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REVIEW ARTICLE

A Systematic Review on the Effectiveness of Tai Chi Exercise in Individuals with Parkinson's Disease from 2003 to 2013☆

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KEYWORDS
Parkinsonism;
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Summary *Objective/Background:* This study aims to review the current evidence on the effectiveness of Tai Chi exercise in individuals with Parkinson's disease (PD) in the past 10 years.
Methods: A systematic review of studies published in English from 2003 to 2013, retrieved from three electronic databases—MEDLINE, Cumulative Index to Nursing and Allied Health Literature, and ScienceDirect—was performed. The review selected only those studies that investigated the effects of Tai Chi exercise on individuals with PD and had a full-length publication. Methodological qualities of the randomized control trials were appraised based on the modified Jadad scale.
Results: Of the 702 articles, eight publications, including four randomized controlled trials, two single-arm intervention studies, and two case reports, were reviewed. Results of this review show that there is an inconsistency of strong empirical evidence to support the efficacy of Tai Chi exercise in the PD population. Furthermore, this review reveals that there is a lack of scientific rigor in the experimental designs of the trials conducted to examine the effects of Tai Chi intervention on the PD population.
Conclusion: Because of the small sample and inconclusive results, this review cannot provide a firm conclusion to support or refute the effectiveness of Tai Chi in improving motor or nonmotor performance in patients with PD. Further research is required to investigate whether there are specific benefits of Tai Chi for people with PD in these areas and future review should include non-English studies, which examine the use of Tai Chi with this type of population.

☆ Conflicts of interest: The author declares that she has no financial or non-financial conflicts of interest related to the subject matter or materials discussed in the manuscript.

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Introduction

Parkinson's disease (PD) is a progressive degenerative neurological condition that causes significant movement impairments such as gait dysfunction and postural instability (Kluding & McGinnis, 2006; McDermott et al., 1995). Its progressive nature and wide diversity of symptoms have caused PD to be viewed as a challenging and complex condition for both patients and health care professionals (Gage, Hendricks, Zhang, & Kazis, 2003; Lindgren, 2004). The commonly known and the most effective intervention for this condition is the use of levodopa. However, one drawback is that using this type of medication on a long-term basis can lead to complications such as dyskinesia (Nijkrake et al., 2007). Furthermore, some motor dysfunctions such as postural instability are less responsive to medication and require alternative approach (Nirenberg & Fahn, 2005; Schapira & Olanow, 2005). Despite optimal medical management, individuals with PD continue to experience gradual deterioration of their bodily functions, and this affects their participation in activities of daily living (Nijkrake et al., 2007). Often, the chronic and debilitating symptoms of this condition cause individuals to turn to complementary therapies for alleviation of the symptoms (Ferry, Johnson, & Wallis, 2002; Tan, Lau, Jamora, & Chan, 2006).

One such example is the practise of Tai Chi exercise. It is a Chinese ancient martial art, which involves slow, controlled movements and maintenance of various postures (Hackney & Earhart, 2008). The movements in Tai Chi involve trunk rotation, flexion, and extension of hips and knees, weight shifting, coordinated arm movements, and postural control (Hackney & Earhart, 2008; Li, Fisher, Harmer, & Shirai, 2003; Wolf, Coogler, & Xu, 1997). These movements make Tai Chi a possible effective intervention to address balance problems. Beneficial effects of Tai Chi exercise in reducing high blood pressure, improving balance, muscle strength, and reducing falls have been reported in several studies (Adler & Roberts, 2006; Taylor-Piliae & Froelicher, 2004; Verhagen, Immink, van der Meulen, & Bierma-Zeinstra, 2004; Wang, Collet, & Lau, 2004). Because deficits in balance and mobility are hallmark signs of the progression of PD (Kluding & McGinnis, 2006), it is plausible to hypothesize that Tai Chi is a suitable modality for PD individuals.

Mechanism of Tai Chi

Studies had postulated that Tai Chi helps to normalize neurotransmitter levels such as dopamine in the motor cortex—basal ganglia—motor cortex feedback loop and ameliorate PD symptoms by bypassing the faulty circuit (MacLaggan, 2000; Morris, 2000). MacLaggan (2000) has suggested that daily repetitive practise of Tai Chi promotes development of new neural pathways and allows faster reactions when responding to postural challenges. Recent evidence indicates that Tai Chi improves anticipatory postural adjustment and elicits responses in specific somatosensory and neuromuscular control pathways responsible for postural control (Tsang & Hui-Chan, 2003, 2004).

Because of its various beneficial effects, Tai Chi has been recommended as a complementary therapy for individuals with PD by the National Parkinson Foundation of the United States (National Parkinson Foundation, 2012). However, little empirical evidence is available on its effectiveness in PD individuals in recent clinical trials. Previous reviews conducted to examine the effects of Tai Chi exercise primarily focused on improving balance and preventing fall in frail/healthy elderly individuals; improving physical health outcomes of those with chronic conditions; improving psychosocial well-being and improving aerobic capacity in older adults (Komagata & Newton, 2003; Taylor-Piliae & Froelicher, 2004; Wang et al, 2004; Wang et al., 2009; Wooton, 2010). So far, there was only one systematic review (Lee, Lam, & Ernst, 2008) that examined the effects of Tai Chi on the PD population. However this review was done 5 years ago, and little is known on the recent evidence in this area. Therefore, the aim of the study is to review the current evidence on the effectiveness of Tai Chi exercise in individuals with PD in the recent 10 years.

Methods

Search strategy

A systematic literature search for articles published from July 2003 to July 2013 was performed. Studies were identified by three electronic databases—MEDLINE, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and ScienceDirect (see the supplementary material online). The keywords used were "Tai Chi, Tai Ji, or Tai Chi Quan" and "Parkinson's Disease or Parkinsonism." The term "Parkinsonism" is used because it refers to a group of movement disorders that have similar features and symptoms as PD (Ulbricht, 2011). Additional method used included reviewing of all reference lists of the identified relevant articles.

Selection criteria

The review selected only available studies published in English and had a full-length publication. All prospective clinical trials [i.e., randomized controlled trials (RCTs), single-group trials, or case reports] related to the effects of Tai Chi on individuals with PD were included. Studies involving adults (i.e., aged >18 years) with all stages of PD and those that had used Tai Chi as other forms of activities for comparison were also included.

