, large randomized trials using a standardized Tai Chi program are required to prove the effect of falls prevention.

3.4. Self-Report Physical Function and Quality of Life. Older Tai Chi participants report higher physical function than their sedentary counterparts. Li and colleagues [11] randomly assigned 94 elderly subjects to either a 6-month Tai Chi group (60 min exercise twice weekly) or a wait-list control group. After training, the Tai Chi group experienced significant improvements in all aspects of physical functioning. The Tai Chi group showed improvement in all 6 functional status measures ranging from daily activities such as walking and lifting to moderate-vigorous activities such as running. The results showed that Tai Chi might improve self-reported physical functioning limitations among physically inactive older individuals. In the Atlanta subgroup of the clinical trial of FICSIT [52], elderly subjects were randomly assigned to three groups (Tai Chi, balance training, or exercise education). After 4 months of training, only Tai Chi participants reported improvement in daily activities and overall life.

Tai Chi exercise programs can slow down the decline in health-related quality of life (ADL) among elderly persons. Dechamps and colleagues [53] randomly assigned 160 institutionalized elderly persons to a Tai Chi program (30 min, 4 times/wk), a cognition-action program (30–45 min, 2 times/wk), or a usual-care control group. After 12 months, the Tai Chi and cognition-action groups showed a lesser decline in ADL than the control group. Walking ability and continence were maintained better in the intervention groups than in the control group. The total Neuropsychiatric Inventory score worsened significantly in the control group, while it was unchanged or improved in the intervention groups.

3.5. Psychological Well-Being. Jin [54] reported that Tai Chi practitioners had increased noradrenaline excretion in urine and decreased salivary cortisol concentration. The increase in urine noradrenaline indicated that the sympathetic nervous system is moderately activated during the Tai Chi practice. The decrease in salivary cortisol concentration denoted that Tai Chi is a low-intensity exercise and has similar effects of meditation. The results implied that Tai Chi could reduce tension, depression, and anxiety, and the stress-reduction effect of Tai Chi was similar to walking at speed of 6 km/hr [55]. It is also reported that a 16-week Tai Chi program could reduce mood disturbance and improve general mood in women [56]. For subjects with cardiovascular risk factors, Taylor-Piliae and colleagues [57] have reported that a 60-minute Tai Chi class 3 times weekly for 12 weeks might improve mood state, reduction in anxiety, anger-tension, and perceived stress.

Wang and colleagues [58] reviewed the effect of Tai Chi on psychological profile in 40 studies including 3817 subjects. Twenty-one of 33 randomized and nonrandomized trials reported that regular practice of Tai Chi improved psychological well-being including reduction of stress, anxiety, and depression and enhanced mood. Seven observational studies also demonstrated beneficial effects on psychological health. Jimenez and colleagues [59] reviewed 35 Tai Chi intervention articles in various populations and reported that Tai Chi might provide health benefits to psychological function. In those studies, 9 out of 11 studies confirmed significant improvements in mood and depressive symptoms, 7 out of 8 studies showed reduction in anger and tension, and 6 out of 10 studies displayed improvements in anxiety reduction.

Tai Chi can be applied in patients with depression. In a recent study, Yeung and colleagues [60] randomly assigned 39 patients with major depressive disorders to a 12-week Tai Chi intervention or a wait-list control group. Compared with the control group, the results showed trends toward improvement in positive treatment-response rate and remission rate in the Tai Chi group.

4. Application of Tai Chi in Medicine

An optimal exercise program for adults should address the health-related physical fitness components of cardiorespiratory (aerobic) fitness, muscular strength and endurance, flexibility, body composition, and neuromotor fitness [61]. Previous research suggests that Tai Chi may improve health-related fitness and psychosocial function. Additionally, Tai Chi includes the warm-up and cool-down, stretching exercises, and gradual progression of volume and intensity, and it seems to be helpful to reduce muscular injury and complications. The discussion below will focus on the clinical application in patients with neurological diseases, rheumatological diseases, orthopedic diseases, cardiopumonary diseases and cancers.

5. Tai Chi for Neurological Disease

5.1. Stroke. It is estimated that 15 million people experience a stroke worldwide each year. In the United States, about 795,000 people experience a new or a recurrent stroke (ischemic or hemorrhagic) each year [62]. Stroke results in a significant decrease in quality of life, which is determined not only by the neurological deficits but also by impairment of cognitive function. In a recent meta-analysis, Stoller and colleagues [63] reported that stroke patients benefited from exercise by improving peak oxygen uptake and walking distance. Stroke patients usually have impaired balance and motor function; thus, Tai Chi exercise may have potential benefits in stroke rehabilitation.

Hart and colleagues [64] assigned 18 community-dwelling stroke patients to a Tai Chi group or a control group. The study group practiced Tai Chi one hour twice weekly for 12 weeks, while the control group received conventional physical therapy. After training, the Tai Chi group showed improvement in social and general functioning, whereas the control group showed improvement in balance and speed of walking. The results implied that physical therapy should be served as a main treatment program for stroke patients, but Tai Chi can be used as an alternative exercise program.

Balance and motor skills in everyday life may benefit when stroke survivors do Tai Chi exercises. Au-Yeung and colleagues [65] randomly assigned 136 stroke patients to a Tai Chi group or a control group practicing general exercises. The Tai Chi group practiced 12 short forms of Tai Chi for 12 weeks. After training, the Tai Chi group showed greater excursion in the center of gravity (COG) amplitude in leaning forward, backward, and toward the affected and nonaffected sides, as well as faster reaction time in moving the COG toward the nonaffected side. The result indicated that Tai Chi training improved standing balance in patients with stroke.

Tai Chi also shows benefits to the psychological function. Wang and colleagues [66] randomly assigned 34 patients with stroke to Tai Chi exercise or conventional rehabilitation in group sessions once a week for 12 weeks. After training, the Tai Chi group had improvement for sleep quality, general health score, anxiety/insomnia score, and depression score. In a recent study, Taylor-Piliae and Coull [67] recruited 28 stroke patients to participate in a community-based Yang Tai Chi training program. Patients practiced Tai Chi ≥150 minutes/week for 12 weeks. The results showed good satisfaction, and the adherence rates were high (≥92%). There were no falls or other adverse events in the training period. Tai Chi appears to be safe and can be considered as a community-based exercise program for stroke patients.

5.2. Parkinson's Disease. Impaired mobility is common among patients with Parkinson's disease (PD). Normal sensorimotor agility and dynamic control are required to maintain balance during motor and cognitive tasks. Gait changes include difficulty in initiating steps, shuffling, and freezing of gait and they are common in patients with PD. Balance difficulties are also prominent during turning and backward walking, and thus patients with PD have high risk of falls [68]. Tai Chi can improve balance, kinesthetic sense, and strength, and hence it may be prescribed as a sensorimotor agility program for patients with PD.

Li and colleagues [69] designed a Tai Chi program for 17 community-dwelling patients with mild-to-moderate idiopathic PD. Patients participated in a 5-day, 90 min/day training program. At the end of this intervention, the program was well received by all participants with respect to participant satisfaction, enjoyment, and intentions to continue. Furthermore, a significant improvement was observed in 50 ft speed walk, timed up-and-go, and functional reach. The results of this pilot study suggested that even a 5-day Tai Chi program was effective for improving physical function in patients with PD.

In another study [70], 33 patients with PD were randomly assigned to a Tai Chi group or a control group. The Tai Chi group participated in 20 training sessions within 10–13 weeks. After training, the Tai Chi group improved more than the control group on the Berg Balance Scale, the Unified Parkinson's Disease Rating Scale, the timed up-and-go, the tandem stance test, the 6-minute walk, and the backward walking. In a recent study, Li and colleagues [71] randomly assigned 195 patients with PD to one of three groups: Tai Chi, resistance training, or stretching. All patients participated in 60-minute exercise sessions twice weekly for 24 weeks. After training, the Tai Chi group performed better than the other two groups in maximum excursion and in directional control. The Tai Chi group also performed better in strength, functional reach, timed up-and-go, motor scores, and number of falls than the stretching group. Additionally, the Tai Chi group outperformed the resistance-training group in stride length and functional reach. This study revealed that Tai Chi could reduce balance impairments in patients with PD, with improved functional capacity and reduced falls. Tai Chi appears to be a safe and effective exercise for patients with mild-to-moderate PD.

5.3. Traumatic Brain Injury. Traumatic brain injury (TBI) is a common disease in the young male population. However, the outcome is disappointing in severely injured patients. Exercise therapy for patients with TBI may improve the motor function and independence.

Shapira and colleagues [72] reported the application of long-term Tai Chi training in 3 patients with severe TBI. After 2 to 4 years of training, all patients can walk without assistance, rarely fall, and feel more secure while walking. One patient can lead independent daily activities and even return to car driving.

To explore the effects of short-term Tai Chi training in patients with TBI, Gemmell and Leathem [73] assigned 18 patients with TBI to a Tai Chi group (a 6-week course) or a control group. The results showed that Tai Chi was associated with significant improvement on all Visual Analogue Mood Scales scores with decreases in sadness, confusion, anger, tension, and fear and with increases in energy and happiness. However, there were no significant between-group differences in the Medical Outcome Study 36-Item Short-Form Health Survey (SF-36) and Rosenberg Self-Esteem Scale. Recently, Blake and Batson [74] examined the effects of a short-term (eight weeks) Tai Chi Qigong program on 20 patients with TBI. Intervention participants attended a Tai Chi Qigong program for one hour per week, while control participants engaged in nonexercise-based social and leisure activities. After the intervention, mood and self-esteem were improved in the Tai Chi group when compared with controls. There were no significant differences in physical functioning between groups.

5.4. Multiple Sclerosis. Husted and colleagues [75] reported that 19 patients with multiple sclerosis participated in an 8-week Tai Chi program. After training, walking speed increased in 21%, and hamstring flexibility increased in 28%. The results may be attributed to the effect of neuromuscular facilitation during Tai Chi practice.

6. Tai Chi for Rheumatological Disease

There are more than 21% of adults in the United States living with rheumatological diseases, conditions that affect the joints and bones and cause chronic joint pain, swelling, and stiffness [76]. Studies have shown that patients with rheumatological diseases can benefit from Tai Chi exercise. Although Tai Chi is performed in a semisquat posture, joint pain can be prevented because most motions of Tai Chi are performed in a closed kinematic chain and in very slow speed [20]. However, patients with arthropathy should perform Tai Chi in high-squat posture to prevent excessive stress on lower extremities. In a recent review, Tai Chi may modulate complex factors and improve health outcomes in patients with rheumatologic conditions. Tai Chi can be recommended to patients with rheumatoid arthritis, osteoarthritis, and fibromyalgia, as an alternative approach to improve patient's well-being [77].

6.1. Rheumatoid Arthritis. Rheumatoid arthritis (RA) is a chronic, inflammatory, and systemic disease which affects the musculoskeletal system. In a Cochrane database systemic review including 4 trials and 206 patients with RA [78], Tai Chi does not exacerbate symptoms of RA. In addition, Tai Chi has significant benefits to lower extremity range of motion for patients with RA.

Recently, two studies reported the benefits of Tai Chi for patients with RA. Wang [79] randomly assigned 20 patients with functional class I or II RA to Tai Chi or attention control group. After 12 weeks of training, half of patients in the Tai Chi group achieved a 20% response of the American College of Rheumatology, but no patient in the control group showed improvement. The Tai Chi group had greater improvement in the disability index, the vitality subscale of the SF-36, and the depression index. Similar trends to improvement for disease activity, functional capacity and health-related quality of life were also observed. In another study [80], 15 patients with RA were instructed on Tai Chi exercise twice weekly for 12 weeks. The result showed that the Tai Chi group improved lower-limb muscle function at the end of the training and at 12 weeks of follow up. Patients also experienced improved physical condition, confidence in moving, balance, and less pain during exercise and in daily life. Others experienced stress reduction, increased body awareness, and confidence in moving. These studies indicated that Tai Chi was a feasible exercise modality for patients with RA.

6.2. Ankylosing Spondylitis. Ankylosing spondylitis (AS) is a chronic inflammatory disease of the axial skeleton with variable involvement of peripheral joints and nonarticular structures. In a recent study [81], Lee and colleagues assigned 40 patients with AS to Tai Chi or control group. The Tai Chi group performed 60 min of Tai Chi twice weekly for eight weeks followed by 8 weeks of home-based Tai Chi. After training, the Tai Chi group showed significant improvement in disease activity and flexibility compared with the control group, and no adverse effects associated with the practice of Tai Chi were reported by the participants.

6.3. Fibromyalgia. Fibromyalgia syndrome is a chronic condition characterized by widespread pain, multiple tender points, nonrestorative sleep, fatigue, cognitive dysfunction, complex somatic symptoms, and poor quality of life [82]. Exercise showed some benefits in the treatment of patients with fibromyalgia. An important study of Tai Chi on fibromyalgia was reported by Wang and colleagues [83]. In this trial, 66 patients with fibromyalgia were randomly assigned to a Tai Chi group or a group that attended wellness education and stretching program. Each session lasted for 60 minutes twice weekly for 12 weeks. After training, the Tai Chi group displayed improvements in the Fibromyalgia Impact Questionnaire (FIQ) total score and SF-36. The SF-36 physical component scores and mental component scores were significantly improved compared with the control group. This study proved that patients with fibromyalgia benefited from Tai Chi training, with no adverse effects.

Jones and colleagues [84] conducted a randomized controlled trial and assigned 101 patients with fibromyalgia to Tai Chi or education group. The Tai Chi participants practiced modified 8-form Yang-style Tai Chi 90 minutes twice weekly for over 12 weeks. After training, the Tai Chi group demonstrated significant improvements in FIQ scores, pain severity, pain interference, sleep, and self-efficacy for pain control compared with the education group. Functional mobility variables including timed up-and-go, static balance, and dynamic balance were also improved in the Tai Chi group. Tai Chi appears to be a safe and acceptable exercise modality for patients with fibromyalgia.

In a recent study, Romero-Zurita and colleagues [85] reported the effects of Tai Chi training in women with fibromyalgia. Thirty-two women with fibromyalgia attended Tai Chi intervention 3 sessions weekly for 28 weeks. After training, patients improved in pain threshold, total number of tender points, and algometer score. Patients also showed improvement in the 6 min walk, back scratching, handgrip strength, chair stand, chair sit & reach, 8-feet up-and-go, and blind flamingo tests. Additionally, the Tai Chi group improved in the total score and six subscales of FIQ: stiffness, pain, fatigue, morning tiredness, anxiety, and depression. Finally, patients also showed improvement in six subscales in SF-36: bodily pain, vitality, physical functioning, physical role, general health, and mental health.

7. Tai Chi for Orthopedic Disease

7.1. Osteoarthritis. Patients with osteoarthritis (OA) show benefits from 6–20 weeks of Tai Chi training. The first randomized trial of Tai Chi and osteoarthritis was conducted by Hartman and colleagues [86]. In this study, 33 older patients with lower extremity OA were assigned to Tai Chi or control group. Tai Chi training included two 1-hour Tai Chi classes per week for 12 weeks. After training, Tai Chi participants experienced significant improvements in self-efficacy for arthritis symptoms, total arthritis self-efficacy, level of tension, and satisfaction with general health status.

Song and colleagues [87] randomly assigned 72 patients with OA to a Tai Chi group or a control group. The Tai Chi group practiced Sun-style Tai Chi for 12 weeks. After training, the Tai Chi group perceived significantly less joint pain and stiffness and reported fewer perceived difficulties in physical functioning, while the control group showed no change or even deterioration in physical functioning. The Tai Chi group also displayed significant improvement in balance and abdominal muscle strength. In a subsequent study, Song and colleagues [88] reported that Tai Chi could improve knee extensor endurance, bone mineral density in the neck of the proximal femur, Ward's triangle, and trochanter and reduce fear of falling in women with OA.

Brismée and colleagues [89] reported a randomized controlled trial including 41 elderly patients with OA. Patients were assigned to a Tai Chi or an attention control group. The Tai Chi group participated in six-week Tai Chi sessions, 40 min/session, three times a week, followed by another six weeks of home-based Tai Chi training, and then a six-week follow up detraining period. Subjects in the attention control group attended six weeks of health lectures, followed by 12 weeks of no activity. After six weeks of training, the Tai Chi group showed significant improvements in overall knee pain, maximum knee pain, and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) subscales of physical function and stiffness compared with the baseline. The Tai Chi group reported lower overall pain and better WOMAC physical function than the attention control group, but all improvements disappeared after detraining. The result implies that a short-term Tai Chi program is beneficial for patients with OA, but long-term practice is needed to maintain the therapeutic effect.

Fransen and colleagues [90] randomly assigned 152 older persons with chronic hip or knee OA to hydrotherapy classes, Tai Chi classes, or a wait-list control group. After 12 weeks of training, both the hydrotherapy group and the Tai Chi group demonstrated improvements for pain, and physical function scores and achieved improvements in the 12-Item Short From Health Survey (SF-12) physical component summary score. This study revealed that Tai Chi and hydrotherapy can provide similar benefits to patients with chronic hip or knee OA.

In a randomized controlled trial conducted by Wang and colleagues [91], 40 patients with OA were assigned to Tai Chi group or attention control group. The Tai Chi group practiced 10 modified Yang Tai Chi postures twice weekly for 12 weeks. After training, the Tai Chi group significantly improved in WOMAC pain, WOMAC physical function, patient and physician global visual analog scale, chair stand time, Center for Epidemiologic Studies Depression Scale, self-efficacy score, and SF-36 physical component summary. The result showed that Tai Chi reduces pain and improves physical function, self-efficacy, depression and health-related quality of life for patients with knee OA.

In a recent randomized controlled study [92], 58 community-dwelling elderly patients with knee OA and cognitive impairment were assigned to a Tai Chi (20-week program) or a control group. After training, the Tai Chi group showed significant improvement in WOMAC pain, physical function, and stiffness score than the control group. The result showed that practicing Tai Chi was effective in reducing pain and stiffness in patients with knee OA and cognitive impairment.

Tai Chi is also beneficial to gait kinematics for the elderly with knee OA. Shen and colleagues [93] applied Tai Chi on 40 patients with knee OA. Patients participated in 6-week Tai Chi training (1 hour/session, 2 sessions/week). After 6 weeks of Tai Chi exercise, patient's stride length, stride frequency, and gait speed were significantly increased, and knee pain was decreased.

7.2. Osteoporosis. Osteoporosis is the most common metabolic bone disorder, and it is estimated that 44 million individuals in the United States over the age of 50 years have osteoporosis or low bone mass [94]. Exercise is an effective therapy to prevent or delay the development of osteoporosis. Qin and colleagues [95] reported that Tai Chi participants had significantly higher bone mineral density (BMD) than the controls in the lumbar spine, the proximal femur, and the ultradistal tibia. The follow up measurements showed generalized bone loss in both groups, but the quantitative computed tomography revealed significantly reduced rate of bone loss in trabecular BMD of the ultradistal tibia and of the cortical BMD of the distal tibial diaphysis. In a subsequent study, Chan and colleagues [96] randomly assigned 132 healthy postmenopausal women to Tai Chi or sedentary control group. The Tai Chi group practiced Tai Chi 45 minutes a day, 5 days a week for 12 months. At 12 months of training, BMD measurements revealed a general bone loss in both Tai Chi and control subjects at lumbar spine, proximal femur, and distal tibia, but with a slower rate in the Tai Chi group. A significant 2.6- to 3.6-fold retardation of bone loss was found in both trabecular and cortical compartments of the distal tibia in the Tai Chi group as compared with the controls.

In a recent trial, Wayne and colleagues [97] reported the application of Tai Chi in 86 postmenopausal osteopenic women aging 45–70 years. Women were assigned to either 9 months of Tai Chi training plus usual care or usual care alone. Protocol analyses of femoral neck BMD changes were significantly different between Tai Chi and usual care-group. Changes in bone formation markers and physical domains of quality of life were more favorable in the Tai Chi group.

7.3. Low-Back Pain. Chronic low-back pain (LBP) is prevalent in the general population, and exercise therapy is among the effective interventions showing small-to-moderate effects for patients with LBP. In a recent randomized trial [98], 160 volunteers with chronic LBP were assigned either to a Tai Chi group or to a wait-list control group. The Tai Chi group participated in 18 training sessions (40 minutes per session over a 10-week period), and the wait-list control group continued with usual healthcare. After training, the Tai Chi group reduced bothersomeness of back symptoms by 1.7 points on a 0–10 scale, reduced pain intensity by 1.3 points on a 0–10 scale, and improved self-report disability by 2.6 points on the 0–24 Roland-Morris Disability Questionnaire scale. Though the improvements were modest and most of the patients were not "completely recovered", the results showed that a 10-week Tai Chi program provides benefits for pain reduction considered clinically worthwhile for those experiencing chronic LBP.

