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## Transforming traditional Tai Ji Quan techniques into integrative movement therapy—*Tai Ji Quan: Moving for Better Balance*

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### Abstract

Tai Ji Quan, developed as a martial art, has traditionally served multiple purposes, including self-defense, competition/performance, and health promotion. With respect to health, the benefits historically and anecdotally associated with Tai Ji Quan are now being supported by scientific and clinical research, with mounting evidence indicating its potential value in preventing and managing various diseases and improving well-being and quality of life in middle-aged and older adults. The research findings produced to date have both public health significance and clinical relevance. However, because of its roots in the martial arts, transforming traditional Tai Ji Quan movements and training approaches into contemporary therapeutic programs and functional applications is needed to maximize its ultimate utility. This paper addresses this issue by introducing *Tai Ji Quan: Moving for Better Balance*, a functional therapy that involves the use of Tai Ji Quan principles and Yang-style-based movements to form an innovative, contemporary therapeutic approach that integrates motor, sensory, and cognitive components to improve postural control, gait, and mobility for older adults and those who have neurodegenerative movement impairments. It provides a synergy of traditional and contemporary Tai Ji Quan practice with the ultimate goal of improving balance and gait, enhancing performance of daily functional tasks, and reducing incidence of falls among older adults.

### Keywords

balance; physical therapy; public health; Tai Ji Quan

### 1. Introduction

Tai Ji Quan originated in China.<sup>1,2,3</sup> The phrase “Tai Ji,” which literally means “supreme ultimate or extreme,” reflects a culturally based philosophical belief that from the origin of the universe (“without extreme”) all things in nature evolve through dynamic and interactive dualities, that is, yin and yang (e.g., female and male; dark and light). This phenomenon is believed to provide the foundation for “Tai Ji.”<sup>1,2</sup> “Quan”, which means “fist” (i.e., boxing),

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links Tai Ji yin-yang concepts to martial arts to describe the interplay between stillness and motion, softness and hardness, emptiness and fullness, and defense and offense in combat movements aimed at achieving the highest state of human harmony and equilibrium.<sup>2</sup> This integration of historical and philosophical concepts with choreographed spiraling combat movements has thus made Tai Ji Quan a unique form of traditional Chinese martial arts (also known as Wushu).<sup>1,2</sup>

Although its exact history remains a mystery, Tai Ji Quan has evolved in the cultural heritage in China over at least 400 years, dating from the late Ming and early Qin Dynasties, and beginning in the family of Chen.<sup>1</sup> The long evolutionary process has resulted in a variety of schools or styles<sup>1-4</sup> that share basic tenets but represent the diversity and enrichment of the traditional martial art. Yang, originated from Chen, is one of the oldest and most enduring of the various styles; in 1956, the Chinese government sponsored the recreation<sup>1</sup> of a simplified 24-form version of Yang-style-based Tai Ji Quan that has since received the most public attention and is the most popular style in practice due to its relaxed posture, the smooth and rhythmic flow of movements, and the simplicity and ease with which it can be learned. More recent simplified versions designed for public health promotion include 8-form and 16-form routines.<sup>1</sup> The non-competitive and non-technical features of contemporary Tai Ji Quan make it ideal for people of various ages who wish to practice it for leisure, mindful nurturing of well-being, enhancement of physical fitness, prevention or slowing of disease progression, and relief from symptoms of disease.<sup>4-7</sup>

Historically, sustained practice of Tai Ji Quan has been thought to bring about multiple health benefits and promote vitality and longevity. Since the late 20th century, many of these benefits have been evaluated through scientific research studies, which have yielded strong empirical support for Tai Ji Quan in promoting various dimensions of physical and mental health, especially in older adults and/or people with chronic conditions.<sup>5-7</sup> The accumulated evidence not only reinforces the value of this ancient art for health benefits but also provides continued impetus for both community and clinical dissemination efforts and more rigorously controlled biomedical research to uncover its full potential.

