Effect of Tai Chi Exercise on Balance Function of Stroke Patients: A Meta-Analysis

Background: Tai Chi is an ancient form of physical activity that has been shown to improve cardiovascular function, but to date there had been no comprehensive systematic review on the effect of Tai Chi exercise on balance function of patients with stroke. This study evaluated the effect of Tai Chi exercise on balance function in stroke patients.

Material/Methods: PubMed, Cochrane library, and China National Knowledge Information databases and the Wan Fang medical network were searched to collect the articles. The random-effects model was used to assess the effect of Tai Chi exercise on balance function of stroke patients.

Results: Six studies were chosen to perform the meta-analysis according to the inclusion and exclusion criteria. There were significant improvements of balance on Berg Balance Scale score (MD=4.823, 95% CI: 2.138–7.508), the standing balance with fall rates (RR=0.300, 95%CI: 0.120–0.770), functional reach test and dynamic gait index in Tai Chi intervention group compared to the control intervention group. However, the short physical performance battery for balance (SPBB) showed Tai Chi did not significantly improve the ability of balance for stroke patients (MD=0.293, 95%CI: −0.099~0.685).

Conclusions: Tai Chi exercise might have a significant impact in improving balance efficiency by increasing BBS score and reducing fall rate.

MeSH Keywords: Meta-Analysis • Postural Balance • Stroke • Tai Ji

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Background

Stroke has high rates of morbidity, mortality, and relapse, and approximately 2 million new strokes occur in China annually [1]. Unfortunately, 70%~80% of stroke patients are left with disability [2,3]. Hence, this disease seriously affects the quality of life and causes heavy economic burdens for families and society. Although a series of stroke prevention efforts has shown promising results among the Chinese population, the stroke burden in China continues to increase over the last 2 decades [4,5].

Previous studies have indicated that balance dysfunction caused by proprioception disorder is a common problem in stroke survivors [6]. This disability influences walking ability and decreases quality of life. Rehabilitation aims to quicken and maximize recovery from stroke by treating the disabilities caused by stroke and attempts to help patients regain freedom of movement as fully as possible [7]. Past studies have shown that physical activity is an important component of a comprehensive stroke rehabilitation program to reduce disabilities [8,9]. Physical activity promotes spontaneous neural functional recovery and regains brain function in patients with cerebral apoplexy to promote the process of functional recovery [10]. Additional benefits of regular physical activity include controlling risk factors of stroke and reducing the incidence rates of first-ever stroke [11,12]. Hence, effective interventions for improving physical function and quality of life among survivors of stroke are critically needed [13–15]. However, most of the world’s population are not sufficiently physically active to gain major health benefits [16].

Tai Chi (TC) is an ancient form of physical activity widely practiced in China for thousands of years. Growing evidence suggests that Tai Chi exercise improves physical functioning, helps prevent falls, and promotes better quality of life among adults of all ages [17–20]. Tai Chi provides benefits to conventional stroke rehabilitation programs by promoting mental concentration and relaxation [21,22]. During Tai Chi, the slow, rhythmic movements are connected together in a continuous sequence, while body weight is shifted from one leg to the other [21]. This challenges the balance control system to keep its center within a changing base of support and increases balance, which is a vital aspect of physical functioning affecting safe performance of activities of daily living and fall prevention among stroke survivors.

A systematic review indicated that Tai Chi exercise improves general cardiorespiratory fitness and functional status, and can beneficial for cardiovascular disease in the elderly population [23]. Many studies have reported that Tai Chi effectively controls many risk factors of stroke [24–29], but there have been no comprehensive systematic reviews on the effect of Tai Chi exercise on balance function of stroke patients. Therefore, the present meta-analysis evaluated the effectiveness of Tai Chi as a supportive therapy for stroke rehabilitation. This systematic review offers information that could help clinicians make evidence-based decisions on the use of Tai Chi exercise for stroke patients.

Material and Methods

Literature search methods for the identification of studies

The literature search was performed in the following electronic databases: PubMed, Cochrane Library, China National Knowledge Information database (CNKI), and Wan Fang medical network, with literature retrieval ending in May 2017. The key words were: “Tai Chi” or “Tai Ji” or “Tai Chi Chuan”, “stroke” and “cerebral apoplexy”, and “balance” or “equilibrium” or “posture control”. The reference lists of identified articles were also searched. Abstracts or unpublished reports were not considered. If an author had written more than 1 article using the same source data, we selected the study with higher sample size.

