Comparing the effectiveness of five traditional Chinese exercises in improving balance function in older adults: a systematic review and Bayesian network meta-analysis

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ABSTRACT

Background: Despite numerous studies affirming the potential of traditional Chinese exercises (TCEs) in enhancing balance in older adults, systematic integration is lacking. This study evaluated the effectiveness of five TCEs—Baduanjin, Liuzijue, Tai Chi, Wuqinxi, and Yijinjing—in improving balance among older adults using network meta-analysis.
Methods: This meta-analysis was registered in PROSPERO with the registration number CRD42023481450. Related articles indexed by Web of Science, Cochrane, PubMed, Embase, China National Knowledge Infrastructure (CNKI), Wanfang, and VIP databases before October 2023 were searched. Randomized controlled trials (RCTs) involving TCEs interventions to improve balance function conducted in older adults who aged ≥60 years were included. Two researchers used Review Manager to assess the quality of the studies, and analyzed the data using Stata and R.
Results: In total, 46 RCTs and 3,333 older adults were included. The aforementioned TCEs had positive effects on improving balance in older adults. Tai Chi revealed significant intervention effects in performing the Single-Leg Stand with eyes Closed (SLSC), 6-Min Walk Test (6MWT), and Short Form 36-Item Physical Component Summary (SF-36PCS). Liuzijue significantly improved performance in the Timed Up and Go Test (TUGT), 6MWT, SF-36PCS, and Berg Balance Scale (BBS). Baduanjin, Wuqinxi, and Yijinjing showed noteworthy intervention effects on the BBS. Tai Chi ranked highest in the SLSC, 6MWT, and SF-36PCS in the surface under the cumulative ranking, while Liuzijue and Yijinjing ranked highest in the TUGT and BBS, respectively.
Conclusion: Tai Chi, Liuzijue, and Yijinjing improved the static, dynamic, and overall balance outcomes, respectively. Older adults can make a reasonable choice among these TCEs based on their needs.

Subjects Geriatrics, Rehabilitation, Sports Medicine
Keywords Older adults, Exercises, Balance, Fall

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INTRODUCTION

The World Health Organization notes that balance disorders are considered one of the most crucial factors undermining the health of older adults (*World Health Organization, 2015*). The balance function refers to the fundamental physiological mechanisms for executing various movements and maintaining overall human health (*Pollock et al., 2000*). Often, balance declines with age (*Xie, Han & Hu, 2022*). The 'World Guidelines for Falls Prevention and Management in Older Adults: A Global Initiative,' proposed by 96 experts from 39 countries, provides guidance on fall risk assessment, risk stratification, intervention strategies, and treatment modalities for seniors living in diverse environments. This underscores the importance of balance enhancement to fall prevention (*Montero-Odasso et al., 2022*). In recent years, the worldwide prevalence of falls among the older population was 26.5% (*Salari et al., 2022*). An estimated 684,000 people die each year due to falls globally (*World Health Organization, 2021*). Furthermore, balance function is associated with cognitive decline (*Tavares et al., 2020*) and can predict mortality (*Araujo et al., 2022*). Therefore, balance training for older adults should be emphasized (*Montero-Odasso et al., 2022*).

Based on the characteristics of balance, it is commonly categorized into static balance, dynamic balance, and overall balance, which collectively form the basis for body stability and coordination (*Neptune & Vistamehr, 2018*). Static balance typically reflects the human body's ability to maintain a stable posture, whereas dynamic balance represents the capacity to automatically adjust and maintain the stability of the body's center of gravity during motion. Overall balance ability encompasses the seamless transition and integration between maintaining static and dynamic balance in various situations. Additionally, some researchers have utilized other health-related outcomes as auxiliary outcomes to evaluate balance (*Syddall et al., 2009*; *Zou et al., 2020*). Given the diverse nature of balance function, implementing suitable exercise interventions is crucial for enhancing balance in older adults.

