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REVIEW

The effectiveness of traditional Chinese medicine-based exercise on physical performance, balance and muscle strength among older adults: a systematic review with meta-analysis

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Abstract

Background Traditional Chinese medicine (TCM) based exercises have been widely used in the prevention and treatment of balance, cardiopulmonary, and other related diseases in older adults. However, there seems to be no consensus on the improvement and comparison of physical performance, balance, and muscle strength in the elderly population.

Objectives To systematically examine the impact of different TCM-based exercises on physical performance, balance, and muscle strength outcomes in the elderly.

Methods We searched PubMed, EMBASE, Scopus, and Cochrane Center, CNKI and Wan Fang between their date of inception and March 2021. This meta-analysis was performed using RevMan5.3 software. Only randomized controlled trials (RCT) or controlled clinical trials (CCT) were considered in TCM-based exercises (Tai Chi, Ba Duan Jin, Qigong). The overall mean difference (MD) or standardized mean difference (SMD), and its 95% confidence interval (CI) were calculated.

Main results A total of 27 studies with 2580 older adults met the inclusion criteria. The pooled analysis indicated that Tai Chi could be more effective in Times up and go (TUG) (MD = − 2.62, 95% CI − 4.00 to − 1.24, $P = 0.0002$), 5 times sit-stand (MD = − 1.89; 95%CI − 3.38 to − 0.40; $P = 0.01$), and handgrip strength outcomes (SMD = 0.69; 95%CI 0.52–0.86; $P < 0.0001$) compared to Ba Duan Jin and Qigong. The older adults performing Qigong could have a better benefit in Single-bed balance (SLB) with eyes closed compared to Tai Chi and Ba Duan Jin (MD = 3.42; 95%CI 1.55 to 5.29; $P = 0.0003$). Tai Chi also had benefits in terms of balance outcomes compared to those in the control group: Berg Balance scale (BBS) (MD = 1.41; 95% CI 0.03–2.85; $P = 0.05$), Functional reach test (FRT) (MD = 1.57; 95%CI 1.22–1.93; $P < 0.0001$). The Tai Chi study meta-analysis demonstrated significant effects on lower limb strength: knee extension (SMD = 0.56; 95%CI 0.26–0.86; $P = 0.0003$), ankle dorsiflexion (SMD = 0.67; 95%CI 0.02–1.31; $P = 0.04$) compared to the controls.

Conclusion This systematic review reveals that TCM-based exercises can effectively improve physical performance outcomes, balance outcomes, and muscle strength in the elderly population. While there is limited evidence on the efficacy of other TCM-based lifestyle interventions, more high-quality clinical trials on this topic are warranted.

Keywords Traditional Chinese medicine · Tai Chi · Ba Duan Jin · Qigong · Physical performance · Balance · Muscle strength · Systematic review

Introduction

The rapid transition of the global population towards aging presents the government and even the entire society with economic, medical, public facilities, and other challenge [1]. The global population of those aged ≥ 65 years will grow to 1.6 billion in the next 50 years according to research [2]. Aging often leads to a progressive decline in muscle mass [3]. In particular, skeletal muscle mass decline leads to a decrease in skeletal muscle strength, resulting in the corresponding reduction of movement and balance functions

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in the elderly population. Therefore, it is important to effectively prevent and delay aging-related skeletal muscle atrophy to improve motor function in older adults.

Previous study has proven that physical exercise substantially contributes to maintaining the physical and mental health of individuals at all life stages [4]. Studies have also confirmed that regular exercise has remarkable benefits in slowing or reversing the musculoskeletal function deterioration that occurs with age [5]. However, different exercises have different effects on the physiological mechanism of skeletal muscle function. For example, resistance exercise is a form of exercise that can significantly improve muscle mass [6]. It can effectively stimulate muscle hypertrophy by shifting the balance between the synthesis and degradation of muscle protein to the synthetic direction, thereby enhancing muscle strength and energy burst [7]. Other studies have shown that aerobic exercise can improve the synthesis quality of skeletal muscle protein by increasing the cell mitochondria volume, improving enzyme activity, thus enhancing skeletal muscle function [8]. Long-term moderate-intensity aerobic exercise can be considered one of the most scientific and effective ways of improving the motor functions in older adults and alleviating the aging-related skeletal muscle atrophy considering the safety and effectiveness of exercise in the older adults [9].

Traditional Chinese medicine (TCM) based exercise is one of the low and moderate-intensity classical aerobic exercises, reflecting not only the characteristics of traditional Chinese fitness culture, but also a practical manifestation of the concept of "preventive disease treatment" in Traditional Chinese medicine [10]. TCM-based exercises such as Tai Chi, Ba Duan Jin, and Qigong have been continuously developed for nearly 2000 years in China [11–14]. Unlike conventional western exercise, which emphasizes the form and intensity of movements, the traditional Chinese method above is characterized by the slow movement of inhalation and exhalation in human breathing. The big upper and lower limbs movement always accompanied by breathing whenever people practice Tai Chi or Ba Duan Jin [10]. In recent decades, practical research has proved that the increasing popularity of TCM-based exercises worldwide has significantly improved the health of all humans, especially older adults [15, 16]. Several meta-analysis literature have demonstrated that TCM-based exercises have an absolute therapeutic value on cardiopulmonary outcomes(peak oxygen uptake, blood pressure, heart rate) in elderly patients with cardiovascular disease and psychosocial outcomes(depression, quality of life) type 2 diabetes patients[16, 17]. However, the efficacy of several common traditional Chinese exercises, including Tai Chi, Ba Duan Jin, and Qigong for motor function in the older population has not been systematically evaluated. Previous studies have shown that upper and lower limb muscle strength, balance function and physical performance of various movements can define the motor function [18]. Therefore, the aim of present systematic review is to investigate the impact of different TCM-based exercises on physical performance, balance, and muscle strength outcomes in elderly.

Methods

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist guidelines to report our review [19]. The protocol for this systematic review was registered with the PROSPERO international prospective register of systematic reviews in December 2020 (CRD42020218346).

Search strategy

Four English electronic databases (PubMed, EMBASE, Scopus and the Cochrane Central Register of Controlled Trials) and two Chinese electronic databases (China National Knowledge Infrastructure, Wan Fang) were searched between their date of inceptions to March 2021. We also conducted a manual search in the Soochow University and Nanjing University of Chinese Medicine libraries to prevent any missing literature. Only full available articles written in English or Chinese were included for assessment. The search terms used were "Tai Chi", "Ba duan jin", "Qigong", "Wuqinxi", "Yijinjing", "Traditional Chinese medicine", "physical performance", "physical ability", "balance", "muscle strength", "skeletal muscle", "elderly", "older adults", "sarcopenia". Various terms were used to systematically search, and the search was limited to controlled clinical trials (CCTs) and randomized controlled trials (RCTs). Our search strategy details are available in Appendix 1.

Eligibility criteria

Four reviewers were divided into two groups (two in each group: Wang and Si; Liang and Li), and each group independently screened the titles. Abstracts or full-text articles were retrieved for further assessment for studies whose relevance could not be determined using the titles. Both groups independently assessed the abstracts and full texts relevance of all potential articles based on pre-established inclusion/exclusion criteria and a supervisor (Lu) made the judgment when there were disagreements. The studies had to have the following characteristics to be included in this review:

Types of participants

The older adults (aged 55 or older) in the study were required to understand and follow simple oral instructions to perform the exercises; studies of patients with severe comorbidities (neurological diseases that impaired movement; cardiovascular disease symptoms that appear during moderate exercise; poorly controlled hypertension; dementia; known to impair movement) and those who were unable to perform TCM-based exercises were excluded.

Types of interventions

Participants in the experimental groups were required to perform TCM-based exercises, including but not limited to Tai Chi, Ba Duan Jin, and Qigong. There was no limit on the form (supervision/self-monitoring), environment (hospital/community), frequency, or duration of the intervention. Participants who conducted TCM-based exercises together with other exercise therapies were excluded from the study.

Comparison

The control group could be treated with placebo or other non-pharmacological treatments, including regular aerobic exercise, routine care, educational programs, etc.

Types of outcome measurements

The selected test outcomes used to evaluate the physical performance, balance function and muscle strength of the older adults were as follows:

Physical performance Times up and go (TUG), five times sit-stand, 30 s chair stand test;
Balance Berg Balance Scale (BBS), functional reach test (FRT) and single-leg balance (SLB);
Muscle strength Handgrip strength, knee extension strength, ankle dorsiflexion strength.

