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Tai chi as an adjunctive therapy for individuals who plateau after vestibular rehabilitation

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Abstract

Objective. This study aimed to evaluate the effectiveness of tai chi on balance in patients with improved but persistent dizziness and imbalance following completion of traditional vestibular rehabilitation therapy.

Method. Patients who completed vestibular rehabilitation therapy with persistent imbalance were prospectively enrolled in a tai chi programme comprising eight weekly classes. Balance was assessed before the first and after the eighth session using the Dynamic Gait Index, Activities-Specific Balance Confidence scale and Dizziness Handicap Inventory.

Results. A total of 37 participants (34 females, 3 males) completed the programme with balance testing. Mean age was 76.8 years (range, 56–91 years). Mean Dynamic Gait Index significantly increased after completion of tai chi ($p < 0.00001$). Mean Activities-Specific Balance Confidence scale score increased from 63.6 to 67.9 per cent ($p = 0.046$). A subset ($n = 18$) of patients completed a Dizziness Handicap Inventory without significant post-therapeutic change ($p = 0.62$). Most (36 of 37; 97.3 per cent) patients demonstrated post-therapy improvement on one or more assessments.

Conclusion. Tai chi is a viable adjunct to improve balance in patients who complete a vestibular rehabilitation therapy programme.

Main Article

Dr K Chow takes responsibility for the integrity of the content of the paper

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Introduction

Balance disorders are common in the USA, with an estimated lifetime incidence of up to 40 per cent.[1,2] Vertigo, dizziness and postural instability in chronically affected adults significantly reduces quality of life and increases the risk of falls, the sequelae of which include fracture, hospitalisation and death.[3,4] The aetiology of vestibular loss can include any combination of infection, aging, head trauma, benign positional paroxysmal vertigo or exposure to ototoxic medications.[5,6] Should the underlying cause of imbalance be fluctuating or spontaneous with prolonged labyrinthine pathology, as in the case of Ménière's Disease, pharmacological and surgical intervention may be warranted. When the aetiology of imbalance is stable, vestibular rehabilitation therapy becomes the 'gold standard' for an effective exercise-based means to manage chronic balance dysfunction.[7]

Vestibular rehabilitation therapy exercises are designed to facilitate adaptation and compensation of the vestibular system to previously lost function.[8] Primary objectives include vertigo or dizziness reduction, improvement in postural stability, enhancement of gaze stability, and resumption of baseline activities of daily living.[7] Although effective, progression in vestibular rehabilitation therapy may be inhibited by non-adherence to the prescribed regimen, as well as behavioural and psychiatric barriers.[9] Adjunct therapies may therefore, in theory, play a role in the management of postural instability where progress through traditional vestibular rehabilitation therapy has plateaued.

Previous studies exploring balance dysfunction treatments have considered the efficacy of tai chi chuan (tai chi), a centuries-old Chinese conditioning exercise derived from martial arts that emphasises full body control.[10] Practitioners of tai chi use methodical, flowing movements in choreographed 'forms' to develop physical, emotional and spiritual well-being.[11] A body of literature encompassing the previous three decades has noted the efficacy of tai chi for primary prevention of chronic disease and the improvement of insomnia, pain reduction, flexibility and self-esteem. In addition, tai chi has been effective in health promotion for patients with cardiovascular disease, cancer, chronic obstructive pulmonary disease, Parkinson's disease and osteoarthritis.[12,13]

When considering balance, examples in the literature have reported overall balance control and proprioception recovery after standalone tai chi therapy.[14,15] However, the use of tai chi in the context of vestibular rehabilitation therapy has been seldom explored. Huang *et al.*, in a systematic review, identified four studies to date that used tai chi tangentially to or instead of a prescribed course of vestibular rehabilitation, none of which explicitly reported plateauing or maximisation of therapeutic benefit.[15] To that end, this study aimed to evaluate the effectiveness and feasibility of a tai chi programme for

adult patients with improved but persistent vestibular symptoms following completion of a traditionally prescribed course of vestibular rehabilitation therapy.

Materials and methods

Patients were recruited from a university-based comprehensive vestibular rehabilitation centre per recommendation by a physical therapist specialising in vestibular disorders. Inclusion criteria were as follows: (1) adults aged 18 years or older, (2) patients with a definitive diagnosis of vestibular dysfunction, (3) patients who were naive to the practice of tai chi; (4) patients who had completed a course of vestibular rehabilitation therapy (minimum 16 sessions) within two months of enrolment, and (5) patients who were discharged secondary to a plateau in progress, with indications that they (6) had persistent vertigo and/or dizziness on discharge.