Traditional Chinese exercises (TCEs) have gained popularity worldwide, owing to their health benefits. TCEs mainly include Baduanjin, Liuzijue, Tai Chi, Wuqinxi, and Yijinjing; these exercises are also endorsed by the consensus statement of Chinese experts on exercise prescription (*Li et al., 2024*). Compared with other exercises, these five TCEs are gentle and slow (*Guo et al., 2016*), and older adults can independently control the intensity and difficulty of these exercises. Baduanjin consists of eight movements to stretch the muscles. It coordinates movements of both the upper and lower extremities, enhancing the flexibility and stability of the spine (*Koh, 1982*). By integrating vocalization and six unique breathing exercises into movements, Liuzijue augments oxygen supply during exercise and thereby improves walking stability (*Shi, Wang & Wang, 2020*). Tai Chi is a gentle martial art with certain combat attributes. Through repetitive transitions between single-leg and double-leg stances, Tai Chi enhances postural stability and strengthens the lower limbs (*Nyman, 2021*). Wuqinxi, which mimics the movements of several animals, benefits both muscle strength and joint stability (*Leon, 2020*). Lastly, Yijinjing, a comprehensive series of flexibility exercises, contributes significantly to increasing the range of motion in lower limb joints (*General Administration of Sport of China, 2012*) (Appendix A). The five exercises, each characterized by distinct mechanisms, collectively contribute to enhancing diverse aspects of balance capabilities.

Although various studies have affirmed the potential of TCEs to improve balance in older adults, existing research lacks systematic integration. The type of TCEs most effective in improving balance in older adults remains unclear. Traditional meta-analysis focuses on comparing two groups, whereas network meta-analysis (NMA) can compare multiple interventions simultaneously and rank the advantages and disadvantages of various interventions for specific outcomes (*Puerto Nino & Brignardello-Petersen, 2023*). Therefore, this NMA aimed to evaluate the effectiveness of five TCEs (Baduanjin, Liuzijue, Tai Chi, Wuqinxi, and Yijinjing) in improving balance in older adults.

METHODS

Search strategy

This research was registered at PROSPERO (CRD42023481450). Two researchers independently conducted a systematic search for relevant randomized controlled trials (RCTs), including those indexed by the Web of Science, Cochrane, PubMed, Embase, China National Knowledge Infrastructure (CNKI), Wanfang, and VIP databases before October 2023. The search terms included "Baduanjin," "Liuzijue," "Tai Chi," "Wuqinxi," "Yijinjing," "elderly," "older," "balance," and "randomized controlled trials." The search strategy involved a combination of MeSH terms and free text, adjusted according to the characteristics of each database. Two independent reviewers (JX and JG) selected and searched the titles, abstracts and further screened the full text against the inclusion criteria. Disagreements were resolved by the corresponding author (BW) until consensus was reached. This study conformed to all Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (Appendix B).

Inclusion criteria

The inclusion criteria were based on the "PICOS" (participants, interventions, comparators, outcomes, and study design) approach. (1) Participants: this study included participants aged ≥60 years with no restrictions on their health status. (2) Interventions: five TCEs (Baduanjin, Liuzijue, Tai Chi, Wuqinxi, and Yijinjing) were included. (3) Comparators: control group either participated in regular exercise or did not receive any exercise interventions. Regular exercises included brisk walking, stretching, and regular aerobic exercises. (4) Outcomes: this study selected three primary outcomes and two secondary outcomes. Primary outcomes included one static balance outcome (Single-Leg Stand with eyes Closed (SLSC)) (*Jonsson, Seiger & Hirschfeld, 2004*), one dynamic balance outcome (Timed Up and Go Test (TUGT)), and one overall balance outcome (Berg Balance Scale (BBS)) (*Berg, 1989*; *Berg et al., 1992*; *Mathias, Nayak & Isaacs, 1986*). Secondary outcomes included two auxiliary balance outcomes (6-Min Walk Test, (6MWT) (*ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories, 2002*) and 36-Item Short Form Health Survey Physical Component Summary (SF-36PCS) (*Ware & Sherbourne, 1992*). (5) Study design: this study included only RCTs.

Endnote (Thompson ISI Research Software, Philadelphia, PA, USA) was utilized to screen the literature, and data extraction was conducted in accordance with the guidelines outlined in the Cochrane Handbook for Systematic Reviews of Interventions (version 6.4; https://training.cochrane.org/handbook/current).

Exclusion criteria

The following kinds of studies were excluded: RCTs where participants were under 60 years old in both the experimental and control group, non-RCTs, case reports, self-controlled studies, cross-sectional studies, reviews, animal experimental studies, qualitative research literature, RCTs not employing specified interventions of TCEs, articles not in Chinese or English, duplicate publications, and literature that did not measure the selected outcome.