Studies on systematic reviews, meta-analysis, and those which did not involve participants with PD were excluded. Other exclusion criteria were animal studies, qualitative studies or descriptive surveys, studies from posters or conference reports, and those with only abstracts or dissertations.

Methodological quality assessment

The selected RCT studies in this review were rated using the modified Jadad scale for their methodological quality. This scale assessed the following three main aspects of clinical

trials: (a) a randomization procedure, with 1 point being given if patients were randomized in group allocation; a bonus point is given if randomization procedure was appropriate; (b) dropouts and withdrawals (1 point is given for a clear description of dropouts and withdrawals); and (c) blinding of patients and raters (2 points; Chao et al., 2009; Jadad et al., 1996; White & Ernst, 1999). Each study could score 0 (lowest quality) to 5 (highest quality) on the modified Jadad scale. Studies with a score of 3 or more were considered as high-quality trials and those below 3 were low-quality trials (Jadad et al., 1996). The Jadad scale was not used as part of the selection criteria, but as a measure of the methodological quality of the selected studies.

Results

Study selection

A total of 702 abstracts were identified in the literature search from the following databases: MEDLINE (n = 108), CINAHL (n = 11), and ScienceDirect (n = 583; see the supplementary material online). After reviewing the titles and abstracts, only eight publications fulfilled the selection criteria and were included in this review; full texts of these eight studies were read (Fig. 1). A total of 694 studies were rejected after reviewing based on the titles and abstracts. The primary reasons to exclude these studies were duplicate identification, purpose of studies did not involve the use of Tai Chi, different target population, posters or conference reports, and lack of availability of full texts.

Eight articles (Amano et al., 2013; Hackney & Earhart, 2008, 2009; Kim, Kim, Jae, & Son, 2011; Kluding & McGinnis, 2006; Li et al., 2007, 2012; and Venglar, 2005) were selected for this review. A summary of all included studies is provided in Table 1. Each selected RCT study was rated using the modified Jadad scale for its methodological quality (Table 2).

Methodological quality of the studies

The methodological design varied among the included studies with four RCTs, two single-group intervention studies with predesign and postdesign, and two case reports. With regard to the methodological quality, all the RCT studies except for one (Hackney & Earhart, 2009) were regarded as high quality with a Jadad score of 3 and above. Most of the RCT studies ensured the blinding of the raters and all had compared the baseline characteristic of the participants in the intervention and control groups.

Characteristics of included studies

A total of 365 participants were included in this review. Sample sizes of the included studies ranged from two to 195 participants. Mean age of the participants ranged from 53 years to 78.5 years. All the participants had PD for at least 2 years or more and were in Hoehn and Yahr Stages I–IV (Goetz et al., 2004).

Currently, in Tai Chi, the following five major ancient styles are practised: Yang, Chen, Wu (Jian Qian), Wu (He Qin), and Sun (Sheng et al., 2006). The term "style" refers to sequences of Tai Chi movements differentiated by lineage names such as Chen, Yang, and Wu. The type of Tai Chi style used in all selected studies (Amano et al., 2013; Hackney & Earhart, 2008, 2009; Kim et al., 2011; Kluding & McGinnis, 2006; Li et al., 2007, 2012; Venglar, 2005) is the Yang style.

By contrast, the forms used in the style greatly varied among the included studies. "Forms" in the Tai Chi style referred to individual movements. Li et al. (2007) had used six forms and Li et al. (2012) used eight forms of traditional Yang style, whereas another study (Kim et al., 2011) had used 12 modified forms. A case report by Kluding and McGinnis (2006) had used four types of movements adapted from 24 forms of the Beijing form, which was based on the Yang style, and two studies by Hackney and Earhart (2008, 2009) reported to have used the first and second circles of the Yang style of Cheng Man-ch'ing. In addition, in a recent study by Amano et al. (2013), the first eight movements of the Yang-style short forms were used. One case report by Venglar (2005) did not specify the type of Tai Chi forms used.

Frequency and duration of the Tai Chi sessions provided varied considerably across the eight studies. Frequency of therapy ranged from once/week to 5 times/week and duration of each session was at least 1 hour. The total number of Tai Chi sessions offered ranged from 5 sessions to 48 sessions and treatment regimes lasted from 1 week to 24 weeks in the reviewed studies.

The types of outcome measures used in the studies included indicators of postural stability and gait initiation, balance scales, functional reach test, timed-up and go test (TUG), gait assessment, clinical motor scores of 14-item Part III of Unified Parkinson's Disease Rating Scale (UPDRS), and other motor performance assessments, as well as self-rated PD questionnaires, numbers of falls, and post-programme questionnaires.

Effects of Tai Chi on motor performance and psychosocial aspect

All the studies in this review had examined the effects of Tai Chi on motor performance of the PD participants. Six of the reviewed eight studies (Hackney & Earhart, 2008; Kim et al., 2011; Kluding & McGinnis, 2006; Li et al., 2007, 2012; Venglar, 2005) in this review supported the effectiveness of Tai Chi in improving the motor performance of the PD participants. Only two studies (Amano et al., 2013; Hackney & Earhart, 2009) did not support its effectiveness.

In addition, five studies (Hackney & Earhart, 2008, 2009; Kluding & McGinnis, 2006; Li et al., 2007; Venglar, 2005) in this review had examined the effects of Tai Chi intervention using subjective measures. All except for one had showed a unanimous agreement that their participants had enjoyed this intervention and had perceived improved physical performance and confidence after the Tai Chi sessions.