Patients were excluded if they: (1) could not communicate in English, (2) were physically unable to perform basic tai chi movements or (3) if they had a history of previous non-adherence to vestibular rehabilitation therapy. Patients were not explicitly excluded if immobility was secondary to pain. This prospective cohort study was approved by the institutional review board at New York Eye and Ear Infirmary of Mount Sinai, number: 07-00032, and all patients gave informed consent.

Tai chi instruction

Tai chi sessions were held at the out-patient vestibular therapy clinic in cohorts with a minimum of 4 patients and maximum of 7 patients per group. Patients were seen in a class instructed by one of the vestibular therapists for a 45–60 minute period, once weekly for 8 weeks. Selected tai chi forms were derived from the Yang style, the most widely utilised form of tai chi, and were chosen to initially minimise head movement to reduce aggravation of vestibular symptoms and optimise weight shifting for postural stability. Each session taught and reinforced two new movements, which were progressively combined over the following sessions to yield a total of 16 cumulative forms upon programme completion. Pictorial tai chi forms with accompanying descriptors can be observed in Appendix 1. Participants were encouraged to practise all tai chi movements learned twice daily.

Measures of vestibular function

The Activities-Specific Balance Confidence scale, Dynamic Gait Index and Dizziness Handicap Inventory were used to assess balance outcomes, with testing undertaken immediately prior to the first tai chi session and directly following the last session. All patients completed the Activities-Specific Balance Confidence scale and the Dynamic Gait Index, pre- and post-treatment.

The Dynamic Gait Index is a measurement of balance and fall risk in older adults and is composed of 8 balance-oriented tasks that are ordinally scored from 0–3. Individual item scores of 0 indicate severe gait impairment, and scores of 3 suggest normal gait function.[17] Combined Dynamic Gait Index scores of 19 or less out of 24 are predictive of increased fall risks in community-dwelling elderly adults and individuals with vestibular dysfunction.[18] Pre- and post-intervention assessment of Dynamic Gait Index was completed by the same therapist.

Both the Activities-Specific Balance Confidence scale and Dizziness Handicap Inventory are self-administered subjective matrices. The Activities-Specific Balance Confidence scale is a 16-item measurement of confidence in personal ability to perform routine balance-oriented functions scored as a percentage (0 per cent as lowest confidence and 100 per cent as highest confidence).[19] Final scores are calculated as an average percentage of all responses, with a threshold less than 50 per cent suggesting a low level of physical function and a threshold less than 67 per cent predicting future falls in older adults.[20,21] The Dizziness Handicap Inventory is a 25-item assessment of severity of debilitation from dizziness, with scores of 0, 2 and 4 points assigned to responses of no, sometimes and yes, respectively. Cumulative scores are derived from the summation of all items for a maximum of 100 points.[22] A higher Dizziness Handicap Inventory score indicates worsened perception of handicap from dizziness, and established score ranges of 0–30, 31–60 and 61–100 indicate mild, moderate and severe handicap, respectively.[23]

Statistical analysis

Pre- and post-treatment measures of balance scores, score change and patient age were analysed as continuous variables. A Shapiro–Wilk test was used to ascertain normality of continuous variables, and changes in pre- and post-treatment Activities-Specific Balance Confidence scale, Dynamic Gait Index and Dizziness Handicap Inventory were compared using a paired samples *t*-test for normally distributed data. The Wilcoxon signed-rank test was used for non-parametric data. Data were recorded as mean and standard deviation. Score differences or change were calculated as raw post-test score minus raw pre-test score.

Patient age was analysed as a potential independent predictor of post-treatment balance outcomes (pre- and post-tai chi Activities-Specific Balance Confidence scale, Dynamic Gait Index, Dizziness Handicap Inventory) using a Spearman's rho correlation. Post-tai chi subjective measures (Activities-Specific Balance Confidence scale and Dizziness Handicap Inventory) were correlated to the post-tai chi objective measure (Dynamic Gait Index) in an additional bivariate analysis using Spearman's rho.