Outcomes

Five outcomes were determined based on the assessment report published by the Academy of the American Physical Therapy Association and the RCTs included in this NMA (*Wang-Hsu & Abbott, 2021*). Primary outcomes included one static balance outcome, one dynamic balance outcome, and one overall balance outcome. Static balance outcome was assessed using the SLSC test. During this test, the participants closed their eyes, lifted one foot, and tried to keep balance for as long as possible. The durations they maintained this position were recorded (*Jonsson, Seiger & Hirschfeld, 2004*). SLSC reflects an individual's ability to maintain stable posture. Dynamic balance outcome was evaluated through the TUGT, which measured the total time taken for an individual to stand up from a seated position, walk three meters, turn around, and return to the chair (*Brett, 2023*). TUGT reflects the stability of an individual's gait during movement. Overall balance outcome was determined using the BBS (*Berg, 1989*; *Berg et al., 1992*; *Mathias, Nayak & Isaacs, 1986*), which comprised 14 questions assessing stability in various balance positions. Additionally, two auxiliary balance outcomes were assessed as secondary outcomes. The 6MWT measured lower limb flexibility by recording the distance participants could walk in 6 min (*ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories, 2002*). Finally, the SF-36PCS was used to evaluate the physical health status of participants (*Ware & Sherbourne, 1992*).

Quality evaluation

Review Manager (version 5.3; https://training.cochrane.org/online-learning/core-software/revman) was used to evaluate the quality of the included RCTs according to the Cochrane risk-of-bias tool (version 5.4; https://methods.cochrane.org/bias/risk-bias-tool). The bias risk assessment was conducted by one author and reviewed by another. For RCTs with disputes, a third author intervened, and a consensus was required for inclusion.

Statistical analysis

Microsoft Excel 2021 (Microsoft Corporation, Redmond, WA, USA) was employed as the primary tool for extracting the data from the screened literature. All data included in this

NMA were continuous variables and expressed as mean differences (MDs). Effect sizes and their 95% confidence intervals (CIs) were calculated with the significance level set at $p < 0.05$. This study did not form a closed loop, thus a consistency model was employed for the NMA. I^2, Q statistic and H statistic are mostly used criterion to assess heterogeneity. I^2 measures the percentage of variation across studies attributable to heterogeneity (*Higgins & Thompson, 2002*), which is a widely embraced metric in meta-analysis renowned for its straightforward assessment criterion. While both the Q statistic and the H statistic are more complicated, and their results may be affected by factors such as the number of studies and sample size. Therefore, this study used I^2 value to choose between a fixed-effects model and a random-effects model. When I^2 is low (<50%), indicating low heterogeneity, a fixed-effects model may provide more accurate estimates. Conversely, when I^2 is high (>50%), indicating substantial heterogeneity, a random-effects model is preferred as it can better account for variability between studies (*Kuan & Tam, 2015*). Pairwise comparisons among the five TCEs were conducted, and a league table was generated. Consistency was assessed by the difference in deviance information criterion (DIC) (*David & Pedro, 2017*). Forest plots serve as graphical tools in Meta-analysis for visually presenting statistical summary results, they clearly depict the effect sizes and their corresponding confidence intervals for each intervention compared to a control group. League tables are utilized for indirectly comparing the efficacy among various interventions. The surface under the cumulative ranking (SUCRA) is employed to rank the intervention effects. A funnel plot was used to assess publication bias in the included literature. Sensitivity analyses were performed to determine whether the risk of bias affected the effect estimates. All statistical analyses were conducted using STATA 15.0 (StataCorp, College Station, TX, USA) and R 4.2.3 (*R Core Team, 2022*) software.

RESULTS

Characteristics of the identified studies

A total of 2,392 articles were identified after initial screening. Through a stepwise selection process, 46 articles were included, with 31 and 15 articles in English, and Chinese, respectively (Fig. 1). The publication years ranged from 2005 to 2023, with 3,333 participants in total. Five TCEs were included: Baduanjin, Liuzijue, Tai Chi,Wuqinxi, and Yijinjing (Appendix C).