7.4. Musculoskeletal Disorder. Musculoskeletal disorder is a leading cause of work disability and productivity losses in industrialized nations. Tai Chi can be used as a simple, convenient workplace intervention that may promote musculoskeletal health without special equipment. A recent study applied Tai Chi to female computer users [99], and 52 subjects participated in a 50-minute Tai Chi class per week for 12 weeks. The results showed significant improvement in heart rate, waist circumference, and hand-grip strength. It implied that Tai Chi was effective in improving musculoskeletal fitness.

In chronic muscular pain, such as tension headache, Tai Chi also shows some benefits. Abbott and colleagues [100] randomly assigned 47 patients with tension headache to either a 15-week Tai Chi program or a wait-list control group. The SF-36 and headache status were obtained at baseline and at 5, 10, and 15 weeks during the intervention period. After training, the results revealed significant improvements in favor of Tai Chi intervention for the headache status score and the subsets of health-related quality of life, including pain, energy/fatigue, social functioning, emotional well-being, and mental health summary scores.

8. Tai Chi for Cardiovascular Disease

In the United States, the relative rate of death attributable to cardiovascular disease (CVD) declined by 32.7% from 1999 to 2009; however, CVD still accounted for 32.3% of all deaths in 2009 [62]. Exercise training is the core component of cardiac rehabilitation (CR) for patients with coronary heart disease (CHD). Tai Chi may be used in CR programs because its exercise intensity is low to moderate, and it can be easily implemented in communities. In a recent study, Taylor-Piliae and colleagues [101] reported a study that included 51 cardiac patients who participated in an outpatient CR program. Patients were assigned to attend a group practicing Tai Chi plus CR or a group to attend CR only. After rehabilitation, subjects attending Tai Chi plus CR had better balance, perceived physical health, and Tai Chi self-efficacy compared with those attending CR only.

8.1. Cardiovascular Risk Factors

8.1.1. Hypertension. Hypertension is the most prevalent form of CVD affecting approximately 1 billion patients worldwide. In the United States, about one in three adults has hypertension [62]. Hypertension is a major risk factor for coronary artery disease, heart failure, stroke, and peripheral vascular disease. Regular exercise and lifestyle change are the core of current recommendations for prevention and treatment of hypertension. Systemic review of randomized clinical trials indicated that aerobic exercise significantly reduced BP, and the reduction appears to be more pronounced in hypertensive subjects [102, 103].

Previous studies have shown that 6- to 12-week Tai Chi training programs might decrease systolic and diastolic BP at rest or after exercise, and hypertensive patients exhibit the most favorable improvement [104–108]. In a recent systemic review, Yeh and colleagues [109] analyzed 26 studies and found positive effect of Tai Chi on blood pressure. In patients with hypertension, studies showed that Tai Chi training might decrease systolic BP (range: −7 to −32 mm Hg) and diastolic BP (−2.4 to −18 mm Hg). In studies for noncardiovascular populations or healthy patients, the decreases ranged from −4 to −18 mm Hg in systolic BP and from −2.3 to −7.5 mm Hg in diastolic BP. For patients with acute myocardial infarction (AMI), both Tai Chi and aerobic exercise were associated with significant reductions in systolic BP, but diastolic BP was decreased in the Tai Chi group only.

8.1.2. Diabetes Mellitus. Diabetes mellitus is a fast growing risk factor for cardiovascular disease. Estimated 19.7 million American adults have diabetes, and the prevalence of prediabetes in the US adult population is 38% [62]. Previous studies have shown that exercise has benefits for those who have diabetes or impaired glucose tolerance [110–112]. In the Da Qing Diabetes Prevention Study [113] for people with impaired glucose tolerance, lifestyle intervention groups (diet and exercise) displayed a 43% lower incidence of diabetes than the control group over the 20-year follow up period.

Several studies have shown the benefits of Tai Chi for diabetic patients. In a pilot study for 12 patients with diabetes, Wang [114] reported that an 8-week Tai Chi program could decrease blood glucose. Additionally, high- and low-affinity insulin receptor numbers and low-affinity insulin receptor-binding capacity were increased. For obese diabetic patients, Chen and colleagues reported that 12 weeks of Chen Tai Chi training induced significant improvement in body mass index, triglyceride (TG), and high-density lipoprotein cholesterol (HDL-C) [115]. In addition, serum malondialdehyde (oxidative stress indicator) and C-reactive protein (inflammation indicator) decreased significantly.

In diabetic patients complicated with peripheral neuropathy, Ahn and Song reported that Tai Chi training one hour twice per week for 12 weeks improved glucose control, balance, neuropathic symptoms, and some dimensions of quality of life [116]. A recent study reported that a 12-week Tai Chi program for diabetic patients obtained significant benefits in quality of life [117]. After training, the Tai Chi group revealed significant improvements in the SF-36 subscales of physical functioning, role physical, bodily pain, and vitality.

8.1.3. Dyslipidemia. Dyslipidemia, or abnormalities in blood lipid and lipoprotein, is a major risk factor of cardiovascular disease. In the United States, 26.0% of adults had hypercholesterolemia during the period from 1999 to 2006, and approximately 27% of adults had a triglyceride level ≥150 mg/dL during 2007 to 2010 [62]. The prevalence of dyslipidemia increases with age and westernized lifestyle, but regular exercise may ameliorate the trend toward abnormal blood lipid profile. A meta-analysis of 31 randomized controlled trials with exercise training reported a significant decrease in total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and triglyceride, and an increase in HDL-C [118].

Tsai and colleagues [107] randomly assigned 88 patients to Tai Chi or sedentary control group. After 12 weeks of classical Yang Tai Chi training, TC, TG, and LDL-C decreased by 15.2, 23.8, and 19.7 mg/dL, respectively, and HDL-C increased by 4.7 mg/dL. By contrast, Thomas and colleagues [119] reported no significant change in TC, TG, LDL-C, and HDL-C after 12 months of Tai Chi training. This may be attributed to differences in baseline lipid concentrations, training amount and intensity, changes in body composition, or the adjunctive interventions such as diet or lipid-lowering agents.

In a recent study, Lan and colleagues [120] assigned 70 dyslipidemic patients to a 12-month Yang Tai Chi training group or the usual-care group. After training, the Tai Chi group showed a significant decrease of 26.3% in TG (from 224.5 ± 216.5 to 165.9 ± 147.8 mg/dL), 7.3% in TC (from 228.0 ± 41.0 to 211.4 ± 46.5 mg/dL), and 11.9% in LDL-C (from 134.3 ± 40.3 to 118.3 ± 41.3 mg/dL), whereas the HDL-C did not increase significantly. In addition, the Tai Chi group also showed a significant decrease in fasting insulin and a decrease in homeostasis model assessment of insulin

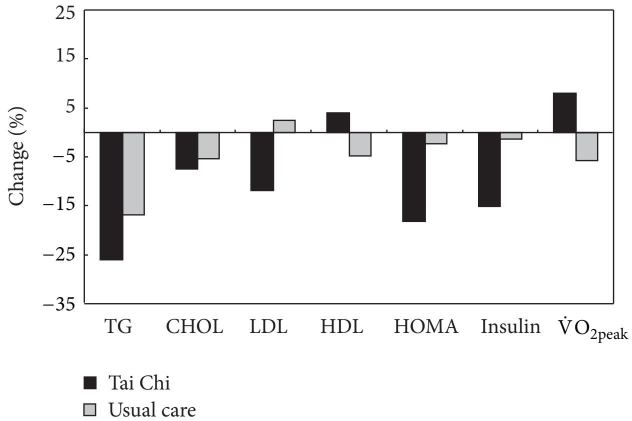

FIGURE 4: Changes of peak $\dot{V}O_2$ and cardiovascular risk factors after 1 year of training in patients with dyslipidemia (Tai Chi group versus usual-care group).

resistance (HOMA) index, which is suggestive of improved insulin resistance (Figure 4).

8.2. Acute Myocardial Infarction. Acute myocardial infarction is the most common cause of mortality in patients with cardiovascular disease, but exercise can significantly reduce the mortality rate in patients with AMI. A recent Cochrane review [121] involved in 47 studies randomizing 10,794 patients with AMI to exercise-based cardiac rehabilitation or usual care. Patients receiving exercise training reduced a 13% of risk for total mortality, a 26% of risk for cardiovascular mortality, and a 31% of risk for hospital admissions. Channer and colleagues [104] randomized 126 patients with AMI to Tai Chi, aerobic exercise, or nonexercise support group. The Tai Chi and the aerobic exercise group participated in an 8-week training program, attended twice weekly for three weeks, and then once weekly for five weeks. The results displayed that Tai Chi was effective for reducing systolic and diastolic BP and that it was safe for patients after AMI.

8.3. Coronary Artery Bypass Grafting. Lan and colleagues [122] assigned 20 patients after coronary artery bypass grafting surgery (CABG) to classical Yang Tai Chi program or maintenance home exercise. After 12 months of training, the Tai Chi group showed significant improvements of oxygen uptake at the peak exercise and the ventilatory threshold. At the peak exercise, the Tai Chi group showed 10.3% increase in $\dot{V}O_2$, while the control group did not show any improvement. Furthermore, the Tai Chi group increased 17.6% in $\dot{V}O_2$ at the ventilatory threshold, while the control group did not display significant change. The result showed that Tai Chi was safe and had benefits in improving functional capacity for patients after CABG.

8.4. Congestive Heart Failure. Congestive heart failure (CHF) is characterized by the inability of the heart to deliver sufficient oxygenated blood to tissue. CHF results in abnormalities in skeletal muscle metabolism, neurohormonal responses, vascular and pulmonary functions. In 2009, heart failure was the underlying cause in 56,410 of those deaths in the United States [62]. Exercise training improves functional capacity and symptoms in patients with CHF, and the increase in exercise tolerance may be attributed to increased skeletal muscle oxidative enzymes and mitochondrial density. Previous studies have shown that low-intensity Tai Chi training benefited patients with CHF [123–128]. In a study by Barrow and colleagues [123], 52 patients with CHF were randomized to Tai Chi or standard medical care group. The Tai Chi group practiced Tai Chi twice a week for 16 weeks. After training, the Tai Chi group did not show significant increase in exercise tolerance, but they had improvement in symptom scores of heart failure and depression scores compared with the control group. Yeh and colleagues [124, 125] also reported that a 12-week Tai Chi training in patients with CHF improved quality of life, sleep quality, and 6-minute walking distance and decreased serum B-type natriuretic peptide (BNP). BNP is produced by ventricular cardiomyocytes and is correlated with left ventricular dysfunction. In a recent study, Yeh and colleagues [126] randomized 100 patients with systolic heart failure into a Tai Chi group or a control group. Tai Chi participants practiced 5 basic simplified Yang Tai Chi movements twice weekly, while the control group participated in an education program. After 12 weeks of training, the Tai Chi group displayed greater improvements in quality of life, exercise self-efficacy, and mood. For patients with CHF, low-intensity exercise such as simplified Tai Chi may increase the acceptance. Interval training protocol by using selected Tai Chi movements is suitable for patients with very low endurance.

Tai Chi can combine endurance exercise to improve functional capacity. Caminiti and colleagues [127] enrolled 60 patients with CHF and randomized them into a combined training group performing Tai Chi plus endurance training, and an endurance training group. After 12 weeks of training, 6-minute walking distance increased in both groups, but the combined training group showed more improvement than the endurance training group. Systolic BP and BNP decreased in the combined training group compared with the endurance training group. Additionally, the combined training group had a greater improvement in physical perception and peak torque of knee extensor compared with the endurance training group.

The left ventricle ejection fraction is found to be preserved in about half of all cases of heart failure. Patients with heart failure with preserved ejection fraction (HFPEF) appear to be older and are more likely to be females, have a history of hypertension, and have less coronary artery diseases [128]. Yeh and colleagues [129] recently used Tai Chi in the treatment of patients with HFPEF, and 16 patients were randomized into 12-week Tai Chi or aerobic exercise. Change in $\dot{V}O_{2peak}$ was similar between groups, but 6-minute walking distance increased more in the Tai Chi group. Both groups had improved Minnesota Living With Heart Failure scores and self-efficacy, but the Tai Chi group showed a decrease in depression scores in contrast to an increase in the aerobic exercise group. In patients with HFPEF, the Tai Chi group displayed similar improvement as the aerobic exercise group despite a lower aerobic training workload.

9. Tai Chi for Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is the fourth leading cause of mortality in the United States. Patients with COPD are at risk for low levels of physical activity, leading to increased morbidity and mortality [130]. The effectiveness of exercise training in people with COPD is well established. However, alternative methods of training such as Tai Chi have not been widely evaluated.

Chan and colleagues [131] have evaluated the effectiveness of a 3-month Tai Chi Qigong (TCQ) program in patients with COPD. 206 patients with COPD were randomly assigned to three groups (TCQ, exercise, and control). Patients in the TCQ group participated in a TCQ program, including two 60-minute sessions each week for 3 months; patients in the exercise group practiced breathing exercise combined with walking. After training, the TCQ group showed greater improvements in the symptom and activity domains. In addition, the forced vital capacity, forced expiratory volume in the first second, walking distance, and exacerbation rate were improved in the TCQ group [132].

In a pilot study conducted by Yeh and colleagues [133], 10 patients with moderate-to-severe COPD were randomized to 12 weeks of Tai Chi plus usual care or usual care alone. After training, there was significant improvement in Chronic Respiratory Questionnaire score in the Tai Chi group compared with the usual-care group. There were nonsignificant trends toward improvement in 6-minute walk distance, depression scale, and shortness of breath score.

In a recent study, Leung and colleagues [134] examined the effect of short-form Sun-style Tai Chi training in people with COPD. Forty-two participants were randomly allocated to Tai Chi or usual-care control group. Participants in the Tai Chi group trained twice weekly for 12 week, and the exercise intensity of Tai Chi was 53% ± 18% of oxygen uptake reserve. Compared with the control, Tai Chi significantly increased endurance shuttle walk time, reduced medial-lateral body sway in semitandem stand, and increased total score on the Chronic Respiratory Disease Questionnaire.

10. Tai Chi for Cancer

Cancer is a leading cause of death worldwide. Exercise therapy is a safe adjunct therapy that can mitigate common treatment-related side effects among cancer patients [135]. Additionally, exercise has beneficial effects on certain domains of health-related quality of life (QOL) including physical functioning, role functioning, social functioning, and fatigue [136]. Tai Chi has been reported to be beneficial for physical, emotional, and neuropsychological functions in patients with breast cancer [137–140], lung cancer [141], and gastric cancer [142].

In a recent randomized trial, 21 breast cancer survivors were assigned to Tai Chi or standard support therapy (controls), and patients in the exercise group practiced Tai Chi three times per week and 60 minutes per session for 12 weeks [140]. After training, the Tai Chi group improved in total QOL, physical functioning, physical role limitations, social functioning, and general mental health. Tai Chi may improve QOL by regulating inflammatory responses and other biomarkers associated with side effects from cancer and its treatments. By contrast, a recent meta-analysis did not show convincing evidence that Tai Chi is effective for supportive breast cancer care [143]. Most Tai Chi studies are focused on QOL of breast cancer survivors; however, the positive results must be interpreted cautiously because most trials suffered from methodological flaws such as a small-sample size and inadequate study design. Further research involving large number of participants is required to determine optimal effects of Tai Chi exercise for cancer patients.

11. Future Research of Tai Chi

The training effect of an exercise program depends on its exercise mode, intensity, frequency, and duration. Although previous studies have shown that Tai Chi has potential benefits, most of the studies have limitations in study design, such as (1) a small-sample size, (2) nonrandomized trials, (3) lack of training intensity measurement, and (4) significant differences in training protocols. In future research, a randomized controlled trial with standardized training protocol should be utilized according to the principles of exercise prescription. Tai Chi participants usually need 12 weeks of training to familiarize the movements. During the familiarization phase, the exercise intensity and amount of training are inconsistent. Therefore, a suitable training program should take at least 6 months of training. Additionally, heart rate monitoring in selected individuals is recommended to determine the exercise intensity of Tai Chi, and the suitable duration of training is 40 to 60 minutes including warm-up and cool-down.

12. Conclusion

Tai Chi is a Chinese traditional conditioning exercise that integrated breathing exercise into body movements. This literature paper reveals that Tai Chi has benefits in health promotion and has potential role as an alternative therapy in neurological, rheumatological, orthopedic, and cardiopulmonary diseases. There are several reasons to recommend Tai Chi as an exercise program for healthy people and patients with chronic diseases. First, Tai Chi does not need special facility or expensive equipment, and it can be practiced anytime and anywhere. Second, Tai Chi is effective in enhancing aerobic capacity, muscular strength, and balance and in improving cardiovascular risk factors. Third, Tai Chi is a low-cost, low- technology exercise, and it can be easily implemented in the community. It is concluded that Tai Chi is effective in promoting health, and it can be prescribed as an alternative exercise program for patients with certain chronic diseases.

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Research Article

Tai Chi for Essential Hypertension

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Objectives. To assess the current clinical evidence of Tai Chi for essential hypertension (EH). *Search Strategy*. 7 electronic databases were searched until 20 April, 2013. *Inclusion Criteria*. We included randomized trials testing Tai Chi versus routine care or antihypertensive drugs. Trials testing Tai Chi combined with antihypertensive drugs versus antihypertensive drugs were also included. *Data Extraction and Analyses*. Study selection, data extraction, quality assessment, and data analyses were conducted according to the Cochrane standards. *Results*. 18 trials were included. Methodological quality of the trials was low. 14 trials compared Tai Chi with routine care. 1 trial compared Tai Chi with antihypertensive drugs. Meta-analysis all showed significant effect of TaiChi in lowering blood pressure (BP). 3 trials compared Tai Chi plus antihypertensive drugs with antihypertensive drugs. Positive results in BP were found in the other 2 combination groups. Most of the trials did not report adverse events, and the safety of Tai Chi is still uncertain. *Conclusions*. There is some encouraging evidence of Tai Chi for EH. However, due to poor methodological quality of included studies, the evidence remains weak. Rigorously designed trials are needed to confirm the evidence.

1. Introduction

Hypertension is a significant medical and public health issue which puts an enormous burden on health care resources and the community [1]. It is a chronic medical condition in which the systemic arterial blood pressure (BP) is elevated. Serious complications including cardiovascular and cerebrovascular diseases would be preventable if the rise in BP with age could be prevented or diminished [2]. The majority of hypertensive patients require long-term treatment. However, effective treatment of essential hypertension (EH) is limited by availability, cost, and adverse effects of conventional western medicine treatment [3]. Thus, a certain proportion of the population, especially in Asia, has turned to complementary and alternative medicine (CAM), including traditional Chinese medicine (TCM), in searching for a treatment modality with potential efficacy and few adverse effects [4–9]. For seeking the best evidence of TCM in making decisions for hypertensive patients, an increasing number of systematic reviews (SRs) and meta-analysis have been conducted to assess the efficiency and safety of TCM for EH [10–14]. It is demonstrated that, as an effective adjunct treatment, TCM could contribute to lowing BP and relieving hypertension-related symptoms for EH.

Tai Chi (also known as Tai Chi Quan or Shadow Boxing), which originated in ancient China, is a Chinese conditioning exercise well known for its graceful movement. It has been practiced for centuries in the East for health promotion and longevity. In recent years, there has been a growing interest and prevalence in Tai Chi exercise in Western societies [15, 16]. During the practice, it combines deep diaphragmatic breathing with continuous body motions to achieve a harmonious balance between body and mind. Previous researches have indicated that Tai Chi exercise may improve health-related fitness (including cardiorespiratory function, muscular strength, balance, and flexibility), quality of life, and psychological well-being. Recent studies also suggest that it may have beneficial effects for patients with cardiovascular conditions and some cardiovascular risk factors, including hypertension [17–19]. It is found out that Tai Chi could contribute to low BP smoothly and improve symptoms and signs especially [19–21]. And the efficacy of Tai Chi for treating hypertension is suggested by a large number of published case series and randomized trials [20–24]. Currently, Tai Chi used alone or combined with antihypertensive drugs has been widely used as an alternative and effective method for the treatment of EH worldwide. However, it has not been evaluated according to the PRISMA systematic review standard. This study aims to assess the current clinical evidence of Tai Chi for EH.