Study selection

RCTs and CCTs, published in either English or Chinese that use TCM-based exercises interventions in older adults, were incorporated in our review, and studies reported in full text were screened for inclusion. This study did not include studies that only TCM exercise as part of the intervention plan, without the essential intervention/outcome details, such as the frequency and duration of the intervention, and/or the method and standard deviation of outcome variables. Additionally, systematic reviews, conference articles and narrative reviews were also excluded.

Risk of bias appraisal

Two authors (Wang and Liang) independently evaluated the risk of bias following the Cochrane Handbook 5.3 for Systematic Reviews of Interventions. Random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other potential sources of bias were evaluated in all included studies and graded as high, low risk of bias, or unclear. Each item evaluated as low risk would receive one point. Any discrepancy was resolved by discussion, and a third investigator (Si) adjudicated whenever the disagreement could not be resolved.

Data extraction and management

The reviewers (Si and Wang) created, undertook, and cross-checked a data extraction form (Wang) to record the data including the first author, publication year, sample size, gender, age, nation, health condition, intervention methods, frequency, intensity, duration and follow-up, type of outcome measure, control intervention, outcome variables, baseline and outcome data, and adverse events. Any disagreement was resolved by consensus between the two reviewers, otherwise, a third reviewer (Lu) would be consulted. The article author was contacted for clarification when lacking required information.

Data synthesis

The Review Manager 5.3 software was used for the meta-analyses in the study with the same outcomes and units. Mean difference (MD) or standardized mean difference (SMD) and odds ratio (OR) with a 95% confidence interval (95%CI), were calculated as a means to identify the effect size for continuous and dichotomous variables, $P < 0.05$ was considered statistically significant. The degree of heterogeneity was analyzed using the Chi-square and I^2 statistic. I^2 values of 25%, 50% and 75% were considered as low, moderate, and high heterogeneity, respectively. The random-effects model was used when heterogeneity was identified because the expected participant diversity and interventions could result in heterogeneity. Otherwise, a narrative description was used where the meta-analysis was inappropriate. The possibility of publication bias was evaluated with the funnel plot and statistical tests. Sensitivity/subgroup analyses were conducted, where appropriate, to explore the influence of intervention dose and risk of bias on the effect size [20]. Sensitivity/Subgroup analyses were appropriately performed where required based on, for example, the age of

participants, nationality, gender, the form of intervention, etc., to explore potential causes of heterogeneity.

Results

Search results

The extensive literature search identified a total of 3221 articles, and two additional articles were identified through manual search. After duplicate removals, 2341 studies remained (1447 in English, 894 in Chinese), and were screened by reviewing their titles and abstracts. 1898 studies were excluded due to obvious irrelevance, leaving 218 full texts to be retrieved for further assessment. After reading the full text and re-screening, the studies including inappropriate literature types, different outcomes, inconsistent standards, and incomplete data were eliminated. 27 studies were finally obtained, including 19 in English and 8 in Chinese [21–47]. (see Fig. 1).

Risk of bias

We assessed the risk of bias in all selected articles (Table 1). Most articles explicitly used the generation of the allocation sequence except for two articles ($n=25$, 92.59%). Concealment allocation was only addressed in four studies (14.81%) [26, 31, 33, 45]). Participants could easily determine which group they are assigned to, based on the particular nature of exercise interventions; therefore, the inapplicability of the participant blindness method can lead to bias in this study. Moreover, a low risk of incomplete outcome bias was reported in 26 articles (96.4%), while a low risk of selective reporting bias was reported in most articles ($n=23$, 96.30%), indicating that selection bias existed in the included studies.

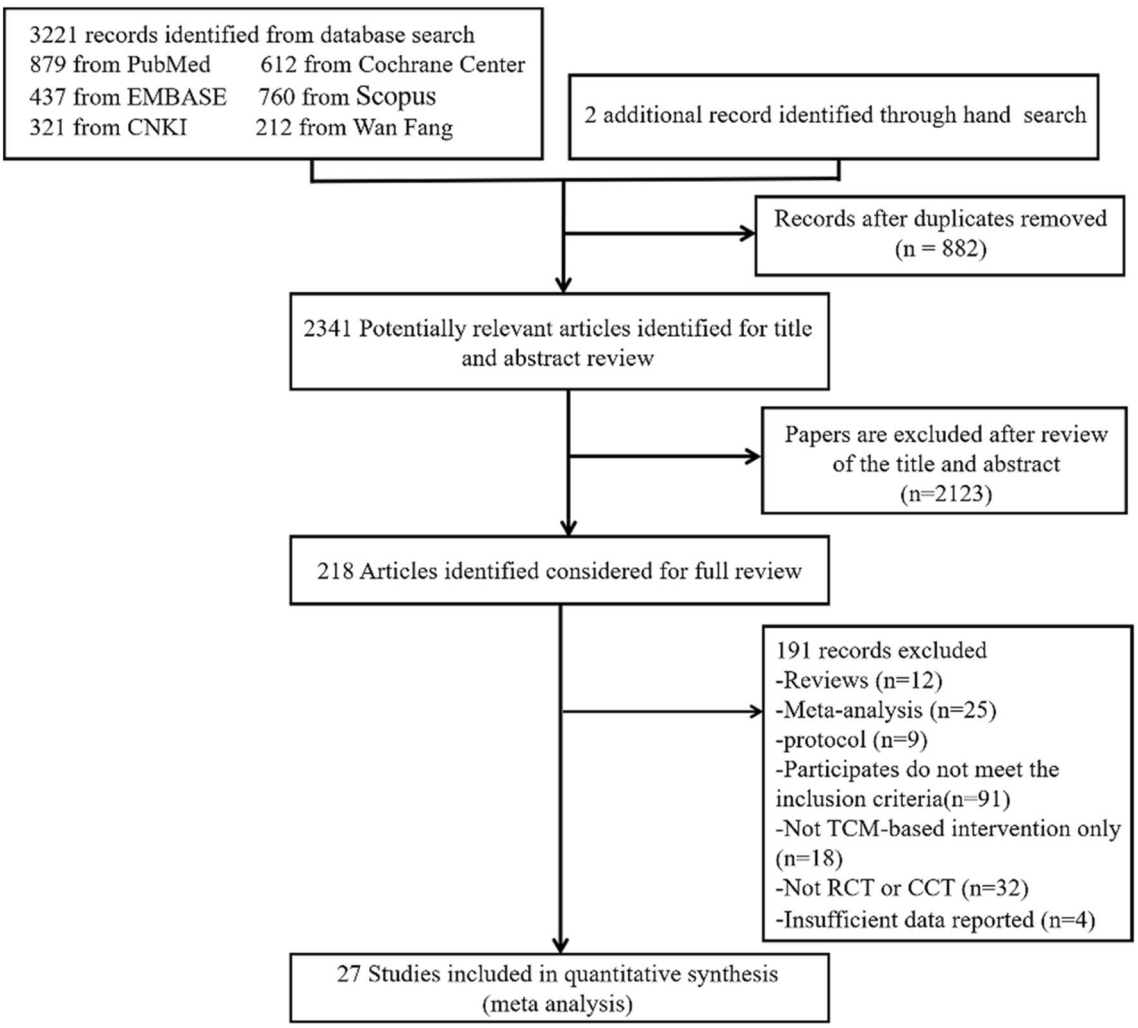


Fig. 1 Flow diagram of the study selection. *CNKI* Chinese National Knowledge Information Database, *RCT* randomized controlled trial, *CCT* controlled clinical trial