Risk of bias

This NMA included 46 RCTs, of which 31 detailed random sequence generation methods and 15 mentioned only random allocation. Given the nature of non-pharmacological interventions, none of the RCTs included in this study reported allocation concealment.

A total of 26 RCTs were single-blind, and these RCTs were blinded to the assessor. Despite participants dropping out in certain studies, the relevant study elaborated on attrition, including specific quantities and reasons. Moreover, missing values did not lead to a bias in the estimates. There is no significant bias in this NMA (Appendix D).

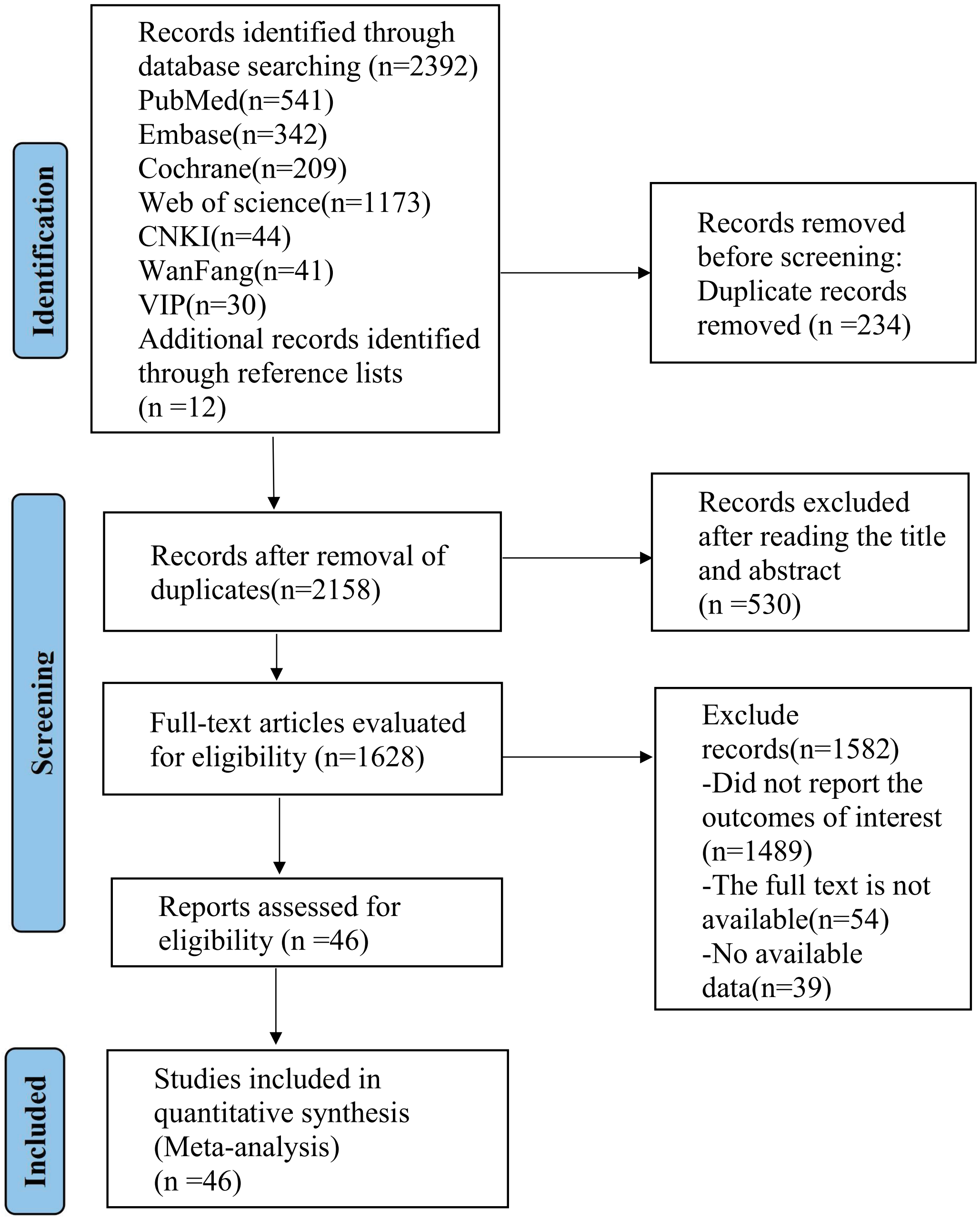

Figure 1 PRISMA flow chart of study selection. Full-size DOI: 10.7717/peerj.18512/fig-1

Network plot

The network plot shows which interventions have been compared directly in RCTs, and which can only be informed indirectly (Fig. 2).