Because of its roots in martial arts, conventional practice of Tai Ji Quan is guided by a set of *a priori* rules, with performance driven by an inner (i.e., mind-initiated and directed) to outer (i.e., movement synergies) process.<sup>1,2</sup> As an integral part of its practice, Tai Ji Quan emphasizes movements performed with “rooted” feet, centered body mass, bilateral weight-shifting initiated from the waist, complementary exchange between motion and tranquility and substantial and insubstantial weight-loading, and smooth and rhythmic movement synchronized with deep abdominal breathing. Underlying these movement-breathing synergies is a deep focus on mindfulness aimed at producing intentional whole-body actions entailing dynamic interaction between stabilizers (as shown with firmly held body positions) and movers (performance of focal movements). The integration of these components and the resulting synergistic movements make Tai Ji Quan a unique modality for addressing dysfunction in postural control and mobility. To integrate these features to produce meaningful therapeutic benefits, Tai Ji Quan-based movement applications must be tailored to drive specific functional recovery for individuals with movement impairment and/or disorders.<sup>7</sup>

This paper, which is based on the cumulative work of the author,<sup>8-15</sup> addresses this practical issue by describing a research-based training therapy (*Tai Ji Quan: Moving for Better Balance*<sup>15</sup> (TJQMBB; formerly known as *Tai Chi: Moving for Better Balance*)<sup>12,13</sup>) that has transformed Tai Ji Quan principles and Yang-style movements into a therapeutic training program with the ultimate goal of improving or restoring movement limitations and cognitive impairment in older adults and individuals who have neurodegenerative impairments. In what follows, the rationale for the need to change traditional training to achieve therapeutic benefits for balance is first presented. Subsequent sections describe the (1) training approach, (2) research process and evidence, (3) community practice, (4) cost and effectiveness, and (5) future directions. The paper concludes with a call for a paradigm shift toward contemporary, functional, and synergistic approaches in Tai Ji Quan practice.

## 2. A new approach – rationale

Postural control, defined as the ability to control one's body position in space for the dual purposes of maintaining postural stability and orientation,<sup>16-18</sup> is critical to functional performance of activities of daily living. With advancing age come physiological changes that result in progressive weakening of body systems,<sup>19</sup> including motor, sensory, and cognition that are critically important for balance, postural alignment, and locomotion.<sup>16-17</sup> While conventional exercise approaches (e.g., strength training) have been shown to delay deterioration in postural control systems, developing alternative approaches that are non-equipment dependent, effective, low cost, safe, and tolerable to people with functional limitations is of great public health significance in terms of providing cost-effective ways to retain or restore function. Tai Ji Quan has all of these attributes.

As alluded to previously, it is important to realize that Tai Ji Quan was developed as a martial art. Therefore, in addition to focusing on mental alertness and flow of internal energy, Tai Ji Quan training strongly emphasizes certain physical characteristics, such as precise and smooth movement, centering of movements with the feet firmly on the ground, and stable head position, all of which are necessary to optimize application of force in combat. While these features meet combat demands, they are not necessarily desirable or efficient from a clinical perspective for training postural control. Unfortunately, because of its original purpose as a martial art, Tai Ji Quan does not target specific health outcomes. Therefore, if the therapeutic potential of Tai Ji Quan is to be fully exploited a more dynamic, tailored approach is warranted, to: (1) optimize kinematics and kinetics of joint movements, (2) maximize the interaction of a person's intrinsic control capacity and the inherently challenging Tai Ji Quan poses, and (3) develop specific movements to drive adaption of functional activities.

TJQMBB was designed to meet these conditions and thereby drive internal and external equilibrium by emphasizing maximum movement excursions of the center of gravity over the base of support, as well as integrating sensory, motor, and cognitive systems and enhancing kinesthetic awareness required for both proactive or reactive postural adjustment and control. To bridge the gap between clinical research, public health, and everyday practice, this protocol takes into account program adaptability and scalability in practice. Details of TJQMBB are described below.