Results

Fifty-one patients (47 female, 4 male) were enrolled in this study from April 2010 to December 2016, of which 37 participants completed pre- and post-intervention testing of vestibular outcome measures. The majority of participants were female (91.9 per cent; 34 female, 3 male). Demographic data are indicated in Table 1. Mean age among patients who completed treatment was 76.7 years (range, 56–91; standard deviation, 3.9 years). Three patients were unable to complete all 8 requisite sessions, and 11 were lost to follow up on post-treatment testing. Average Dynamic Gait Index, Activities-Specific Balance Confidence scale and Dizziness Handicap Inventory for patients with mean differences are displayed in Table 2.

Among the 37 assessed patients, 36 (97.3 per cent) improved in one or more balance outcome measure. A total of 34 of 37 (91.9 per cent) showed improved gait on the Dynamic Gait Index, 24 of 37 (64.9 per cent) increased in confidence for balance-related tasks on the Activities-Specific Balance Confidence scale and 7 of 18 (38.9 per cent) showed improvement on the Dizziness Handicap Inventory.

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Table 1. Demographic data and balance assessment of tai chi participants

Patient characteristics	Value (*n* (%))
Sex	
– Female	34 (91.9)
– Male	3 (8.1)
Age group	
– 50–59 years	2 (5.4)
– 60–69 years	6 (16.2)
– 70–79 years	11 (29.7)
– 80+ years	18 (48.6)
Completed balance assessment	
– Dynamic Gait Index	37 (100)
– ABC	37 (100)
– Dizziness Handicap Inventory	18 (48.6)

ABC = Activities-Specific Balance Confidence scale

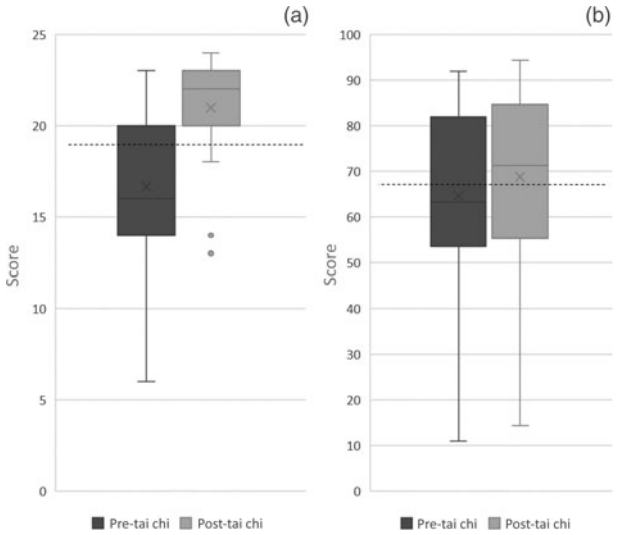

Fig. 1. Change in mean (a) Dynamic Gait Index and (b) mean Activities-Specific Balance Confidence scale before and after tai chi therapy ($p < 0.001$, $p = 0.046$, paired *t*-test, respectively). Designated threshold for fall risk is indicated for each respective assessment of balance. A Dynamic Gait Index at or below 19 and Activities-Specific Balance Confidence scale below 67 per cent indicate the patient is at a higher risk of falls.

Mean Dynamic Gait Index and Activities-Specific Balance Confidence scale scores increased significantly upon completion of the tai chi programme ($t = 8.88$, 1.73; $p < 0.00001$, $p = 0.0458$; paired samples *t*-test) (Figure 1, Table 2). Mean Dizziness Handicap Inventory scores did not significantly change ($z = -0.49$, $p = 0.62$; Wilcoxon signed-rank test). Age was not associated with score changes in Dynamic Gait Index or Activities-Specific Balance Confidence scale ($r_s = 0.21$, -0.15; $p = 0.21$, 0.36; Spearman's rho). However, age was negatively and moderately correlated to a change in Dizziness Handicap Inventory ($r_s = -0.57$, $p = 0.01$; Spearman's rho). Post-tai chi Activities-Specific Balance Confidence scale was moderately and positively correlated with post-tai chi Dynamic Gait Index, and post-tai chi Dynamic Gait Index was strongly and negatively correlated with post-tai chi Dizziness Handicap Inventory ($r_s = 0.48$, -0.63, $p = 0.002$, 0.005; Spearman's rho) (Figure 2). Both aforementioned correlations indicated improved outcomes (lower Dizziness Handicap Inventory and higher Dynamic Gait Index and Activities-Specific Balance Confidence scale indicate better balance).