Discussion

In this review, there are equal number of randomized control trials and uncontrolled clinical trials (i.e., case

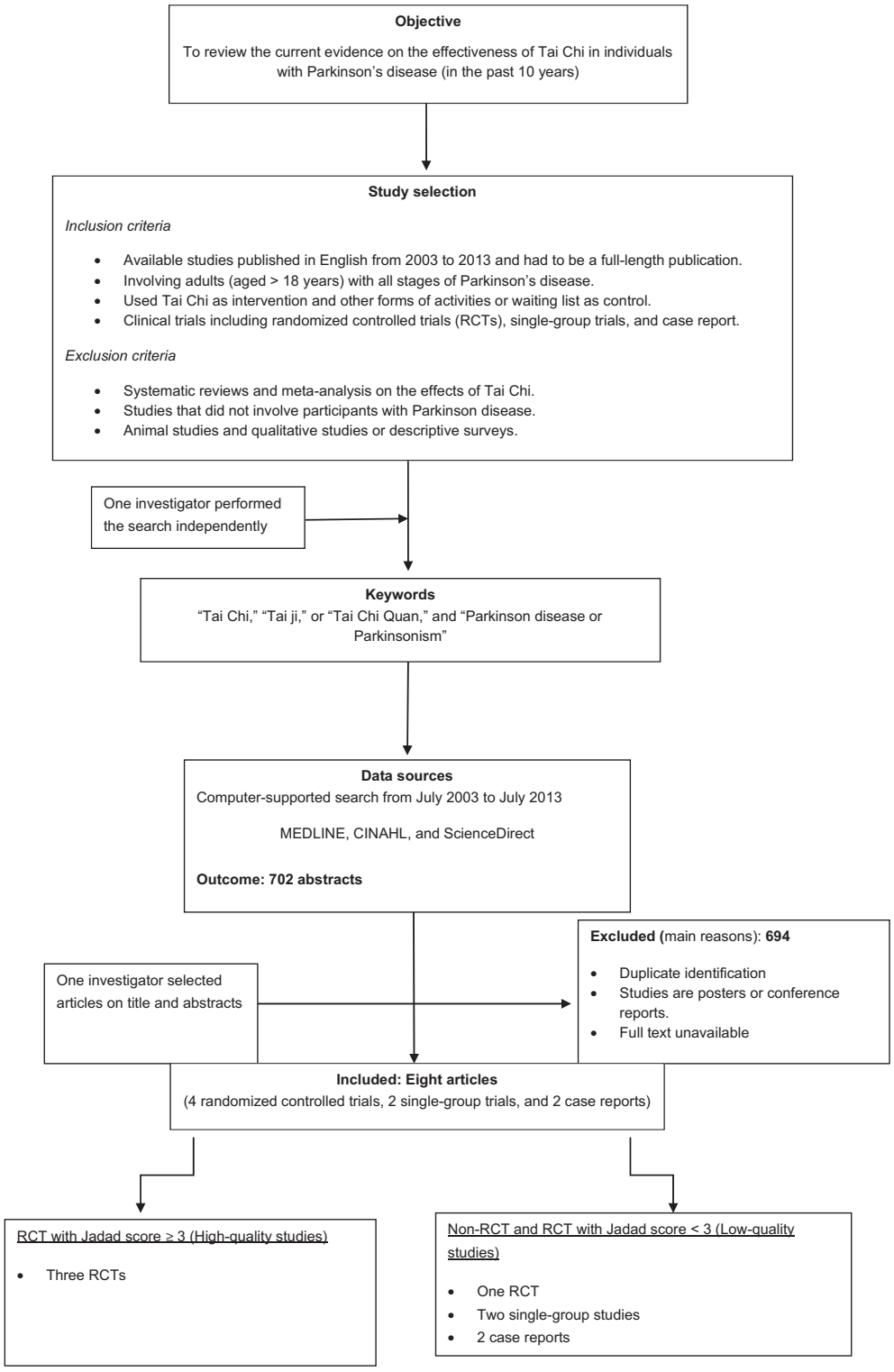

Figure 1 Study selection. CINAHL = Cumulative Index to Nursing and Allied Health Literature.

studies and single-group study). Nevertheless, of these studies, only three RCTs had stronger methodological quality of the study design with a Jadad score of 3 and above. Consistent to an earlier systematic review (Lee et al., 2008), this review reveals that there is a lack of scientific rigor in the experimental designs of the trials conducted to examine the effects of Tai Chi intervention on the PD population.

Table 1 Summary of Studies Investigating Use of Tai Chi with PD Population.

Reference	Study design (N)	Comparison groups	Time with PD and stage of Hoehn and Yahr (mean ± SD)	Treatment regimen (wk × session × duration/d)	Length of study	Outcome measure	Results	Remarks
Venglar (2005)	Case study ($N = 2$)	Single group Tai Chi (TC) class: the Yang style Intervention: 2 mo	Participant A: 20 y; in Hoehn and Yahr Stage 2 Participant B: 5 y; in Hoehn and Yahr Stage 2.5	TC class: 8 wk × 1 × 60 min Participants were encouraged to practise additional 90 min/wk over 8 wk and were provided with video and paper as supplements	5 mo	• Functional reach • Timed up and go test (TUG) • Activities-specific balance confidence scale (ABC) • Post-programme feedback Patients were assessed prior to and after programme and at 1st and 2nd mo of follow-up	• Both participants had improved in balance confidence as reflected in the ABC scale • Participant A had a drop from 51% to 31% in the ABC scale and Participant B had a drop from 78% to 72% in the ABC scale • Both participants had improvements in distance of reach, as reflected in the functional reach test. • Participant A had improved in average TUG scores in 2 mo postintervention, but Participant B did not improve in average TUG performance.	Weak study design
Kluding and McGinnis (2006)	Case study ($N = 2$)	Single group Intervention: 3 mo community fitness programme 1st mo: balance class by PT: 60 min/ session, two times/wk for 4 wk 2nd mo: patients joined a community-based fitness centre with exercise	Participant A: 4 y; in Hoehn and Yahr Stage 3 Participant B: 3 y; in Hoehn and Yahr Stage 2	1st mo: balance class — 4 wk × 2 session × 60 min 3rd mo: TC session — 4 wk × 2 session ×	3 mo	• Functional reach • TUG • Berg balance • Post-programme feedback Patients were assessed prior to and after programme and at	• Participants had improvements in lower limb strength and balance • Improved balance was noted with increased functional reach, reduced TUG and increased score in Berg balance	Weak study design Mixture of interventions

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Table 1 (*continued*)