The size of the nodes represents the sample size of each study, with larger circles indicating a larger number of participants for each intervention. The lines connecting the nodes show direct comparisons between interventions, with the thickness of the lines reflecting the number of studies that compare each pair of interventions. In terms of each outcome, TCEs were compared with control group. Among SLSC, TUGT, and BBS, most

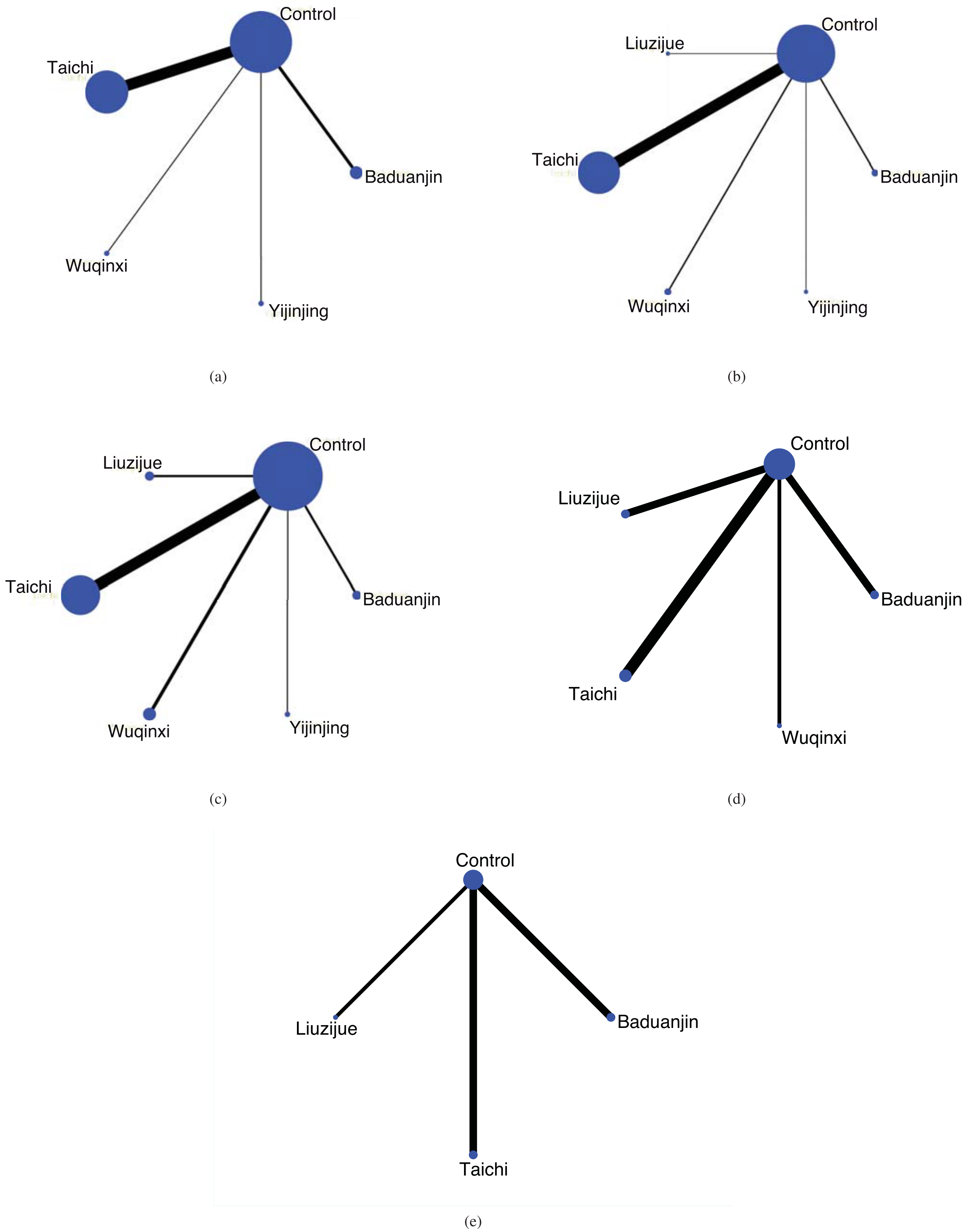

Figure 2 Network plot of comparing the efficacy on balance function of different TCEs. (A) SLSC, (B) TUGT, (C) BBS, (D) 6MWT, (E) SF-36PCS.