Discussion

Tai chi has demonstrably ameliorated symptoms of imbalance in previous studies. Huang *et al.* identified four such trials spanning 2006–2012, all of which reported positive results in vestibulopathy using differing measures of balance.[16] No papers to date have explored the use of tai chi in continually symptomatic patients who plateau in vestibular rehabilitation therapy performance. Consequently, the addition of a novel prospective cohort to this limited body of literature affords the possibility for future adjustments to the management of contemporary vestibular rehabilitation therapy.

The results of this investigation suggest a modified tai chi programme can plausibly improve balance outcomes in individuals who fail to maximise benefit from vestibular rehabilitation therapy, with significant recovery in the Dynamic Gait Index and Activities-Specific Balance Confidence scale in this cohort after tai chi therapy. It can be further suggested that functional ability and balance confidence are improved after completion of the tai chi programme. In addition to the vestibular, visuospatial and proprioceptive systems, general balance is controlled by an amalgamation of factors affecting static and dynamic balance, notably mental condition and confidence.[24] To that end, bivariate analysis of subjective balance measures found moderate to strong associations between perceived level of handicap or confidence in balance abilities (Dizziness Handicap Inventory or Activities-Specific Balance Confidence scale) and improvement in practical performance in balance-related tasks (Dynamic Gait Index).

Participation in a low-stress, less physically demanding form of balance training such as tai chi likely facilitates the development of perceived self-efficacy that is observable on the Activities-Specific Balance Confidence scale and Dizziness Handicap Inventory. Perceived self-efficacy is defined by Albert Bandura as an individual's belief about their ability to produce certain levels of performance that in turn influence life-affecting events.[25] In the context of our findings, further improvement after plateaued vestibular rehabilitation therapy progress in this cohort may be attributed to group dynamics or a comparatively higher degree of engagement. Although vestibular rehabilitation therapy is typically individualised, it may not encourage the social interactions

Table 2. Mean balance assessment matrices before and after tai chi programme

Parameter	Pre-tai chi	Post-tai chi	Mean difference	*P*-value
Dynamic Gait Index (mean ± SD; score)	16.7 ± 4.0	21.0 ± 2.7	4.3 ± 2.9	<0.001*
ABC (mean ± SD; %)	63.6 ± 19.7	68.0 ± 17.7	4.3 ± 14.9	0.046*
Dizziness Handicap Inventory (mean ± SD; score)	35.9 ± 15.9	36.3 ± 14.3	−0.4 ± 14.5	0.624

*Statistically significant values. SD = standard deviation; ABC = Activities-Specific Balance Confidence scale

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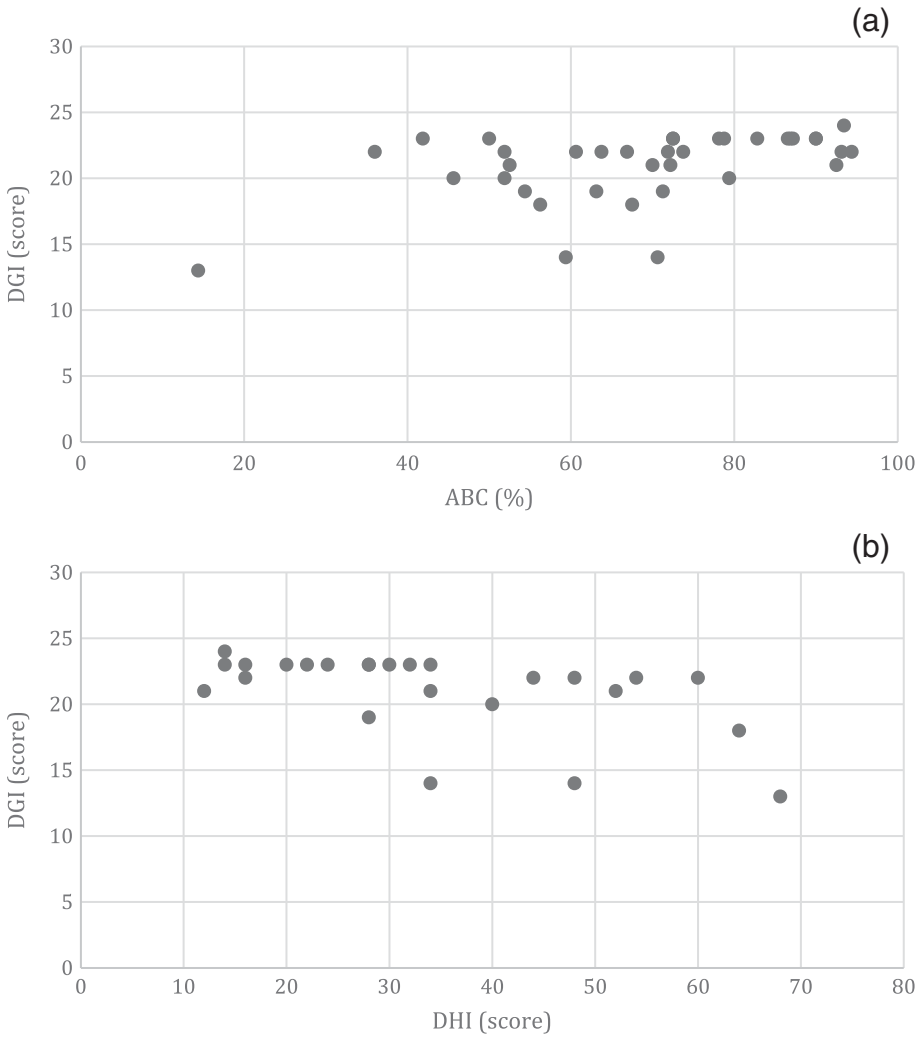

