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## Tai Ji Quan Exercise for People with Parkinson's Disease and Other Neurodegenerative Movement Disorders

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### Abstract

The merits of Tai Ji Quan in preventing or ameliorating chronic disease conditions are increasingly being explored in the biomedical research and clinical rehabilitation communities. Recent findings suggest that this ancient martial art's modality, when implemented as a complementary exercise regimen, can be therapeutically beneficial to people with neurodegenerative conditions. This article builds on a recent clinical trial that demonstrated the benefits of Tai Ji Quan for patients with Parkinson's disease by introducing an enhanced training approach that emphasizes integration of multiple facets of movement control mechanisms aimed at reducing or alleviating dysfunctional movement-related symptoms. This innovative approach to traditional Tai Ji Quan practice reflects the need for it to be adapted to modern behavioural medicine and the potential for it to fill a gap between research and clinical practice. The ultimate goal of this approach is to identify the extent of health benefits of Tai Ji Quan as an integrated and alternative intervention used to meet the increasing demand for adjunct clinical treatments for movement disorders and chronic disease prevention.

### Keywords

Tai Ji Quan; Parkinson's Disease; Movement Disorders

## 1. Introduction

Parkinson's disease is a neurodegenerative disorder of the central nervous system that affects movement, muscle control and balance. The disease is progressive, with symptoms becoming more severe over time, leading to loss of postural stability, gait dysfunction, difficulty managing activities of daily living, and frequent falls [1-2]. Although cardinal clinical symptoms, such as tremor, slowness and stiffness, impaired balance, and rigidity of the muscles [2-3], are treated primarily with pharmacological therapy [4], exercise or physical therapy is often considered an integral part of disease management [5-7].

A recent clinical trial [8] has shown that practice of Tai Ji Quan, an exercise of choreographed deliberate movements, improved postural stability, gait, and other functional outcomes in patients with mild-to-moderate Parkinson's disease. Specifically, the researchers found that after a 6-month training period, patients who took part in Tai Ji Quan exercises experienced a significant improvement in centre-of-gravity movement excursions over the base of support, as well as improvement in movement control during excursion, stride length, and ability to reach functionally farther in a forward direction, 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.

Li et al.'s [8] study provides one of the first instances of clinical evidence that Tai Ji Quan (commonly known as Tai Chi or Tai Chi Chuan in the western literature) [9-10] has the potential to be utilized as a complementary, behavioural-based therapy to relieve or improve motor-related symptoms (e.g., difficulties with balance, walking, and voluntary motor tasks) in individuals with neurodegenerative diseases, such as Parkinson's disease. Given that there are significant variations in responsiveness to drug therapy and that many dopaminergic medications induce significant side effects and motor complications [11-12], exploration of any non-pharmacological approaches, such as Tai Ji Quan, that could improve control of voluntary movements in activities of daily living is clinically relevant.

It is well known that Tai Ji Quan, which is viewed as part of China's cultural heritage with a history of more than 300 years, was originally intended for martial arts applications [13]. Although there are various styles or schools, its training regimen has traditionally focused on developing effective combat techniques and self-defence applications. As a martial art, the practitioner engages an opponent with the goal of neutralizing the opponent's use of force and responding with a countering force. In this process, physical and mental equilibrium is sought between the practitioner and opponent through interaction and reconciliation of the dynamic forces induced during motion. However, applications of Tai Ji Quan are not limited to self-defence or competition. The benefits derived from this movement art extend to the promotion of health. Indeed, its popularity has risen due to increasing evidence of its efficacy in promoting healing and well-being, and in improving health-related quality of life. This ancient art of exercise regimen is now practiced by people of all ages throughout the world.

In the past two decades, interest in the health benefits and therapeutic merits of Tai Ji Quan has grown among the biomedical research and clinical rehabilitation communities. It is now apparent that its unique features of mind-body integration (i.e., mind-directed movements), movement kinematics, and inherent postural control mechanisms have made Tai Ji Quan both applicable and amenable to the prevention and/or treatment of various chronic medical conditions [14-15], including heart failure [16], fibromyalgia [17-18], and balance impairment [19-20]. Therefore, translation of the original intent of Tai Ji Quan practice to contemporary therapeutic applications aimed at preventing or reducing movement-related disorders clearly represents a clinical innovation with potential applications in modern behavioural medicine.