Reference	Study design (*N*)	Comparison groups	Time with PD and stage of Hoehn and Yahr (mean ± SD)	Treatment regimen (wk × session × duration/d)	Length of study	Outcome measure	Results	Remarks
		physiologists supervising 3rd mo: TC session by PT, two times/wk for 4 wk; duration not specified. Four TC movements practised: "commencing", "part wild horse mane", and "grasp bird's tail"; the Beijing style based on the Yang style				8 mo follow-up (phone call)	• Participants reported enjoyment in TC session • Both participants continued to engage in physical exercise after the programme at 8 mo	
Li et al. (2007)	Single-arm, unmasked intervention trial using a pretest–post-test with study design (N = 17)	Core programme consisted of six forms of TC on basis of the traditional Yang TC style These forms were as follows: • Form 1: Moving hands like cloud • Form 2: Parting the wild horse's mane • Form 3: Stepping up and thrusting downward • Form 4: Striking the opponent's ear with both fists • Form 5: Repulsing monkey • Form 6: Grasping the peacock's tail The 90-min exercise session followed a sequence of a warm-up (10 min), learning and practising core TC	Time with PD: 3.7 y Stage of PD: Stage I: 12, Stage II: 4, Stage III: 1	1 wk × 5 session × 90 min	1 mo	Subjective outcome measure: programme evaluation interview Physical performance measures: 50-ft speed-walk test, up-and-go test, and functional reach test Outcome measures were collected 1 or 2 days prior to commencement of the intervention and 1 day after termination of intervention	Subjective outcome measure: • Participants enjoyed the brief exercise intervention • Participants felt that exercise programme helped to improve their balance and confidence Physical measures: • 50-ft speed-walk test: significant change from pretest with $p = .002$, with 14% improvement • Up and go test: significant change from pretest with $p = .01$, with 14% improvement • Functional reach test: change from pretest with $p = .01$, with 13% improvement	Weak study design: Susceptible to uncontrolled threats to both internal and external validity. Selection biases might occur because the self-selected sample might differ from general PD population characteristics. Limited generalizability of the findings due to small group size and unusual practise time frame used in this study (i.e. 90 min per session for 5 consecutive days).

		forms (50 min) and cool down and activity period (10 min)						
Hackney and Earhart (2008)	Single-blinded randomized controlled trial ($N = 33$)	1. Intervention group: TC session consisted of first and second circles of Yang short style of Cheng Man-ch'ing 2. Control group: no intervention	Intervention group: $n = 17$, time with PD: 8.7 ± 4.7; in Hoehn Yahr Stage 2 Control group: $n = 16$, time with PD: 5.5 ± 3.3; in Hoehn and Yahr Stage 2	13 wk × 2 × 60 min Total session: 20	13 wk	• Unified Parkinson's Disease Rating Scale Motor Subscale 3 (UPDRS) • Berg Balance scale • Tandem scale • One leg stance test • TUG • Gait assessed by kinematic were gait velocity, stride length and functional ambulation profile (FAP) • Gait endurance measured by 6-min walk test • Post-test questionnaire (subjective measure) Outcome measures were rated by blinded rater through videotape	The TC group had greater improvement in Berg Balance scores. The TC group also improved on the UPDRS motor subscale 3, tandem stance, Timed Up and Go and 6-min walk test while the control group showed little change on these measures. For kinematics test, the TC group had improved FAP, stride length and velocity for backward walking indicated improved backward walking in the TC group only. Both groups did not improve in one leg stance and forward walking. For subjective measure, majority of the TC participants reported that they enjoyed participating and noted improvements in physical performance.	• Small sample size • Short duration of training; longer training may increase the benefit of TC
Hackney and Earhart (2009)	Randomized controlled trial ($N = 61$, after 14 participants dropped out) Participants were randomly assigned into four groups: Waltz, tango, TC, and control	1. Waltz/Foxtrot group (30 min Waltz, 30 min Foxtrot) taught by professional instructors 2. Tango group taught by professional instructors 3. TC group: progressive lessons on TC's first and second circles, including 37 postures of	Waltz/Foxtrot group: $n = 17$, time with PD: 9.2 ± 1.4; in Hoehn and Yahr Stage 2 Tango group: $n = 14$, time with PD: 6.9 ± 1.3; in Hoehn and Yahr Stage 2.1 TC group: $n = 13$, time with PD: 8.7 ± 1.3; in Hoehn and Yahr Stage 2 Control group:	13 wk × 2 × 60 min Total session: 20	13 wk	• Parkinson's Disease Questionnaire-39 (PDQ-39) items • Pretest assessment: occurred 1 wk prior to commencing class, the outcome measure was collected 1 wk after participants had completed sessions	• The tango group showed significant decrease in scores in mobility, social support and PDQ-39 stigma, indicating improved HRQoL • There were no significant differences between preassessment and postassessment in the Waltz/Foxtrot, TC and control groups	Study did not describe clearly the method of randomization and no blinding of raters and patients where patients were raters as well. Use of PDQ-39 may be biased towards more severe cases.

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Table 1 (*continued*)

Reference	Study design (*N*)	Comparison groups	Time with PD and stage of Hoehn and Yahr (mean ± SD)	Treatment regimen (wk × session × duration/d)	Length of study	Outcome measure	Results	Remarks
		Yang Short style of Cheng Man-ch'ing from an experienced instructor 4. Control group: no intervention	$n = 17$, time with PD: 5.9 ± 1.0; in Hoehn Yahr Stage 2.2					
Kim et al. (2011)	Single-arm intervention trial using a pretest–post-test with study design (N = 10)	Intervention: Core programme consisted of 12 modified forms of the Yang style of TC exercise. The cycle of 12 movements was repeated approximately six times during training sessions. The 60-min TC session consisted of 10 min of warm-up, 40-min period of 12 easy to learn and easy to perform Yang-style TC movements and 10 min of cool-down exercises.	Time with PD: 40.2 ± 28.9 mo Stage of PD: 2.95 ± 0.5	12 wk × 3 sessions × 60 min	12 wk	UPDRS motor subscale: Centre of pressure (COP) variables: • Anteroposterior (A–P) and mediolateral (M–L) displacement of COP • A–P (or M–L) displacement was defined as the total displacement between the minimum and maximum A–P (or M–L) COP location for the length of time, either the left or right foot was in contact with the force plate Outcome measures were collected 1 wk prior to initiation of TC exercise and 1 wk after completion of 12 wk of TC exercise	• Significant difference between prior to and after TC exercise in A–P and M–L displacement of COP of the participants • All these variables were significantly improved at post-test compared with pretest • Participants had showed 122% and 130% increase in A–P and M–L displacement of COP for both swing and stance limbs	Small sample size with no control group. Short intervention duration. Participants recruited from communal living facilities and may not be representative of the population. No follow-up was done to see if improvements were permanent or temporary. Exact timing and spatial events of gait parameters after TC exercise were not investigated.
Li et al. (2012)	Single-blinded randomized control trial (N = 195)	1. TC group: consisted of six TC movements integrated into eight-form routine (Yang style) 2. Resistance training (RT) group: exercise focused on	Time with PD: TC and Resistance group: 8 ± 9 y STR group: 6 ± 5 y Stage of PD: 84% in Stage 2 and above, with median of 2.5	24 wk × 2 sessions × 60 min Total sessions: 48	9 mo	Primary outcomes (2 indicators of postural stability) • Maximum excursion: limits of self-initiated movement as patient's shift or lean their centre of gravity without falling	• The TC group performed consistently better than the RT and STR groups in maximum excursion and in directional control • The TC group performed better	This study did not use a double-blind design, where participants were aware of the intervention assignment; this may introduce placebo biases in the results