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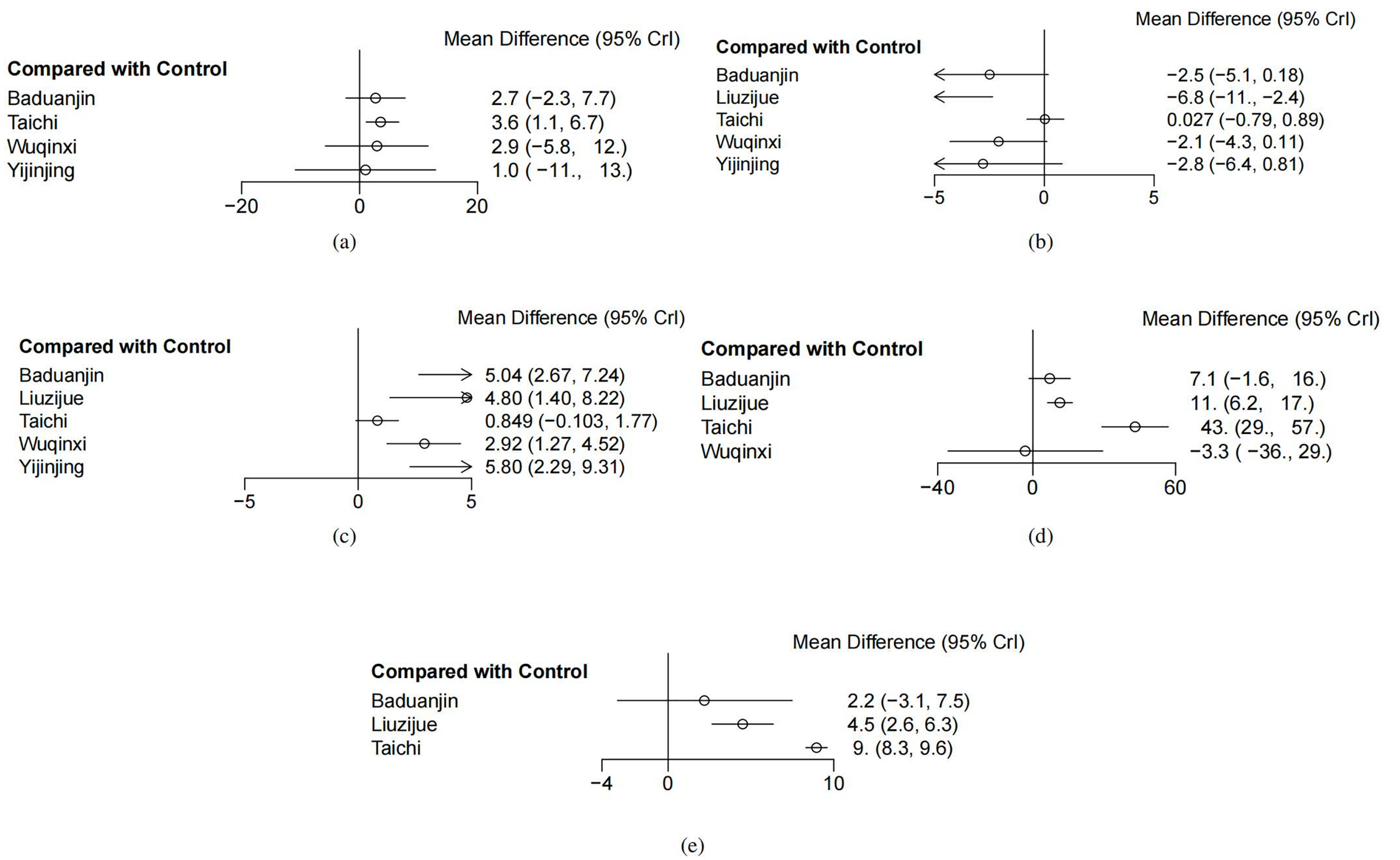

Figure 3 Forest plots of the effects of different TCEs compared to the control group. (A) SLSC, (B) TUGT, (C) BBS, (D) 6MWT, (E) SF-36PCS.
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studies focused on comparing Tai Chi with control group. For 6MWT and SF-36PCS, the numbers of comparative studies between different TCEs and control group were approximately similar.

