

Received: 2018.07.05
Accepted: 2018.09.04
Published: 2018.12.03

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

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

BE 1 **Shouzhi Wu**
C 2 **Jian Chen**
E 3 **Shuyi Wang**
F 3 **Mingfei Jiang**
B 3 **Ximei Wang**
AG 3 **Yufeng Wen**

1 School of Public Foundation, Wannan Medical College, Wuhu, Anhui, P.R. China
2 Hunan Provincial People's Hospital, Changsha, Hunan, P.R. China
3 School of Laboratory Medicine, Wannan Medical College, Wuhu, Anhui, P.R. China

Corresponding Author: Yufeng Wen, e-mail: wyf@wnmc.edu.cn

Source of support: This work was supported by the Key Projects of the Humanities and Social Sciences Research in Anhui Province

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**

Full-text PDF: <https://www.basic.medscimonit.com/abstract/index/idArt/911951>

 1679  2  —  48



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 be 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 I^2 statistic. The fixed-effects model was utilized if the heterogeneity test indicated no significant difference ($I^2 < 50\%$; $P > 0.1$); 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 ($I^2 = 99\%$). 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 Woollacott [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
					Experimental	Control		
Taylor-Piliae [30] (2011)	RCT	28	Yang	4	A 60-min Tai Chi class 3 times a week for 12 weeks	Written materials and resources for participating in community-based physical activity suitable for older adults	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	Silver Sneakers strength and range of movement exercises (SS)/ usual care (UC).	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	Subjects 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	Subjects received acupuncture and conventional therapies	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	Subjects performed conventional 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	Subjects performed conventional 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.

References:

- Liu M, Wu B, Wang WZ et al: Stroke in China: Epidemiology, prevention, and management strategies. *Lancet Neurol*, 2007; 6(5): 456–64
- Zheng G, Huang M, Liu F et al: Tai Chi Chuan for the primary prevention of stroke in middle-aged and elderly adults: A systematic review. *Evid Based Complement Alternat Med*, 2015; 2015: 742152
- Chen BL, Guo JB, Liu MS et al: Effect of traditional Chinese exercise on gait and balance for stroke: A systematic review and meta-analysis. *Physiotherapy*, 2015; 10(8): e219–20
- Feigin VL, Wang W, Fu H et al: Primary stroke prevention in China – a new approach. *Neurol Res*, 2015; 37(5): 378–80
- Kim JS: Stroke in Asia: A global disaster. *Int J Stroke*, 2015; 9(7): 856–57
- Skc K, Zhao D, Tibuakuu M et al: Frailty and subclinical coronary atherosclerosis: The Multicenter AIDS Cohort Study (MACS). *Atherosclerosis*, 2017; 266: 240–47
- Newman AB, Gottdiener JS, Mcburnie MA et al: Associations of subclinical cardiovascular disease with frailty. *J Gerontol*, 2001; 56(3): M158–66
- Carlson JE, Ostir GV, Black SA et al: Disability in older adults. 2: Physical activity as prevention. *Behav Med*, 1999; 24(4): 157–68
- Krakauer JW: Motor learning: Its relevance to stroke recovery and neuro-rehabilitation. *Curr Opin Neurol*, 2006; 19(1): 84–90
- Egan KJ, Janssen H, Sena ES et al: Exercise reduces infarct volume and facilitates neurobehavioral recovery: Results from a systematic review and meta-analysis of exercise in experimental models of focal ischemia. *Neurorehabil Neural Repair*, 2014; 28(8): 800–12
- Tang CY, Lai CC, Huang PH et al: Magnolol reduces renal ischemia and reperfusion injury via inhibition of apoptosis. *Am J Chin Med*, 2017; 45(7): 1–19
- Batchelor F, Hill K, Mackintosh S, Said C: What works in falls prevention after stroke? A systematic review and meta-analysis. *Stroke*, 2010; 41(8): 1715–22
- Wong AM, Pei YC, Lan C et al: Is Tai Chi Chuan effective in improving lower limb response time to prevent backward falls in the elderly? *Age (Dordr)*, 2009; 31(2): 163–70
- Ge W: Evaluation of the effectiveness of Tai Chi for improving balance and preventing falls in the older population – a review. *J Am Geriatr Soc*, 2010; 50(4): 746–54
- Bouley A J, Yaghi S: CADASIL as a multiple sclerosis mimic. *Rhode Island Medical Journal*, 2017; 100(11): 37
- Li F, Harmer P, Fisher KJ et al: Tai Chi and fall reductions in older adults: A randomized controlled trial. *J Gerontol A Biol Sci Med Sci*, 2005; 60(2): 187–94
- Low S, Ang LW, Goh KS, Chew SK: A systematic review of the effectiveness of Tai Chi on fall reduction among the elderly. *Arch Gerontol Geriatr*, 2009; 48(3): 325–31
- Wooton AC: An integrative review of Tai Chi research: An alternative form of physical activity to improve balance and prevent falls in older adults. *Orthop Nurs*, 2010; 29(2): 108–16
- Ho TJ, Liang WM, Lien CH et al: Health-related quality of life in the elderly practicing Tai Chi Chuan. *J Altern Complement Med*, 2007; 13(10): 1077–83
- Lan C, Lai JS, Chen SY: Tai Chi Chuan: An ancient wisdom on exercise and health promotion. *Sports Med*, 2002; 32(4): 217–24
- Taylorpililae RE, Haskell WL: Tai Chi exercise and stroke rehabilitation. *Top Stroke Rehabil*, 2007; 14(4): 9–22
- Verhagen AP, Immink M, van der Meulen A, Bierma-Zeinstra SM: The efficacy of Tai Chi Chuan in older adults: A systematic review. *Fam Pract*, 2004; 21(1): 107–13