Criteria for considering studies for this review

All of the identified randomized control trials (RCTs) were included in the study. Non-RCTs, observational studies, case series, and case reports were excluded. No restrictions of time or language were imposed. Trials which included the treatment group with Tai Chi exercise as a main intervention and the control group with the general physical therapy or others intervention were included.

Outcome measures

The outcome measures of the ability of balance were evaluated with the following: Berg Balance Scale (BBS), the Short Physical Performance Battery (SPPB) for balance, fall rates, Functional Reach Test (FRT), and Dynamic Gait Index (DGI). The primary outcome measures were SPPB, BBS, and fall rates. BBS was evaluated to assess the balance by scale, with higher scores indicating better balance. Dynamic balance was measured using the FRT and the DGI.

Data extraction and management

Two reviewers assessed the eligibility of the searched studies independently using the inclusion and exclusion criteria. The following data were extracted from studies: first author and year, study design, sample, TC style, Jadad score, intervention, balance measure, and findings. If there were disagreements about study identification and data extraction, then we
consulted the third reviewer. We also contacted the original authors to provide additional relevant information if necessary.

**Assessment of quality and statistical analysis**

The methodological quality of all literature was assessed according to Jadad score [30]. The Jadad score included 3 aspects of evaluation: description of randomization, blinding, and withdrawals. The score ranged from 0 to 5 points. Articles with higher Jadad scores had higher methodological quality. Statistical heterogeneity was measured using the chi-squared test and I² statistic. The fixed-effects model was utilized if the heterogeneity test indicated no significant difference (I²<50%; P>0.1); otherwise, the random-effects model was used. Subgroup analysis or sensitivity analysis was applied to explore the cause of heterogeneity among studies. P<0.05 was considered statistically significant.

**Results**

**Characteristics of studies**

Characteristics of studies are presented in Table 1. A total of 186 articles were identified from PubMed, Cochrane library, China National Knowledge Information database (CNKI), and Wan Fang medicine network, and 28 potentially eligible studies were identified based on titles and abstracts. After carefully reading full contents, only 6 articles [31–37] were chosen to perform the meta-analysis according to the inclusion and exclusion criteria. These 6 articles were published between 2004 and 2016 in China, Korea, and the United States. The sample sizes ranged from 16 to 145.

**Quality of the evidence**

Table 1 shows that the methodological quality of 6 studies was moderate, with an average Jadad score of 3.7. Three articles described the methods of randomization [31,32,34] and 1 reported details on allocation concealment [34]. Finally, the results showed that the quality of the evidence (Jadad) was acceptable.

**Tai Chi exercise compared with other forms of exercise**

Table 2 shows that the pooled estimate of effect for the BBS was extremely heterogeneous (I²=99%). The BBS score was significantly higher with Tai Chi than for the controls in the random-effects model (MD=4.823, 95%CI: 2.138–7.508, P<0.001). Two articles that used the short physical performance battery for balance demonstrated that Tai Chi did not improve the ability of balance for stroke patients (MD=0.293, 95%CI: −0.099–0.685). One study assessed the standing balance with fall rates, and found it was significantly affected by Tai Chi compared with the control intervention (RR=0.300, 95%CI: 0.120–0.770), and FRT and DGI in the Tai Chi group were significantly higher than in the control group.

**Discussion**

Some reviews have evaluated the effects of traditional Chinese exercise versus some other forms of exercise or non-intervention on cardiorespiratory fitness or upper-extremity dysfunction with stroke patients or healthy adults [38,39]. However, none has focused on balance function of patients with stroke. Balance function is important for stroke patients to prevent falls and worse consequences. Tai Chi is a Chinese traditional mind-body exercise with a low to moderate exercise intensity [40]. Previous studies have indicated the effectiveness of Tai Chi in enhancing balance and preventing falls among elder participants with or without chronic disease [41–45]. Therefore, this systematic review identified few RCTs on Tai Chi for rehabilitation in stroke patients.

In the present study, 6 articles with 347 participants comparing Tai Chi exercise with non-intervention were included. We attempted to contact authors by e-mail for more relevant information, but most replies were unsatisfactory and did not answer our questions, and some authors did not respond at all. Our review suggests that Tai Chi exercise significantly improves balance efficiency by increasing the BBS score (MD=4.823) and reducing the fall rate (RR=0.300). Moreover, FRT and DGI in the Tai Chi group were significantly higher than in the control group. There was substantial unexplained statistical heterogeneity observed in the BBS score, which suggests the need for caution in interpreting these results. The pooled estimate of effect for the BBS is extremely heterogeneous and might be related to differences among studies in the study population, different Tai Chi types, and intensity and duration in these articles.