Table 1 Risk of bias assessment of included studies

References	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other sources of bias	Total
Audette et al. [22]	Low	Unclear	High	Low	Low	Low	Unclear	4
Chewning et al. [23]	Low	Unclear	High	Low	Low	Low	Unclear	4
Fang et al. [45]	Low	Low	High	Low	High	Unclear	Unclear	3
Hosseini et al. [26]	Low	Low	High	Low	Low	Low	Unclear	5
Hu [27]	Low	Unclear	High	High	Low	Low	Unclear	3
Li et al. [31]	Low	Low	High	Low	Low	Low	Unclear	5
Li et al. [28]	Low	Unclear	High	Low	Low	Low	Unclear	4
Li et al. [21]	Low	Unclear	Low	Low	Low	Low	Unclear	5
Liu et al. [25]	Low	Unclear	High	Unclear	Low	Low	Unclear	3
Liu et al. [38]	Unclear	Unclear	High	Low	Low	Low	Unclear	3
Liu et al. [30]	Unclear	Unclear	High	Low	Low	Unclear	Unclear	2
Lu et al. [35]	Low	Unclear	Low	Unclear	Low	Low	Unclear	4
Luo et al. [29]	Low	Unclear	High	Low	Low	Low	Unclear	4
Penn et al. [43]	Low	Unclear	High	Low	Low	Low	Unclear	4
Qi [46]	Low	Unclear	High	Low	Low	Unclear	Unclear	3
Song et al. [37]	Low	Unclear	High	Low	Low	Low	Unclear	4
Wang [36]	Low	Unclear	High	Unclear	Low	Low	Unclear	3
Wolf et al. [49]	Low	Unclear	High	Low	Low	Low	Unclear	4
Woo et al. [33]	Low	Low	High	Low	Low	Low	Unclear	5
Yıldırım et al. [39]	Low	Unclear	Low	Low	Low	Low	Unclear	5
Zhang et al. [32]	Low	Unclear	High	Low	Low	Low	Unclear	4
Zhang [34]	Low	Unclear	High	High	Low	Low	Unclear	3
Zhao et al. [41]	Low	Unclear	High	Low	Low	Low	Unclear	4
Zhou et al. [45]	Low	Unclear	High	Low	Low	Unclear	Unclear	3
Zhu et al. [40]	Low	Unclear	High	Low	Low	Low	Unclear	4
Zhu et al. [42]	Low	Unclear	High	Low	Low	Low	Unclear	4
Zhu et al. [44]	Low	Unclear	High	Low	Low	Low	Unclear	4

Low: Low risk of bias; Unclear: Unclear risk of bias; High: High risk of bias (mean score for risk of bias is 3.81)

Study characteristics

A total of 27 studies involving 2580 participant were used. The characteristics of the included studies are summarized in Table 2. The 27 studies examined the effectiveness of different types of TCM-based exercises, including Tai Chi, Ba Duan Jin, and other types of Qigong. Seventeen studies investigated the effect of Tai Chi [21–24, 26, 28, 29, 31–33, 35, 37, 39–41, 43, 44]. Three studies investigated the effect of Ba Duan Jin [30, 38, 47], and seven studies investigated the effect of Qigong (Yijinjing and Wuqinxi) [25, 27, 34, 36, 42, 45, 46]. The 27 articles involved 2580 patients with healthy older adults (16 articles), sarcopenic older adults (5 articles), frail older adults (4 articles) and inactive older adults (2 articles). Fifteen studies included daily activities and daily walking control groups [23, 25–30, 32–34, 36, 40, 42, 46, 47], five studies included wellness education control groups [24, 38, 43–45], Two studies included brisk walking control groups [22, 37], three studies included manual activity control groups [21, 35, 41], and the remaining two studies included regular stretching control group and combined exercise control group (walking, strength exercise and stretching) respectively [31, 39]. Further, the included studies originated from the People's Republic of China ($n = 17$, 62.96%), the United States ($n = 5$, 18.52%), Hong Kong, China, ($n = 2$, 7.40%), Taiwan, China ($n = 1$, 3.70%), Turkey ($n = 1$, 3.70%) and Iran ($n = 1$, 3.70%) (Table 2).

Effect of TCM-based exercises on physical performance

Nineteen studies involving 2137 participants evaluated physical performance as an outcome.

Table 2 Characteristics of 27 included studies

Reference	Participants	Interventions							Outcomes (measures)
	Country/region	Sample size (IG:CG)	Mean age (SD)	Gender ratio	Target population	IG vs. CG	Session duration (IG)	Duration of trial period	
Audette et al. [22]	USA	11:08	IG: 71.5 ± 4.6 CG: 71.3 ± 4.4	Female: 19	Sedentary older adults	Yang style Tai Chi vs. brisk walking*	60 min	4 times a week for 12 weeks	HS; KES; SLB
Chewning et al. [23]	USA	94:103	IG: 75.0 ± 7.4 CG: 72.8 ± 7.0	Male: 31 Female: 166	Healthy older adults	Yang style Tai Chi vs. daily activities#	90 min	2 times a week for 6 weeks	TUG; 30sCST
Fang et al. [45]	China	18:18	IG: 82.8 ± 8.5 CG:76.3 ± 9.9	Male: 12 Female: 24	Sarcopenic older adults	Yijinjing vs. wellness education+	30 min	3 times a week for 6 months	TUG
Hosseini et al. [26]	Iran	30:30	60–80	Male: 33 Female: 27	Healthy older adults	Taichi softball vs. daily activities#	55 min	2 times a week for 8 weeks	TUG
Hu [27]	China	25:25	IG: 65.24 ± 2.94 CG: 65.52 ± 3.09	Female: 50	Healthy older adults	Yijinjing vs. daily activities#	60 min	3 times a week for 16 weeks	SLB; 5tSS
Li et al. [31]	USA	125:131	77.48 ± 4.95	Male: 77 Female: 179	Inactive older adults	Yang style Tai Chi vs. regular stretching*	60 min	3 times a week for 6 months	BBS; FRT; TUG; SLB
Li et al. [28]	China	22:18	IG: 64.9 ± 3.2 CG: 65.6 ± 3.5	Male: 20 Female: 20	Healthy older adults	Simplified Tai Chi vs. daily activities#	60 min	4 times a week for 16 weeks	Strength: KES; ADFS
Li et al. [21]	USA	224:223	IG: 77.5 ± 5.6 CG: 77.8 ± 5.9	Male: 154 Female: 293	Frail older adults	Therapeutic Tai Ji Quan vs. manual activity*	60 min	2 times a week for 24 weeks	FRT; TUG
Liu et al. [25]	China	32:30	65.7 ± 3.1	Female: 62	Healthy older adults	Yijinjing vs. daily activities#	40–50 min	6 times a week for 6 months	SLB; HS
Liu et al. [38]	China	47:48	≥ 60	Unknown	Healthy older adults	Baduanjin + wellness education vs. wellness education+	40 min	2 times a week for 6 weeks	TUG
Liu et al. [30]	China	47:48	IG: 67.1 ± 6.18 CG: 66.63 ± 5.98	Male: 20 Female: 75	Healthy older adults	Baduanjin vs. daily walking#	40 min	2 times a week for 12 weeks	BBS; TUG; SLB
Lu et al. [35]	Hong Kong, China	16:15	IG: 73.9 ± 6.6 CG: 68.9 ± 5.8	Female: 31	Healthy older adults	Yang style Tai Chi vs. manual activity*	90 min	3 times a week for 16 months	Strength: KES
Luo et al. [29]	China	40:40	IG: 62.2 ± 3.43 CG: 62.6 ± 3.54	Male: 46 Female: 34	Healthy older adults	Taichi softball vs. daily activities#	90 min	4 times a week for 7 weeks	HS; 30sCST; TUG
Penn et al. [43]	Taiwan, China	15:15	IG: 75.27 ± 5.2 CG: 73.4 ± 8.2	Male: 5 Female: 25	Healthy older adults	Yang style Tai Chi vs. wellness education+	30 min	3 times a week for 8 weeks	BBS; TUG; FRT; Strength: KES; KFS; ADFS;
Qi [46]	China	34:32	60–80	Male: 25 Female: 41	Healthy older adults	Wuqinxi vs. daily activities#	90 min	5 times a week for 12 weeks	TUG; SLB; 5tSS
Song et al. [37]	China	31:30	IG: 62.14 ± 5.52 CG: 62.85 ± 5.29	Male: 15 Female: 50	Inactive older adults	Chen style Tai Chi vs. brisk walking*	40 min	6 times a week for 12 months	Strength: KES
Wang [36]	China	57:53	IG: 61.40 ± 1.57 CG: 62.11 ± 1.53	Male: 36 Female: 74	Healthy older adults	Wuqinxi vs. daily activities#	60 min	5 times a week for 12 weeks	SLB; 5tSS; HS
Wolf et al. [49]	USA	145:141	IG: 80.9 ± 6.6 CG: 80.8 ± 5.8	Male: 17 Female: 269	Frail older adults	Simplified Tai Chi vs. wellness education+	60 min progressing to 90 min	Twice a week for 48 weeks	FRT; SLB; HS
Woo et al. [33]	Hong Kong, China	60:60	IG: 68.2 ± 2.4 CG: 68.07 ± 2.7	Male: 60 Female: 60	Healthy older adults	Yang style Tai Chi vs. daily activities#	60 min	3 times a week for 12 months	HS; KES
Yıldırım et al. [39]	Turkey	30:30	IG: 62.9 ± 2.5 CG: 64.4 ± 7.5	Male: 7 Female: 53	Frail older adults	Yang style Tai Chi vs. combined exercise*	60 min	3 times a week for 12 weeks	BBS; TUG; SLB
Zhang et al. [32]	China	24:23	IG: 70.2 ± 3.6 CG: 70.6 ± 4.9	Male: 25 Female: 24	Frail older adults	Simplified Tai Chi vs. daily activities#	60 min	7 times a week for 8 weeks	SLB