23. Lo H M, Yeh CY, Chang SC et al: A Tai Chi exercise programme improved exercise behaviour and reduced blood pressure in outpatients with hypertension. *Int J Nurs Pract*, 2012; 18(6): 545–51
24. Thornton EW, Sykes KS, Tang WK: Health benefits of Tai Chi exercise: Improved balance and blood pressure in middle-aged women. *Health Promot Int*, 2004; 19(1): 33–38
25. Lu WA, Kuo CD: Three months of Tai Chi Chuan exercise can reduce serum triglyceride and endothelin-1 in the elderly. *Complement Ther Clin Pract*, 2013; 19(4): 204–8
26. Liu X, Miller YD, Burton NW et al: The effect of Tai Chi on health-related quality of life in people with elevated blood glucose or diabetes: A randomized controlled trial. *Qual Life Res*, 2013; 22(7): 1783–86
27. Lee MS, Choi TY, Lim HJ, Ernst E: Tai chi for management of type 2 diabetes mellitus: A systematic review. *Chin J Integr Med*, 2011; 17(10): 789–93
28. Lin CL, Lin CP, Lien SY: [The effect of tai chi for blood pressure, blood sugar, blood lipid control for patients with chronic diseases: A systematic review]. *Hu Li Za Zhi*, 2013; 60(1): 69–77 [in Chinese]
29. Jadad AR, Moore RA, Carroll D et al: Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials*, 1996; 17(1): 1–12
30. Taylor-Piliae RE, Coull BM: Community-based Yang-style Tai Chi is safe and feasible in chronic stroke: A pilot study. *Clin Rehabil*, 2012; 26(2): 121–31
31. Taylor-Piliae RE, Hoke TM, Hepworth JT et al: Effect of Tai Chi on physical function, fall rates and quality of life among older stroke survivors – archives of physical medicine and rehabilitation. *Arch Phys Med Rehabil*, 2014; 95(5): 816–24
32. Kim H, Kim YL, Lee SM: Effects of therapeutic Tai Chi on balance, gait, and quality of life in chronic stroke patients. *Int J Rehabil Res*, 2015; 38(2): 156–61
33. Auyeung SS, Huichan CW, Tang JC: Short-form Tai Chi improves standing balance of people with chronic stroke. *Neurorehabil Neural Repair*, 2009; 23(5): 515–22
34. Marchandot B, Messas N, Jesel L et al: Unexpected problems of antithrombotic therapy with an unusual side effect of vitamin K antagonists after mitral valve replacement. *J Heart Valve Dis*, 2017; 26(3): 309–13
35. Minghui O, Yao C, Ma X et al: IL-6 promoter polymorphism increased risks of recurrent stroke in the young patients with moderate internal carotid artery stenosis. *J Cell Biochem*, 2017; 119(3): 2886–90
36. Gow BJ, Hausdorff JM, Manor B et al: Can Tai Chi training impact fractal stride time dynamics, an index of gait health, in older adults? Cross-sectional and randomized trial studies. *PLoS One*, 2017; 12(10): e0186212
37. Hall AM, Maher CG, Lam P et al: Tai Chi exercise for treatment of pain and disability in people with persistent low back pain: A randomized controlled trial. *Arthritis Care Res (Hoboken)*, 2011; 63(11): 1576–83
38. Zheng G, Li S, Huang M et al: The effect of Tai Chi training on cardiorespiratory fitness in healthy adults: A systematic review and meta-analysis. *PLoS One*, 2015; 10(2): e0117360
39. Lan C, Chen SY, Lai JS: Relative exercise intensity of Tai Chi chuan is similar in different ages and genders. *Am J Chin Med*, 2004; 32(01): 151–60
40. Li JX, Xu DQ, Hong Y: Effects of 16-week Tai Chi intervention on postural stability and proprioception of knee and ankle in older people. *Age Ageing*, 2008; 37(5): 575–78
41. Voukelatos A, Cumming RG, Lord SR, Rissel C: A randomized, controlled trial of Tai Chi for the prevention of falls: The Central Sydney Tai Chi trial. *J Am Geriatr Soc*, 2010; 55(8): 1185–91
42. Li Y, Devault CN, Van Oteghen S: Effects of extended Tai Chi intervention on balance and selected motor functions of the elderly. *Am J Chin Med*, 2007; 35(03): 383–91
43. Maciaszek J, Osiński W, Szeklicki R, Stemplewski R: Effect of Tai Chi on body balance: Randomized controlled trial in men with osteopenia or osteoporosis. *Am J Chin Med*, 2007; 35(01): 1–9
44. Lin MR, Hwang HF, Wang YW et al: Community-based tai chi and its effect on injurious falls, balance, gait, and fear of falling in older people. *Phys Ther*, 2006; 86(9): 1189–201
45. Gatts S K, Woollacott MH: How Tai Chi improves balance: biomechanics of recovery to a walking slip in impaired seniors. *Gait Posture*, 2007; 25(2): 205–14
46. Gatts S K, Woollacott MH: Neural mechanisms underlying balance improvement with short term Tai Chi training. *Aging Clin Exp Res*, 2006; 18(1): 7–19
47. Man DW, Tsang WW, Hui-Chan CW: Do older tai chi practitioners have better attention and memory function? *J Altern Complement Med*, 2010; 16(12): 1259–64
48. Lam LCW, Chau RCM, Wong BML et al: Interim follow-up of a randomized controlled trial comparing Chinese style mind body (Tai Chi) and stretching exercises on cognitive function in subjects at risk of progressive cognitive decline. *Int J Geriatr Psychiatry*, 2011; 26(7): 733–40