Effects of five TCEs compared to control group

Forest plots present intervention effects of the five TCEs compared with the control group, illustrating their effect sizes across various outcomes, along with their respective confidence intervals (Fig. 3).

Primary outcomes: (1) **SLSC**. In total, 16 RCTs were related to SLSC with 1,045 participants. The intervention effect of Tai Chi (MD = 3.6, 95% CI [1.1–6.7]) was superior to the control group, with a statistically significant difference ($p < 0.05$). Baduanjin (MD = 2.7, 95% CI [−2.3 to 7.7]), Wuqinxi (MD = 2.9, 95% CI [−5.8 to 12.0]), and Yijinjing (MD = 1.0, 95% CI [−11.0 to 13.0]) had no statistically significant difference from the control group. (2) **TUGT**. Twenty-one RCTs were related to the TUGT, with 1,676 participants. Liuzijue (MD = −6.8, 95% CI [−11.0 to −2.4]) was significantly superior to the control group ($p < 0.05$). Baduanjin (MD = −2.5, 95% CI [−5.1 to 0.18]), Tai Chi (MD = 0.027, 95% CI [−0.79 to 0.89]), Wuqinxi (MD = −2.1, 95% CI [−4.3 to 0.11]), and

Yijinjing (MD =−2.8, 95% CI [−6.4 to 0.81]) had no statistically significant difference from the control group. (3) **BBS**. Eighteen RCTs were related to the BBS, with 1,516 participants. The intervention effects of Baduanjin (MD = 5.04, 95% CI [2.67–7.24]), Liuzijue (MD = 4.80, 95% CI [1.40–8.22]), Wuqinxi (MD = 2.92, 95% CI [1.27–4.52]), and Yijinjing (MD = 5.80, 95% CI [2.29–9.31]) were significantly superior to those in the control group ($p < 0.05$). Tai Chi (MD = 0.849, 95% CI [−0.103 to 1.77]) had no statistically significant difference from the control group.

Secondary outcomes: (1) **6MWT**. Seven RCTs were related to the 6MWT, with 522 participants. Among various TCEs, the intervention effects of Liuzijue (MD = 11.0, 95% CI [6.2–17.0]) and Tai Chi (MD = 43.0, 95% CI [29.0–57.0]) were significantly better than those in the control group ($p < 0.05$). Baduanjin (MD = 7.1, 95% CI [−1.6 to 16.0]) and Wuqinxi (MD = −3.3, 95% CI [−36.0 to 29.0]) had no statistically significant differences from the control group. (2) **SF-36PCS**. Five RCTs were related to the SF-36PCS, with 334 participants. The intervention effects of Liuzijue (MD = 4.5, 95% CI [2.6–6.3]) and Tai Chi (MD = 9.0, 95% CI [8.3–9.6]) differed significantly from those in the control group ($p < 0.05$). Baduanjin (MD = 2.2, 95% CI [−3.1 to 7.5]) had no statistically significant difference from the control group.

Comparison between different TCEs

The league table exhibits the relative effects among various TCEs, clearly indicating whether there are differences in intervention efficacy between these TCEs (Appendix E).

Primary outcomes: (1) **SLSC.** The Tai Chi group (MD = −3.57, 95% CI [−6.66 to −1.12]) was statistically superior to the control group ($p < 0.05$). (2) **TUGT.** The Liuzijue group (MD = 6.76, 95% CI [2.35–11.17]) was significantly better than the control group and was statistically different from the Tai Chi group and (MD = −6.79, 95% CI [−11.28 to −2.31]; $p < 0.05$). (3) **BBS.** The Baduanjin (MD = 5.04, 95% CI [2.67–7.24]), Liuzijue (MD = −4.8, 95% CI [−8.22 to −1.4]), Wuqinxi (MD = −2.92, 95% CI [−4.52 to −1.27]), and Yijinjing (MD = −5.8, 95% CI [−9.31 to −2.29]) groups were statistically superior to the control group ($p < 0.05$). The intervention effects in the Baduanjin (MD = 4.2, 95% CI [1.64–6.59]), Liuzijue (MD = 3.95, 95% CI [0.44–7.51]), Wuqinxi (MD = −2.08, 95% CI [−3.93 to −0.17]), and Yijinjing (MD = −4.96, 95% CI [−8.58 to −1.33]) groups were statistically superior to those in the Tai Chi group ($p < 0.05$).