Table 2 (continued)

Reference	Participants	Interventions							Outcomes (measures)
	Country/region	Sample size (IG:CG)	Mean age (SD)	Gender ratio	Target population	IG vs. CG	Session duration (IG)	Duration of trial period	
Zhang [34]	China	26:30	63 ± 5	Male: 7 Female: 49	Healthy older adults	Yijinjing vs. daily activities#	40 min	3 times a week for 12 weeks	TUG; SLB
Zhao et al. [41]	China	20:21	IG: 70.2 ± 3.9 CG: 69.9 ± 3.3	Male: 12 Female: 29	Healthy older adults	Yang style Tai Chi vs. manual activity*	90 min	3 times a week for 16 weeks	30sCST
Zhou et al. [45]	China	30:31	IG: 59.70 ± 6.23 CG: 61.13 ± 6.04	Male: 25 Female: 36	Healthy older adults	Baduanjin vs. daily walking#	30 min	5 times a week for 12 weeks	TUG; SLB
Zhu et al. [40]	China	30:30	IG: 64 ± 3 CG: 64 ± 4	Male: 23 Female: 37	Sarcopenic older adults	Yang style Tai Chi vs. daily activities#	60 min	5 times a week for 18 months	BBS; TUG; SLB; 5tSS; Strength: KES; ADFS;
Zhu et al. [42]	China	32:31	IG: 66.3 ± 10.8 CG:65.6 ± 11.4	Male: 32 Female: 31	Sarcopenic older adults	Yijinjing vs. daily activities#	40 min	7 times a week for 12 weeks	HS
Zhu et al. [44]	China	24:27	IG: 88.8 ± 3.7 CG: 87.5 ± 3.0	Male: 51	Sarcopenic older adults	Simplified Tai Chi vs. wellness education+	40 min	5 times a week for 8 weeks	TUG; 5tSS; SLB; HS; Strength: KES; KFS; ADFS;

IG Intervention group, *CG* Control group, *SD* Standard Deviation, *BBS* Berg balance scale, *FRT* Functional reach test, *SLB* Single-leg balance, *TUG* Times up and go, *5tSS* 5 times sit-stand, *30sCST* 30 s chair stand test, Muscle Strength, *HS* Handgrip strength, *KES* Knee extension strength, *ADFS* Ankle dorsiflexion strength

* Active-exercise control group

+Active non-exercise control group

#Blank control group

Times up and go

Fifteen articles reported the TUG outcome [21, 23, 26, 29–31, 34, 38–40, 43–47], nine of which were about Tai Chi, three of Ba Duan Jin, and three about Qigong. Tai Chi was found to decrease TUG time by 2.62 s (95% CI − 4.00 to − 1.24, $P = 0.0002$) compared with the active control group and blank control group based on a random-effects model. However, the heterogeneity in the studies was substantial with $I^2 = 96\%$, and no significant change was observed after the sensitivity analysis of one or two studies were removed. Three Ba Duan Jin CCTs evaluated TUG as an outcome and reported significant effects compared with the daily walking and wellness education control group (MD = − 0.96, 95% CI − 1.40 to − 0.51, $P < 0.0001$; $I^2 = 0\%$, $P = 0.66$) [30, 38, 47]. Three other studies concluded that Qigong groups performed better on the TUG (MD = − 2.00, 95% CI − 3.12 to − 0.88, $P = 0.0001$; $I^2 = 70\%$, $P = 0.02$) compared with daily activities and wellness education control groups [34, 45, 46]. The heterogeneity reduced to $I^2 = 29\%$ after the sensitivity analysis when one study was removed [45].

The pooled analysis of the fifteen studies had a statistically significant effect on decreasing TUG (MD = − 2.13; 95%CI − 2.93 to − 1.32; $P < 0.00001$) (see Fig. 2).

Five times sit–stand

Five Times Sit to Stand were reported in five studies [27, 36, 40, 44, 46]. The pooled analysis of the five articles demonstrated a beneficial effect on five times sit to stand outcome (MD = − 1.24; 95%CI − 1.99 to − 0.49; $P = 0.001$). Subgroup analysis revealed that Tai Chi exercise was more effective in improving the speed of Five Times Sit to Stand speed compared with Qigong (MD = − 1.89; 95%CI − 3.38 to v0.40; $P = 0.01$) (see Fig. 3).

30 s chair stand test

Three Tai Chi exercise articles reported the outcome of the 30 s Chair Stand Test [23, 29, 41]. The overall MD effect was 4.40 (95%CI 0.79–8.00; $P = 0.02$; $I^2 = 93\%$, $P < 0.00001$), demonstrating that the completion time of 30 s Chair Stand Test of the older adults in the intervention group was remarkably increased compared with daily activities or manual Activity group. It showed low heterogeneity ($I^2 = 0\%$) after the sensitivity analysis when one study was removed [29] (see Fig. 4).

Effects of TCM-based exercises on balance

The balance was assessed in 16 studies involving a total of 1756 participants [21, 22, 24, 25, 27, 30–32, 34, 36, 39, 40, 43, 44, 46, 47]. Berg Balance Scale, Functional Reach Test and Single-Leg Balance outcomes were all used to illustrate the balance function of participants.

Berg Balance Scale

BBS outcome was reported in five Tai Chi articles [31, 39, 40, 43] and Baduanjin [30]. The Tai Chi exercise meta-analysis revealed that there was a significant effect on BBS (MD = 1.41; 95% CI 0.03–2.85; $P = 0.05$) compared with active and blank control groups but with high heterogeneity ($I^2 = 85\%$). Sensitivity analysis showed that there was a low heterogeneity ($I^2 = 0\%$) when one study was removed [39]. The direction of influence on BBS favored TCM-based exercises intervention compared with the control group when all five studies were combined in the pooled analysis (MD = 1.58; 95%CI 0.31 to 2.85; $P = 0.01$) (see Fig. 5).

Functional reach test

Four Tai Chi studies covered FRT outcomes [21, 24, 31, 43]. No significant heterogeneity was found in the four articles ($P = 0.68$, $I^2 = 0\%$). The overall MD estimate was 1.57 (95%CI 1.22 to 1.93; $P < 0.0001$), pointing that there was a remarkable increase in the distance covered by the older adults in the experimental group to complete FRT outcome compared with active exercise and wellness education control groups (see Fig. 6).

Single-leg balance

Thirteen studies reported SLB outcome, six of which were about Tai Chi [22, 24, 31, 39, 40, 44], two about Ba Duan Jin [30, 45], and five about Qigong [22, 24, 31, 39, 40, 44]. The pooled SLB analyses (eyes closed) indicated that TCM-based exercises are effective in prolonging the standing time on one leg with eyes closed (MD = 2.63; 95%CI 1.94 to 3.33; $P < 0.0001$). What is noteworthy is that subgroup analysis indicated that Qigong exercise could result in a better effect on SLB with eyes closed (MD = 3.42; 95%CI 1.55 to 5.29;