From a martial arts perspective, the training approach developed by Li et al. [21]—which was recently applied in a Parkinson's population [8]—is considered unconventional. It is, however, unique in that it consists of a set of functional yet simple Tai Ji Quan-based movements designed to modify and relieve motor symptoms and functional disabilities (e.g., bradykinesia, postural instability, and shuffling gait). In this respect, the approach represents a significant enhancement of traditional Tai Ji Quan practice because it transforms the movements into therapeutic training for postural control, daily functioning, and clinical rehabilitation for those with functional limitations, including older adults and individuals with movement disorders.

Although Li et al. have not yet been able to specifically isolate the mechanism(s) by which their Tai Ji Quan-based protocol elicits enhanced function, it is not difficult to map these movements to the therapeutic training of the movement disorders experienced by patients.

Tai Ji Quan practice consists primarily of a combination of static and dynamic balance actions that include both forms and transitional movements between forms. The therapeutic effectiveness of Li et al.'s derivation of Tai Ji Quan arises from specifically manipulating its multi-segmental (with multiple joints), multi-directional (on multiple planes), and intentional actions to become a more effective form of closed kinetic-chain-based activity for physical rehabilitation [22]. These features form the foundation for the evolution of this approach, which transforms the martial arts or general fitness regime into a functional-based movement modality that improves postural control, gait, and physical function.

Through a research-guided approach, Li and his colleagues have tailored their training protocol to focus on stimulating musculoskeletal, sensory, and cognitive components of the postural control systems. Specifically, the approach trains patients to engage in (1) self-initiated, intentionally controlled centre-of-gravity movements within the base of support (unilateral weight-bearing, rotational weight-shifting in multiple directions, medial-lateral, anterior-posterior, rotational ankle sways); (2) multidirectional stepping and walking in a Tai Ji Quan form/movement (with varying base of support, velocity, and magnitude of motion); (3) corrective postural response strategies (ankle sway, hip flexion/extension, stepping movements); (4) coordinated, multiplanar eye-head movements (with head turning side to side, tilting up and down, rotating) for gaze stabilization; and (5) performance of motor tasks (balance-challenging, multi-segment, directional postural control) and cognitive tasks (movement recognition, orientation, retrieval, switching). These training features tax and promote sensory integration, limits of stability, functional adaptation, anticipatory control, compensatory responses, effective gait patterns, and cognition, offering a comprehensive approach to physical therapy and rehabilitation training for patients recovering from injuries and post-surgical problems and conditions, such as temporary or chronic balance, vestibular, and movement disorders.

The emphasis on limits of stability and sensory integration training represents an important innovation in the contemporary application of Tai Ji Quan to clinical problems involving movement disorders. Unlike traditional Tai Ji Quan, which focuses on maintaining the centre of gravity well within the performer's base of support during movement, Li et al. stress both the movement and magnitude of centre-of-gravity displacement within the full range of one's base of support while executing self-initiated Tai Ji Quan forms/movements. Thus, a performer engages in extending and maximizing the limits of stability, that is, maximizing the angular movements from vertical that can be tolerated without either a step, stumble, or fall. This approach encourages elicitation of corrective postural strategies or reactions to instability that can help patients recover equilibrium under varying daily tasks and environmental conditions. Thus, Li et al.'s protocol helps performers achieve stability and balance by embracing instability induced during the performance of volitional transitional and endpoint movement excursions.

Similarly, this approach capitalizes on the multi-segmental dynamic of Tai Ji Quan movements across multiple planes and is directed toward maximal involvement and integration of visual, vestibular, and proprioceptive input during the performance of its forms and movements. The functional value of this approach is that it allows patients to develop effective compensatory strategies for postural stability in situations (e.g., walking in the dark, on unsteady surfaces, or in crowds) when one or more senses are compromised.

The integration of the multifaceted training features described previously are designed to improve both static and dynamic postural stability, kinesthetic sense and control of body positioning in space, functional walking activities, movement symmetry and coordination, increased range of motion around the ankle joints, enhanced sensory integration, and increased lower-extremity strength. It should also be noted that, to increase the therapeutic

relevance, the training routine builds on key principles underlying motor control, motor learning, postural stability, and gait and mobility training [23-24].