### 3. Training approach

#### 3.1. Focus and emphasis

TJQMBB embraces key components that contribute to postural control.<sup>16-18</sup> Specifically, it focuses on stimulating musculoskeletal, sensory, and cognitive systems via self-initiated, deliberately controlled and coordinated movements such as unilateral weight-bearing and weight-shifting, trunk rotation, ankle sways, and coordinated eye-head-hand movements. These integrated features incorporate all aspects of postural control strategies to improve sensory integration, limits of stability, functional adaptation, anticipatory control, compensatory responses, and effective gait patterns.

To ensure both clinical and functional relevance, the protocol links to physical and occupational therapy practice and daily task-oriented, functional activities. Thus, it emphasizes activities such as sit-to-standing, walking, turning, reaching, and eye-head-hand coordination. With this focus, the program represents a significant enhancement of traditional Tai Ji Quan by building on martial arts movements to strengthen dynamic and static postural control, daily functioning, and clinical rehabilitation for older adults and individuals with physical limitations.

The following provides a synopsis of the key training points contained in the TJQMBB program.

*Limits of stability* refers to the maximum distance participants can intentionally displace their center of gravity (the point where all the body weight is concentrated) and lean their body in a given direction without losing balance, stepping, or grasping. By embracing Tai Ji Quan yin and yang theory,<sup>1,2</sup> the program translates the dualities into a dynamic exchange of stability (movements within the base of support) and instability (movements on the periphery of the base of support). As such, training involves voluntarily controlled Tai Ji Quan postural movement excursions of the center of gravity over and/or around the edge of the base of support, with the goal of increasing the sway envelope<sup>16</sup> and thereby expanding limits of stability, which is an essential prerequisite for performing daily activities such as stepping, reaching, and moving from sitting to standing.

*Balance/postural control strategies* refer to the ability to effectively control center of gravity over the base of support during either static or dynamic activities. Common techniques involve the use of in-place strategies, e.g., the ankles (in response to small body perturbation) and hips (in response to moderate body perturbation), and change-of-support strategies, such as stepping (in response to movements that push the center of gravity outside the base of support).<sup>16</sup> Accordingly, TJQMBB utilizes self-initiated, controlled Tai Ji Quan movements to create postural sway at the ankles and/or hips to engage participants in adaptive training of these movement strategies. These sway exercises are practiced in either an anticipatory mode (postural adjustments made in anticipation of a voluntary, destabilizing form/movement execution) or a reactive mode (in response to somatosensory feedback of self-induced body displacement).<sup>16</sup>

*Symmetrical movements* refer to movements that are performed equally on each side of the body. All eight forms in the routine are practiced on each side, to improve movement coordination and symmetry through repetitive bilateral and reciprocal limb movements. The clinical significance of focusing on training movement symmetry is that asymmetry is common among individuals with knee/hip replacement and hemiparetic stroke, resulting in overcompensation of the uninvolved/unimpaired limb in performing daily activities, such as transitioning from sitting to standing or *visa versa*, and walking activities.

*Functional vestibulo-ocular reflex* refers to the ability to maintain a stable gaze during active head movement. The training protocol uses Tai Ji Quan-based forms,<sup>3</sup> such as *Part Wild Horse's Mane* and *Wave Hands like Clouds*, which require coordinated eye-head movements to stimulate the vestibulo-ocular reflex. Specific exercises, practiced in seated, standing, or walking positions, involve smooth eye-pursuit and rapid (saccadic) eye movements to the peripheries while moving the head and leading hand.

*Sensory integration* refers to the ability to organize one's sensory systems (vision, vestibular, somatosensory) while interacting with the environment. To effectively integrate various senses with respect to performing simple-to-complex Tai Ji Quan movements, the protocol includes a set of adapted exercises that is used in clinical practice.<sup>16,17</sup> Specifically, training focuses on alterations of sensory input with manipulation tasks performed under conditions of active head movement, with the eyes closed, and ankle/hip sways to drive adaptation and movement compensation when one or more senses are compromised.