		strengthening the muscles that are important for posture, balance, and gait 3. Stretching (STR) group: low-intensity exercise programme encompassing seated and standing stretches				• Directional control: measure of movement accuracy by comparing the amount of movement towards the target with amount of extraneous movement Secondary outcomes • Gait (stride length and walking velocity) • Strength of bilateral knee extensors and flexors • Functional reach test • TUG • 14-item UPDRS III • Number of falls Outcome measures were assessed at baseline, 3 and 6 mo, and 3 mo after intervention. Assessments were conducted while participants were in the "on" period.	than the STR group in all secondary outcome measures and outperformed the RT group in stride length and functional reach test • The TC group had lower fall incidence as compared with the STR group but not as compared with the RT group • The effects of TC were maintained at 3 mo after intervention	Authors did not explain the 19 participants who did not complete the intervention and 10 participants who did not have complete data on outcome measures at follow-up. The study did not use a control group with no intervention; hence net gain of TC training cannot be gauged.
Amano et al.(2013)	Two single-blinded randomized control trials ($N = 45$) Project 1: $N = 21$ Project 2: $N = 24$	*Project 1:* • The TC group ($n = 12$) consisted of first eight movements of the Yang-style short forms • The control Qigong (QG) group ($n = 9$): emphasized prolonged, intense contemplative or deep mediation, series of exercises in "energy discipline"	Time with PD: *Project 1:* TC group: 7 ± 7 y QG group: 12 ± 7 y *Project 2:* TC group: 8 ± 5 y QG group: 5 ± 3 y Stage of PD: *Project 1:* TC group: 2.3 ± 0.4 QG group: 2.2 ± 0.4 *Project 2:* TC group: 2.4 ± 0.6 QG group:	*Project 1:* 16 wk × 2 sessions × 60 min Total sessions: 32 *Project 2* 16 wk × 3 sessions × 60 min Total sessions: 48	16 wk	1. Gait initiation: • Magnitude of posterior and lateral COP displacement • Mean COP velocity in posterior and lateral directions prior to an initial heel-off of the swing limb 2. Gait outcome: • Cadence • Gait velocity	The TC groups in either projects (Projects 1 and 2) in this study did not improve significantly in the UPDRS Part III score, selected gait initiation parameters or gait performance as compared with the control group (QG or no intervention). Hence, authors concluded that combined results in both projects suggest that 16 wk of class-based TC were ineffective in improving wither gait initiation, gait performance	This study did not use a double-blinded design, where participants were aware of intervention assignment; this may introduce placebo biases in the results. The authors did not describe their method of randomization procedures. Small sample size of each group in

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Table 1 (*continued*)

Reference	Study design (*N*)	Comparison groups	Time with PD and stage of Hoehn and Yahr (mean ± SD)	Treatment regimen (wk × session × duration/d)	Length of study	Outcome measure	Results	Remarks
		Project 2: • The TC group ($n = 15$) consisted of first eight movements of the Yang-style short forms • Control group ($n = 9$): no intervention	2.4 ± 0.4			• Step length • Step duration • Swing time [% of gait cycle (GC)] • Double limb support time (% of GC) • Gait asymmetry 3. Clinical motor score: 14-item Part III of UPDRS	or reducing Parkinsonian disability reflected in UPDRS	both projects.

HRQoL = health-related quality of life; min = minute; mo = month; PD = Parkinson's disease; PT = physiotherapist; SD = standard deviation; wk = week; y = year.

Effects of Tai Chi on motor performance

Despite the fact that Tai Chi is an officially recommended modality for individuals with PD (National Parkinson Foundation, 2012), this review showed contradictory findings of the effectiveness of Tai Chi in improving the motor performance of the PD population.

Although a majority of the studies (Hackney & Earhart, 2008; Kim et al., 2011; Kluding & McGinnis, 2006; Li et al., 2007, 2012; Venglar, 2005) in this review supported the effectiveness of Tai Chi, only two of these studies had a stronger methodological quality with a Jadad score of 3. These studies consisted of two case reports, two single-group studies, and two RCTs. Case reports by Kluding & McGinnis (2006) and Venglar (2005) documented that their participants had either improved in balance and lower limb muscle strength or results of functional reach and TUG tests. However, the study by Kluding and McGinnis (2006) had used multiple interventions and thus improvements in balance and strength could not be solely attributed to Tai Chi intervention. Similarly, single-group studies by Li et al. (2007) and Kim et al. (2011) reported that Tai Chi intervention had either improved the participants' performance on physical measures such as 50-ft speed-walk test, TUG, and functional reach test or gait parameters. With several threats to the internal validity of the study designs, findings of these studies are highly susceptible to bias and provide only little useful information on the value of Tai Chi as a therapeutic intervention for the PD population (Lee et al., 2008).

For studies with a stronger methodological quality, the work of both Hackney and Earhart (2008) and Li et al. (2012) supported the effectiveness of the Tai Chi exercise on motor performance. Hackney and Earhart (2008) conducted a single-blinded RCT to examine the effects of Tai Chi on balance and mobility in the PD participants and found that their Tai Chi group had greater improvements in the balance scores, UPDRS motor scores, and gait scores. Worthy to note, their study had compared the Tai Chi group with a nonintervention control group, and therefore, Hackney and Earhart's (2008) study cannot prove the advantageous benefits of Tai Chi over the other currently available interventions for PD to attenuate mobility and balance problems (Amano et al., 2013).