Fig. 2. Spearman correlation between subjective and objective measurement of balance for (a) Activities-Specific Balance Confidence (ABC) scale versus Dynamic Gait Index (DGI) and for (b) Dizziness Handicap Inventory (DHI) versus Dynamic Gait Index (r_s= 0.48, −0.63; p = 0.002, p = 0.005, Spearman's rho, respectively). Higher Activities–Specific Balance Confidence scale and lower Dizziness Handicap Inventory scores suggest greater subjective balance.

of tai chi group therapy, which is conducive to resilience in a prescriptive exercise regimen.

- Balance disorders are common, and accidental falls and their sequelae may result in severe morbidity
- Vestibular rehabilitation therapy is a well-recognised, effective exercise-based treatment for balance dysfunction
- Tai chi has been minimally explored as an adjunct to vestibular rehabilitation therapy
- Empirically, tai chi can improve balance in patients who no longer attain benefit from traditional vestibular rehabilitation

Of particular interest are the predictive thresholds for fall risk established by Shumway-Cook *et al.* for the Dynamic Gait Index (score of 19 or less) and Myers *et al.* for the Activities-Specific Balance Confidence scale (score of lower than 67 per cent).[17,19] For both measures, pre-tai chi mean scores were initially below the threshold indicating a higher fall risk but significantly increased to surpass the aforementioned set points after the eighth tai chi session (Figure 1). Although it would be premature to conclude that performance of tai chi definitively reduces fall risk, subject participation in comparable programmes noted in the study by Huang *et al.* may have contributed towards adaptation, habituation, or substitution of sensorimotor and psychosocial factors of balance.[7,15] It is possible that any combination of these facets, or the development of improved self-efficacy, may be contributory to a reduced fall risk in this cohort.

This study had several limitations. Although 97.3 per cent of patients had at least one improved balance outcome measure, comparisons of the benefits from tai chi to a control group were limited by methodological constraints. Although the areas of improvement in vestibular rehabilitation therapy (improved postural reflexes, sensory organisation and gaze stability) have been widely documented, there is no data available to suggest spontaneous or continued recovery of dizziness, vertigo, daily function and behavioural confidence after discharge in the absence of further intervention.[26] Therefore, although this cohort experienced significant improvement in balance measures, the lack of a control group makes it difficult to ascertain how longitudinal performance would have been affected in the absence of intervention.

Cohort distribution by underlying vestibular pathology further limited the generalisability of study findings because patients enrolled in this study had a diverse array of vestibular diagnoses. Symptomatology similarly varied among patients, including any combination of dizziness, vertigo and imbalance. Owing to existing limitations, the use of tai chi as an adjunct to, or as a facet of, vestibular rehabilitation therapy is worthy of further investigation.

Conclusion

Tai chi demonstrates promise as a post-rehabilitative adjuvant to further recover balance in patients with vestibular disorders who have completed a course of vestibular rehabilitation therapy.