The improvement of balance function of patients after stroke by Tai Chi exercise is a part of their comprehensive rehabilitation, and there is an inherent relationship with this functional rehabilitation. Gatts and Woolacott [46,47] investigated neural and bio-mechanical mechanisms of Tai Chi affecting balance and suggested that Tai Chi enhances neuromuscular responses, controlling the ankle joint of the perturbed leg, and enhances balance responses via efficacious use of mechanisms, controlling the stepping strategies of the swing leg. Stroke is an important cause of cognitive impairment, so treatment to improve cognition and prevent cognitive decline should be an crucial element of stroke rehabilitation. A recent cross-sectional study and a randomized controlled trial showed that Tai Chi exercise can offer specific benefits with respect to cognition [48].
**Table 1. Characteristics of included studies.**

| Author (year)      | Study design | Sample | TC style | Jadad score | Intervention | Balance measure | Findings                                                                                                                                 |
|--------------------|--------------|--------|----------|-------------|--------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Taylor-Piliae [30] (2011) | RCT          | 28     | Yang     | 4           | A 60-min Tai Chi class 3 times a week for 12 weeks | SPPB score (balance) | The study findings are consistent with prior Tai Chi research among community-dwelling stroke survivors reporting improvements in balance |
| Taylor-Piliae [31] (2014) | RCT          | 145    | Yang     | 4           | Participants assigned to the TC (Tai Chi) group attended a 1-h class 3 times a week for 12 weeks | 1. SPPB score (balance) 2. Fall rates | A 12-week TC intervention was more effective in reducing fall rates than SS or UC interventions |
| Kim [32] (2011)    | RCT          | 22     | Unspecified style | 3           | The experimental group performed therapeutic Tai Chi 60 min/session, twice per week, for 6 weeks and underwent 30 min of general physical therapy twice per day, 10 times/week, for 6 weeks | Dynamic balance was measured using the functional reach test (FRT) and the dynamic gait index (DGI) | Both the Tai Chi group and the control group showed a significant improvement in sway length and sway velocity, and the Tai Chi group showed greater improvement than the control group in degree of variation |
| Zhou [33] (2013)   | RCT          | 68     | Unspecified style | 5           | Subjects received acupuncture and conventional therapies, and received intensive training in Tai Chi gait | Berg balance scale (BBS) | The intensive group gained more benefit than the routine group in improving balance capacity |
| Huang [34] (2016)  | RCT          | 16     | Yang     | 3           | Subjects performed Tai Chi practice for 1 h twice weekly | Berg balance scale (BBS) | The experimental group of Berg balance scale score higher than the control group |
| Zhou [35] (2010)   | RCT          | 68     | Yang     | 3           | Subjects performed Tai Chi practice twice weekly | Berg balance scale (BBS) | The balance function integration improved remarkably after treatment in both groups, and there was statistical significance between the 2 group (P<0.05) |

**Total** | 347          | 3.7    |          |             |              |                    |                                                                                                                                           |

SPPB – short physical performance battery; RCT – randomized controlled trial.
Table 2. The effect of Tai Chi exercise on balance function of stroke patients.

| Outcomes               | Number of studies* | Number of participants | Effect size (MD/RR, 95% CI) | P value |
|------------------------|--------------------|------------------------|-----------------------------|---------|
| BBS                    | 3                  | 150                    | 4.823 (2.138–7.508)*        | 0.000   |
| SPPB (balance score)  | 2                  | 139                    | 0.293 (~0.099–0.685)*       | 0.140   |
| Fall rates             | 1                  | 101                    | 0.300 (0.120–0.770)         | 0.001   |
| FRT                    | 1                  | 22                     | 3.540±0.570                 | 0.000   |
| DGI                    | 1                  | 22                     | 2.000±0.360                 | 0.000   |

* There is overlap between studies. * Randomized effect model.

This may be an indirect effect of Tai Chi intervention on the balance function of stroke patients.

Conclusions

Tai Chi exercise appears to have a significant impact on improving balance efficiency by increasing BBS score and reducing fall rate.

Limitations

First, even though we are confident that our search strategy has located all relevant data on the subject, one can never be absolutely certain; thus, a degree of uncertainty remains. Second, the studies included multiple interference factors, and the results of the meta-analysis were triggered to reach high heterogeneity and low reliability. Last but not least, most of the included studies were of low quality due to lack of information on random sequence generation, allocation concealment, and the blinding of outcome assessors. Therefore, more rigorous randomized controlled trials with larger samples and longer duration are required to determine whether Tai Chi is effective in stroke rehabilitation.

Conflict of interests

None.

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