The study by Li et al. (2012) is one of the few studies that evaluated the efficacy of Tai Chi intervention and compared it with other interventions such as resistance training and stretching. The authors found that their Tai Chi group had outperformed the resistance training and stretching groups in two indicators of postural stability (i.e., the maximum excursion and directional control). Furthermore, in their study, the long-term effect of Tai Chi postintervention was observed, where the improvements observed in the Tai Chi group were maintained up to 3 months after the intervention. Despite the promising results of Li and Lao's (2012) study, one criticism of this study was that the success of Tai Chi could be due to placebo effects as the study did not use a double-blinded design.

Two randomized control trials (Amano et al., 2013; Hackney & Earhart, 2009) in this review did not show positive results of Tai Chi intervention in the PD populations. The work of Hackney and Earhart (2009) had compared the

Table 2 Modified Jadad Scale.

Jadad scale items	Hackney and Earhart (2008)	Hackney and Earhart (2009)	Li et al. (2012)	Amano et al. (2013)
1. Randomization	1	1	1	1
2. Appropriate randomized method	1	0	1	0
3. Blinding of patients	0	0	0	0
4. Blinding of raters	1	0	1	1
5. Description of dropouts and withdrawal	1	1	0	1
Total score	4	2	3	3
Quality of clinical trials	High	Low	High	High

effects of Tai Chi with other forms of exercises (i.e., Tango and Waltz) and found that there was no significant improvement in the motor performance of their PD participants after Tai Chi intervention. Interesting to note, the authors had used the Parkinson's Disease Questionnaire-39 (PDQ-39) Mobility subscale, a disease-specific subjective health measure, for their measurements. The use of PDQ-39 has been criticized on its bias towards individuals with more severe disability and not those with lesser severity (Hagell & Nygren, 2007); in addition, its responsiveness to smaller clinical changes has warranted further examination (Marinus, Ramaker, Hilten, & Stiggelbout, 2002). Thus, it can be inferred that failure of PDQ-39 to detect any motor improvements in Hackney & Earhart's (2009) study may be due to the clinimetric properties of the instrument and not the Tai Chi intervention. Furthermore, the length of Tai Chi intervention may play a significant role in showing whether the intervention was successful (Low, Ang, Goh, & Chew, 2009; Wooton, 2010); the length of Tai Chi intervention in Hackney and Earhart's (2009) study was 13 weeks, which was a relatively short duration to provide the full benefits of Tai Chi exercise to individuals with PD (Hackney & Earhart, 2008; Kim et al., 2011). Also, in this review, this RCT scored a Jadad score of 2, which was considered as low-quality evidence.

Another RCT of a higher quality is the work by Amano et al. (2013). Their study also did not support the efficacy of Tai Chi intervention in individuals with PD. The study included two separate 16 weeks of randomized clinical trials where the author compared Tai Chi to Qigong in Project 1 and Tai Chi to no intervention in Project 2. Results showed that both the Tai Chi groups in Projects 1 and 2 did not show significant improvement in UPDRS Part III score, gait initiation parameters, and gait performance as compared with the Qigong or no-intervention control groups. The author explained that the contradictory findings may be due to the wide variability of Tai Chi exercise regimens and heterogeneity of the population. The authors also highlighted that it is rather challenging to design an optimal Tai Chi exercise regime and duration for the PD population, which has large between-patient differences.

In a nutshell, although the trend in the selected studies seems to support the effectiveness of Tai Chi exercise to improve motor performance of PD participants, more high-quality evidence is still required. Improvement in motor performance after Tai Chi has been supported by several studies, which had used non-PD individuals (Hass et al., 2004; Kim, 2009; Wooton, 2010), implying that Tai Chi may have a unique effect in this aspect. Nevertheless, the inconsistency across the reviewed Tai Chi studies in PD suggests that the effect of Tai Chi in improving mobility and balance in persons with PD remained inconclusive (Amano et al., 2013), and this warrants further research prior to when firm conclusions can be made.

Effects of Tai Chi on psychosocial aspect or perceived improvements

Four studies in this review reported that Tai Chi exercise was considered as an attractive and favourable activity for their participants. Li et al. (2007) reported that all of their participants had enjoyed the Tai Chi sessions and expressed strong interest in continuing this activity. The authors added that their participants felt that Tai Chi exercise had improved their balance and confidence to achieve functional independence. Similar results were found in the other three studies (Hackney & Earhart, 2008; Kluding & McGinnis, 2006; Venglar, 2005) in which the majority of their participants had enjoyed Tai Chi intervention, and reported perceived improvements in physical performance such as balance. Nevertheless, one drawback is that three of these studies (Kluding & McGinnis, 2006; Li et al., 2007; Venglar, 2005) did not have a control group. In addition, the other study (Hackney & Earhart, 2008) had used a passive control group with no intervention given, and hence it failed to compare the effects of Tai Chi with other forms of exercise.

Hackney and Earhart (2009) had used the PDQ-39 to compare effects of Tai Chi intervention with other forms of exercise such as Tango. They found that there were improved emotional well-being stigma and social support scores in their participants who received Tai Chi, but the results did not meet a statistical significance when compared with other forms of exercises.

With the inconclusive findings from this review, more evidence is warranted to establish the positive effects of Tai Chi intervention on the perceived physical and psychosocial improvements of the participants.

Types of Tai Chi styles and forms used

All the studies in this review had used the Yang style. This is consistent with a previous systematic review that reported that the Yang style is the most popular style practised by the older population (Liu & Frank, 2010). One possible reason is due to the unique characteristics of movements used in the Yang style. For this style, it involves slow, graceful, and sequential movements from one pose to the

next in an upright posture (Liu & Frank, 2010), making it easier and safer for individuals with PD who already have mobility problems to practise. Other styles such as the Chen style use quick and explosive movements that require more energy expenditure during practise (Li, Hong, & Chan, 2001), making it unsuitable for the PD population. It is plausible to suggest that the Yang style of Tai Chi might be more preferred to be used with the PD population for future research.