2. Methods

2.1. Database and Search Strategies. Literature searches were conducted in the following 7 electronic databases: Chinese National Knowledge Infrastructure (CNKI) (1980–2013), Chinese Scientific Journal Database (VIP) (1989–2013), Chinese Biomedical Literature Database (CBM) (1978–2013), Wanfang data (1998–2013), Cochrane Library (January, 2013), EMBASE (1980–2013), and PubMed (1959–2013). We also searched the reference list of retrieved papers. As Tai Chi is mainly practiced and studied in China, four major databases in Chinese were searched to retrieve the maximum possible number of trials of Tai Chi for EH. All of those searches were ended on 20 April, 2013. Ongoing registered clinical trials were searched in the website of Chinese clinical trial registry (http://www.chictr.org/en/) and international clinical trial registry by U.S. national institutes of health (http://clinicaltrials.gov/). The following search terms were used individually or combined: "hypertension," "essential hypertension," "primary hypertension," "blood pressure," "Tai Chi," "T'ai Chi," "Tai Chi Quan," "Taijiquan," "Shadow Boxing," "clinical trial," and "randomized controlled trial". The bibliographies of included studies were searched for additional references.

2.2. Inclusion Criteria. Only patients with EH could be involved in this review, which is diagnosed by systolic blood pressure (SBP) ≥140 mmHg, or, diastolic blood pressure (DBP) ≥90 mmHg. We included all the parallel randomized controlled trials (RCTs) testing Tai Chi used alone versus antihypertensive drugs, routine care, or other exercise in patients with hypertension. RCTs testing Tai Chi combined with antihypertensive drugs versus antihypertensive drugs were included as well. There were no restrictions on population characteristics, language, and publication type. The main outcome measure was BP. Duplicated publications reporting the same groups of participants were excluded.

2.3. Data Extraction and Quality Assessment. Two authors conducted the literature searching (X. J. Xiong, S. J. Li), study selection (X. J. Xiong, W. Liu), and data extraction (X. J. Xiong, B. Feng) independently. The extracted data included authors, title of study, year of publication, study size, age and sex of the participants, study characteristics, diagnosis standard, details of methodological information, treatment process, details of the intervention and control, outcomes, and adverse effects for each study. Disagreement was resolved by discussion and reached consensus through a third party (J. Wang).

The criteria from the Cochrane Handbook for Systematic Review of Interventions, Version 5.1.0 (X. J. Xiong, F. Teng) were used to assess the methodological quality of trials independently [43]. The items included the followings 7 aspects: random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other biases. The quality of all the included trials was categorized to low/unclear/high risk of bias ("Yes" for a low of bias, "No" for a high risk of bias, "Unclear" otherwise). Then trials were categorized into three levels: low risk of bias (all the items were in low risk of bias), high risk of bias (at least one item was in high risk of bias), and unclear risk of bias (at least one item was in unclear).

2.4. Data Synthesis. We used the Revman 5.1 software provided by the Cochrane Collaboration for data analyses. Dichotomous data were presented as risk ratio (RR) and continuous outcomes as mean difference (MD) or weight mean difference (WMD), both with 95% confidence interval (CI). Heterogeneity was recognized significant when $I^2 \geq 50\%$. Fixed effects model was used if there is no significant heterogeneity of the data; random effects model was used if significant heterogeneity existed ($50\% < I^2 < 85\%$). Publication bias would be explored by funnel plot analysis if sufficient studies were found.

3. Result

3.1. Description of Included Trials. As shown in Figure 1, the flow chart depicted the search process and study selection. After primary searches from the above 7 electronic databases, 353 articles were retrieved: CNKI ($n = 161$), VIP ($n = 71$), CBM ($n = 46$), Wanfang data ($n = 21$), Cochrane Library ($n = 5$), Pubmed ($n = 17$), and EMBASE ($n = 32$). 206 articles were screened after 152 duplicates were removed. After reading the subjects and abstracts, 155 articles were excluded. Full texts of 51 articles were retrieved, and 33 articles were excluded with reasons listed as below: participants did not meet the inclusive criteria ($n = 22$), duplication ($n = 1$), no control group ($n = 5$), the intervention included other Chinese herbal formulae ($n = 2$), and no data for extraction ($n = 3$). Finally, 18 RCTs [25–42] were included. 16 RCTs of them were published in Chinese [25–33, 35–41]; 1 RCT was published in English [34]; 1 RCT was published in Korean [42]. The characteristics of included trials were listed in Table 1.

1371 patients with EH were included. There was a wide variation in the age of subjects (35–75 years). 18 trials specified six diagnostic criteria of hypertension, five trials [27, 29, 32, 33, 39] used Chinese Guidelines for the Management of Hypertension-2005 (CGMH-2005), four trials [26, 28, 36, 37] used 1999 WHO-ISH guidelines for the management of hypertension (1999 WHO-ISH GMH), one trial [30] used

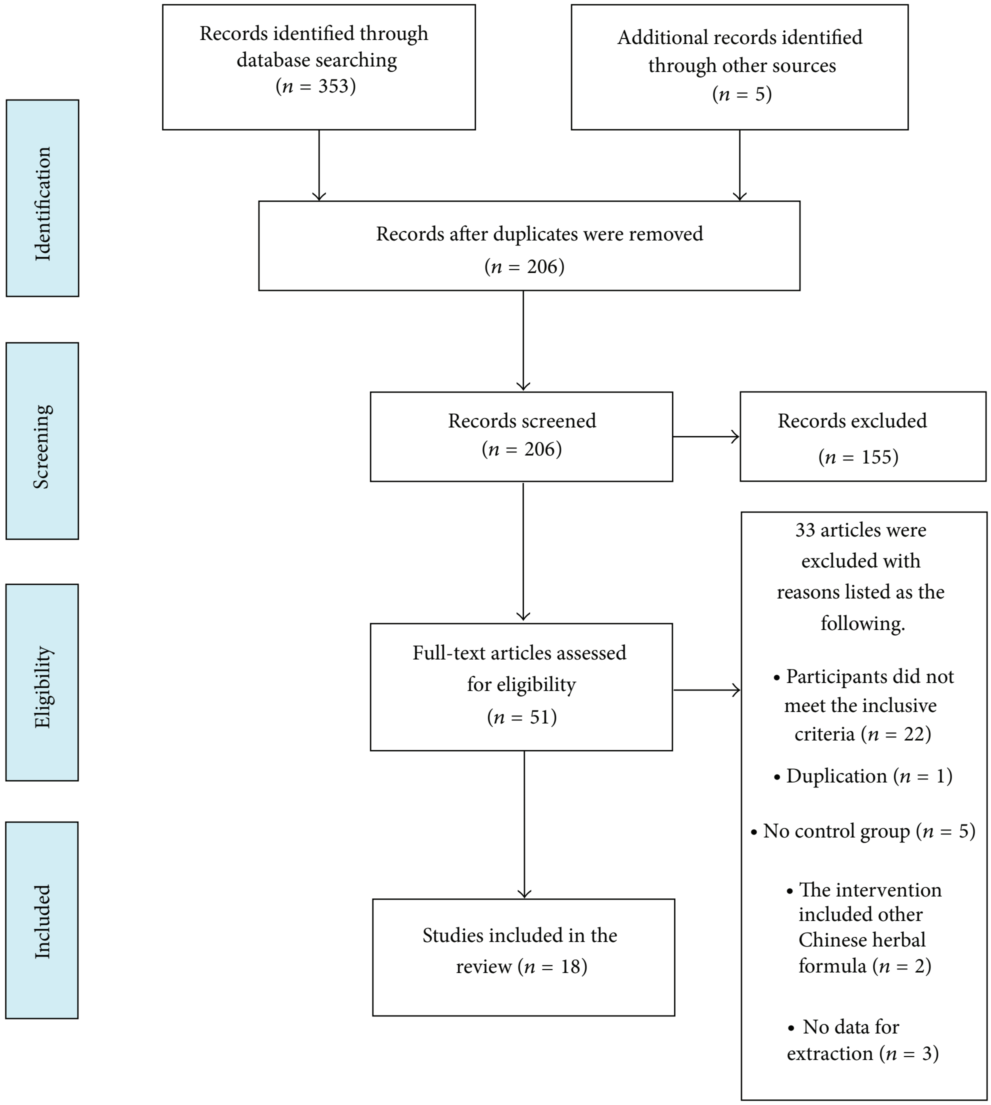

Figure 1: PRISMA 2009 flow diagram.

Chinese Guidelines for the Management of Hypertension-1999 (CGMH-1999), one trial [38] used the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7), one trial [42] used the Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-6), and six trials [25, 31, 34, 35, 40, 41] only demonstrated patients with EH without specific information about diagnostic standard.

Interventions included all the exercises based on Tai Chi alone (including 12-type Tai Chi, 24-type Tai Chi, 48-type Tai Chi, Yang-type Tai Chi, and Chen-type Tai Chi) or combined with antihypertensive drugs. The controls included routine care (including walking, slow-running, and aerobics) or antihypertensive drugs alone. Four trials [29, 32, 41, 42] investigated Tai Chi using alone versus routine care. Six trials [25–27, 30, 35, 38] investigated 24-type Tai Chi using alone versus routine care. One trial [37] investigated 48-type Tai Chi using alone versus routine care. One trial [34] investigated Yang-type Tai Chi using alone versus routine care. One trial [33] investigated 24-type Tai Chi, 48-type Tai Chi, and Yang-type Tai Chi together versus routine care. One trial [40] investigated 12-type Tai Chi using alone versus routine care. One trial [31] investigated Tai Chi using alone versus antihypertensive drugs (reserpine or compound rutin tablets). One trial [28] investigated Tai Chi combined with cilazapril versus cilazapril. One trial [36] investigated 24-type Tai Chi combined with cilazapril versus cilazapril. One trial [39] investigated Chen-type Tai Chi combined with nifedipine versus nifedipine.

The total treatment duration ranged from 2 to 60 months. The variable exercises of Tai Chi are presented in Table 1. All of the 18 trials used the BP as the outcome measure. Adverse effect was also described.

Table 1: Characteristics and methodological quality of included studies.

Study ID	Sample	Diagnosis standard	Intervention	Control	Course	Outcome measure
Wei et al. 2003 [25]	46	Unclear	24-type Tai Chi	routine care	12 m	BP
Han et al. 2010 [26]	60	1999 WHO-ISH GMH	24-type Tai Chi	routine care	60 m	BP
Wang et al. 2011 [27]	30	CGMH-2005	24-type Tai Chi	routine care	12 w	BP
Tang 2009 [28]	32	1999 WHO-ISH GMH	Tai Chi + control	cilazapril (25 mg qd)	6 m	BP
Chen et al. 2011 [29]	441	CGMH-2005	Tai Chi	routine care	24 m	BP
Mao and Sha 2006 [30]	62	CGMH-1999	24-type Tai Chi	routine care	8 w	BP
Yi et al. 1990 [31]	20	Unclear	Tai Chi	reserpine (4 mg tid), or compound rutin tablets (20 mg tid)	18 m	BP
Chen 2011 [32]	61	CGMH-2005	Tai Chi	routine care	12 m	BP
He et al. 2011 [33]	49	CGMH-2005	24-type Tai Chi, 48-type Tai Chi, and Yang-type Tai Chi	routine care	20 w	BP
Lo et al. 2012 [34]	58	Unclear	Yang-type Tai Chi	routine care	8 w	BP
Wang 2007 [35]	46	Unclear	24-type Tai Chi	routine care	8 m	BP
Luo 2006 [36]	84	1999 WHO-ISH GMH	24-type Tai Chi + control	cilazapril (2.5–5.0 mg qd)	6 m	BP
Wang et al. 2007 [37]	84	1999 WHO-ISH GMH	48-type Tai Chi	routine care	6 m	BP
Zhou 2007 [38]	120	JNC-7	24-type Tai Chi	routine care	12 w	BP
Chen and Lv 2006 [39]	40	CGMH-2005	Chen-type Tai Chi + control	nifedipine (50–100 mg qd)	10 w	BP
Song and Yu 2011 [40]	50	Unclear	12-type Tai Chi	routine care	2 m	BP
Wang et al. 2011 [41]	60	Unclear	Tai Chi	routine care	16 w	BP
Lee 2004 [42]	28	JNC-6	Tai Chi	routine care	6 w	BP

m: month; w: week.

3.2. Methodological Quality of Included Trials. The majority of the included trials were assessed to be of general poor methodological quality according to the predefined quality assessment criteria (as shown in Table 2). The randomized allocation of participants was mentioned in all trials; however, only 2 trials stated the methods for sequence generation with stratified sampling [26, 30]. The remaining 16 trials [25, 27–29, 31–42] did not mention the concrete random sequence generation at all. Insufficient information was provided to judge whether or not it was conducted properly. Allocation concealment, blinding of participants and personnel, and blinding of outcome assessment were not mentioned in all trials. 2 trials [26, 34] reported drop-out. The rest of trials [25, 27–42] have not reported it at all. None of trials had a pretrial estimation of sample size. One trial [26] mentioned 5-year follow-up. We tried to contact the author by telephone, fax, email, and other ways for further detailed information about the trials; however, no information could be got until now.

3.3. Effect of the Interventions. All the included trials [25–42] compared Tai Chi used alone or combined with antihypertensive drugs with routine care or antihypertensive drugs. A change in BP was reported in all the RCTs. According to the different intervention strategies, it could be divided into the following subgroups.

3.3.1. Tai Chi versus Routine Care. As mentioned above, there were 5 types of Tai Chi used in this review, including 12-type Tai Chi, 24-type Tai Chi, 48-type Tai Chi, Yang-type Tai Chi, and Chen-type Tai Chi. Therefore, we combined all these types together for comprehensive analysis. 14 trials comparing Tai Chi with routine care were included [25–27, 29, 30, 32–35, 37, 38, 40–42]. Among them, 4 trials [25, 32, 35, 37] used three classes to evaluate treatment effects on BP: significant effective (DBP decreased by 10 mmHg reaching the normal range, or, DBP has not yet returned to normal but has been reduced ≥20 mmHg), effective (DBP decreased to less than 10 mmHg reaching the normal range, or, DBP decreased by 10–19 mmHg, but did not reach the normal range, or, SBP decreased ≥30 mmHg), and ineffective (Not to meet the above standards). The trial showed significant difference in favor of the Tai Chi group as compared to routine care group (RR: 3.39 [1.81, 6.34]; $P = 0.0001$) (Table 3).

Table 2: Quality assessment of included randomized controlled trials.

Included trials	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other sources of bias	Risk of bias
Wei et al. 2003 [25]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Han et al. 2010 [26]	Stratified sampling	Unclear	Unclear	Unclear	Yes	No	Unclear	Unclear
Wang et al. 2011 [27]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Tang 2009 [28]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Chen et al. 2011 [29]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Mao and Sha 2006 [30]	Stratified sampling	Unclear	Unclear	Unclear	No	No	Unclear	Unclear
Yi et al. 1990 [31]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Chen 2011 [32]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
He et al. 2011 [33]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Lo et al. 2012 [34]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Wang 2007 [35]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Luo 2006 [36]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Wang et al. 2007 [37]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Zhou 2007 [38]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Chen and Lv 2006 [39]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Song and Yu 2011 [40]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Wang et al. 2011 [41]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Lee 2004 [42]	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High

Table 3: Analyses of blood pressure.

Trials		Intervention (n/N)	Control (n/N)	RR [95% CI]	P value
Tai Chi versus routine care					
24-type Tai Chi versus routine care	1	20/23	14/23	4.29 [0.98, 18.72]	0.05
Tai Chi versus routine care	1	25/31	15/30	4.17 [1.33, 13.07]	0.01
24-type Tai Chi versus routine care	1	20/23	13/23	5.13 [1.18, 22.24]	0.03
48-type Tai Chi versus routine care	1	36/42	32/42	1.18 [0.61, 5.74]	0.27
Meta-Analysis	4	101/119	74/118	3.39 [1.81, 6.34]	0.0001
Tai Chi plus antihypertensive drugs versus antihypertensive drugs					
24-type Tai Chi plus cilazapril versus cilazapril	1	40/44	32/40	2.50 [0.69, 9.06]	0.16
Meta-Analysis	1	40/44	32/40	2.50 [0.69, 9.06]	0.16

When it comes to SBP, 10 trials [17, 27, 29, 30, 33, 34, 38, 40–42] showed heterogeneity in the results. Thus, random-effects model was used for statistical analysis. The meta-analysis showed there is significant beneficial effect on the Tai Chi group as compared to routine care group (WMD: −12.43 [−12.62, −12.24]; $P < 0.00001$) (Table 4).

When it comes to DBP, 10 trials [17, 27, 29, 30, 33, 34, 38, 40–42] showed heterogeneity in the results. Thus, random-effects model was used for statistical analysis. The meta-analysis showed that there is significant beneficial effect on the Tai Chi group as compared to routine care group (WMD: −6.03 [−6.16, −5.90]; $P < 0.00001$) (Table 5).

3.3.2. Tai Chi versus Antihypertensive Drugs (Western Medicine). 1 trial [31] investigated Tai Chi using alone versus antihypertensive drugs (reserpine or compound rutin tablets). When it comes to SBP, it showed no applicable heterogeneity in the result. Thus, fixed-effects model was used for statistical analysis. The meta-analysis showed that there is significant beneficial effect on the Tai Chi group as compared to antihypertensive drugs group (WMD: −14.30 [−14.31, −14.29]; $P < 0.00001$) (Table 4).

When it comes to DBP, it also showed no applicable heterogeneity in the result. Thus, fixed-effects model was used for statistical analysis. The meta-analysis showed that

Table 4: Analyses of systolic blood pressure.

Trials		WMD [95% CI]	P value
Tai Chi versus routine care			
24-type Tai Chi versus routine care	1	−10.50 [−10.86, −10.14]	<0.00001
24-type Tai Chi versus routine care	1	−12.36 [−14.76, −9.96]	<0.00001
Tai Chi versus routine care	1	−8.48 [−8.82, −8.14]	<0.00001
24-type Tai Chi versus routine care	1	−24.42 [−26.18, −22.66]	<0.00001
24/48/Yang-type Tai Chi versus routine care	1	−18.30 [−19.37, −17.23]	<0.00001
Yang-type Tai Chi versus routine care	1	−4.34 [−5.20, −3.48]	<0.00001
24-type Tai Chi versus routine care	1	−18.20 [−18.54, −17.86]	<0.00001
12-type Tai Chi versus routine care	1	−15.92 [−18.56, −13.28]	<0.00001
Tai Chi versus routine care	1	−12.97 [−15.10, −10.84]	<0.00001
Tai Chi versus routine care	1	−17.60 [−23.44, −11.76]	<0.00001
Meta-analysis	10	−12.43 [−12.62, −12.24]	<0.00001
Tai Chi versus antihypertensive drugs			
Tai Chi versus antihypertensive drugs (reserpine or compound rutin tablets)	1	−14.30 [−14.31, −14.29]	<0.00001
Meta-analysis	1	−14.30 [−14.31, −14.29]	<0.00001
Tai Chi plus antihypertensive drugs versus antihypertensive drugs			
Tai Chi plus cilazapril versus cilazapril	1	−7.60 [−9.24, −5.96]	<0.00001
Chen-type Tai Chi plus nifedipine versus nifedipine	1	−24.00 [−28.75, −19.25]	<0.00001
Meta-analysis	2	−9.34 [−10.89, −7.79]	<0.00001

Table 5: Analyses of diastolic blood pressure.

Trials		WMD [95% CI]	P value
Tai Chi versus routine care			
24-type Tai Chi versus routine care	1	−3.70 [−4.89, −2.51]	<0.00001
24-type Tai Chi versus routine care	1	−5.07 [−5.26, −4.88]	<0.00001
Tai Chi versus routine care	1	−4.06 [−4.34, −3.78]	<0.00001
24-type Tai Chi versus routine care	1	−11.18 [−11.67, −10.69]	<0.00001
24/48/Yang-type Tai Chi versus routine care	1	−9.10 [−9.44, −8.76]	<0.00001
Yang-type Tai Chi versus routine care	1	−1.20 [−3.57, 1.17]	0.32
24-type Tai Chi versus routine care	1	−6.90 [−7.92, −5.88]	<0.00001
12-type Tai Chi versus routine care	1	−5.04 [−6.69, −3.39]	<0.00001
Tai Chi versus routine care	1	−7.20 [−9.39, −5.01]	<0.00001
Tai Chi versus routine care	1	−11.70 [−12.56, −10.84]	<0.00001
Meta-analysis	10	−6.03 [−6.16, −5.90]	<0.00001
Tai Chi versus antihypertensive drugs			
Tai Chi versus antihypertensive drugs (reserpine or compound rutin tablets)	1	−6.00 [−6.01, −5.99]	<0.00001
Meta-analysis	1	−6.00 [−6.01, −5.99]	<0.00001
Tai Chi plus antihypertensive drugs versus antihypertensive drugs			
Tai Chi plus cilazapril versus cilazapril	1	−7.07 [−7.63, −6.51]	<0.00001
Chen-type Tai Chi plus nifedipine versus nifedipine	1	−10.60 [−14.11, −7.09]	<0.00001
Meta-analysis	2	−7.16 [−7.71, −6.60]	<0.00001

there is significant beneficial effect on the Tai Chi group as compared to antihypertensive drugs group (WMD: −6.00 [−6.01, −5.99]; $P < 0.00001$) (Table 5).