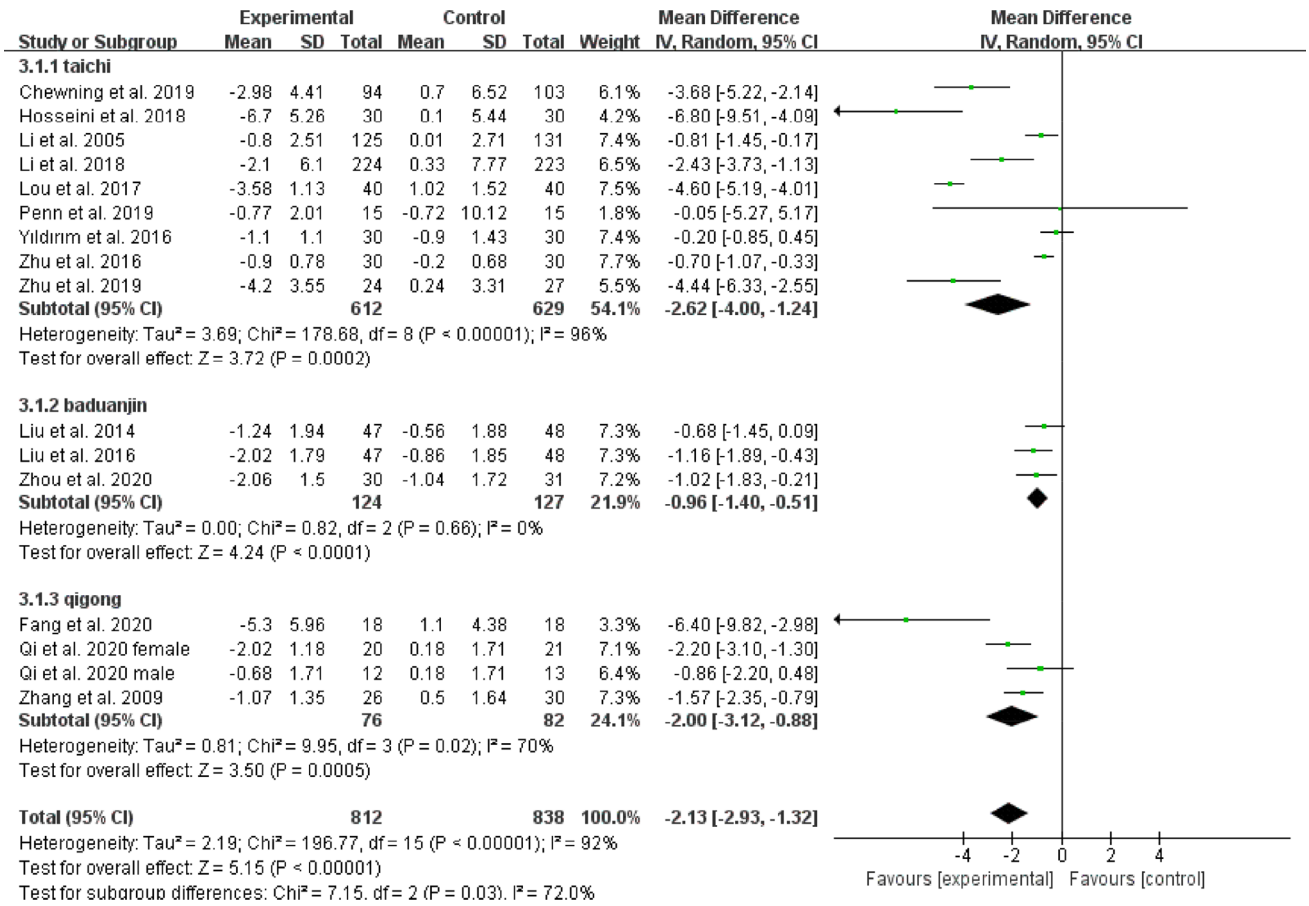


Fig. 2 Forest plot of effect of TCM-based exercises on TUG

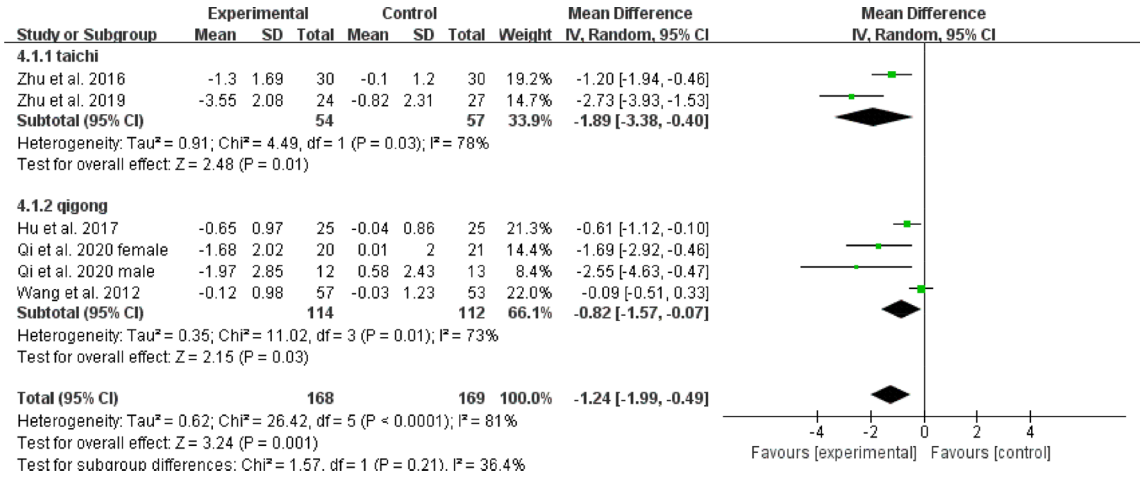


Fig. 3 Forest plot of effect of TCM-based exercises on five times sit-stand

$P = 0.0003$). The Tai Chi exercise ($I^2 = 90\%$) and Qigong ($I^2 = 88\%$) heterogeneity were relatively high, but there was no obvious change after sensitivity analysis when one or two studies were excluded. (see Fig. 7a).

Five studies reported the SLB outcome with eyes opened [22, 24, 31, 32, 39]. No significant heterogeneity was found in the studies ($P = 0.10$, $I^2 = 49\%$). The pooled SLB analyses (eyes opened) revealed that the ability of balance control on one leg in the Tai Chi intervention group was significantly improved compared with active and non-exercise controls (MD = 6.13; 95%CI 4.22 to 8.03; $P < 0.0001$) (see Fig. 7b).

Effects of TCM-based exercises on muscle strength

Thirteen studies involving 1013 participants reported muscle strength outcomes [22, 24, 25, 28, 29, 33, 35–37, 40, 42–44].

Handgrip strength

Handgrip strength was assessed in eight studies, five Tai Chi articles, and three Qigong [22, 24, 25, 29, 33, 36, 42, 44]. The combined result of the eight articles indicated that there was a substantial moderate effect of TCM-based exercises on handgrip strength (SMD = 0.56; 95%CI 0.36–0.76; $P < 0.0001$; $I^2 = 38\%$, $P = 0.13$). Moreover, subgroup analysis showed that Tai Chi exercise had more effect in improving handgrip strength compared with Qigong (SMD = 0.69; 95%CI 0.52–0.86; $P < 0.0001$; $I^2 = 0\%$, $P = 0.56$) (see Fig. 8).

Knee extension strength

Eight articles investigated the effects of Tai Chi on knee extension strength of dominant or right knee extension [22, 28, 33, 35, 37, 40, 43, 44]. The aggregated result of the included studies demonstrated that there was a significantly moderate effect on knee extension (SMD = 0.56; 95%CI 0.26–0.86; $P = 0.0003$; $I^2 = 52\%$, $P = 0.04$) compared with active and blank control groups (see Fig. 9a). The heterogeneity decreased to $I^2 = 11\%$ after the sensitivity analysis when one study was removed [40].

Ankle dorsiflexion strength

Four articles investigated the effects of Tai Chi on ankle dorsiflexion strength [28, 40, 43, 44]. The pooled study analyses revealed that there was a significant moderate effect on ankle dorsiflexion (SMD = 0.67; 95%CI 0.02–1.31; $P = 0.04$) with high heterogeneity compared with daily activities or wellness education group. The heterogeneity was $I^2 = 0\%$ after