*Functional mobility* refers to the ability to ambulate independently and safely in a free living environment. The training protocol simulates several functionally-oriented daily tasks, such as transfers (getting out of a chair or rising from a bed), sit-to-standing, reaching, turning, initiating/terminating gait, and walking/navigating in busy and attention-demanding environments. The format of the exercises varies, ranging from individual, to pair, to group-based activities. To make them more clinically relevant, these exercises are also tied to some common clinical mobility tests, such as Timed Up and Go,<sup>20</sup> Functional Reach,<sup>21</sup> and 4-Step Square Test.<sup>22</sup>

*Cognitive function* involves multiple cognitive domains, including basic functions such as attention and memory, and higher-level functions such as speech and language, decision making, and executive control.<sup>23</sup> Tai Ji Quan exercises inherently involve a high level of deliberate intention and conscious effort to execute and control a series of postures, thereby requiring attention, working memory, and executive control for postural balance. Based on a dual-task paradigm, training in this program requires that students concurrently perform simple-to-complex, balance-challenging, and multi-joint and multi-segment directional postural control movements, as well as a secondary cognitive task that increases attentional demands and memory interference. Specifically, practice is infused with cognitive tasks that involve verbalizing, spelling, recalling movements/forms, and performing forms in either a sequential or random order, with switching and variations in practice configurations, movement complexity, direction, and speed.

### 3.2. Program components

The TJQMBB program consists of an 8-form routine core with built-in practice variations and a subroutine of *Mini-Therapeutic Movements*, which collectively comprise a set of simple yet therapeutic and functional Tai Qi Quan-based moves.<sup>13,15</sup> Of the eight forms, the first, named *Move a Ball*, is considered a preparatory form with a ball gesture. The remaining seven were adopted from the simplified set of 24-form Tai Ji Quan<sup>1-3</sup> in a sequence ranging from simple to complex: *Part Wild Horse's Mane*; *Single Whip*; *Wave Hands like Clouds*; *Repulse Monkey*; *Brush Knees*; *Fair Lady Works at Shuttle*; and *Grasp Peacock's Tail*, which includes movements of warding-off, pulling, pressing, and pushing.

The program includes variations in the practice of the 8-form routine with the intent of maintaining interest and increasing difficulty, for example by altering positions (sitting, moving from sitting to standing, or standing), form order (forward and backward), orientation (performing forms in different directions), configurations (practiced unilaterally and bilaterally), and complexity (increasing demands on attention and postural control).

To enhance clinical relevance, the program also includes a subroutine that contains a set of Tai Ji Quan-based individual forms and movements that have been transformed into therapeutic applications for improving ankle stability, effective weight transfer, active eye-head movement, and spatial orientation, as well as enhancing skills directly transferable to daily functional activities such as reaching, transitioning from sitting to standing (and *visa versa*), stepping and turning, and walking. The goal of these exercises is to adapt and integrate sensorimotor systems, refine postural control and movement strategies, improve gait and locomotion, strengthen lower-extremity muscles, and increase flexibility. These exercises in the subroutine can easily be integrated into practice sessions of the overall program.

To increase the program scalability, the forms/movements in the protocol are both modifiable and adaptable to meet the specific needs of target populations. For example, movements can be practiced using a chair, progressing through sit-and-stand and to chair-assisted, thus imposing a variety of challenges to meet the specific needs and performance capabilities of participants. Movements in the program can be practiced either in single forms or as a whole sequential/non-sequential routine. A simplified set of home-based standing and walking exercises is included to encourage additional out-of-class practice. These features, in contrast to traditional practice, enhance the likelihood of broad program dissemination and sustainability in practice.