3.3.3. Tai Chi plus Antihypertensive Drugs versus Antihypertensive Drugs (Western Medicine). 3 trials [28, 36, 39] investigated Tai Chi combined with antihypertensive drugs versus antihypertensive drugs. Among them, 1 trial [36] used three classes to evaluate treatment effects on BP. The trials showed no significant difference between Tai Chi plus antihypertensive drugs group and antihypertensive drugs (cilazapril) group (RR: 2.50 [0.69, 9.06]; $P = 0.16$) (Table 3).

When it comes to SBP, 2 independent trials [28, 39] showed significant heterogeneity in the results. Thus, random-effects model was used for statistical analysis. The meta-analysis showed that there are significant beneficial effects on the Tai Chi plus antihypertensive drugs group as compared to antihypertensive drugs group (WMD: −9.34 [−10.89, −7.79]; $P < 0.00001$) (Table 4).

When it comes to DBP, 2 independent trials [28, 39] also showed significant heterogeneity in the results. Thus, random-effects model was used for statistical analysis. The meta-analysis showed that there are significant beneficial effects on the Tai Chi plus antihypertensive drugs group as compared to antihypertensive drugs group (WMD: −7.16 [−7.71, −6.60]; $P < 0.00001$) (Table 5).

3.4. Publication Bias. The number of trials was too small to conduct any sufficient additional analysis of publication bias.

3.5. Adverse Effect. Only 1 trial mentioned the adverse effect [30]. The other 17 trials [25–29, 31–42] did not report it at all. No specific symptoms and signs were found about Tai Chi in the trial.

4. Discussion

Currently, with increasing concern about long-term medication and the potential adverse effects of antihypertensive drugs [44–46], nondrug therapy and natural herbal products have gained more and more popularity by hypertensive patients worldwide [47–54]. As a special form of exercise, Tai Chi has made great contributions to the healthcare and well-being of the people for its unique advantages in preventing and curing diseases, especially in China. And until now, more and more researches have been conducted to explore the health-enhancing qualities of Tai Chi for various cardiovascular diseases (CVDs) and cerebrovascular diseases [17–24]. It has become an effective mean of secondary prevention of CVDs. It is found that Tai Chi could not only contribute to lowing BP smoothly, recovering the heart function, reversing cardiovascular risk factors, but also improving symptoms and quality of life (QOL) [55–57]. Although there are 2 SRs about Tai Chi on lowering resting blood pressure (including hypertension, acute myocardial infarction, older people with chronic conditions, healthy elderly men, middle-aged women, and other diseases) [52, 57], the role of Tai Chi for EH is still unknown due to different inclusion criteria and search strategies. Therefore, this paper aims to assess the current clinical evidence of Tai Chi for EH.

This systematic review included 18 randomized trials with 1371 hypertensive patients. As compared to routine care groups, positive results in SBP (WMD: −12.43 [−12.62, −12.24]; $P < 0.00001$), DBP (WMD: −6.03 [−6.16, −5.90]; $P < 0.00001$), and BP (RR: 3.39 [1.81, 6.34]; $P = 0.0001$) were found in Tai Chi group, indicating that BP could be improved, and SBP and DBP could be decreased by 12.43 mmHg and 6.03 mmHg, respectively, after Tai Chi treatment. As compared to antihypertensive drugs (reserpine or compound rutin tablets) group, positive results in SBP (WMD: −14.30 [−14.31, −14.29]; $P < 0.00001$) and DBP (WMD: −6.00 [−6.01, −5.99]; $P < 0.00001$) were found in Tai Chi group, indicating that SBP and DBP could be decreased by 14.30 mmHg and 6.00 mmHg, respectively, after Tai Chi treatment. As compared to antihypertensive drugs groups, there is no difference between Tai Chi plus cilazapril group and cilazapril group in BP (RR: 2.50 [0.69, 9.06]; $P = 0.16$), indicating that no more beneficial effect was found in the combination therapy; however, positive results in SBP (WMD: −9.34 [−10.89, −7.79]; $P < 0.00001$) and DBP (WMD: −7.16 [−7.71, −6.60]; $P < 0.00001$) were found in the other 2 Tai Chi plus antihypertensive drugs groups, indicating that SBP and DBP could be decreased by 9.34 mmHg and 7.16 mmHg, respectively, after the combination therapy. In conclusion, except cilazapril treatment group, BP was improved in the other subgroups, and a significant decrease in both SBP and DBP was found. Recently, it is confirmed by many studies that a small reduction in BP may result in a large reduction in the risk of stroke and myocardial infarction [58]. What is more, a reduction of 5 mmHg in SBP has been associated with a 7% reduction in all-cause mortality [59]. Based on the paper and meta-analyses of the outcome on either SBP or DBP, Tai Chi may have positive effects for BP. Our review showed that SBP and DBP could be decreased by 9.34–14.30 mmHg and 6.00–7.16 mmHg, respectively, indicating that Tai Chi could not only reduce BP, but also have potential protective effect on reducing the risk of cardiovascular and cerebrovascular diseases. It is worth noting that the cardiovascular protective effect of Tai Chi is closely related to the long-term adherence to regular exercise. In this review, the total treatment duration ranged from 2 to 60 months. In particular, Han et al., 2010, [26] conducted a 5-year follow-up trial, showing that Tai Chi is helpful to control the hypertension and release tension emotion in order to improve QOF in middle-aged and elderly patients with EH.

However, although positive results were found in this meta-analysis, the encouraging clinical evidence of Tai Chi for EH might be weakened due to the small sample size and poor methodological qualities of included trials. And the positive findings should be interpreted conservatively. Firstly, the methodological quality of the included RCTs is assessed to be generally low. All trials included in this paper had risk of bias in terms of design, reporting, and methodology. They provided only inadequate reporting of study design, allocation sequence, and allocation concealment. Thus, potential selection bias might be generated. Randomization was mentioned but without further details in most trials, which do not allow a proper judgment of the conduction of the RCTs. It could not rule out the possibility that declared RCTs may not be really randomized. Both blinding of participants and personnel and blinding of outcome assessment have not been used due to the difficulty of operation. Thus, potential performance bias and detection bias might be generated. Drop-out was only reported in 2 trials [26, 34]. The majority of trials have not reported it at all. None of trials had a pretrial estimation of sample size. Most of the included trials were not multicenter, large scale RCTs. If poorly designed, results would show larger differences as compared to the well designed trials, and the credibility about the conclusions will be greatly reduced.

Secondly, adverse effects are not highly valued in most of the included trials. As we know that, safety is the basis for medication. However, it is always ignored and should be given priority in TCM [60–63]. In our review, only 1 trial reported the adverse effect of Tai Chi, and no adverse effect was found [30]. Most of the trials [25–29, 31–42] did not report it at all. Therefore, a definite conclusion about the safety of Tai Chi cannot be made clearly. It needs to be monitored rigorously and reported appropriately in the future clinical trials.

Thirdly, the primary goal of treatment for EH is to reduce the mortality or prevent progression to severe complications [64]. Only one trial [26] reported the 5-year follow-up of Tai Chi. It was found out that there are 2 patients died of cerebral hemorrhage in the control group. However, there were no serious cardiovascular and cerebrovascular events in Tai Chi group. The outcomes from most of the included trials are mainly BP. Thus, there is a lack of definite data from all the trials on clinically relevant outcomes such as the mortality and incidence of complications. Clinical pieces of evidence of the efficacy of TCM on the mortality and morbidity of hypertension need to be strengthened in future researches.

In summary, there is some encouraging evidence of Tai Chi for lowering BP in hypertensive patients, but the evidence remains weak due to poor methodological quality of included studies. Rigorously designed trials seem to be warranted to confirm the results.

Conflict of Interests

All authors declare that they have no conflict of interests.

Authors' Contribution

J. Wang, B. Feng, X. Yang, W. Liu, F. Teng, and S. Li contributed equally to this paper.

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Research Article

Psychoneuroimmunology-Based Stress Management during Adjuvant Chemotherapy for Early Breast Cancer

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Objective. In a randomized trial of women with early stage breast cancer undergoing adjuvant chemotherapy, two stress management interventions, tai chi training and spiritual growth groups, were compared to a usual care control group, to evaluate psychosocial functioning, quality of life (QOL), and biological markers thought to reflect cancer- and treatment-specific mechanisms. *Method*. The sample consisted of 145 women aged 27–75 years; 75% were Caucasian and 25% African American. A total of 109 participants completed the study, yielding a 75% retention rate. Grounded in a psychoneuroimmunology framework, the overarching hypothesis was that both interventions would reduce perceived stress, enhance QOL and psychosocial functioning, normalize levels of stress-related neuroendocrine mediators, and attenuate immunosuppression. *Results*. While interesting patterns were seen across the sample and over time, the interventions had no appreciable effects when delivered during the period of chemotherapy. *Conclusions*. Findings highlight the complex nature of biobehavioral interventions in relation to treatment trajectories and potential outcomes. Psychosocial interventions like these may lack sufficient power to overcome the psychosocial or physiological stress experienced *during the chemotherapy treatment period*. It may be that interventions requiring less activity and/or group attendance would have enhanced therapeutic effects, and more active interventions need to be tested prior to and following recovery from chemotherapy.

1. Introduction

A growing body of research with persons having chronic and potentially fatal illnesses such as cancer indicates that a variety of complementary or "mind-body" interventions, including strategies for stress management, can not only mitigate psychological distress and improve coping skills, but also enhance immune function through neuroendocrine-immune system modulation [1]. Briefly, PNI is concerned with the mechanisms of multidimensional psychobehavioral neuroendocrine-immune system interactions. Fundamental mechanisms involve (a) the hypothalamic-pituitary-adrenocortical (HPA) system, which coordinates the release of corticotropin (ACTH), endorphins, and glucocorticoids; (b) the sympathetic nervous system via direct innervation of immune cell receptors for neurotransmitters; and (c) the sympathetic-adrenomedullary (SAM) system, which coordinates the release of catecholamines and enkephalins [2].

Serious physical illnesses such as cancer are major stressors that tend to bring about negative affective states. Glaser and Keicolt-Glaser [3] summarized convincing evidence that both psychological stress and negative emotions augment the production of proinflammatory cytokines, concluding that these stress-related changes thus have broad implications for health. Virtually all stressors, both psychological and physiological, are associated with immune activation and enhanced production of proinflammatory cytokines such as tumor-necrosis-factor-alpha (TNF-α), interleukin-1beta (IL-1β), and IL-6 [4, 5]. Other PNI-based mechanisms of increasing interest include endorphins and enkephalins, given mounting evidence that these opioid peptides have the desired response of downregulating neuroendocrine and

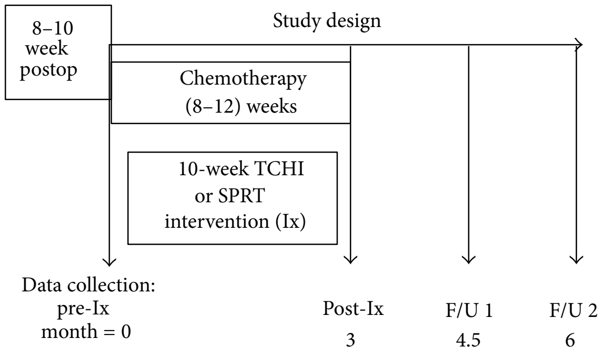

Figure 1: Study design.

autonomic stress responses and may counteract some aspects of cortisol-induced immunosuppression [6–8].

More women are living longer with breast cancer, which raises concerns for the quality of life of those women at diagnosis, during treatment, and beyond. The treatment period is known to be a highly stressful time for the growing population of breast cancer survivors, both psychologically and physiologically [9–11]. Women with breast cancer comprise the largest group of cancer survivors in the USA, and most are relatively young at the time of diagnosis [12], which underscores the importance of identifying strategies to enhance health and QOL in survivorship.

2. Methods

Following informed consent and eligibility screening, participants were randomized using a computer generated randomization table, to enter the next scheduled 10-week treatment group (TCHI or SPRT) or the usual care control group. As depicted in Figure 1, data were collected at preintervention, prior to the initiation of chemotherapy (preintervention (Pre-Ix)), within a week following the intervention (postintervention (Post-Ix)), at 4.5 months (followup 1 (F/U 1)) and 6 months after enrollment (followup 2 (F/U 2)), and at comparable times for usual care control group participants.

Using a broad psychoneuroimmunology (PNI) framework [13] to examine multiple aspects of potential stress-related mechanisms, we evaluated the effects of 10-week interventions of tai chi training (TCHI) or spiritual growth groups (SPRT) in comparison to a usual care control group among women receiving adjuvant chemotherapy for stages I–IIIA breast cancer. We tested effects of these interventions on (a) enhancing psychological well-being (perceived stress, quality of life (QOL), and depressive symptoms), (b) normalizing levels of stress-related neuroendocrine mediators (endogenous opioids), and (c) attenuating immunosuppression (cytokine patterns). Previous studies using these somewhat novel interventions in persons with HIV infection documented selected psychosocial and physiological effects including enhanced QOL, increased plasma levels of interferon-gamma (IFN-γ), and increased lymphocyte proliferative function [14, 15]. In order to expand the application of these interventions among populations with immune-mediated or immune-moderated conditions, we sought to test the effects of these PNI-based approaches for women receiving adjuvant chemotherapy for early stage breast cancer.

2.1. Measures

2.1.1. Psychosocial Instruments. Perceived stress related to diagnosis and treatment for breast cancer will be measured by the Impact of Events Scale (IES) [16]. Because of its specific nature and previous sensitivity to psychosocial interventions, we used the IES to measure the subjective distress of living with breast cancer. The IES has excellent psychometric properties and is not confounded with physical symptoms. It is a 15-item instrument with response options that indicate how frequently within the past 7 days each distressing thought related to having breast cancer and chemotherapy has occurred. Higher scores on the subscales of intrusive and avoidant thinking indicate greater psychological distress.

General QOL, along with QOL specific to living with breast cancer, was measured by the *Functional Assessment of Cancer Therapy-Breast* (FACT-B) cancer instrument [17]. The FACT-B (version 4) is a 44-item self-report instrument designed to assess QOL in breast cancer along the dimensions of functional well-being, physical well-being, emotional well-being, and breast cancer-specific factors. The instrument has demonstrated good validity and reliability in a variety of studies among women with breast cancer [18, 19].

Depressive symptoms are commonly measured in people with cancer by the *Center for Epidemiological Studies-Depression* (CES-D) scale [20]. The CES-D is a 20-item scale that asks participants to report the extent to which they experienced each of the symptoms in the preceding week. The CES-D has been widely used in persons with breast cancer with alpha coefficient of .88, test-retest reliability .51–.67, and convergent validity established by significant correlations with other established measures of depression [6, 21, 22].

2.1.2. Neuroendocrine Measures. Endorphins and enkephalins also are stress-related neuroendocrine mediators, but little clinical or biobehavioral research examining these endogenous opioids has yet been conducted. However, there is mounting evidence that opioid peptides, which are widely distributed throughout the central, peripheral, and autonomic nervous systems as well as multiple endocrine and target tissues, downregulate neuroendocrine and autonomic stress responses [6]. Opioids have been shown to affect *in vitro* function of virtually all cells of the immune system and generally have dose-dependent effects such that low doses enhance and high doses suppress immune function. Endorphins and enkephalins also are stress-related neuroendocrine mediators, but little clinical or biobehavioral research examining these endogenous opioids has yet been conducted [24, 25]. Given the available evidence and increasing interest in positive stress responses, quantification of opioid peptides is indicated in clinical studies to begin to explore their potential roles in neuroendocrine mediation of the stress process. Participants were provided with a styrofoam ice chest in order to keep their urine specimens on ice for

12-hour overnight collection periods. Urine samples were cryopreserved and batch-assayed for levels of beta-endorphin and leu-enkephalin using commercial, standardized enzyme-linked immunosorbent assay (ELISA) kits (MD Biosciences) according to the manufacturer's protocols.

2.1.3. Immunological Measures. The role of cytokines, particularly the proinflammatory cytokines involved in acute phase responses (IL-1, IL-6, and TNF-α), has been of considerable interest in recent research on psychobehavioral changes, commonly termed as "sickness behaviors" and including fatigue and depressed mood, in persons with cancer [26, 27]. Using Bio-Plex Pro (Bio-Rad Inc.) magnetic bead technology, levels of a standardized panel of cytokines, chemokines, and growth factors in cryopreserved plasma samples were analyzed using well-established protocols. The Bio-Rad 17-plex panel was used to measure IL-1β, IL-2, IL-4, IL-5, IL-6, IL-7, IL-8, IL-10, IL-12 (p70), IL-13, IL-17, granulocyte colony stimulating factor (G-CSF), granulocyte-macrophage-(GM-) CSF, IFN-γ, monocyte-chemotactic-protein-1 (MCP-1) (MCAF), macrophage-inflammatory-protein (MIP-) 1β, and tumor-necrosis-factor-alpha (TNF-α).

2.2. Interventions. Intervention groups met for 90 minutes each week for a total of 10 weeks. Participants were required to attend a minimum of 8 sessions to remain in the study. Based on prior research and in consideration of the potential physical limitations of our participants, a focused short form of tai chi training (TCHI) involving eight movements was used in this study [28]. The sequence of movements was focused on developing each individual's skills in balancing, focused breathing, gentle physical posturing and movement, and the active use of consciousness for relaxation. Movements were taught in a sequence that allowed repetitive instruction as well as a progressive building of skills. Training was designed to promote increased control of attention, increased flexibility, and an integrated mind-body relaxation experience. Additionally, the particular meanings and metaphors associated with the TCHI movements were integrated to provide a cognitive component to enhance stress management. For example, when teaching the "5 Elements," the concepts of ongoing change and transformation are discussed as represented by the seasons of the year, and the 5 elements as wood are transformed by fire into earth, the earth gives rise to minerals, minerals become water, and water nourishes wood completing the supporting cycle of life. Training videotapes/DVDs were produced and distributed to participants for weekly and ongoing practice of the techniques. To quantify TCHI practice between sessions, weekly practice cards were distributed; however, the limited number of cards returned prevented valid assessment of the amount of practice between sessions. Additionally, while not quantifiable, participants consistently reported using and enjoying the TCHI DVDs.

The spiritual growth groups (SPRT) [29] were designed for personal exploration and group sharing of spirituality, aimed at enhancing awareness of the meaning and expression of spirituality while supporting both secular and religious views of spirituality in a group format. Each session was designed to explore an aspect of spirituality, including the intellectual process of knowing or apprehending spirituality; the experiential component of interconnecting one's spirit with self, others, nature, God, or a higher power; and an appreciation of the multisensory experience of spirituality.

2.3. Data Analytic Approaches. We used mixed linear modeling to compare changes in the usual care control group with each intervention group and to accommodate for the correlated structure in the repeated measures for three time periods (Pre-Ix to Post-Ix, Pre-Ix to F/U 1, and Pre-Ix to F/U 2). In an attempt to satisfy the model assumptions, the cytokines were log transformed using $\log_e$ (natural log). No effects for potential cofactors such as age, race, menopausal status, type of therapy, and stage of disease were found in the initial modeling, and thus they were removed from the final models.

3. Results

The sample consisted of 145 women aged 27–75 years (average = 50 years); 75% were Caucasian and 25% African American. A total of 109 participants completed the intervention or comparable usual care control group measures, yielding a 75% retention rate. The predominant reason for attrition, involving a full 40% of withdrawals, was related to intervention group meetings (i.e., not being able or not wanting to continue group meetings). No differences were seen in the demographics for those who withdrew and those who remained in the study.