The therapeutic scope of Li et al.'s protocol [8,21] on motor, sensory, and cognitive systems can be illustrated by deconstructing the performance of an unguided (i.e., without visual or verbal instructions from an instructor) single form, such as "Part Wild Horse Mane" (executed from right to left). Beginning from a static "hold-a-ball" posture set in front of the body, an action plan is devised by the patient (through the parietal lobes and supplementary and premotor cortices) to step diagonally forward to move into the "Part Wild Horse Mane" posture on the left side. The action is then initiated (through the motor cortex) beginning with a lateral weight shift onto the right limb and continuing with a rotational trunk movement that allows the body weight to be fully loaded on the stance (right) limb. During this weight-shifting action, sensory input from multiple sources (vision, vestibular, proprioceptive) helps to compensate for lateral instability that results in narrowing of the base of support via the rotational mediolateral excursion, and a vestibulo-ocular reflex is elicited as the head follows the direction of the lateral-rotational trunk movement to stabilize visual acuity during movement transition.

Once the weight shift to the right limb is completed and the body is stable but now on a narrower base of support, gait initiation begins with lifting the toes/foot on the swing (left) limb, followed by stepping diagonally forward. This transitional act results in a widening of the base of support, which is fully anticipatory (i.e., preplanned) in nature. With heel strike, body weight is transferred onto the left limb by rotating the trunk leftward to bring the right hip forward (note that this trunk-rotation action propels the forward body motion). With the left hand moving forward (in coordination with the trunk rotation) and right hand pushing down to the right-side hip, a posture of "Part Wild Horse Mane" to the left is set in place. A further heel push-off of the extended (right) limb, followed by a light rock-back with toes up, completes the single-side "Part Wild Horse Mane" action form. Note that the performance can be facilitated, especially during the initial learning stage, by using external visual or auditory cues from an instructor. Furthermore, because all movements are preplanned, feed-forward (anticipatory action) is a dominant characteristic of this performance. Reactive, compensatory adjustments are only necessary in the event of loss of balance in transitioning.

Execution of these sequential movements requires cognitive planning, retrieval of the specific series of movements, and, finally, initiating them with consciously controlled excursions (i.e., centre-of-gravity displacement over the base of support). The planning, preparation, initiation, and kinesthetically guided action of these modified Tai Ji Quan exercises may thus be of particular benefit for individuals with movement disorders, such as Parkinson's disease and Huntington's disease, where there are clinical problems involving the basal ganglia and other parts of the brain [25-26]. Learning and practice of Tai Ji Quan forms are initially driven by visually and/or verbally triggered and guided movements from an instructor. Such attentional strategies and sensory cueing are often used in clinical rehabilitation to improve motor and functional outcomes [5]. Therefore, sustained training may lead to internally generated, self-initiated movements that are more anticipatory in nature (i.e., internally cued movements rather than externally guided; consciously controlled movements rather than automatic). Thus, the strategy of training attention and intentionally guided movements can prepare patients to more readily respond to unanticipated postural disturbances, and consequently react more quickly to restore equilibrium [27].

The basal ganglia play a critical role in initiating and regulating motor commands and voluntary movements that involve extensive coordination, such as those used in Tai Ji Quan. Experimental studies show that the globus pallidus (one of the nuclei in the basal ganglia)

provides direct inputs (projection) to the supplementary motor area during execution of internally generated sequential movements [28-29], suggesting that it may mediate cognitive aspects of movement, such as the multiple-segment movement sequencing in Tai Ji Quan. Thus, damage in the basal ganglia may hinder execution of internally generated movements, such as is often observed in patients with Parkinson's disease [30-31]. But this also suggests that training with internally guided movements may enhance the ability to initiate movements and ambulate. This also implies that training in Tai Ji Quan would be more beneficial if practice of self-initiated and directed movements is encouraged, that is, the movements are initiated and practiced by patients themselves rather than being visually and verbally guided by an instructor in the traditional manner.

The extent to which the practice of Tai Ji Quan can prevent or delay progression of motor symptoms in neurodegenerative diseases remains to be seen. However, given the results of the work with people with Parkinson's disease, the therapeutically oriented Tai Ji Quan training described above has potential to also benefit patients with other movement disorders, such as muscular sclerosis or Huntington's disease. To be most useful, the modified Tai Ji Quan protocol must address the specifics of movement disorders that are relevant to individual patients. Clinically integrated training with an emphasis on mental concentration, motor control and coordination, and sensory integration of bodily movements is likely to bring about clinically meaningful change in functional outcomes.

The research carried out by Li and his colleagues [8,21] represents innovative thinking in the transformation and application of traditional Tai Ji Quan practice to contemporary treatment of neurodegenerative movement problems. The transformation is based on therapeutic relevance and functional values supported by scientific evidence. This clinically oriented but scientifically driven approach represents a significant paradigm shift that is likely to further enhance the utility of traditional Tai Ji Quan, in that it will serve to improve motor and functional outcomes in people with movement-related disorders.

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