### 3.3. Teaching and practice phase and emphasis

There are two phases in teaching and practicing the program: (1) skill acquisition, and (2) reinforcement, with the goal of completing the skill acquisition phase between weeks 10 and 14 of a 24-week program.<sup>15</sup> The skill acquisition phase focuses primarily on teaching the 8-form routine with variations and mini-therapeutic movements, whereas the reinforcement phase focuses on practice repetition and integration of program components described previously. In principle, teaching and practice follows a gradual, part-to-whole, and easy-to-

difficult progression with an emphasis on movement repetition, variation in practice, and integration of program core components.

As with the training approach, teaching and practice of the program emphasizes key movement points, including ankle sway in multiple directions, dorsiflexion/plantarflexion, firm surface contact using the toes, trunk-driven rotational movement, weight shift, multiplanar active head movement, and concurrent cognitive tasks involving recalling, switching, verbalizing, spatial orientation, and natural breathing that follows the rhythm of the movements.

The program follows the principles of motor control and learning<sup>16</sup> in that the moves are (1) performed while seated, standing, or stepping, with varying speeds, ranges of motion, sensory inputs, and bases of support; (2) taught in various patterns (blocked vs. random vs. variable) and/or under dual-task conditions (by adding secondary cognitive tasks); and (3) practiced and *reinforced* using varying cues (ranging from the instructor's auditory and visual cues to internalized self-commanded cues).

#### 4. Research process and evidence

Introduced in 2003,<sup>5</sup> the 8-form routine (originally named *Easy Tai Chi*) was initially evaluated in a randomized controlled trial in which older adult participants were assigned to either a Tai Ji Quan group or a low-impact group exercising three times per week for 24 weeks.<sup>9</sup> At the end of 24 weeks, it was shown that, relative to those in the low-impact exercise condition, Tai Ji Quan participants showed improvements on four clinical physical performance measures: single-leg stands (right:  $p < 0.001$ ; left:  $p < 0.001$ ); chair rise ( $p = 0.003$ ); and 50-foot speed walk ( $p = 0.003$ ).

These promising results provided a scientific basis and clinical impetus for continued refinement efforts for the training protocol (under the revised name *Tai Chi: Moving for Better Balance*<sup>12</sup>). With a strong focus on balance, gait, and mobility, Li et al.<sup>12</sup> emphasized training for movement symmetry, active head movement, bilateral weight-shifting, control of movement of the center of body mass within its full limits of stability, and variable walking/stepping, all of which are essential ingredients for posture control and locomotion.

In a community-based dissemination study with a pre-post design,<sup>13</sup> the application of the revised routine showed encouraging results. At the end of a 12-week intervention, participants exhibited significant pre- to post-intervention improvements in forward functional reach (32.31 cm pretest, 34.39 cm posttest;  $p < 0.0001$ ), Timed Up and Go test (7.40 s pre-test, 7.17 s post-test;  $P < 0.0004$ ), chair stands (10.60 s pre-test, 10.07 s post-test;  $p < 0.0006$ ), and 50-foot walk speed (12.78 s pre-test, 12.14 s post-test;  $p < 0.001$ ). These effects were maintained during a 12-week post-intervention follow-up. Of the 135 participants who provided data, seven reported one or more falls during the first 6 weeks of the class, but no further falls were reported by anyone from week 7 through the end of the 12-week program. Of the 105 participants contacted during the 12-week post-intervention follow-up, only two participants reported a single fall each.

The findings from the aforementioned study led to a strong emphasis on limits of stability training and subsequent development of several therapeutically based mini-movements using Tai Ji Quan. With an enhanced protocol, Li et al.<sup>14</sup> applied this newly refined approach to a sample of patients with mild to moderate Parkinson's disease. In this study, patients were randomized into three exercise groups: Tai Ji Quan, resistance training, or low-impact stretching exercise. Each group exercised twice per week for 24 weeks. At the end of the study, the results showed that patients who took part in Tai Ji Quan exercises experienced significant improvement in center-of-gravity movement excursions over the base of support, sensory integration (vision, somatosensory, vestibular), and movement control during excursion, stride length, and the ability to reach forward, compared to those who participated in either resistance strength training or low-impact exercise. Furthermore, compared to those in the low-impact group, the Tai Ji Quan participants showed improved functional mobility and motor symptoms, as well as reduced incidence of falls.