Intervention and usual care control group participants did not differ by age, race, menopausal status, diagnostic stage, or treatment approach nor by self-reported physical or functional well-being. Additionally, group participants were comparably distributed across breast cancer stage. Participants received relatively consistent protocols for chemotherapy regimens, guided by national standards and ongoing clinical trials at a National Cancer Institute-designated Cancer Center or its affiliated local institutions. Following surgical removal of their breast tumors, the majority of participants received regimens of cyclophosphamide and doxorubicin every 2-3 weeks for a total of 4 doses.

For all participants, levels of stress were highest at baseline, decreased over the period of chemotherapy, and then plateaued over the recovery period. Similarly, QOL scores decreased during chemotherapy but increased by the first follow-up time point. Figure 2 illustrates this type of pattern with the IES scores, while Table 1 displays the total sample scores for the IES and FACT-B over time, none of which were different by group. However, immediately following postintervention, TCHI participants demonstrated an increase ($P = 0.003$) in depressive symptoms (mean = 15.4, SE = 1.4) as compared to the standard care (mean = 9.2, SE = 1.8) and SPRT (mean = 10.1, SE = 2.2) groups. This pattern was not evident 6 weeks later at F/U 1, and levels of depressive symptoms declined for all groups of participants over time (Figure 3).

Significant elevations were seen in urinary beta-endorphin levels for the SPRT group immediately following

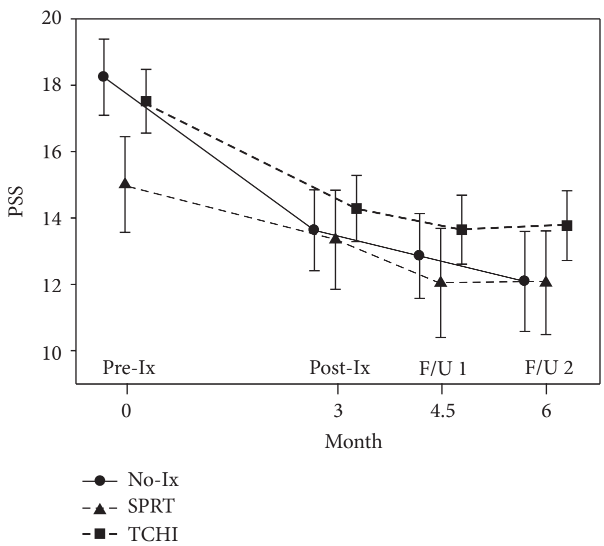

Figure 2: Perceived stress scores (IES) for groups over time.

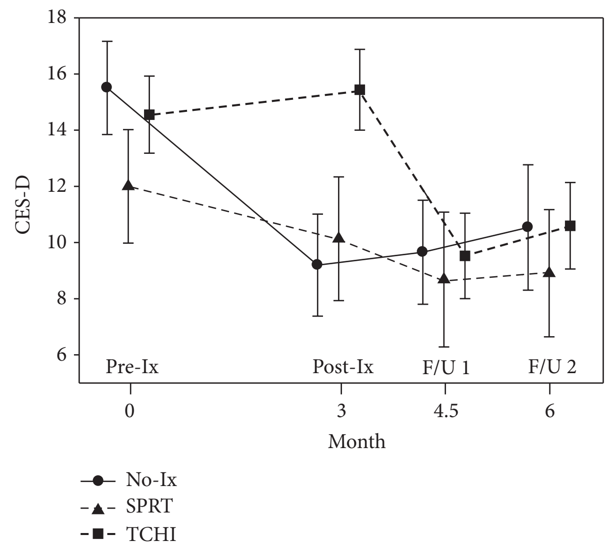

Figure 3: Depressive symptom scores (CES-D) for groups over time.

Table 1: Psychological well-being and quality of life: means (SE) for total sample over time.

Measure	Time			
	Pre-Ix	Post-Ix	F/U 1	F/U 2
IES*	16.92 (0.69)	13.75 (0.72)	12.85 (0.78)	12.63 (0.80)
FACT-B†	105.19 (2.03)	102.96 (2.12)	110.19 (2.20)	110.63 (2.27)

*Means are significantly different over time ($P < 0.0001$) with Pre-Ix mean significantly greater than Post-Ix, F/U 1, and F/U 2 means.

†Means are significantly different over time ($P < 0.0001$) with Pre-Ix and Post-Ix means significantly greater than F/U 1 and F/U 2 means.

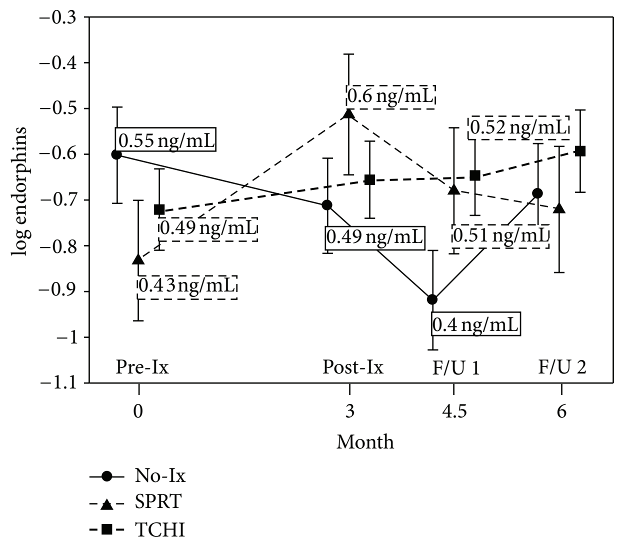

Figure 4: Urinary endorphin levels by group over time. Means in boxes are back-transformed from $\log_e$ (natural log) used for analysis and are shown for timepoints with significantly different values only.

intervention and for both SPRT and TCHI at the 4.5-month followup (Figure 4). There were no significant differences in enkephalin levels between groups at any measured time point.

As displayed in Figure 5 for IL-1β, trends of declining levels during chemotherapy, followed by recovery of cytokine levels, were seen for several proinflammatory cytokines (IL-1β, IL-2, IL-6, and IFN-γ). However, the only significant differences between the two treatment groups and the usual care control group in the cytokines were seen in IFN-γ. As shown in Figure 6, significant elevations in IFN-γ were noted for both intervention groups at the 6-month followup possibly reflecting better recovery of proinflammatory cytokine production.

4. Discussion and Conclusions

The increase in the stress levels in TCHI participants demonstrated at postintervention when compared to the usual care control group might be an indication of increased self-awareness and/or "centering," reflected as psychological distress. TCHI, like other mindfulness-based interventions, focuses on enhancing mindfulness and self-awareness, which may temporarily increase depressive-like symptoms in the face of critical illness situations such as cancer chemotherapy. Factors such as self-awareness and mindfulness, however, were not directly measured in this study. Additionally, TCHI groups were small, typically 3–5 women, and participants voiced discomfort related to learning a new skill in small groups. Chintamani and colleagues [10] found that response to chemotherapy was the most significant variable affecting psychological status in 84 Indian women with locally advanced breast cancer. While sample size, cultural factors, and stage of disease limit generalizability of these findings, it is reasonable to assume that response to treatment impacts psychological status in women with breast cancer. In the current study, we did not specifically track response to treatment and thus could not examine whether this was a factor contributing to study outcomes.

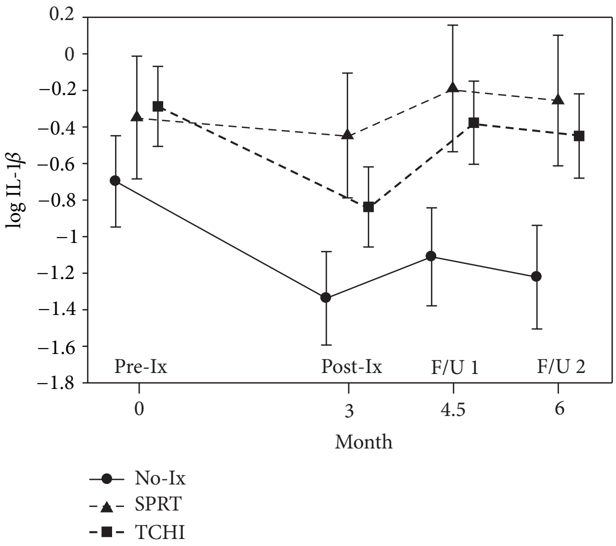

Figure 5: IL-1β levels by group over time.

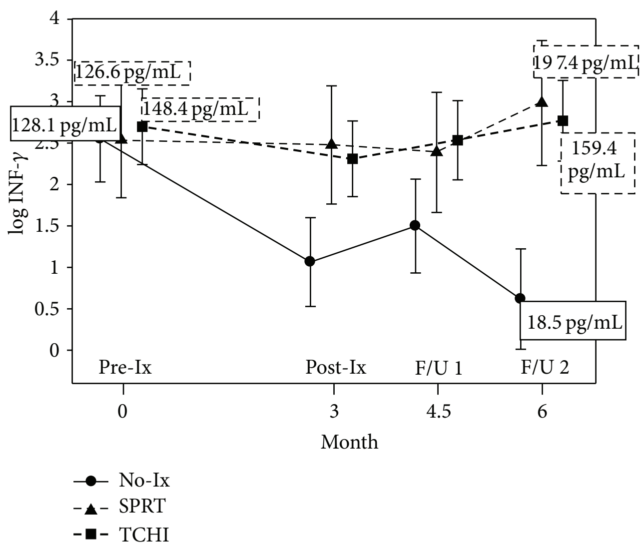

Figure 6: IFN-γ levels by group over time. Means in boxes are back-transformed from $\log_e$ (natural log) used for analysis and are shown for timepoints with significantly different values only.

Limited studies of traditional stress management interventions, particularly cognitive behavioral stress management (CBSM), have been found to enhance some aspects of psychosocial and physiological function in women newly diagnosed with breast cancer. For example, Antoni and colleagues [30] found that a 10-week CBSM intervention in a sample of 128 women reduced cancer-specific anxiety and promoted physiological adaptation as evidenced by reduced cortisol and increased IL-2, IFN-γ, and IL-2:IL-4 ratio. Additionally, the intervention was associated with increases in participants' perceived ability to relax as well as reductions in afternoon cortisol levels during and immediately following treatment [27].

CBSM offers a variety of techniques for inducing relaxation and cognitively restructuring perceptions of and responses to stress, thereby enabling participants to choose the method that works best for them. While the TCHI intervention offered a variety of different movements, the *combination* of movements is consistent with the strength of traditional TCHI practice, and selection of individual movements is not encouraged. The SPRT intervention also offered several activities; however, each activity was focused on the exploration of one's spirituality and not necessarily congruent with inducing relaxation per se. Indeed, such interventions as TCHI and SPRT may lack the "potency" to overcome the psychological stress and physiological effects of chemotherapy itself. It may be that interventions requiring less activity and/or group attendance would have more therapeutic effects in persons receiving chemotherapy treatment regimens.

While there were significant changes in urinary beta-endorphin levels, there were no significant findings for leu-enkephalin. Given the available evidence and increasing interest in positive stress responses, quantification of endogenous opioid peptides is a promising addition in clinical studies to begin to explore their potential roles in the stress process, including immune function.

Generally, the type, timing, and sequencing of stress management interventions have as yet undefined effects on outcomes. Findings of this study highlight the complex nature of biobehavioral interventions in relation to treatment trajectories and potential outcomes. Psychosocial interventions like TCHI or SPRT may lack sufficient power to overcome the psychosocial or physiological stress experienced during the period of treatment with immunosuppressive chemotherapeutic agents and commonly experienced side effects such as fatigue and gastrointestinal disturbances.

Because of the inherent complexity in production, mechanisms of action, pleotropic effects, and cytokine patterns rather than levels of production of one or a selected few "representative" cytokines need to be evaluated. State-of-the-science technologies and emerging analytic approaches to evaluate patterns of cytokines are now being used to discern clinically meaningful effects and potential mechanistic insights [22, 31].

Most of the research on psychosocial interventions in breast cancer involves patients who have completed the active treatment. Ours is one of few reports of psychosocial interventions involving movement and spirituality for individuals during the period of active chemotherapy and/or radiotherapy for cancer. We undertook a "high-risk" study with respect to the delivery of somewhat novel interventions during a period of high stress and complex physical symptoms related to breast cancer and its treatment. While informal subjective feedback from participants was positive among most women who completed the interventions, the quantitative measures indicated little effect of either intervention in this study.

Conflict of Interests

There are no conflict of interests.

Acknowledgments

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Research Article

Shoulder Mobility, Muscular Strength, and Quality of Life in Breast Cancer Survivors with and without Tai Chi Qigong Training

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Objectives. To compare the shoulder mobility, muscular strength, and quality of life (QOL) among breast cancer survivors with and without Tai Chi (TC) Qigong training to those of healthy individuals and to explore the associations between shoulder impairments and QOL in breast cancer survivors with regular TC Qigong training. *Methods*. Eleven breast cancer survivors with regular TC Qigong training, 12 sedentary breast cancer survivors, and 16 healthy participants completed the study. Shoulder mobility and rotator muscle strength were assessed by goniometry and isokinetic dynamometer, respectively. QOL was assessed using the Functional Assessment of Cancer Therapy-Breast (FACT-B) questionnaire. *Results*. Goniometric measurements of the active range of motion in the flexion, abduction, and hand-behind-the-back directions were similar among the three groups. The TC Qigong-trained breast cancer survivors had significantly higher isokinetic peak torques of the shoulder rotator muscles (at 180°/s) than untrained survivors, and their isokinetic shoulder muscular strength reached the level of healthy individuals. Greater shoulder muscular strength was significantly associated with better functional wellbeing in breast cancer survivors with TC Qigong training. However, no significant between-group difference was found in FACT-B total scores. *Conclusions*. TC Qigong training might improve shoulder muscular strength and functional wellbeing in breast cancer survivors.

1. Introduction

Breast cancer (CA) is the most common malignant disease affecting women of all ages [1]. Despite the increased survival rates of breast CA patients [1], conventional treatments (e.g., mastectomy and radiotherapy) often result in side effects such as impaired shoulder function with decrements in shoulder muscular strength, shoulder mobility, and functional capacity [2, 3]. These side effects may persist or even increase several years posttreatment and are often severe enough to reduce self-esteem and diminish the quality of life (QOL) of breast cancer survivors [3, 4].

To manage the side effects of conventional cancer treatments and restore physical functioning and QOL, many female breast cancer survivors turn to complementary therapies such as Tai Chi and Qigong [5]. These mind-body exercise interventions simultaneously address physical and psychological needs and thus are particularly suitable for breast CA survivors [5].

Tai Chi (TC) Qigong, a mind-body exercise, was developed in China in the late 1970s and has gained popularity in both Eastern and Western countries [6, 7]. It is a simplified version of the traditional TC form and incorporates many Qigong training elements such as awareness of body movements and diaphragmatic breathing during practice. TC Qigong represents the essence of mind-body exercise [6, 7]. Training in TC Qigong has been reported to improve physical functioning and QOL in elderly people with chronic diseases [6, 8]. However, its potential for improving shoulder impairments and associated QOL in breast CA survivors is still not clear. To the best of our knowledge, only one study has investigated the effect of Tai Chi Chi Kung (TC Qigong) training on shoulder flexibility and handgrip strength in breast CA survivors [9]. Although the results were promising, the authors did not measure the functional mobility of the affected shoulder (e.g., hand-behind-the-back mobility) or shoulder muscular strength, which are crucial for many daily activities [10]. A study by Mustian and colleagues also reported that TC training could improve QOL in breast CA survivors, but they did not correlate QOL with any physical impairment [11].

The objectives of this study were (1) to compare the shoulder mobility and muscular strength among breast CA survivors with and without TC Qigong training with that of healthy individuals, (2) to compare the QOL of breast CA survivors with and without TC Qigong training, and (3) to explore the associations between shoulder impairments and QOL in breast CA survivors with regular TC Qigong training.

2. Methods

2.1. Sample Size Calculation. Previous studies have shown that breast CA patients or survivors who exercise regularly have greater shoulder mobility and muscular strength when compared to control participants [12–14]. The reported effect sizes ranged from 1.2 to 3.1 for shoulder range of motion (ROM) [12] and from 0.7 to 1.3 for shoulder muscular strength [13]. According to a meta-analysis, the effect sizes for improving QOL outcome measures ranged from 0.2 to 1.0 [14]. In light of the scientific evidence, a relatively large effect size of 1.3 was expected for this study. Based on an alpha value of 5% and power of 80%, a sample of 22 breast CA survivors was needed.

2.2. Participants. Eleven women who had recovered from breast CA and received TC Qigong training at the Hong Kong Wushu and Art Service Centre, which provides TC Qigong training classes for cancer survivors, were recruited (TC Qigong CA group). In addition, age- and sex-matched control participants both with (CA-control group, $n = 12$) and without (healthy-control group, $n = 16$) history of breast CA were recruited from CA self-help groups and from the community, respectively. The inclusion criteria for the TC Qigong CA and CA-control participants were as follows (1) having a history of breast CA; (2) having received a mastectomy with or without adjuvant chemotherapy or radiotherapy; (3) having completed conventional breast CA treatments and being medically stable; (4) having no cognitive or psychological disorder (e.g., depression); (5) having no known neurological deficit resulting from breast CA treatments; (6) being aged 18 or older. An additional requirement for the participants in the TC Qigong CA group was that they had practiced the 18 Forms Tai Chi Internal Qigong for more than six months consecutively (three sessions per week, one hour per session). This practice comprises 18 movements designed to release tension in the body, promote relaxation, and increase awareness of breathing. Typical TC movements such as weight shifting, arm swinging, and punching and the gentle stretching of various body parts are performed smoothly with mental guidance and coordinated breath control [6]. The details of this TC Internal Qigong form have been described in Mak [7].

Individuals were excluded if they met any of the following criteria: (1) having significant neurological, musculoskeletal (e.g., history of shoulder dislocation or frozen shoulder), cardiovascular, peripheral vascular, or kidney disorders; (2) being receiving chemotherapy/radiotherapy, anti-cancer medication, acupuncture, or other cancer treatments; (3) having recurrent breast CA or cancer spread to other organs; (4) being exercising regularly; (5) having a smoking habit; (6) having received a lumpectomy instead of a mastectomy; or (7) being pregnant. The participants in the healthy-control group fulfilled the same aforementioned inclusion and exclusion criteria with the exceptions that they had no previous diagnosis of CA and hence had not received cancer treatment and had no previous experience in TC Qigong.

Ethics approval was obtained from the Human Subjects Ethics Review Subcommittee of the administering institute. The study was explained to each participant and written informed consent was obtained from those who agreed to participate.

2.3. Procedures. All of the assessment procedures were conducted in accordance with the Declaration of Helsinki and took place in the Sports Training and Rehabilitation Laboratory at the administering university. Standardized physical measurements were conducted by a registered physiotherapist who was blinded to the subject group. The demographic and QOL data were collected by a research assistant.

2.4. Outcome Measures

2.4.1. Shoulder Mobility. A universal goniometer was used to measure the active ROM of shoulder flexion and abduction for the affected or the dominant arm (for bilateral mastectomy cases and healthy control participants). The ROM of the contralateral (unaffected) shoulder was not assessed because radiotherapy or chemotherapy can also affect the contralateral shoulder, making bilateral comparison unreliable [15]. Only active ROM was measured, as it is more functional than passive ROM [16].

The measurements were recorded while the participant was seated and the humerus was rotated externally through complete shoulder flexion and abduction. A standardized protocol was followed to minimize compensatory trunk movements or other trick movements [10]. All ROM measurements were for the affected shoulder complex (i.e., the scapula was not fixed) rather than for isolated movements of the glenohumeral joint. In addition, hand-behind-the-back mobility (i.e., the combined active ROM of scapular adduction and medial rotation, shoulder extension and internal rotation, elbow flexion, forearm pronation, wrist radial deviation, and finger extension) was assessed by measuring the distance (with a cloth measuring tape) between the spinous process of the seventh cervical vertebra and the tip of the middle finger as the participant reached up the back [10]. A shorter distance generally implies greater functional mobility in the affected upper limb. Hand-behind-the-back flexibility was examined because it is essential for performing many daily activities such as fastening a bra [10]. Shoulder ROM was measured three times in each movement direction and the highest value was used for analysis. Intrarater reliability for shoulder goniometric measurement was reported to be excellent in a previous study (ICC: 0.94, 95% CI: 0.91–0.99) [17].