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When compared with their post-vestibular rehabilitation therapy baseline, patients who completed a modified tai chi programme were likely to perform better on routine balance-oriented tasks and may become more confident in their postural abilities. Further investigation of tai chi as an adjunct after vestibular rehabilitation therapy may inform future means by which limits in therapeutic performance can be surpassed.

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Competing interests. None declared

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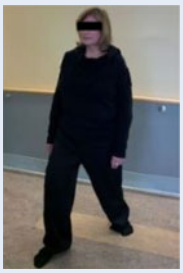
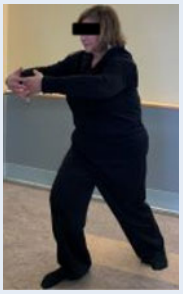
Appendix 1 Tai chi form

Tai chi form	Description	Image
Bow stance	Start with feet shoulder width apart, turn left foot out 45 degrees, step right foot forward (comfortable distance forward), keep feet in this position. Slowly shift body weight from the left foot to the right foot (do not lift feet off the floor). Inhale when shifting weight to left foot. Exhale when shifting weight to right foot. Switch feet & repeat.	
Bow & arrow	Start with feet shoulder width apart, raise both arms to the right, draw left arm back as if pulling an arrow back while shifting body weight to the left (inhale through your nose as you do this). Exhale through your mouth as you move left arm forward back to starting position. Lower both arms down & switch sides. Now raise both arms to the left, inhale as you shift weight to the right & draw the arrow back. Release the arrow & repeat as above.	
First tai chi movement	Begin with feet shoulder width apart, raise both arms up to no higher than shoulder height. Pull the hands towards the chest horizontally while dropping the elbows down. Press hands down the front of the body to the floor with palms facing down. Bend knees slightly as you push your hands down (straightening the arms) & exhale through your mouth. Inhale while you straighten your arms & legs & repeat as above.	
Gathering	Feet are in same position as bow stance & weight shifting is the same as well. Arms are stretched wide open (horizontally) while weight is on back leg. As you shift forward, exhale through your mouth & move the arms forward until fingertips meet. Turn palms toward you & bring arms toward your chest as you shift backward. Switch feet & repeat.	
Polishing the table top	Feet are shoulder width apart; knees bent slightly (maintained during this movement). Arms are resting forward in front at hip level. Shift your weight to the right, rotate trunk to the right, & move hands to the right as if you are polishing a semi-circular table in front of you. Shift your weight to the left, rotate trunk to the left, & move hands to the left. Inhale once you are turned to the left & exhale as you are rotating to the right. Repeat.	

(*Continued*)

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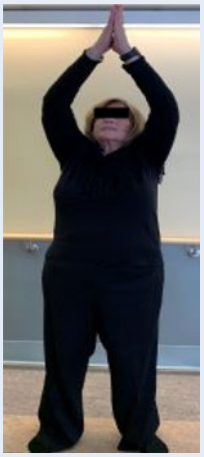
Appendix 1 (*Continued.*)

Tai chi form	Description	Image
Gathering energy	Start with feet shoulder width apart. Raise both arms to the side & up overhead (palms facing upwards). Palms touch overhead & descend down in front of chest (hands in prayer position). Bend knees slightly as palms come down & exhale through mouth. Straighten knees, raise arms overhead as above & inhale deeply through nose. Optional to have head positioned up while raising arms overhead & head positioned down while hands are descending down in front of body.	
Punching	Feet are shoulder width apart. Swing both arms up the right side. Draw left arm back as in the bow & arrow exercise. Slowly & gently punch the left arm forward while simultaneously drawing right arm back. Punch the right arm forward while left arm draws back. Drop both arms & switch sides raising both arms to left. Inhale through nose as you draw arm back. Exhale through mouth as you punch & switch sides. Repeat as above to opposite side.	
Stepping	Feet are shoulder width apart & knees slightly bent. Shift all your weight onto right leg. Slowly lift left leg & place heel one step length forward on the ground. Slowly transfer weight forward onto left foot from heel, to midfoot, to forefoot & toes (keeping heel on the ground). Seventy per cent of your weight should be transferred & shifted forward on the left foot. Slowly peel your toes off the floor, feeling the weight transfer back towards the heel, & slowly place the left foot back in the starting position. Exhale as you shift weight forward. Inhale as you shift weight backward. Repeat for opposite side.	
Stoking the fire	Feet are shoulder width apart & knees slightly bent. Inhale through nose as you stretch both arms out to the sides with palms facing upwards (no higher than shoulder level). Exhale while moving arms in front of you with palms down & knees slightly bent (making sure elbows are bent as well). Inhale & repeat as above.	