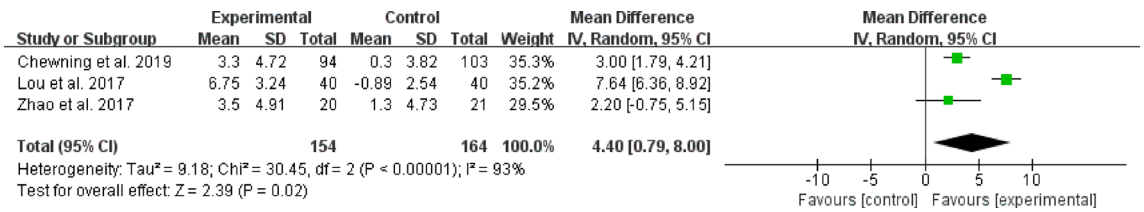


Fig. 4 Forest plot of effect of Tai Chi on 30 s chair stand test

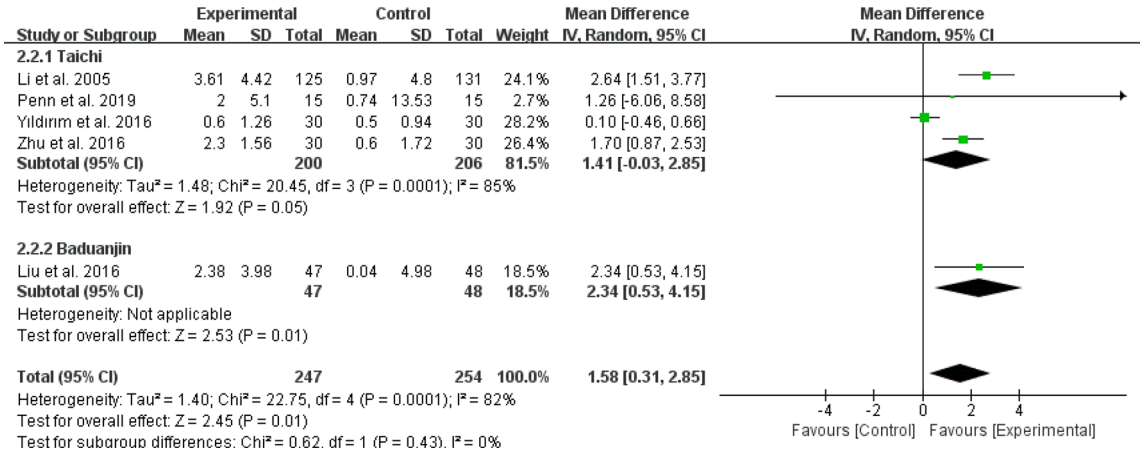


Fig. 5 Forest plot of effect of TCM-based exercises on BBS

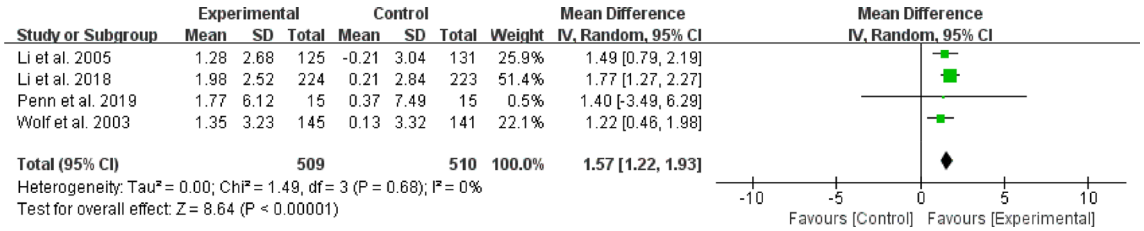


Fig. 6 Forest plot of effect of Tai Chi on FRT

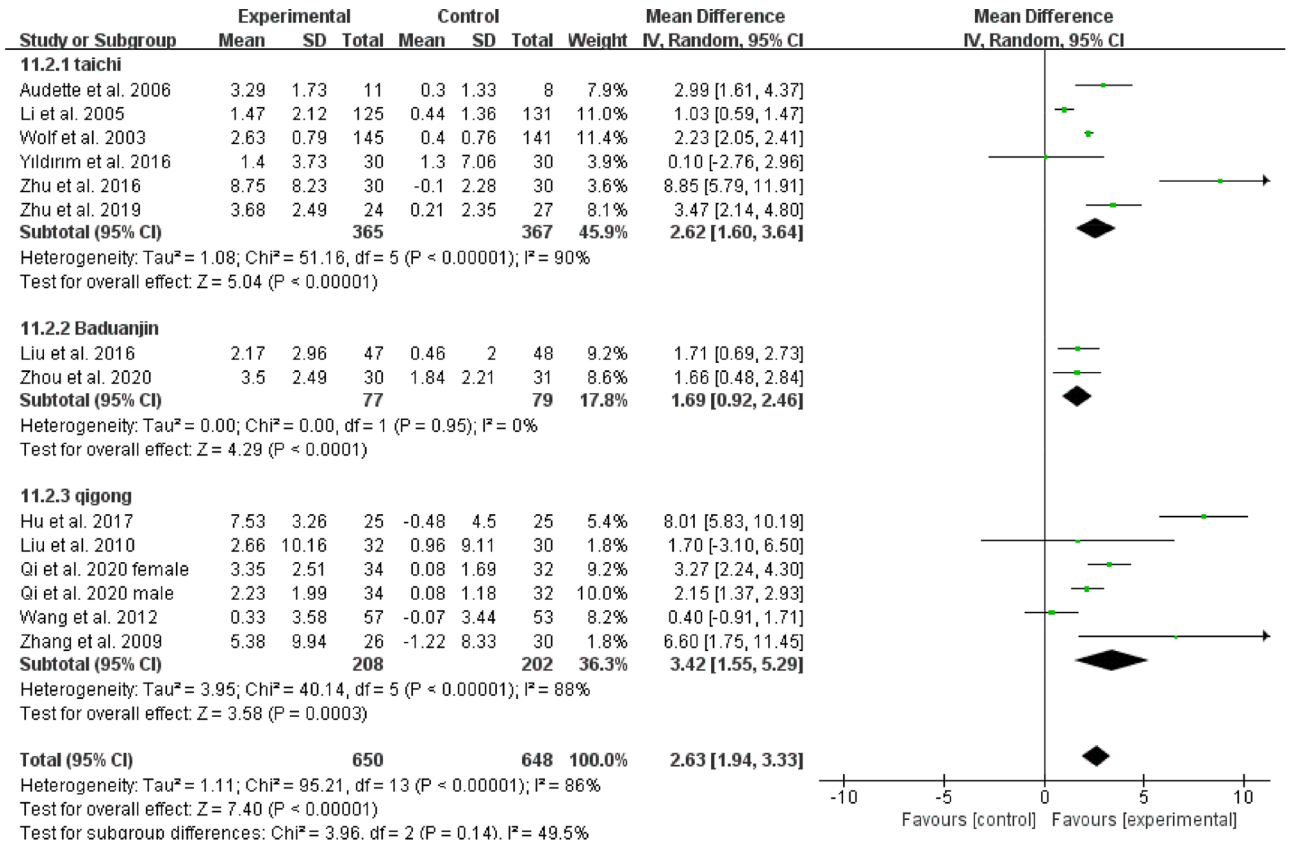
the sensitivity analysis when one study was removed [40]. (see Fig. 9b).

Publication bias

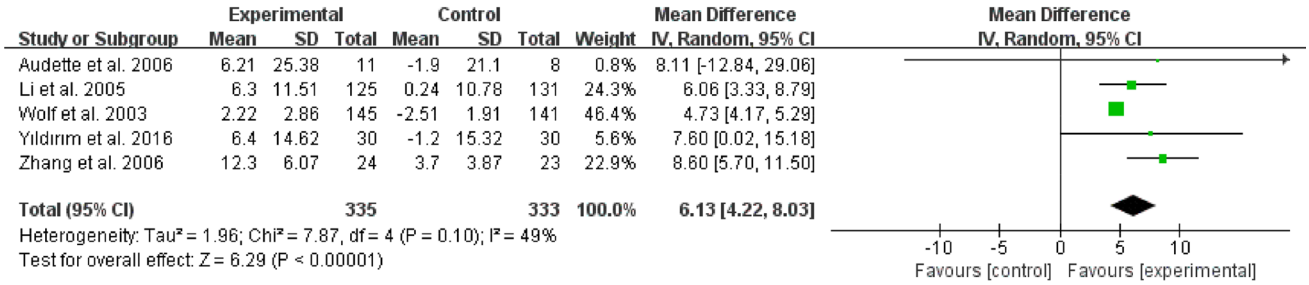
The TUG study outcome was used to make a funnel chart. The visual inspection of two funnel charts suggested that there was an asymmetric funnel plot (see Fig. 10). The quality of research methods, and lack of literature on TCM-based exercises such as Ba Duan Jin ($n=3$), or the difficulty in publishing negative results could lead to the possible publication bias.

Subgroup analysis of Tai Chi exercise

Only the subgroup Tai Chi exercises analysis was conducted in this study because there are few other types of TCM-based exercises (Ba Duan Jin and Qigong) included in the literature. The subgroup analysis showed that there were no significant group differences in various Tai Chi interventions, intervention duration, weekly class frequency, and control intervention types. RCTs with intervention frequency of more than three times weekly had more effects on physical performance (MD = −0.3.2, $P=0.04$), balance (MD = 4.67, $P=0.0002$) and muscle Strength (SMD = 0.62, $P=0.007$). Long-term duration of Tai Chi intervention (> 11520 min) could have a more significant impact on knee extension muscle strength in older adults (SMD = 0.74, $P=0.005$). It should be noted that Taichi softball has a higher effect on improving physical performance (TUG, $P<0.01$) compared with Yang Style. Moreover, the frequency of Tai Chi intervention less than three times weekly was more significant in improving the TUG outcomes than three times weekly. Considering the reasons, the total trial period of Tai Chi intervention three times weekly was 8–12 weeks, while the session duration of each intervention was only 30–60 min. Among the included literatures whose frequency was less than three times weekly, the study with the largest sample size had a total trial duration of 24 weeks ($n=447$) [21], and another study had a session duration of 90 min each time [23]. This difference between the total trial period and the session duration of each exercise may be responsible for the more significant effect on TUG in the subgroup analysis when the intervention duration was less than three times per week compared to three times per week. However, the stability of the above subgroup analysis results should be comprehensively considered because there are a few studies on



(a)



(b)

Fig. 7 **a** Forest plot of effect of TCM-based exercises on SLB eyes closed. **b** Forest plot of effect of Tai Chi on SLB eyes opened

Taichi softball ($n=2$) or even the whole Tai Chi ($n=17$) (Table 3).