2.4.2. Shoulder Isokinetic Muscular Strength. All of the participants were first screened for contraindications of isokinetic testing according to the method described by Chan et al. [18]. The maximum strengths of the shoulder internal and external rotator muscles (primarily the rotator cuff muscles) of the affected upper limb or the dominant limb (for bilateral mastectomy cases and healthy control participants) were measured using a Cybex Norm isokinetic dynamometer (Computer Sports Medicine Inc., Stoughton, MA, USA). The shoulder rotator muscles were assessed because they dynamically stabilize the glenohumeral joint during many functional activities, and changes in strength may result in shoulder disorders [19]. In addition, the manipulation of the pectoral muscles (major internal rotator of the shoulder) and potential injury to the pectoral nerves during mastectomy may weaken the shoulder internal rotators, which may affect the QOL of breast CA survivors [20].

During the test, each participant laid on the testing couch in a crook-lying position. The participant's trunk was stabilized with straps and the nontested hand held onto the handle of the couch. The affected shoulder was positioned at 90° of abduction, elbow in 90° of flexion, and forearm in vertical, with the hand grasping the handle of the wrist/shoulder adapter (i.e., neutral starting position). The longitudinal axis of the humerus was aligned with the rotation axis of the dynamometer. The testing range for the external rotator muscles was from 70° internal rotation to 90° external rotation while the testing range for the internal rotator muscles was from 90° external rotation to 70° internal rotation [21]. An intermediate testing velocity of 180°/s was adopted because it is more functional and resembles the movement speed of many daily activities [22]. Familiarization trials were performed in the form of three submaximal and three maximal concentric shoulder internal/external rotator muscle contractions. After correcting for the effect of gravity on shoulder torque, five maximal concentric contractions of the shoulder internal and external rotator muscles were recorded as a test ensemble [21]. The average values of the five bodyweight-adjusted peak torques of both shoulder internal and external rotators were used for analysis.

2.4.3. Quality of Life. QOL was assessed using the Functional Assessment of Cancer Therapy-Breast (FACT-B, version 4) scale. The reliability and validity of this instrument have been reported to be high [23, 24]. However, only the two CA groups completed the questionnaire because it is specifically designed for breast CA patients and survivors [23, 24].

The FACT-B includes 36 questions divided into five subscales: physical wellbeing (7 items), social/familial wellbeing (7 items), emotional well-being (6 items), functional well-being (7 items), and breast CA-specific concerns (9 items). These subscales comprise QOL-related statements that respondents rate on a 5-point Likert scale of agreement ranging from "not at all" (score 0) to "very much" (score 4). Item scores within a subscale were summed to produce a subscale score. The five subscale scores were then summed to obtain the total FACT-B score (i.e., item scores for all 36 items). A higher score indicates a more favorable QOL [23, 24].

2.5. Statistical Analysis. The Shapiro-Wilk statistic was first used to check the normality of the data. One way analysis of variance (ANOVA) was then used to compare the differences among the TC Qigong, CA-control, and healthy-control groups for the demographic and shoulder active ROM data and the isokinetic peak torques of the shoulder rotator muscles. Bonferroni tests were used to analyze the data post hoc as necessary.

To compare the QOL variables between the TC Qigong CA and CA-control groups, a single multivariate analysis of variance (MANOVA) incorporating all of the FACT-B subscale scores was performed. The results from this analysis showed the effects of the group on all of the FACT-B subscale outcomes and the corresponding Bonferroni-adjusted P values, thus avoiding the increased probability of committing the type I errors associated with multiple comparisons. As the FACT-B total score was the sum of all subscale scores, an independent t-test was performed separately to compare this variable between the TC Qigong CA and the CA-control groups. Partial eta-squared and Cohen's d, which are the standardized measures of effect sizes for ANOVA and t-test, respectively, are also presented for the outcomes. By convention, partial eta-squared values of 0.01, 0.06, and 0.14 are considered to be small, medium, and large effect sizes, respectively, while Cohen's d values of 0.20, 0.50, and 0.80 are considered to be small, medium, and large, respectively [25].

If there were any significant between-group differences in the outcome measures, Pearson's product-moment correlation coefficient (Pearson's r) was used to explore the bivariate correlations between the physical impairment outcomes (i.e., shoulder ROM and muscular strength variables) and the QOL outcomes (i.e., FACT-B-derived variables) in the TC Qigong CA group. All of the statistical analyses were performed using SPSS version 20.0 and a significance level of 0.05 (two tailed) was chosen.

3. Results

The characteristics of the participants are presented in Table 1. There were no significant differences between groups for any of the demographic variables ($P > 0.05$). Shoulder active ROM in flexion ($P = 0.598$), abduction ($P = 0.964$), and hand-behind-the-back ($P = 0.464$) directions were similar among the three groups (Table 2). However, significant between-group differences were found in the isokinetic peak torques of shoulder internal rotators ($P < 0.025$) and external rotators ($P < 0.025$). Post hoc tests revealed that participants in the TC Qigong CA group had significantly higher isokinetic peak torques (shoulder internal rotators, $P = 0.049$; shoulder external rotators, $P = 0.040$) than the CA-control participants. When compared to the healthy-control participants, the TC Qigong-trained breast CA survivors demonstrated no difference in shoulder isokinetic peak torques ($P > 0.05$), whereas the breast CA survivors without TC Qigong training showed significantly lower shoulder isokinetic peak torques (shoulder internal rotators, $P = 0.033$; shoulder external rotators, $P = 0.025$) (Table 2). None of the participants complained of shoulder pain or discomfort during the ROM and muscle strength assessments.

Analysis of the FACT-B scores revealed no significant differences in the physical, social/familial, or emotional well-being subscale scores, or between the total FACT-B scores of the two CA groups ($P > 0.05$). However, the TC Qigong participants had higher functional well-being subscale scores ($P = 0.012$) and lower breast CA-specific concern subscale scores ($P = 0.036$) than the CA-control participants (Table 2). A further correlation analysis showed that only the FACT-B functional well-being subscale score was positively correlated with the isokinetic peak torque of shoulder internal rotators ($r = 0.952$, $P < 0.001$) and external rotators ($r = 0.876$, $P < 0.001$) in the TC Qigong CA participants.

4. Discussion

4.1. Shoulder Mobility. Our results demonstrate that all of our participants had a full range of shoulder motion in the flexion and abduction directions compared with the normative data [10] (Table 2). In addition, we found no significant difference in active shoulder ROM (flexion, abduction, and hand-behind-the-back directions) between breast CA survivors and healthy controls. This finding is in contrast to those of previous studies, which have reported restricted shoulder movements in breast CA survivors [12, 26]. A major reason for this discrepancy could be the differences in reporting shoulder ROM. Most previous studies compared the mobility of the affected shoulder to that of the unaffected shoulder and reported shoulder ROM deficits on the affected side [13, 26], whereas our study compared shoulder ROM in breast CA survivors to that of matched controls. Moreover, variations in postsurgical durations, the age ranges of participants, the treatments received, and the length of rehabilitation [15] might explain the inconsistent findings. The participants in our TC Qigong CA group had been recovering from breast CA for a prolonged period (average 6.8 years) and thus may have been fully rehabilitated and regained full shoulder mobility. TC Qigong training may not be able to increase shoulder flexibility. Certainly, a further prospective study would be necessary to confirm this postulation.

4.2. Shoulder Isokinetic Muscular Strength. In agreement with Harrington et al., who reported reduced isometric shoulder strength, including internal and external rotator muscle strength, in breast CA survivors compared to healthy control participants [15], we also found that the body-weight-adjusted isokinetic peak torques of the shoulder internal and external rotators were lower in breast CA survivors (without TC Qigong training) than in the healthy control participants. Surgical trauma together with activity avoidance may be the major causes of shoulder muscle weakness [20, 27]. It seems that TC Qigong is a suitable exercise to improve shoulder muscular strength (Table 2) and therefore QOL in CA survivors [3, 4].

Although TC Qigong training focuses on relaxation and involves minimal muscle work, our results revealed that TC Qigong-trained participants had greater shoulder rotator muscle strength than the CA-control participants who had never received TC Qigong training. The body-weight-adjusted isokinetic peak torques of shoulder internal and external rotators in the TC Qigong-trained participants were actually comparable to those of the healthy control participants (Table 2). Coincidentally, Mustian et al. also reported improved hand grip strength in breast CA survivors after 12 weeks of TC Chi Kung (Qigong) training [9]. However, according to the exercise prescription guidelines of the American College of Sports Medicine, TC Qigong exercise involving free active upper limb movements does not meet the criteria for muscle strengthening (i.e., exercise close to volitional fatigue) [28]. Why might TC Qigong training improve upper limb muscle strength in breast cancer survivors? We postulate that the improvement is due to the mental training incorporated into this mind-body exercise. TC Qigong practitioners use the mind to control body movements during practice. There is evidence that mental control of muscle contractions can enhance the cortical output signals that drive the “mentally trained muscles” to a higher activation level and thus increase muscular strength [29]. Moreover, although the exercise intensity of TC Qigong appears low, ROM exercises may prevent muscle atrophy and reduce scar fibrosis and hence attenuate significant loss of muscular strength [30].

4.3. Quality of Life. Another encouraging finding was that the scores on the FACT-B functional well-being subscale in the TC Qigong CA group were significantly higher than those of the CA-control group (Table 2). This result is consistent with that of Oh et al. [31], who used a randomized controlled study design and found that the FACT functional well-being subscale scores of cancer patients improved significantly and were higher than those of the control participants after 10 weeks of Qigong training. However, their study did not offer any explanation of the patients’ improved daily functioning such as the ability to work and enjoy life after Qigong exercise [31]. We attempted to provide such an explanation through correlation analysis and our results suggest that

Table 1: Characteristics of participants (mean ± SD).

	TC Qigong CA group (n = 11)	CA-control group (n = 12)	Healthy-control group (n = 16)	P
Age (year)	58.3 ± 10.1	53.8 ± 4.2	56.8 ± 6.4	0.304
Height (cm)	155.5 ± 4.3	156.7 ± 6.0	156.5 ± 5.6	0.859
Weight (kg)	50.4 ± 7.4	55.6 ± 8.8	57.2 ± 5.5	0.063
Body mass index (kg/m^2)	20.8 ± 3.0	22.6 ± 3.3	23.3 ± 1.2	0.054
Breast CA affected/surgical side (n)	Left = 6; Right = 4; Bilateral = 1	Left = 10; Right = 2	N/A	—
Mastectomy (n)	11	12	0	—
Postmastectomy duration (year)	6.8 ± 4.3	7.2 ± 4.0	N/A	0.843
Radiotherapy (n)	11	12	0	—
Chemotherapy (n)	2	1	0	—
Qigong experience (year)	0.9 ± 0.2	0	0	—

Table 2: Comparison of outcome measures between groups (mean ± SD).

	TC Qigong CA group (n = 11)	CA-control group (n = 12)	Healthy-control group (n = 16)	Effect size	P
Shoulder active ROM (affected side/dominant side)					
Flexion (degree)	178.2 ± 4.6	176.8 ± 6.8	178.8 ± 3.4	0.028	0.598
Abduction (degree)	179.1 ± 3.0	179.1 ± 2.9	179.3 ± 2.5	0.002	0.964
Hand behind back (cm)	8.7 ± 6.3	6.0 ± 4.5	8.1 ± 5.8	0.042	0.464
Body-weight-adjusted isokinetic peak torque at 180°/s (affected side/dominant side)					
Shoulder internal rotators (Nm)	26.7 ± 5.4†	19.9 ± 7.0	26.5 ± 6.6†	0.198	0.019**
Shoulder external rotators (Nm)	27.8 ± 5.3†	21.7 ± 6.4	27.7 ± 5.2†	0.210	0.014**
FACT-B					
Physical wellbeing	24.6 ± 5.2	22.5 ± 6.3	N/A	0.033	0.406
Social/family wellbeing	18.5 ± 2.4	14.8 ± 5.9	N/A	0.153	0.065
Emotional wellbeing	20.6 ± 2.5	18.2 ± 4.9	N/A	0.089	0.167
Functional wellbeing	25.6 ± 2.5	21.2 ± 4.7	N/A	0.264	0.012*
Breast CA-specific concerns	25.7 ± 5.0	30.3 ± 4.9	N/A	0.193	0.036*
Total score	114.9 ± 10.3	107.0 ± 16.0	N/A	0.587	0.179

* Denotes a significant difference at $P < 0.05$.
** Denotes a significant difference at $P < 0.025$.
† Denotes a significant difference at $P < 0.05$ when compared with the CA-control group.

higher shoulder rotator muscle strength was associated with higher FACT-B functional well-being subscale scores in the TC Qigong participants. This finding is logical because the shoulder rotators, including the rotator cuff muscles, are the major dynamic stabilizers of the glenohumeral joint during many daily functional activities. Decreases in the strength profile have been found to result in shoulder disorders, functional disability, and reduced QOL in patient populations [19, 32].

Despite the potential positive effect of TC Qigong training on functional well-being in breast CA survivors, the exercise may not relieve survivors' concerns about breast CA-related problems. Our results reveal that the breast CA survivors who participated in TC Qigong training experienced more side effects of conventional cancer treatments (e.g., swollen arm), and their psychological status (e.g., self-esteem relating to sexual attractiveness), as reflected by the FACT-B breast CA-specific concerns score (Table 2), was inferior to that of the CA-control group participants. These findings are quite different from those of a previous study that reported improved self-esteem and health-related QOL in breast CA survivors after TC Chi Kung (Qigong) training [11]. Because this is a cross-sectional study, it is uncertain whether the negative findings were due to the ineffectiveness of TC Qigong exercise or due to sampling (self-selection) bias. Perhaps those breast CA survivors who had greater concerns about their physical and psychological health were keener to participate in TC Qigong training. Thus, this group of participants might be more sensitive to the negative changes related to cancer treatments. Randomized controlled studies may be necessary to confirm the effects of TC Qigong training on FACT-B breast CA-specific concerns.

Regarding the physical, social/family, and emotional well-being subscale scores, no between-group differences were observed in this study (Table 2). Again, these findings are quite different from those of Oh et al., who discovered the positive effects of Qigong training on the QOL of CA patients [31]. We conjecture that our insignificant findings were due to our relatively small sample size. Indeed, the effect sizes of these three subscale scores ranged from moderate to large (0.033–0.153, resp.). Further investigation using a larger sample might detect between-group differences.

As no between-group differences were found for most of the FACT-B subscale scores, the total FACT-B score, which is the sum of all subscale scores, was similar between the two groups (Table 2). This implies that, overall, participants in the TC Qigong CA group had a QOL that was similar to that of those in the CA-control group. Our findings disagree with those of a previous study that reported improved QOL in breast CA patients after TC Chi Kung (Qigong) training [11]. Further prospective studies using larger samples are necessary to confirm the results.

4.4. Study Limitations and Recommendation for Future Research. TC Qigong training appears to improve shoulder rotator muscle strength and functional well-being in breast CA survivors. However, due to the cross-sectional research design and relatively small sample size, we cannot confirm the results without larger-scale, randomized controlled clinical trials. Moreover, some of our participants could not recall the exact type of surgery (e.g., radical or modified mastectomy) they had received and we were unable to retrieve their medical records. Exercise history was also not documented in this study. All these factors may confound the results. Further study may include a more homogenous sample and request the participants to present their surgical or medical records and exercise history during the screening process.

5. Conclusions

Although there was no obvious impairment of shoulder mobility, impairment of shoulder rotator muscle strength was apparent among the breast CA survivors. Tai Chi Qigong training might improve shoulder muscular strength and, therefore, the functional well-being of breast CA survivors. TC Qigong can be considered as a potential therapeutic intervention for long-term breast CA survivors.

Conflict of Interests

The authors declare that they have no conflict of interests with respect to the authorship or publication of this paper.

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Review Article

Effects of Qigong on Depression: A Systemic Review

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Physical exercises and relaxation have been found to be beneficial for depression. However, there is little evidence on the use of Qigong, a mind-body practice integrating gentle exercise and relaxation, in the management of depression. The aim of this paper is to evaluate the effects of Qigong on depression. The paper examined clinical trials measuring the effect of Qigong on depression within six large-scale medical research databases (PubMed, Medline, ProQuest, Science Direct, EMBASE, and PsycInfo) till October 2011. Key words "Qigong," "depression," and "mood" were used. Ten studies were identified as original randomized controlled trial (RCT) studies investigating the effect of Qigong on depression as primary ($n = 2$) or secondary outcome ($n = 8$). Four studies reported positive results of the Qigong treatment on depression; two reported that Qigong effect on depression was as effective as physical exercise. One study reported that Qigong was comparable to a conventional rehabilitation program, but the remaining three studies found no benefits of Qigong on depression. While the evidence suggests the potential effects of Qigong in the treatment of depression, the review of the literature shows inconclusive results. Further research using rigorous study designs is necessary to investigate the effectiveness of Qigong in depression.

1. Introduction

Depression is a common illness occurring in approximately 5–13% of women and 2–8% of men at any particular point in time. Depression has a lifetime prevalence rate of 16.2% and a twelve-month prevalence rate of 6.6% [1, 2]. By 2020, depression is projected to become the second global leading cause of disability [3]. The annual cost of depression in the United States exceeds $80 billion, surpassing that of other chronic illnesses such as diabetes and hypertension [4]. Depression not only accounts for up to 70% of psychiatric hospitalizations and 60% of suicides, but also complicates the management of other diseases [5]. Despite the growing number of marketed antidepressants, between 19 and 34% of patients with depression do not respond to acute antidepressant treatment. 29–46% of patients with depression fail to achieve full remission, and up to 50% of patients experience recurrence [6, 7]. Given the scale of this problem, there is a need to explore alternative and complementary forms of treatment. In recent years, there has been a growing interest in alternative medical approaches to treating depression, including acupuncture [8, 9], Tai Chi [10], meditation [11, 12], and Qigong [13, 14].

Qigong is a traditional Chinese mind-body medicine dating back to over one thousand years. It consists of two types: internal and external Qigong. Internal Qigong is a form of mind-body medicine that involves coordinated gentle exercise and relaxation through meditation and breathing [15]. The practice of internal Qigong promotes balance and is believed to combat energy blockages by facilitating the flow of vital energy around the body [16]. In doing so, it contributes to both physical and psychological well-being. External Qigong, on the other hand, is a branch of energy medicine in which an experienced Qigong practitioner sends or emits Qi—a form of energy—to a patient for the treatment of that patient's illnesses [17].

Existing literature has reported that internal Qigong decreases heart rate [18], blood pressure [19], lipid levels [19], and circulating stress hormones [20] as well as improves the body's immune function [20, 21]. Moreover, a recent review which examined 77 articles on the physiological and psychological effects of Tai Chi and Qigong suggests that both Tai Chi and Qigong have beneficial effects on bone density, cardiopulmonary functions, physical and immune functions, self-efficacy, and quality of life and improve psychological symptoms [22]. Most of the earlier studies on Qigong recruited subjects with a variety of medical conditions; however, only a few specifically examined the effects of Qigong on patients with depression. This paper aims to fill the gap in the literature by examining the reported effects of internal Qigong on depression and demonstrates the need for further research.

2. Methods

A literature search reviewing all published articles prior to October 2011 on the effect of Qigong on depression was conducted using PubMed, Medline (1950~), ProQuest (1950~), ScienceDirect (1950~), EMBASE, and PsycINFO (1806~). Key words "Qigong," "depression," and "mood" were used in the literature search. Identified records were initially screened for eligibility based on title and abstract. Reference lists of identified papers and reviews were manually searched for additional studies in related areas. Articles were finally selected based on the analysis of the full text. Two reviewers, B. Oh, and A. Yeung, independently applied the inclusion criteria. The two reviewers compared results and resolved any discrepancies by agreement.

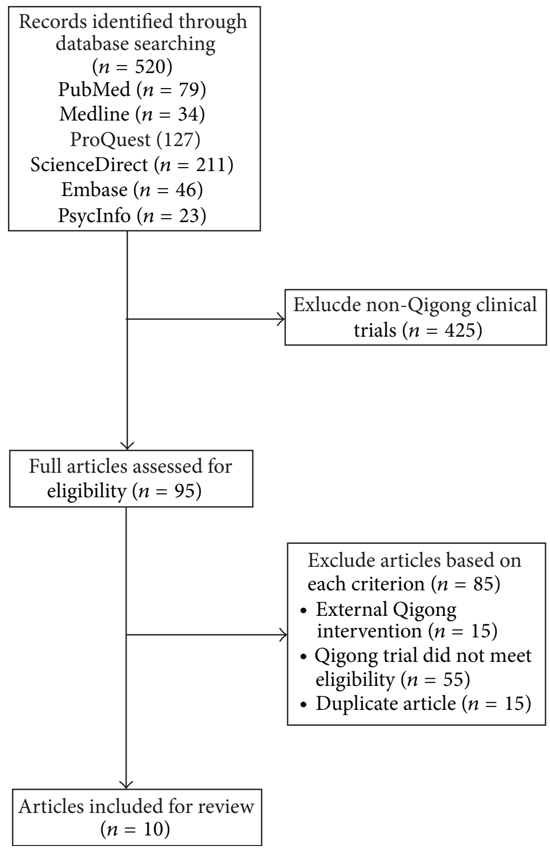

Figure 1: Flowchart of review process.