(*Continued*)

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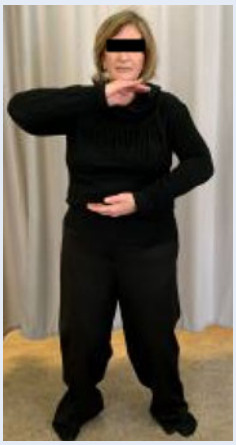
Appendix 1 (*Continued.*)

Tai chi form	Description	Image
Pitching	Feet are shoulder width apart. Shift weight towards the right foot. Tap the toes of left foot next to the right foot. During this sequence, elbows bend up to the right (keep shoulders relaxed & elbows close to trunk). Return left foot to starting position & arms will rest down in the centre. Inhale as your arms are resting in the centre. Exhale as you shift your weight from one side. Repeat to opposite side. Optional: turn your head & look at your fingers while elbows are bent.	
Turning the wheel	Position feet in bow stance. Place hands at chest level as if you were holding a basketball between them. Move hands in circular motion as if you were turning a wheel clockwise in front of you. Palms are facing each other. As hands draw back towards you, shift your weight backwards. As hands circle away from you, shift your weight forwards. Inhale as arms come towards you. Exhale as arms move away from you. Then reverse the direction of the circle & repeat in counter-clockwise motion. Switch legs & repeat as above on opposite side.	
Embrace the moon	Feet are shoulder width apart. Place arms out to sides, with palms facing down towards floor. Gently bend knees as arms come in towards your trunk. Arms are positioned as if they are cradling a large round ball (right arm on top at chest level & left arm on bottom by level of belly button). Return arms to the side as knees straighten. Repeat with left arm on top of the 'ball/moon' & right arm on bottom. Inhale as arms are opening out to the sides. Exhale as arms 'cradle the ball/moon'.	

(*Continued*)

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Appendix 1 (*Continued.*)

Tai chi form	Description	Image
Crane spreads wings	Feet are shoulder width apart. Position arms diagonally with right hand high & left hand low (left palm facing up). The left hand travels up diagonally to meet the right hand, & right hand will catch the back of the left wrist as it is rising up to meet the right. Rotate the torso to left with your hands in the same position. Then let right hand drop down diagonally while left hand is in the high position (right palm facing up). The right hand will travel back diagonally across the body & will be caught by the left hand. Rotate the torso to the right & repeat. Inhale as your arms are stretched in opposite diagonals. Exhale as your arms come together & rotate. Optional: allow your head to follow the movement of the hand as it lowers & raises.	
Swimming	Feet are placed in bow stance. Backs of the hands come together in front of the chest. Maintain this position of the hands as you shift your weight forward. Arms separate & stretch to the sides as you shift your weight backwards. This motion is similar to the arm motion of breast stroke. Exhale as your weight shifts forward. Inhale as your weight shifts backwards. Repeat to opposite side.	
Rooster stands on one leg	Feet are shoulder width apart. Shift your weight to the right leg as you lift your left arm & leg simultaneously & hold. As you are holding this position, focus through a 'V-shape' formed by your left hand. Lower both the left arm & leg down & perform a mini squat. Shift your weight to left leg as you lift your right arm & leg simultaneously & hold. As you are holding this position, focus through a V-shape formed by your right hand. Pick a side to follow a cycle of breathing: when you lift that side's elbow up & knee up, inhale, & as you lower & switch sides, exhale. You may want to lean your back gently against the wall for balance; as your balance improves, position yourself away from the wall.	

(*Continued*)

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Appendix 1 (*Continued.*)

Tai chi form	Description	Image
Repulse monkey	Feet are shoulder width apart. Left arm is extended out in front of you (90 degrees). Circle the right arm around to the back & then push that hand past your face. As you extend the right arm to the front, simultaneously pull left arm back with palm up & circle the left arm out to the back. Head & torso will turn to observe the hand as it swings around to the back. Repeat. Soften the knees to allow ease of trunk rotation. Pick one hand to follow a cycle of breathing: as you push that hand past your face, exhale, & as you draw that same arm back, inhale.	

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