Discussion

The effect of TCM-based exercise on the physical performance, balance and muscle strength on older adults

TCM-based exercise is an ancient Chinese fitness exercise. It is non-violent and has gentle movements which are very suitable for older adults whose skeletal muscle function gradually degrades [48]. Moreover, TCM-based exercise especially Tai Chi is believed to prevent the older adults from falling, as its movements contain multiple elements that enhance balance, posture control, posture alignment and concentration [49, 50]. Previous systematic reviews mainly focused on specific traditional Chinese exercises, such as Tai Chi and Qigong [15, 51]. There are also relatively few studies on Ba Duan Jin. Additionally, many systematic reviews have concluded that older adults have a specific disease such as COPD, heart disease or osteoporosis, and less stable older adults or sarcopenia [52–54]. This systematic review has

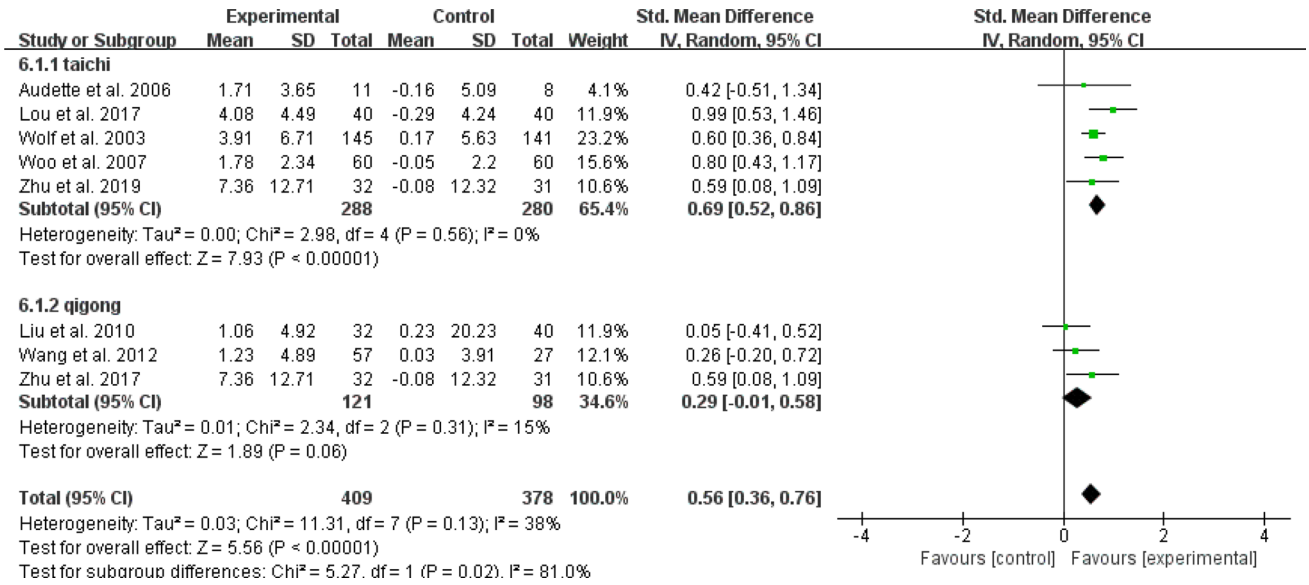
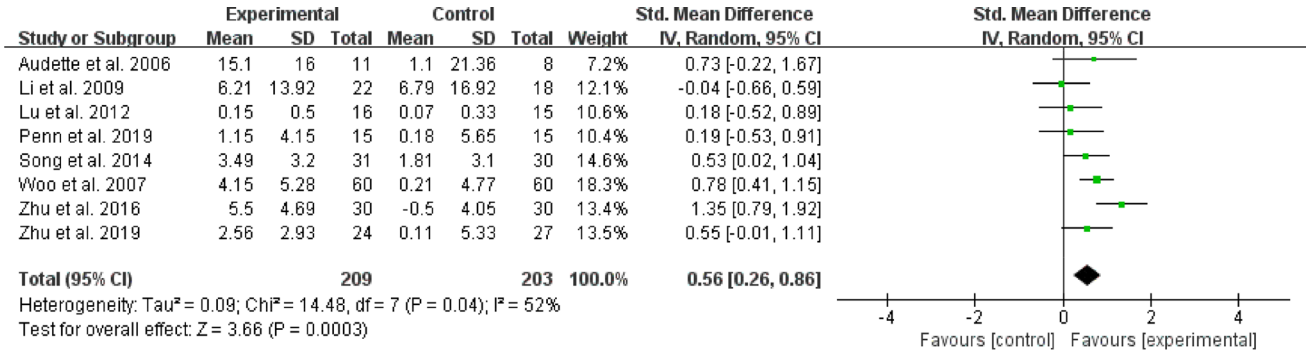
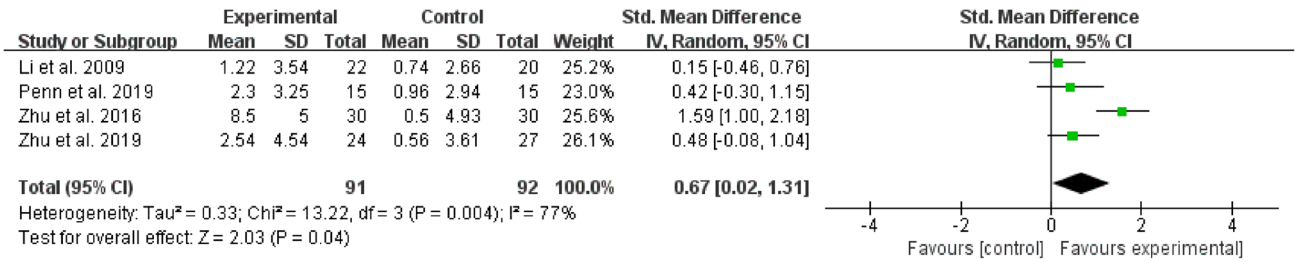


Fig. 8 Forest plot of effect of TCM-based exercises on Handgrip strength



(a)



(b)

Fig. 9 **a** Forest plot of effect of Tai Chi on Knee extension strength. **b** Forest plot of effect of Tai Chi on Ankle dorsiflexion strength

collected a large number of experimental pieces of evidences to evaluate the effectiveness of TCM-based exercises to assess its overall effect on physical performance, balance and muscle strength in healthy or sub-healthy older adults compared with other exercises or health education.

The data showed that all the three TCM-based exercises can remarkably improve the exercise performance of the older adults: quantitative analysis showed that Tai Chi can shorten the subjects in the TUG test by 2.62 s compared with the control group, whereas Ba Duan Jin and Qigong

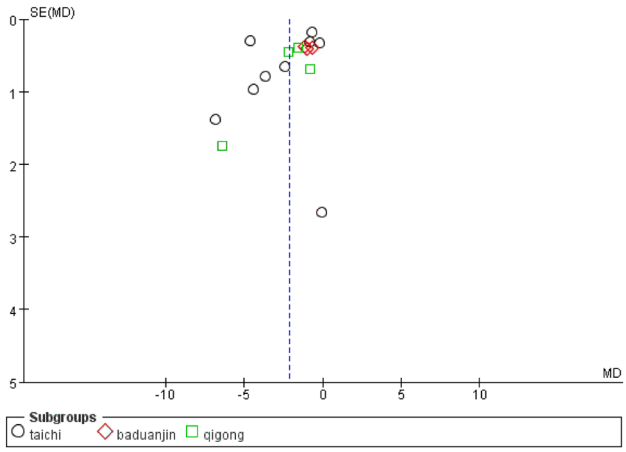


Fig. 10 Funnel plot of publication bias for TUG

can shorten the TUG test by 0.96 s and 2 s, respectively. Subgroup analysis results indicate that Tai Chi could have an advantage in improving the effect of TUG outcome compared with other two kinds of exercises. These results are consistent with previous research showing that Tai Chi could improve walking ability and prevent falls in older people by improving flexibility and reaction time in the lower extremities [55].