3. Eligibility Criteria

Studies which investigated the effects of Qigong on depression as primary or secondary outcomes based on randomized controlled trial (RCT) design were eligible. Articles reporting on interventions using external Qigong or Tai Chi were excluded. The literature search included only papers with the full article published in English.

4. Results

The initial literature search identified 520 articles using the key words "Qigong," "depression," and "mood," of which 425 non-Qigong clinical trial articles were excluded. Of the 95 remaining articles, 10 articles met the eligibility criteria and were reviewed, as shown in Figure 1. Of the ten studies shown in Table 1, two studies measured depression as a primary outcome [13, 23] and eight studies measured depression as a secondary outcome. The former two studies measured the effects of Qigong on geriatric depression.

In one of these two studies, Tsang et al. [23] showed that Qigong was as effective as a conventional rehabilitation program in a pilot study. In a subsequent study with a larger sample size, Tsang et al. [13] demonstrated a significant difference between the Qigong intervention and the control group. The remaining eight studies measured depression as a secondary outcome among patients who were recruited based on other medical conditions. Of eight studies, three studies reported a significant difference between Qigong intervention and control groups [24–26]. Two studies showed that Qigong was as effective as physical exercise [27, 28]. Three studies did not find a significant difference between the Qigong intervention and the control group [29–31].

These studies were conducted in Hong Kong ($n = 3$), Korea ($n = 1$), Germany ($n = 2$), Sweden ($n = 2$), Australia ($n = 1$), and the USA ($n = 1$) between 2003 and 2009. Among them, there were ten RCTs, which employed two arms (Qigong versus control group). Six of these ten studies used a sham intervention for the control groups. None of the studies used a double-blind design.

Sample sizes ranged from 50 to 162 subjects. Study populations varied, with two studies conducted on geriatric patients with depression. Other study populations included patients with fibromyalgia, hypertension, Parkinson's disease, cancer, burnout, severe chronic pain, and female college students. One study did not report a detailed demographic profile of its participants, as the study was conducted during a Qigong retreat [32]. The mean age of participants ranged from 19 to 82.

The duration of Qigong interventions also varied across studies. Qigong intervention period ranged from 6 to 16 weeks (6 weeks ($n = 1$), 8 weeks ($n = 2$), 12 weeks ($n = 4$), and 16 weeks ($n = 2$)), and one study involved a four-day Qigong retreat. The duration of each intervention also varied

Table 1: Two studies investigating the effects of Qigong on depression as primary and eight studies as secondary outcomes.

Author Year Country	Design Blinding	Sample size	Subject Mean age Sex (m/f)	Intervention control	Outcome measure Followup Analysis	Result Dropout	Adverse event	Conclusion and discussion
Tsang et al. [23] 2003 Hong Kong	RCT Non-blinding	Total (n = 50) Intervention (n = 25) Control (n = 25)	Geriatric patients 74 (26/24)	Eight-section brocades Qigong (a) 12 weeks (b) 60 minutes (c) 6 visits (d) 2x/week Traditional remedial rehabilitation activities	(1) Geriatric Depression Scale (2) Perceived Benefit Questionnaire (3) Hong Kong Chinese Version World Health Organization Quality of Life (4) Self-concept Scale No follow-up	(1) NS (2) $P < 0.001$ (3) NS (4) NS n/a	Not reported	Eight section brocades Qigong is promising as an alternative psychosocial intervention for depressed elderly with chronic physical illness. Although there is no evidence, there is an optimistic stance that Qigong results in better treatment compliance and better outcome compared to Western exercise protocols like aerobics
Astin et al. [29] 2003 USA	RCT Non-blinding	Total (n = 128) Intervention (n = 64) Control (n = 64)	Patients with fibromyalgia syndrome 48 (1/127)	Mindfulness meditation with Qigong movement therapy (a) 8 weeks (b) 150 minutes (90 min mindfulness, 60 min Qigong) (c) 8 visits (d) 1x/week Education support group	(1) Pain measured with 36-Item Short-Form Health Survey (2) Fibromyalgia Impact Questionnaire (3) Beck Depression Inventory (4) Myalgic score (5) Coping strategies Follow-up (a) Week 4 (b) Week 24 Completers analysis	(1) NS (2) NS (3) NS (4) NS (5) NS 49%	Not reported	Both intervention and control groups showed improvement on a number of outcome variables, however, no evidence showed that the mindfulness meditation and Qigong intervention for fibromyalgia was superior to education support group.
Kim et al. [24] 2004 Korea	RCT Non-blinding	Total (n = 54) Intervention (n = 26) Control (n = 28)	Female college students 19–21 (0/54)	Meridian exercise (a) 6 weeks (b) 30 minutes (c) 12 visits (d) 2x/week Standard care only	(1) State Anxiety Inventory (2) Depression Status Inventory (3) Self-Esteem Inventory No followup: ITT analyses	(1) $P < 0.001$ (2) $P < 0.001$ (3) $P < 0.001$ n/a	Not reported	Meridian exercise decreased anxiety and depression and increased self-esteem. Study suggests that meridian exercise enabled female students to manage their mental health within the community. Future studies are needed to examine the lasting effect of the intervention, including physiological indices

Table 1: Continued.

Author Year Country	Design Blinding	Sample size	Subject Mean age Sex (m/f)	Intervention control	Outcome measure Followup Analysis	Result Dropout	Adverse event	Conclusion and discussion
Cheung et al. [27] 2005 Hong Kong	RCT Non-blinding	Total ($n = 91$) Intervention ($n = 47$) Control ($n = 44$)	Patients with essential hyperten-sion 54 (37/51)	Guolin Qigong (a) 4 weeks (b) 120 minutes (c) 8 visits (d) 2x/week Conventional exercise	(1) Blood pressure (2) 36-Item Short-Form Health Survey (3) Beck Anxiety Inventory (4) Beck Depression Inventory No followup ITT analyses	(1) NS (2) NS (3) NS (4) NS 16.5%	Vestibular neuronitis, unrelated to Qigong practice	Goulin Qigong and conventional exercise had similar effects on blood pressure in patients with mild hypertension. While no additional benefits were identified, Qigong treatment serves as a nondrug alternative to conventional exercise in the treatment of hypertension
Tsang et al. [13] 2006 Hong Kong	RCT Single blind	Total ($n = 82$) Intervention ($n = 34$) Control ($n = 48$)	Geriatric patients 82 (16/66)	Baduanjin Qigong (a) 16 weeks (b) 30–45 minutes (c) 48 visits (d) 3x/week Newspaper reading	(1) Geriatric Depression Scale (2) Chinese General Self-Efficacy Scale (3) Personal Well-Being Index (4) General Health Questionnaire-12 (5) Self-Concept Scale (6) Perceived Benefit Questionnaire Followup: (a) Week 4 (b) Week 8	(1) $P = 0.041$ (2) $P < 0.001$ (3) $P < 0.001$ (4) $P = 0.042$ (5) Subscales significant (6) $P < 0.001$ 15.8%	Not reported	Regular Qigong practice could reduce depression, and improve self-efficacy and personal well-being among geriatric patients with chronic physical illness and depression. Study shows that practice needs to continue and last for long-term effects
Schmitz-Hübsch et al. [30] 2006 Germany	RCT Non-blinding Pilot study	Total ($n = 56$) Intervention ($n = 32$) Control ($n = 24$)	Patients with Parkin-son's Disease 63 (43/13)	Qigong (frolic of the crane, eight-section brocades in sitting position) (a) 24 weeks (8-week intervention, 8-week no intervention, 8-week intervention) (b) 90 minutes (c) 16 visits (d) 1x/week No intervention	(1) Unified Parkinson's Disease Rating Scale-Motor (2) Parkinson's Disease Questionnaire (3) Montgomery-Asperg Depression Rating Scale Followup: (a) 12 months ITT analyses	(1) $P = 0.008$ (2) NS (3) NS 12.5%	Not reported	Results suggest positive effects of Qigong on symptoms of autonomic dysfunction in patients with Parkinson's disease. Given high acceptance and compliance with therapy, Qigong is a promising treatment with possible effects on motor as well as nonmotor symptoms. Group instruction, as well as self-exercise of Qigong, moreover serves as cost-effective application

Table 1: Continued.

Author Year Country	Design Blinding	Sample size	Subject Mean age Sex (m/f)	Intervention control	Outcome measure Followup Analysis	Result Dropout	Adverse event	Conclusion and discussion
Johansson et al. [25] 2008 Sweden	RCT Non-blinding	Total ($n = 59$) Intervention ($n = 28$) Control ($n = 31$)	Summer school camp participants 51 (8/51)	Jichu Gong (a) 4-day retreat Lecture on Chinese medicine	(1) Profile of Mood Status (2) State and Trait Anxiety Inventory No followup Completers analyses	(1) $P < 0.0005$ (2) $P < 0.0005$ 3%	Not reported	Study supports the effectiveness of Qigong to promote mental health. More studies are necessary to verify the finding
Oh et al. [26] 2009 Australia	RCT Non-blinding	Total ($n = 162$) Intervention ($n = 79$) Control ($n = 83$)	Cancer patients 60 (69/93)	Medical Qigong + standard care (a) 12 weeks (b) 90 minutes (c) 12 visits (d) 1x/week Standard care only	(1) Functional Assessment of Cancer Therapy-General (2) Functional Assessment of Cancer Therapy-Fatigue (3) Profile of Mood Status (4) Inflammation (CRP) No followup ITT analyses	(1) $P < 0.01$ (2) $P < 0.01$ (3) $P = 0.021$ (mood disturbance) $P = 0.0290$ (depression) (4) $P = 0.044$ 24%	Reported no adverse event	Medical Qigong can improve cancer patients overall quality of life and mood status as well as reduce specific side effects of cancer treatment. Qigong treatment may also produce long-term physical benefits due to reduction of CRP inflammation
Stenlund et. al. [31] 2009 Sweden	RCT Non-blinding	Total ($n = 82$) Intervention ($n = 41$) Control ($n = 41$)	Patients with burnout	Qigong + basic care (a) 12 weeks (b) 60 minutes (c) 12 visits (d) 1x/week Basic care at the stress clinic	(1) Shirom-Melamed Burnout Questionnaire (2) 36-Item Short Form Health Survey (Swedish) (3) Self-Concept Questionnaire (4) Checklist Individual Strength Questionnaire (5) Hospital Anxiety and Depression Scale (6) Physical Assessment Scale of the Relaxation Inventory No followup ITT analyses Completers analyses	(1) NS (2) NS (3) NS (4) NS (5) NS (6) NS 17%	Not reported	12-week intervention of Qigong had no additional benefit compared to basic care in burnout patients

from 30 minutes ($n = 1$), 45 minutes ($n = 2$), 60 minutes ($n = 3$), and 90 minutes ($n = 2$) to 120 minutes ($n = 1$). Most studies ($n = 7$) offered Qigong interventions twice a week. One study [32] did not describe the length or frequency of the intervention. Three out of the 10 studies had long-term follow-up assessments at 24 weeks [29], 6 months [28], and 12 months [30].

The ten studies used different instruments to measure depression outcomes. Two studies used the Geriatric Depression Scale (GDS), two used the Beck Depression Inventory (BDI), and two used the Profile of Mood States (POMS). Other instruments included the Depression Status Inventory (DSI), Montgomery-Asberg Depression Rating Scale (MADRS), Hospital Anxiety and Depression Scale (HADS), and Allgemeine Depressionsskala (ADS).

With the exception of one study that had an unusually high dropout rate of 49% [29], most studies had satisfactory dropout rates ranging from 3% to 24%. Two studies did not report their dropout rates [23, 24]. Two studies [27, 28] reported adverse events that were not directly related to the practice of Qigong; eight studies did not report adverse events; and one reported no adverse effects of Qigong intervention [26]. Two studies which recruited patients with hypertension and chronic neck pain reported adverse events not specifically related to the intervention, such as muscle ache, tension, nausea, and vestibular neuronitis.

Of the ten studies, five conducted intention-to-treat (ITT) statistical analyses, two conducted completers analyses [25, 29], and one performed both ITT and completer analyses [31]. Two studies did not report the details of their data analysis methods [13, 23].

5. Discussion

This paper suggests that the effect of Qigong in the treatment of depression is inconclusive, although potential effects of Qigong in the treatment of depression was supported by the biopsychosocial model [33], relaxation response theory [34, 35], and evidence on the positive effects of exercise [36, 37]. Further, our review result was not consistent with the previous review conducted by Jahnke et al., which reported the effect of Qigong and Tai Chi in the treatment of psychological symptoms including depression [22]. Their review concluded that Qigong and Tai Chi can reduce psychological symptoms including depression. The differences in results may be due to the different inclusion criteria used in the two reviews. In Jahnke et al.'s review [22], their results were based more on tai chi studies than on Qigong studies, while our review assessed exclusively Qigong studies. Although, tai chi is considered as part of moving Qigong, the differences and similarities of basic philosophy and practices between tai chi and Qigong are debated among the academic researchers, particularly in Western world [22, 38]. Interestingly, the result of this review is similar to a recent review conducted by Tsang et al. with 12 RCTs which compared the effects of mindful exercises versus nonmindful exercises [39]. This review reported that both mindful and nonmindful physical exercises were effective in the treatment of depression or depressive symptoms in the short term. Our paper also showed that Qigong was as effective as physical exercise and rehabilitation program for treatment of depression. Results from Jahnke et al. [22] and our review are compatible with two recent reviews on the efficacy of exercise on depression, both concluding that exercise has a mild treatment effect on depression [36, 37]. These findings suggest that future studies are needed to examine the mechanism of the effects of Qigong, tai chi, and physical exercise on the brain to decipher the similarities and differences of their effects on depression.

One of most remarkable findings of this review ($n = 10$) was that participants did not report any psychotic reactions from Qigong, as previous literature has indicated as possible concern [25]. The inconsistent results based on the above reviews may reflect dose response of subjects receiving Qigong intervention with different frequencies, lengths, and intensities. A limitation of this review is that it included studies with small sample sizes and no appropriate sham intervention for control group, no blinding of subjects and Qigong instructors, and they used various instruments to measure depression outcomes. There was moreover a publication selection bias, as we only examined studies published in English.

Future studies may take into account the following suggestions for methodology. First, participants who meet the criteria for major depressive disorder, dysthymic disorder, or depressive disorder not otherwise specified based on DSM-IV criteria should be included. Since Qigong originated in the East, different ethnic groups may be recruited to examine if cultural differences could be a mediator or moderator of treatment outcomes. A three-arm design (Qigong intervention versus sham Qigong versus usual care or waitlist group) with adequate sample size is recommended to detect statistical and clinical significance, as suggested by Oh et al. [26]. Dose-response relationship can be examined by varying length (e.g., 30 minutes versus 60 minutes versus 90 minutes), frequency (e.g., weekly versus biweekly versus every 4 weeks), and intensity of intervention, as measured by physical activity intensity scale. Both quantitative and qualitative outcome measures are recommended in order to capture the complexity of depression treatment effect. Measureing of biomarkers, such as immune function, cytokines, and DNA damage level, may provide objective information on the physiological and psychological effects of Qigong intervention. Finally, a cost-benefit analysis could examine possible health policy considerations.

In conclusion, all studies suggest that Qigong intervention for patients with major depressive disorder is safe and feasible; however, evidence for its effectiveness is limited. Future study with more robust design is warranted.

Conflict of Interests

B. Oh, S. M. Choi, A. Inamori, D. Rosenthal, and A. Yeung, confirm that there are no known conflict of interests associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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Research Article

Effects of Aging and Tai Chi on a Finger-Pointing Task with a Choice Paradigm

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Background. This cross-sectional study examined the effect of aging on performing finger-pointing tasks involving choices and whether experienced older Tai Chi practitioners perform better than healthy older controls in such tasks. *Methods*. Thirty students and 30 healthy older controls were compared with 31 Tai Chi practitioners. All the subjects performed a rapid index finger-pointing task. The visual signal appeared randomly under 3 conditions: (1) to touch a black ball as quickly and as accurately as possible, (2) not to touch a white ball, (3) to touch only the white ball when a black and a white ball appeared simultaneously. Reaction time (RT) of anterior deltoid electromyogram, movement time (MT) from electromyogram onset to touching of the target, end-point accuracy from the center of the target, and the number of wrong movements were recorded. *Results*. Young students displayed significantly faster RT and MT, achieving significantly greater end-point accuracy and fewer wrong movements than older controls. Older Tai Chi practitioners had significantly faster MT than older controls. *Conclusion*. Finger-pointing tasks with a choice paradigm became slower and less accurate with age. Positive findings suggest that Tai Chi may slow down the aging effect on eye-hand coordination tasks involving choices that require more cognitive progressing.

1. Introduction

Eye-hand coordination requires skillful and integrated use of the eyes, arms, hands, and fingers in goal-directed precision movements [1]. The more complicated the stimulus presented and the more decisions to be made, the slower will be the reaction time of persons of any age [2]. Studies have shown that reaction time slows with advancing age, and the slowing-down becomes more pronounced as the task difficulty increases [2, 3]. Other investigators have suggested that increases in task complexity would lead to increases in the demand on central processing resources. Since older adults have fewer available resources for processing information in the brain, their performance could be affected more than that of younger adults when task complexity increases [3]. Thus, age-dependent-task complexity effect is probably due to age-induced changes in the cognitive processing resources of the central nervous system.

Tai Chi, a mind-body exercise, has a long history and is now practiced by millions of older adults both in the East and the West. Performing its 108 forms amounts to complex motor skill training [4] and requires a great deal of eye-hand coordination and balance control. Previous findings in our laboratory have shown that experienced Tai Chi practitioners display significantly better accuracy than controls similar in age, gender, Mini-Mental Status Examination scores, and physical activity level in finger pointing toward stationary signals appearing contralaterally and centrally to their pointing hand [5]. The practitioners also demonstrated significantly better accuracy when the visual target was moving. Of special interest is that their accuracy was similar to that of much younger controls [5].

Previous studies have shown that exercise could improve cognitive functioning in addition to physical performance. This possibility is of particular interest owing to the increased prevalence of cognitive deficits in the aging population [6]. Tai Chi requires its practitioners to incorporate deep and rhythmic breathing as well as mental concentration [4, 7]. Its practice has been demonstrated to improve relaxation, emotional and psychological status [8]. Our own previous investigations have demonstrated that Tai Chi practitioners displayed significantly better attention and memory than healthy control subjects and practitioners of less cognitively demanding aerobic activities [9]. Therefore, the objectives of the present study were to examine (1) the effect of aging on finger-pointing tasks with a choice paradigm that required more cognitive processing and (2) the extent to which experienced Tai Chi practitioners demonstrated better performance than controls similar in age, height, gender, and physical level.

2. Methods

2.1. Participants. 30 young university students (aged 24.2 $\pm$ 3.1 years) were compared with 30 healthy older control subjects (aged 72.3 $\pm$ 7.2 years) and 31 experienced (mean = 7.1 $\pm$ 6.5 years of practice) Tai Chi practitioners (aged 70.3 $\pm$ 5.9 years) in this cross-sectional study. Students were recruited from a local university, while older control subjects were recruited from several community elderly centers. The latter had no previous experience in Tai Chi, though some claimed to take regular morning walks or do stretching exercises. To be included in the Tai Chi group, subjects had to practice Tai Chi more than 1.5 hours per week for 3 years or more. All older subjects were subjected to 4 screening tests. They had to (1) score at least 24 in the Mini-Mental Status Examination (MMSE) to exclude cognitive deficits [10, 11]. They also had to (2) attain 20/20 or above in Snellen's visual acuity test [12], with eye glasses if necessary; (3) demonstrate sufficient active range of motion in their upper limbs to perform the finger-pointing tasks; and (4) complete a modified Minnesota Leisure Time Physical Activity Questionnaire [13–16].