As Tai Chi movements exist in numerous forms, the forms used among the reviewed studies varied greatly. Therefore, this review cannot provide any conclusive recommendation on the appropriate type of forms of Tai Chi movements.

Limitations of review

The strength of this review is that it has adopted a systematic method in identifying relevant trials and appraised the methodological strength of the studies. A more thorough literature search using more electronic databases and hand searching of articles may yield more studies with better study design to add strength to the conclusion and discussion. Another limitation in this review was publication bias. This review has limited the search for articles published in English and articles in other languages such as Chinese were not reviewed. Because Tai Chi was an ancient Chinese martial art, clinical trials that had explored the use of Tai Chi in individuals with PD might be published in Chinese and were not identified in this review (Verhagen et al., 2004). Furthermore, some of the reviewed studies did not specify the time of assessment and drug intake. As a result, the assessment at the beginning of the study could have been performed in the "off phase" and the assessment could have been performed at the end in the "on phase" or vice versa (Jöbges, Spittler-Schneiders, Renner, & Hummelsheim, 2007). Thus, the uncontrolled timing of medication will bias the results and restrict the power of the studies (Jöbges et al., 2007).

Conclusion

Owing to the small sample and inconclusive results, this review cannot provide a firm conclusion to support or refute the effectiveness of Tai Chi exercise in the PD population in improving motor or nonmotor performance. Further research is required to investigate whether there are specific benefits of Tai Chi for people with PD in these areas. In addition, future review may need to include non-English studies that examine the use of Tai Chi in individuals with PD.

Clinical messages

- There is inadequate evidence for the use of Tai Chi in the PD population as there is a lack of scientific rigor in the experimental designs of the trials.
- Further research is needed to investigate whether there are specific benefits of Tai Chi for individuals with PD in these areas and future review should include non-English studies that examine the use of Tai Chi with this type of population.

References

Adler, P. A., & Roberts, B. L. (2006). The use of Tai Chi to improve health in older adults. *Orthopaedic Nursing, 25*(2), 122—126.

Amano, S., Nocera, J. R., Vallabhajosula, S., Juncos, J. L., Gregor, R. J., Waddell, D. E., et al. (2013). The effect of Tai Chi exercise on gait initiation and gait performance in persons with Parkinson's disease. *Parkinsonism and Related Disorders, 19*(11), 955—960.

Chao, L. F., Zhang, A. L., Liu, H. E., Cheng, M. H., Lam, H. B., & Lo, S. K. (2009). The efficacy of acupoint stimulation for the management of therapy-related adverse events in patients with breast cancer: a systematic review. *Breast Cancer Research and Treatment, 118*(2), 255—267.

Ferry, P., Johnson, M., & Wallis, P. (2002). Use of complementary therapies and non-prescribed medication in patients with Parkinson's disease. *Postgraduate Medical Journal, 78*(924), 612—614.

Gage, H., Hendricks, A., Zhang, S., & Kazis, L. (2003). The relative health related quality of life of veterans with Parkinson's disease. *Journal of Neurology, Neurosurgery, and Psychiatry, 74*(2), 163—169.

Goetz, C. G., Poewe, W., Rascol, O., Sampaio, C., Stebbins, G. T., Counsell, C., et al. (2004). Movement Disorder Society Task force report on the Hoehn and Yahr staging scale: status and recommendations. *Movement Disorders, 19*(9), 1020—1028.

Hackney, M. E., & Earhart, G. M. (2008). Tai Chi improves balance and mobility in people with Parkinson disease. *Gait & Posture, 28*(3), 456—460.

Hackney, M. E., & Earhart, G. M. (2009). Health-related quality of life and alternative forms of exercise in Parkinson disease. *Parkinsonism and Related Disorders, 15*(9), 644—648.

Hagell, P., & Nygren, C. (2007). The 39 item Parkinson's Disease Questionnaire (PDQ-39) revisited: implications for evidence based medicine. *Journal of Neurology, Neurosurgery, Psychiatry, 78*(11), 1191—1198.

Hass, C. J., Gregor, R. J., Waddell, D. E., Oliver, A., Smith, D. W., Fleming, R. P., et al. (2004). The influence of Tai Chi training on the center of pressure trajectory during gait initiation in older adults. *Archives of Physical Medicine and Rehabilitation, 85*(10), 1593—1598.

Jadad, A. R., Moore, R. A., Carroll, D., Jenkinson, C., Reynolds, D. J., Gavaghan, D. J., et al. (1996). Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Controlled Clinical Trials, 17*(1), 1—12.

Jöbges, M., Spittler-Schneiders, H., Renner, C. I., & Hummelsheim, H. (2007). Clinical relevance of rehabilitation programs for Parkinson's disease. I: non-symptom-specific therapeutic approaches. *Parkinsonism and Related Disorders, 13*(4), 195—202.

Kim, H.-D. (2009). Effects of Tai Chi exercise on the center of pressure trace during obstacle crossing in older adults who are at a risk of falling. *Journal of Physical Therapy Science, 21*(1), 49—54.

Kim, H.-D., Kim, T.-Y., Jae, H. D., & Son, S.-T. (2011). The effects of Tai Chi based exercise on dynamic postural control of Parkinson's disease patients while initiating gait. *Journal of Physical Therapy Science, 23*(2), 265—269.

Kluding, P., & McGinnis, P. Q. (2006). Multidimensional exercise for people with Parkinson's disease: a case report. *Physiotherapy Theory and Practice, 22*(3), 153—162.

Komagata, S., & Newton, R. (2003). The effectiveness of Tai Chi on improving balance in older adults: an evidence-based review. *Journal of Geriatric Physical Therapy, 26*(2), 9—16.

Lee, M. S., Lam, P., & Ernst, E. (2008). Effectiveness of Tai Chi for Parkinson's disease: a critical review. *Parkinson and Related Disorders, 14*(8), 589—594.

Li, F., Fisher, K. J., Harmer, P., & Shirai, M. (2003). A simpler eight-form easy Tai Chi for elderly adults. *Journal of Aging and Physical Activity, 11*(2), 217—229.

Li, F. Z., Harmer, P., Fisher, K. J., Xu, J. H., Fitzgerald, K., & Vongjaturapat, N. (2007). Tai Chi-based exercise for older adults with Parkinson's disease: a pilot-program evaluation. *Journal of Aging and Physical Activity, 15*(2), 139—151.