TCM-based exercises can improve the balance function of the older adults. Quantitative analysis showed that Tai Chi exercise could increase the BBS by 1.41 points and FRT distance by 1.57 cm. The quantitative SLB analysis demonstrated that Qigong can prolong the standing time on one leg of elderly subjects by 3.42 s in the eyes closed test, whereas Tai Chi and Ba Duan Jin can prolong by 2.62 s and 1.69 s, respectively. Therefore, it can be assumed that Qigong is more effective than Tai Chi and Ba Duan Jin in improving the performance of eye-closing standing on one leg. Since only one Tai Chi exercise data item was collected in the SLB eye-opening test, it could only be concluded from the synthetic analysis that Tai Chi can increase the standing time on one leg with eyes opened by 6.13 s compared with the control group. Unlike other exercises that emphasize speed or endurance, TCM-based exercise action has continuous and slow movements. The kind of movement, in which the center of gravity is constantly shifting and the weight on both sides is constantly changing, is related to the human body using its own internal input to control the center of mass, which is beneficial in improving balance control ability in the older adults, whether in the eyes opened or closed tests [13].

TCM-based exercises can have a significant effect on strengthening the muscle strength of upper and lower limbs. SMD was used for effect-size analysis in this study because of inconsistent measurement units. Meta-analysis showed that both Tai Chi and Qigong can improve handgrip strength, and Tai Chi could be more effective in improving the handgrip strength of participants compared to Qigong. Meta-analysis showed that both Tai Chi and Qigong can improve handgrip strength to a certain extent, but Qigong does not present a significant increase in handgrip strength compared to Tai Chi, and Tai Chi could more effectively improve the handgrip strength of participants. In addition, there were no studies available for knee extension strength and ankle dorsiflexion other than Tai Chi. Tai Chi exercise had a moderate effect on the lower extremity muscle strength, including the hip, knee, and ankle joint peripheral muscles. The above results were statistically significant ($P < 0.05$).

Heterogeneity analysis

It is worth noting that the forest plot of outcome indicated that there was significant heterogeneity ($I^2 \geq 50\%$) and this could be caused by various phenomenon. First, objective, or subjective measures could result in high heterogeneity. There were differences in the measurement methods of various outcomes in some included articles. For example, Woo et al. adopted a handgrip dynamometer GripD to measure grip strength, requiring the test subject to bend the index finger to 90°; while Zhu et al. required the subjects to flex the elbow to 90° in the sitting position and maintain a maximum grip of 5 s. Second, the incomplete consistency in the control groups of the included literature could also affect the accuracy of the results. In this review, the various control groups include active-exercise controls, active non-exercise control group and blank control group. Each type of control group includes stretching, brisk walking, health education and daily activities, etc. These different movement types and active exercise and non-exercise control groups could cause the heterogeneity increase of the merger analysis. Third, in the included Tai Chi and Qigong experimental group, different forms of Tai Chi such as Yang style Tai Chi, Chen style Tai Chi and simplified Tai Chi were both included in the Tai Chi group, while Wuqinxi and Yijining, were both included in the Qigong experimental group. The influence of the diversity of these specific forms of exercise on outcomes is also worth considering. Fourth, this study did not further compare the efficacy differences between male and female elderly on various functional outcomes. Most of the literature had a combination of male and female participants, whereas a few studies included only females, which could also lead to heterogeneity.

Limitations and prospects

Our review had several limitations. This review included only journal articles published in English and Chinese,

Table 3 Exploratory comparison of Tai Chi subgroup differences in TUG, SLB, KES outcomes

Subgroups	Study (*n*)	Subjects (*n*)	MD/SMD (95% Cl)	*P* value of Overall Effect	I^2 (%)	*P* value of heterogeneity
Type of intervention						
TUG						
Yang style	5	603	−1.00 [−1.75, −0.24]	0.010	76	0.002
Taichi Softball	2	140	−5.29 [−7.28, −3.29]	< 0.001	59	0.120
SLB eyes closed						
Yang style	4	395	3.00 [0.50, 5.50]	0.02	90	< 0.001
Simplified Taichi	2	337	2.67 [1.51, 3.83]	< 0.001	69	0.070
KES						
Yang style	5	251	0.58 [0.32, 0.83]	< 0.001	0	0.470
Simplified Taichi	2	91	0.27 [−0.30, 0.85]	0.350	47	0.170
Type of control intervention						
TUG						
Active	3	763	−0.99 [−1.99, 0.01]	0.050	78	0.010
Regular	6	478	−3.54 [−5.80, −1.27]	0.002	97	< 0.001
SLB eyes closed						
Active	3	335	1.55 [0.02, 3.08]	0.050	74	0.020
Regular	3	397	4.29 [1.87, 6.70]	< 0.001	91	< 0.001
KES						
Active	3	110	0.46 [0.08, 0.84]	0.020	0	0.620
Regular	5	301	0.60 [0.16, 1.04]	0.008	69	0.010
Duration of intervention						
TUG						
≤ 1600 min	4	338	−4.30 [−6.06, −2.54]	< 0.001	54	0.090
2160–3840 min	3	587	−2.41 [−5.50, 0.68]	0.130	98	< 0.001
SLB eyes closed						
2160–3840 min	2	79	1.83 [−0.95, 4.60]	0.200	69	0.070
4320–6000 min	2	542	1.65 [0.47, 2.82]	0.006	96	< 0.001
KES						
≤ 1600 min	2	81	0.41 [−0.03, 0.86]	0.070	0	0.440
2160–3840 min	2	59	0.26 [−0.47, 0.99]	0.490	43	0.190
≥ 11520 min	4	272	0.74 [0.32, 1.15]	0.005	61	0.060
Frequency of weekly						
TUG						
> 3 times	3	191	−3.20 [−6.30, −0.10]	0.040	98	< 0.001
= 3 times	3	346	−0.50 [−0.96, −0.05]	0.030	0	0.410
< 3 times	3	704	−3.99 [−6.06, −1.93]	< 0.001	76	0.020
SLB eyes closed						
> 3 times	3	130	4.67 [2.20, 7.13]	< 0.001	83	0.002
= 3 times	2	316	1.01 [0.58, 1.44]	< 0.001	0	0.530
KES						
> 3 times	5	231	0.62 [0.17, 1.08]	0.007	63	0.030
= 3 times	3	181	0.48 [0.04, 0.92]	0.030	42	0.180

and four of the studies were excluded because of the insufficient information of the results, failing to contact the authors. Besides, this study did not conduct a subgroup analysis of exercise patterns other than Tai Chi because each TCM-based exercise included fewer studies but more outcomes, and Chinese subjects were mostly selected in our included studies. Intensity is known to be one of the essential factors that affect the effectiveness of an exercise. When choosing the same exercise mode for training, intensity

control can directly affect the effect size of the exercise. TCM-based exercise is a medium- and low-intensity aerobic exercise. However, during clinical trials, few pieces of research mentioned the specific control of intensity during exercise, and more from the frequency and duration. Therefore, future research can intervene in TCM-based exercise from the exercise intensity monitoring perspective.

The total number of clinical studies on Ba Duan Jin and Qigong on the older adults is less than that of Tai Chi. Several outcomes including 30 s Chair Stand Test, BBS, FRT and lower limb muscle strength are only included in one TCM-based exercise (Tai Chi). Therefore, future clinical studies should pay more attention to the research on the efficacy of Ba Duan Jin and other types of Qigong on the motor function of older adults. It is worth mentioning that Qigong has various forms such as Wuqinxi, Liuzijue and Yijinjing. In future studies, specific forms of Qigong exercise can be further explored and discussed.

Conclusions

Overall, this systematic review shows that a TCM-based exercise is an exercise option with favorable effects on physical performance, balance, and muscle strength for older adults. It also demonstrates that Tai Chi can be more effective in physical performance and handgrip strength compared with Ba Duan Jin and Qigong, while an intervention frequency of more than three times a week can achieve optimal exercise results. However, conclusions on the effectiveness of Ba Duan Jin and Qigong on measures of physical performance, balance and lower limb strength cannot be included because of the limited number of eligible studies. Besides improving the RCT quality, more research on other forms of TCM-based exercise is also crucial.

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Declarations

Conflict of interest Authors declare that there are no conflicts of interest regarding the publication of this paper.

Statement of human and animal rights This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

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