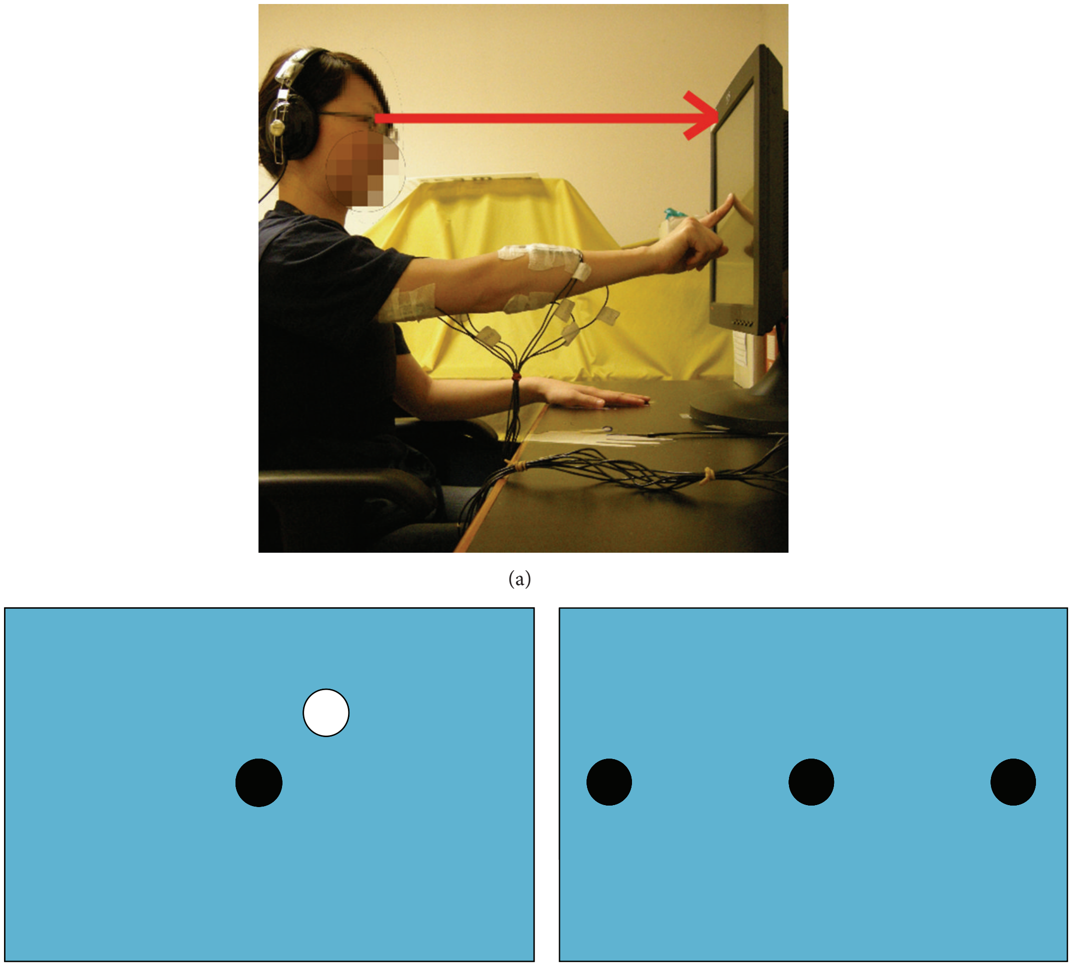
Subjects with any eye pathology such as glaucoma or cataract which affected the finger pointing test were excluded, as well as those suffering from any pathology affecting their upper limb function such as stroke, Parkinson's disease, or any disabling neurological or musculoskeletal disorder. Other exclusion criteria were peripheral neuropathies of the upper extremities or metastatic cancer. The project was approved by the Ethics Committee of The Hong Kong Polytechnic University, and written informed consent was obtained from all subjects before the study began.

2.2. Test Procedures. Subjects were instructed to point with the index finger of their dominant hand (used for writing or holding chopsticks) as quickly and as accurately as possible, from a fixed starting position on a desk to a visual signal appearing on a vertical display unit (3M Touch Systems; 3M Optical Systems Division, 300 Griffin Brook Park Drive, Methuen, MA 01844, USA). The visual display unit was fixed on and perpendicular to the supporting surface, with its upper edge at each subject's eye level 36 cm from the supporting surface. To start, subjects' index finger rested on the desktop 10 cm from the screen. The visual signal was a ball with a 1.2 cm diameter. Subjects sat still on a height-adjustable chair with the arm rests in front of a computer-controlled LCD touch screen, with their hands resting on a table and their elbows, hips, knees, and ankle joints positioned at about 90°. The chair height was adjusted so that the upper edge of the visual display unit was at the subject's eye level. A mark was positioned at the center of the upper edge of the display unit, and subjects were asked to fixate their eyes on it during the testing (Figure 1(a)). Their upper trunks were strapped to the chair with a Velcro belt to prevent trunk movement. This is because finger pointing can involve either trunk and arm movement or arm movement alone [17]. Since data collection involved recording electromyographic (EMG) responses of arm muscles only, it was necessary to inhibit trunk movement so that subjects pointed to the visual target with only arm movement.

A visual signal appeared randomly under 3 conditions: (1) a black ball required the subjects to touch it as quickly and as accurately as possible; (2) a white ball required the subjects not to touch it; (3) both black and white balls required subjects to touch only the white ball but not the black ball (Figure 1(b)). The LCD panel was 34 cm wide and 27 cm tall and was divided into 1000 (unmarked) sections from left to right and from top to bottom. The visual signals that required touching appeared at positions 100, 500 (middle-left) 500, 500 (centre), and 900, 500 (middle-right) of the LCD monitor (Figure 1(c)). Conditions 1 and 3 appeared 15 times each and condition 2 for 10 times. Thus, there were a total of 40 runs appearing in a random order for each subject. Each set of coordinates was touched 10 times. Familiarization trials were given for each condition before data recording, to ensure that subjects understood how to perform the task.

2.3. Data Recording and Analysis. A pair of surface electrodes was used to record EMG activity in the anterior deltoid muscle (prime mover for arm reaching movement component) [18] of subjects' dominant arm. The electrode pair was attached with electrolyte gel and adhesive tape along the muscle as recommended by Cram and Kasman [19]. EMG signals were recorded using stainless steel surface electrodes (B & L Engineering, 1901 Carnegie Ave, Ste Q, Santa Ana, CA 92705 USA; interelectrode spacing = 1.375 in (3.493 cm)), amplified with a gain of 320 and a total input impedance of more than 100 mega Ohms over a bandwidth of 12 Hz to 3000 Hz. They were sampled at 1,000 Hz and were stored for off-line analysis using an analog/digital converter card (National Instruments, 11500 N Mopac Expwy, Austin, TX 78759-3504, USA). These EMG signals were subsequently processed using the LabView software suite. They were full-wave rectified and smoothed using a second-order Butterworth low pass filter with a cut off frequency of 10 Hz.

Four measures, namely, reaction time, movement time, end-point accuracy, and number of wrong movements were used to compare among the 3 groups. (1) Reaction time (RT) was the time from the appearance of the ball on the screen to the onset of the anterior deltoid EMG response, defined as the time point when the EMG signal deviated more than 3 standard deviations from the baseline. This point was determined using a tailor-made LabView software program and then visually verified each time. (2) Movement time (MT) was defined as the time from the onset of the EMG response to the time when the ball was touched, called "end point" in this study. This included the time required for muscle torque



(a)

(b)

(c)

Figure 1: (a) The experimental setup. (b) Condition 3 with the appearance of white and black balls (not drawn to scale). (c) Visual signal locations (not drawn to scale).

generation to complete the pointing task. By convention, EMG movement time is defined as the interval from the onset to the end of the EMG signal. Because older adults displayed longer biomechanical delay due to muscle atrophy and related neuromuscular degeneration with age [20], we included the time for generating the muscle torque required to complete the pointing task, for comparison of the MT across the 3 cohorts in this study. (3) Precision in locating the ball on the LCD screen, termed "end-point accuracy", was defined as the absolute deviation of the subject's finger pointing location from the center of the ball. (4) The number of wrong movements was defined as touching either the white ball in condition 2 or the black ball in condition 3.

2.4. Statistical Analysis. To ensure data reliability, an intraclass correlation coefficient (ICC) was used to assess the test-retest reliability of the outcome measures. One-way analysis of variance (ANOVA) was used to compare age, height, and arm length among the 3 groups, and gender was compared using a chi-square test. Since the starting position of the hand and the visual display unit was fixed for all participants, any differences in arm length might constitute a covariate in finger-pointing tasks that involved cognitive processing in a choice paradigm. Therefore, subjects' arm length would be treated as a covariate in the statistical analysis, if a significant difference were found. Arm length was defined as the distance between a subject's acromion and the tip of the middle finger. For comparisons between the 2 older groups, independent t-tests were conducted with the MMSE scores, and a chi-square test was used for comparisons of older subjects' physical activity level. Multivariate analysis of variance (MANOVA) was used to compare each of the outcome measures, namely, RT, MT, and end-point accuracy, among the 3 groups and the 3 locations. If statistically significant differences were found in the multivariate tests, univariate tests were conducted for each of the locations. *Post hoc* analysis using Bonferroni's adjustment was conducted if a significant difference was found in the univariate test. One-way ANOVA was used to compare the number of wrong movements among the 3 groups. If a statistically significant difference was found in the one-way ANOVA, *post hoc* analysis using Bonferroni's adjustment was conducted. A

Table 1: Comparisons of age, height, and arm length among young control, older control, and older Tai Chi subjects and of Mini-Mental Status Examination and physical activity levels between the two older groups.

	Young control subjects (n = 30)	Older control subjects (n = 30)	Tai Chi subjects (n = 31)	P
Age (y)	24.2 ± 3.1	72.3 ± 7.2†	70.3 ± 5.9†	<0.001*
Height (m)	1.67 ± 0.08	1.58 ± 0.08†	1.59 ± 0.07†	<0.001*
Arm length (cm)	70.5 ± 4.3	65.3 ± 5.8†	67.2 ± 4.3†	<0.001*
Gender (M/F)	15/15	15/15	15/16	0.989
MMSE score	—	26.7 ± 2.0	26.6 ± 1.9	0.966
Physical activity level				0.364
Light < 4 METs	—	n = 15	n = 10	
Moderate 4–5.5 METs	—	n = 11	n = 16	
Heavy > 5.5 METs	—	n = 4	n = 5	

Note. Values are mean ± SD for this and all subsequent tables.
Abbreviations: F: female; M: male. MMSE: Mini Mental Status Examination; MET: metabolic equivalent.
—: denotes "There was no need to record the data."
*denotes significant difference at $P < 0.01$ level using one-way ANOVA.
†denotes significant difference from the young controls at $P < 0.05$ level by means of *post hoc* analysis using Bonferroni's adjustment.

significance level (α) of 0.05 was chosen for the statistical comparisons.

3. Results

3.1. Subjects. 80 elderly subjects volunteered to participate in this study. Two Tai Chi practitioners were excluded because they had less than 3 years of practicing Tai Chi. Among the control subjects, 3 were excluded because of previous Tai Chi experience; 8 were excluded due to MMSE scores lower than 24; and a further 6 subjects were excluded because they were unable to score 20/20 or more in Snellen's acuity test.

Table 1 shows significant differences in the age, height, and arm length between young control and older (control and Tai Chi) subjects. Arm length, being a confounding variable in finger pointing tasks, was treated as a covariate in the MANOVA statistical analysis. The results in Table 1 also demonstrate that Tai Chi practitioners and older control subjects were similar with respect to age, height, arm length, gender, MMSE scores, and physical activity levels.

3.2. Test-Retest Reliability. Among the 61 older adult participants, 6 males (3 Tai Chi subjects) and 14 females (9 Tai Chi subjects) with a mean age = 69.2 ± 7.1 years returned to the laboratory 1 week after the first finger-pointing trials for a second assessment. The ICC values for the RT, MT, and end point accuracy were 0.66 (confidence interval 0.41–0.80), 0.85 (confidence interval 0.74–0.91), and 0.68 (confidence interval 0.41–0.82), respectively, which indicated moderate-to-satisfactory reliability. The ICC value for the number of wrong movements was 0.46 (confidence interval −0.51–0.80). This was considered as fair reliability and should be treated with caution.

3.3. Finger-Pointing Tasks with a Cognitive Component. Young university students showed significantly faster RT and MT times, with significantly greater end-point accuracy and fewer wrong movements than older control subjects in finger pointing to all 3 target locations ($P < 0.05$ for all, Table 2). Tai Chi practitioners achieved a significantly faster MT and made fewer wrong movements in finger pointing to all 3 locations than older control subjects. They also demonstrated significantly better end-point accuracy than older controls, when the visual targets appeared contralateral to their pointing hand. Of special interest is that RT in finger pointing to the center and ipsilateral target locations, end-point accuracy, and number of wrong movements were even similar to those of young subjects (Table 2).

4. Discussion

4.1. Effects of Aging. Because many situations in daily life require people to set priorities and choose responses to different signals, we have chosen to study a finger-pointing task involving a choice paradigm in this study. Our results demonstrate that eye-hand coordination in a finger-pointing task with a choice paradigm declines with age. These findings agree with those of our previous investigations on the effects of aging on finger-pointing tasks with stationary and moving targets [5] and with other investigations on eye-hand coordination [3, 21]. Moreover, with the addition of a choice paradigm, we found that declines in eye-hand performance were comparatively greater in older than younger control subjects, as it will emerge below.

Compared with a simple and fast finger-pointing task using a stationary visual signal with the same experimental set-up in our previous study [5], both young university students and older control adults had slower RT and MT when a choice paradigm was added to the finger-pointing task in our present study. Using the central visual target location (500, 500) as an example, the RT and MT of the young students in the simple task were 289.6 ms and 583.2 ms [5], while the same measures using a choice paradigm were 431.6 ms and 617.9 ms (Table 2), representing an increase of 49% and 6%, respectively. However, the within-group increases in RT and MT for the older adults were more than

Table 2: Comparison of anterior deltoid reaction time, movement time, end-point accuracy, and number of errors in finger pointing with a choice paradigm.

	Young control subjects ($n = 30$)	Older control subjects ($n = 30$)	Tai Chi subjects ($n = 31$)	P
EMG reaction time (ms)				
Middle left	430.8 ± 90.9	569.4 ± 156.5†	522.2 ± 126.3†	<0.001**
Center	431.6 ± 92.0	515.1 ± 109.8†	488.6 ± 99.0	0.006**
Middle right	447.1 ± 92.5	568.8 ± 159.1†	518.8 ± 97.0	0.001**
EMG movement time (ms)				
Middle left	660.0 ± 116.4	1032.6 ± 284.7††	886.5 ± 183.5†	<0.001**
Center	617.9 ± 115.9	990.1 ± 250.2††	845.2 ± 167.6†	<0.001**
Middle right	585.6 ± 103.0	942.2 ± 206.9††	801.9 ± 159.1†	<0.001**
End-point accuracy (mm)				
Middle left	9.4 ± 2.5	24.3 ± 25.8††	12.7 ± 9.8	0.002**
Center	7.3 ± 2.4	16.8 ± 22.8†	11.4 ± 8.3	0.040**
Middle right	9.9 ± 3.9	16.7 ± 13.8†	11.6 ± 8.4	0.022**
Wrong movement (number)	0.2 ± 0.5	3.3 ± 6.0††	1.0 ± 1.5	0.003*

*denotes significant difference at $P < 0.01$ using one-way ANOVA.
**denotes significant difference at $P < 0.05$ using univariate tests, after multivariate ANOVA showing $P < 0.05$.
†denotes significant difference from young controls at $P < 0.05$ by means of *post hoc* analysis using Bonferroni's adjustment.
††denotes significant difference from young controls and Tai Chi practitioners at $P < 0.05$ by means of *post hoc* analysis using Bonferroni's adjustment.

those for the young subjects, being 60% (322.2 ms [5] versus 515.1 ms) for RT and 29% (768.7 ms [5] versus 990.1 ms) for MT. The young subjects' end-point accuracy in touching the center of the visual target was similar in simple and choice conditions, being 7.28 mm and 7.33, respectively, with an increase in error of only 0.7%. However, the older adults performed more poorly in the choice paradigm, showing an error of 16.8 mm (Table 2) compared with 12.8 mm in the simpler task [5], which represented an increase of 31%. The cognitive demand introduced in a choice paradigm appeared to have affected performance of finger-pointing tasks to a greater extent in the older than the young subjects. Fitts' law describes characteristics of arm movements using the equation $\mathrm{MT} = a + b\log_2 2D/W$, where MT represents the movement time, D the distance moved, and W the width of the target, with a and b as constants [22]. Such an equation has not taken into consideration any cognitive component of the task, nor the effect of aging as shown in our previous [5] and present cross-sectional studies between young and older subjects.

4.2. Effects of Tai Chi Practice

4.2.1. Movement Time. Tai Chi practitioners achieved significantly faster MT in finger pointing to all 3 target locations than those of older controls (Table 2). This differs from our previous findings that both older groups demonstrated similar MT when they performed simple and fast finger pointing to stationary and moving visual targets in a no-choice situation [5]. The latter finding that both groups could reach stationary visual targets with similar MT [5] would have precluded possible between-group differences in musculoskeletal and neuromuscular factors, including range of joint movement and muscle strength in that task. However, in addition to these factors, eye-hand coordination also involves perceptual, cognitive, and motor staging factors [3, 23, 24]. Shumway-Cook and Woollacott [20] detailed the key cognitive skills in eye-hand coordination tasks as "problem solving, selective attention, planning, memory, and intention, among others." While one can reach for objects with neuromuscular capability alone, "one's ability to acquire a range of solutions for difficult tasks and correctly identify the usefulness of objects is affected by cognition."

The mean MT that Tai Chi practitioners needed to touch the visual target in the central location (500, 500) was 762.3 ms in the stationary protocol [5]. It increased only slightly to 845.2 ms in the choice paradigm, an increase of just 11% (Table 2). This is much less than the increase of 29% reported previously for the older control subjects. The difference in the findings between the 2 studies on simple and choice paradigms may be explained in terms of greater cognitive skills being required to perform eye-hand coordination in a choice paradigm [3, 24].

4.2.2. End-Point Accuracy. Tai Chi practitioners demonstrated better end-point accuracy than older control subjects in pointing to a contralateral visual signal (average errors of 12.7 mm versus 24.3 mm for middle left target location, resp.), even though they were moving significantly faster (MT = 886.5 ms versus 1032.6 ms; Table 2). Previous study had shown that 8 weeks of Tai Chi training enabled older adults (average age = 78.8 years) to achieve smoother movements, showing fewer jerky movements than those involved in a walking or jogging program, when they were instructed to move a stylus with their dominant hand to reach a final target by crossing another intermediate target with a curved line [25]. In a previous cross-sectional study, we also found that experienced Tai Chi practitioners were significantly more accurate in pointing to stationary and moving visual signals than older controls similar in age, gender, and physical activity level, and their performance was even similar to that of young university students [5]. Tai Chi requires the practitioners to follow their hand movements closely with their eyes. Such specific eye-following-hand training may help to enhance eye-hand coordination in the practitioners [5, 26]. Also, Tai Chi practice puts great emphasis on both exact joint positioning and direction of movement. In fact, previous findings from our laboratory have shown that experienced Tai Chi practitioners had better joint proprioception [13]. It should be noted that joint proprioception has been shown to be an important source for accurate reaching movements [27, 28]. Taken together, these factors could have led to improved end-point accuracy of the finger, despite the use of a choice paradigm requiring more cognitive processing.

4.2.3. Wrong Movements. Table 2 showed that Tai Chi practitioners made significantly fewer wrong movements than older controls. Such a finding may be due to their better attention in the signal encoding process and their better registration of the visual signal in the memory retrieval process than control subjects, as shown by our previous study [9]. A possible explanation is that Tai Chi practice requires the practitioners to pay attention to and to recall a long sequence of movements, usually from 24 to 108 forms.

Since this study used a cross-sectional design, a causal relation between Tai Chi practice and better finger-pointing performance could not be established. A longitudinal study would be required to establish the causal relationship between the two. Because only healthy older adults were examined, the results cannot be extrapolated to younger or frail older individuals or to those who have a history of visual or cognitive problems.

5. Conclusions

Limitations aside, the findings from this cross-sectional study suggest that experienced Tai Chi practitioners may function better than older controls in daily activities that require eye-hand coordination to reach an object of choice, such as reaching for a spoon located amongst an assortment of cutleries or for the needed key in a bunch of keys. Worthy of note is that their RT in finger pointing to the central and ipsilateral locations of a visual signal in a choice paradigm, end-point accuracy, and number of wrong movements were even similar to those of the young control subjects.

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