In an effort to improve sensorimotor integration, the training protocol (currently named *Tai Ji Quan: Moving for Better Balance*)<sup>15</sup> was expanded to include several exercises to: (1) develop training movement patterns and strategies, and (2) maximize integration of proprioception, visual, and vestibular function. In a subsequent evaluation involving patients referred by healthcare providers, Li et al.<sup>15</sup> reported that, after a twice-weekly, 24-week training period, participants exhibited significant improvement in: (a) limits of stability (maximum excursion, movement control), (b) sensory integration, (c) gait measures of stride length and walking velocity, (d) Functional reach, (e) Timed Up and Go, and (f) time to rise from a chair. Overall, these studies reported consistent results supporting the progressive protocol refinements made since the program's inception.

More recently, cognition has been incorporated into the program to provide a holistic approach to function by integrating motor, sensory, and cognitive components. The basis for including this dimension is that by ensuring that Tai Ji Quan practice involves significant attention, spatial-temporal orientation, memory, and executive functioning in addition to deliberate multi-segmental bodily movements and postural demands, it will tax the physiological and neurophysiological processes that drive beneficial neural adaptations in the brain. Thus, the TJQMBB teaching and training protocol now involves simultaneous performance of Tai Ji Quan movements with cognitive tasks, including movement recall, verbalization of forms, selective attention, and form/task switching.

The feasibility and initial validity of this addition to the overall protocol has been evaluated in a pilot study.<sup>24</sup> Specifically, Li et al.<sup>24</sup> examined whether this enhanced protocol could improve global cognitive function and, if so, whether improvement could be related to improved physical performance. Using a pretest-posttest design without randomization, 46 participants aged 65 years who scored between 20 and 25 on the mini-mental state examination (MMSE)<sup>25</sup> were allocated to either a 14-week Tai Ji Quan program ( $n = 22$ ) or a control program ( $n = 24$ ). The primary outcome used MMSE as a measure of global cognitive function, and secondary outcomes included 50-foot speed walk, Timed Up and Go, and Activities-Specific Balance Confidence efficacy<sup>26</sup> measures.



After 14 weeks, Tai Ji Quan participants showed significant improvement on MMSE (mean = 2.95,  $p < 0.001$ ) compared to controls (mean = 0.63,  $p = 0.08$ ) and performed significantly better compared to the controls in both physical performance and balance efficacy measures ( $p < 0.05$ ). Improvement in cognition was related to improved physical performance and balance efficacy. These results provide preliminary evidence of the efficacy and utility of TJQMBB in promoting cognitive function in older adults.

## 5. Community dissemination

While there are numerous versions of Tai Ji Quan currently available, few are evidence based, and fewer still have been translated into community practice. To address this research-to-practice issue, Li and his colleagues<sup>13,15</sup> have conducted community outreach studies evaluating the dissemination potential of the program in broad community settings. As evaluated within the theoretical framework of RE-AIM,<sup>27</sup> the program has received excellent uptake (adoption) by community senior services and clinical practitioners and has reached the target population of community older adults. The program has also been successfully implemented in community settings with good fidelity and desirable outcomes. Furthermore, the program is well maintained at the implementer level (aging service agencies, healthcare providers) and individual level (individual participants).

While ongoing work focuses on expanding community uptake and reach, TJQMBB has been adopted by injury prevention departments and aging and elderly service agencies in states across the US, including California, Colorado, Connecticut, Florida, Maryland, Massachusetts, Nebraska, New Hampshire, New Mexico, New York, Oklahoma, and Oregon. The work presented by Fink and Houston<sup>28</sup> in this issue demonstrates the utility of the program with details of how it was implemented in multi-ethnic community settings with non-native English speakers. Instructor training, available through the author or authorized representatives, provides relevant knowledge about program components, training emphases, a teaching schedule, and fidelity components, as well as information on the teaching essentials necessary to successfully implement the program in community and/or clinical settings.