Li, F. Z., Harmer, P., Fitzgerald, K., Eckstrom, E., Stock, R., Galver, J., et al. (2012). Tai Chi and postural stability in patients with Parkinson's disease (clinical report). *New England Journal of Medicine, 366*(6), 511—519.

Li, J., Hong, Y., & Chan, K. (2001). Tai Chi: physiological characteristics and beneficial effects on health. *British Journal of Sports Medicine, 35*(3), 148—156.

Lindgren, P. (2004). Economic evidence in Parkinson's disease: a review. *The European Journal of Health Economics, 5*(Suppl. 1), S63—S66.

Liu, H., & Frank, A. (2010). Tai Chi as a balance improvement exercise for older adults: a systematic review. *Journal of Geriatric Physical Therapy (2001), 33*(3), 103—109.

Liu, T., & Lao, L. (2012). Tai Chi for patients with Parkinson's disease. *The New England Journal of Medicine, 366*(18), 1737—1738.

Low, S., Ang, L. W., Goh, K. S., & Chew, S. K. (2009). A systematic review of the effectiveness of Tai Chi on fall reduction among the elderly. *Archives of Gerontology and Geriatrics, 48*(3), 325—331.

MacLaggan, L. (2000). *The impact of Tai Chi Chuan training on the gait, balance, fear of falling, quality of life, and tremor in four women with moderate idiopathic Parkinson's disease. Master of Science in Physiotherapy thesis*. Halifax, Nova Scotia: Dalhousie University.

Marinus, J., Ramaker, C., Hilten, J. J. V., & Stiggelbout, A. M. (2002). Health-related quality of life in Parkinson's disease: a systematic review of disease specific instruments. *Journal of Neurology, Neurosurgery, and Psychiatry, 72*(2), 241—248.

McDermott, M. P., Jankovic, J., Carter, J., Fahn, S., Gauthier, S., Goetz, C. G., et al. (1995). Factors predictive of the need for levodopa therapy in early, untreated Parkinson's disease. The Parkinson Study Group. *Archives of Neurology, 52*(6), 565—570.

Morris, M. E. (2000). Movement disorders in people with Parkinson disease: a model for physical therapy. *Physical Therapy, 80*(6), 578—597.

National Parkinson Foundation.(2012). Retrieved March 30, 2012, from http://www.parkinson.org/About-Us/Press-Room/NPF-In-The-News/2010/August/Parkinson-s-disease-patients-find-benefits-in-mart.aspx.

Nijkrake, M. J., Keus, S. H., Kalf, J. G., Sturkenboom, I. H., Munneke, M., Kappelle, A. C., et al. (2007). Allied health care interventions and complementary therapies in Parkinson's disease. *Parkinsonism and Related Disorders, 13*(Suppl. 3), S488—S494.

Nirenberg, M. J., & Fahn, S. (2005). The role of levodopa and catechol-O-methyltransferase inhibitors. In A. H. V. Schapira, & C. W. Olanow (Eds.), *Principles of treatment in Parkinson's disease* (pp. 3—24). Philadelphia: Butterworth—Heinemann Elsevier.

Schapira, A. H. V., & Olanow, C. W. (2005). The medical management of Parkinson's disease. In A. H. V. Schapira, & C. W. Olanow (Eds.), *Principles of treatment in Parkinson's disease* (pp. 119—143). Philadelphia: Butterworth—Heinemann Elsevier.

Sheng, J. Z., Gu, L. X., & Fu, Z. W. (2006). *The comprehensive book of Tai Ji Quan* (2nd ed.). Beijing: People's Sports Press.

Tan, L. C., Lau, P. N., Jamora, R. D., & Chan, E. S. (2006). Use of complementary therapies in patients with Parkinson's disease in Singapore. *Movement Disorders, 21*(1), 86—89.

Taylor-Piliae, R. E., & Froelicher, E. S. (2004). The effectiveness of Tai Chi exercise in improving aerobic capacity; a meta-analysis. *Journal of Cardiovascular Nursing, 19*(1), 48—57.

Tsang, W. W. N., & Hui-Chan, C. W. Y. (2003). Effects of Tai Chi on joint proprioception and stability limits in elderly subjects. *Medicine and Science in Sports and Exercise, 35*(12), 1962—1971.

Tsang, W. W. N., & Hui-Chan, C. W. Y. (2004). Effects of exercise on joint sense and balance in elderly men: Tai Chi versus golf. *Medicine and Science in Sports and Exercise, 36*(4), 658—667.

Ulbricht, C. (2011). Parkinson's disease: an integrative approach: a natural standard monograph. *Alternative and Complementary Therapies, 17*(3), 175—180.

Venglar, M. (2005). Case report: Tai Chi and Parkinsonism. *Physiotherapy Research International, 10*(2), 116—121.

Verhagen, A. P., Immink, M., van der Meulen, A., & Bierma-Zeinstra, S. M. (2004). The efficacy of Tai Chi Chuan in older adults: A systematic review. *Family Practice, 21*(1), 107—113.

Wang, C., Collet, J. P., & Lau, J. (2004). The effect of Tai Chi on health outcomes in patients with chronic conditions: a systematic review. *Archives of Internal Medicine, 164*(5), 493—501.

Wang, W. C., Zhang, A. L., Rasmussen, B., Lin, L. W., Dunning, T., Kang, S. W., et al. (2009). The effect of Tai Chi on psychosocial well-being: a systematic review of randomized controlled trials. *Journal of Acupuncture and Meridian Studies, 2*(3), 171—181.

White, A. R., & Ernst, E. (1999). A systematic review of randomized controlled trials of acupuncture for neck pain. *Rheumatology (Oxford), 38*(2), 143—147.

Wolf, S. L., Coogler, C., & Xu, T. (1997). Exploring the basis for Tai Chi Chuan as a therapeutic exercise approach. *Archives of Physical Medicine and Rehabilitation, 78*(8), 886—892.

Wooton, A. C. (2010). An integrative review of Tai Chi Research: an alternative form of physical activity to improve balance and prevent falls in older adults. *Orthopaedic Nursing, 29*(2), 108—116.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.hkjot.2013.11.001.