## 6. Costs and effectiveness

In all our previous work, we have attempted to address two fundamental scientific and practical questions regarding the potential of Tai Ji Quan to improve balance, strength, and mobility and to prevent falls: (1) “Does it work to reduce falls and risk of falling?” and (2) “Does it work in practice?” An additional and compelling question is whether the program is worthwhile in terms of its public health benefits and economic value. In other words, while the program has been shown to be efficacious, it has not been clear that its implementation was more economical in terms of health gains than existing exercise interventions (i.e., was more cost-effective).

This question was explored in a recent economic evaluation study<sup>29</sup> that involved a secondary analysis of falls data from a trial involving people with Parkinson's disease.<sup>14</sup> The analyses showed that, over the course of a 6-month study, the Tai Ji Quan program had both the lowest cost among three interventions and was the most effective in reducing incidence

of falls. Specifically, the Tai Ji Quan program cost US\$8 less per additional fall prevented and US\$4446 less per additional quality-adjusted life year (QALY) gained compared to a Stretching intervention, and US\$79 less per fall prevented and US\$72,649 less per additional QALY compared to the difference between a Strength intervention and a Stretching protocol. Sensitivity analysis showed robustness in the estimates of costs per fall averted and QALY gained with Tai Ji Quan relative to the Stretching comparator program. It was therefore concluded that compared to conventional strength training or stretching exercises, Tai Ji Quan training appears to have significant potential as a cost-effective strategy for preventing falls in people with Parkinson's disease.

## 7. Future directions

While the aforementioned preliminary studies have shown promising outcomes, various basic and dissemination research questions remain that should be evaluated in future studies. First, kinematic analysis is needed to understand how training with an emphasis on balance strategies results in better coordination and, consequently, how improved movement patterns can be translated into functional tasks such as leaning forward and stepping. Second, although our pilot research shows promising results for general cognitive function, the extent to which the protocol can improve multiple domains of cognitive function (e.g., working memory, selective attention, execution function) remains to be determined. Third, research to date has provided ample evidence of the efficacy of the program in modifying and improving clinical outcomes. However, the mechanisms underlying these changes remain largely unexplored. Therefore future studies should examine how control and integration of sensory input and motor output produce specific clinical changes in postural control. Fourth, with the growing emphasis on patient-reported outcomes in research<sup>30-34</sup> and our preliminary work with patients with Parkinson's disease,<sup>35</sup> future studies should focus on evaluating participant perceptions of health-related quality of life and/or benefits derived from Tai Ji Quan practice, the relationship between intervention effects and participant-reported outcomes, and the impact of participant-reported perceptions on continuing practice or long-term adherence.

Finally, as an evidence-based fall prevention program, there is a need to conduct large-scale comparative effectiveness studies and cost analysis of the program as it relates to broad dissemination and adoption by practitioners, healthcare professionals, policymakers, health plans, and others in the community.<sup>36</sup> As healthcare systems and clinical practice begin to emphasize the importance of screening older adults for the risk of falls,<sup>37-39</sup> data are needed on how the program can be translated into a form that can be quickly useable by clinicians. In addition, information on cost-effectiveness will be of great importance to public health and policy in informing service providers and healthcare systems on how to best invest funds for delivery of the most effective preventive services.<sup>40,41</sup>

## 8. Conclusion

The approach presented in this article represents a significant paradigm shift in the application of Tai Ji Quan and is a model for tailoring Tai Ji Quan to address functional impairment/deficits that were not of primary concern in its creation or subsequent evolution

as a martial art or recreational activity. TJQMBB integrates traditional and contemporary practices to specifically train motor-sensory-cognitive systems and postural control, with the ultimate goal of enhancing quality of life by improving balance and gait, performance of daily functional tasks, and mental faculties, as well as by reducing the incidence of falls among older adults.

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