Secondary outcomes: (1) **6MWT.** The Tai Chi group was superior to the Baduanjin group (MD = −35.93, 95% CI [−52.3 to −19.58]) and exhibited better results than the control group (MD = −42.98, 95% CI [−56.89 to −29.05]). The intervention effect in the Tai Chi group was better than that in the Liuzijue (MD = −31.61, 95% CI [−46.46 to −16.75]) and Wuqinxi (MD = 46.26, 95% CI [10.75–81.4]) groups. The intervention effect in the Liuzijue group (MD = −11.36, 95% CI [−16.58 to −6.2]) was statistically superior to that in the control group ($p < 0.05$). (2) **SF-36PCS.** The Tai Chi group (MD = −8.95, 95% CI [−9.59 to −8.32]) was statistically superior to the control group. The intervention effect in the Tai Chi group (MD = −4.45, 95% CI [−6.41 to −2.49]) was significantly superior to that in the Liuzijue group, while the Liuzijue group (MD = −4.5, 95% CI [−6.36 to −2.65]) was significantly superior the control group ($p < 0.05$).

Ranking of different TCEs

The surface under the cumulative ranking (SUCRA) line shows the percentage of effectiveness of each TCEs. The percentage represents the efficacy of each intervention, a large percentage indicates a more effective intervention (Fig. 4, Appendix F).

Primary outcomes: (1) **SLSC**. Tai Chi (71.7%) > Wuqinxi (58.7%) > Baduanjin (58.3%) > Yijinjing (42.0%) > control group (19.3%). (2) **TUGT**. Liuzijue (96.6%) > Yijinjing (63.1%) > Baduanjin (60.5%) > Wuqinxi (54.6%) > control group (13.1%) > Tai Chi (12.2%). (3) **BBS**. Yijinjing (84.5%) > Baduanjin (76.9%) > Liuzijue (72.2%) > Wuqinxi (45.5%) > Tai Chi (20.1%) > control group (0.9%).

Secondary outcomes: (1) **6MWT**. Tai Chi (99.8%) > Liuzijue (65.2%) > Baduanjin (46.8%) > Wuqinxi (22.2%) > control group (15.8%). (2) **SF-36PCS**. Tai Chi (99.7%) > Liuzijue (59.7%) > Baduanjin (33.4%) > control group (6.9%).

Publication bias analysis

The funnels of most studies were relatively evenly distributed on both sides (Appendix G). However, some asymmetry in the distribution was observed, possibly due to publication bias.

DISCUSSION

This study is the first NMA to compare the effectiveness of five TCEs in improving balance in older adults. Multiple balance outcomes—including static balance outcome, dynamic balance outcome, overall balance outcome, and auxiliary balance outcomes—were investigated.

Static balance outcome: SLSC

Tai Chi significantly improved SLSC, and ranked the highest. SLSC is intimately linked to the level of lower limb muscle strength in older adults (*Thongchoomsin et al., 2020*). As people age, their lower limb muscles tend to become stiff and weak, contributing to reduced balance (*Seene & Kaasik, 2012*). Tai Chi involves specific movements that require constant flexion and rotation of the knee joint, thereby enhancing balance by strengthening and conditioning the lower limbs (*Jiang, 2018*; *Liu, 2013*; *National Health Service England, 2024*). Moreover, studies have shown that Tai Chi significantly increases electromyographic activity in the gastrocnemius and rectus femoris and improves hip joint movement angles in the supporting leg (*Huang, 2016*; *Liu, 2013*). Therefore, Tai Chi has a better strengthening effect on the hamstrings and quadriceps than other exercises such as Wuqinxi and Baduanjin, thus helping improve static balance in older adults (*Liu, 2013*).

Additionally, the improvement in SLSC observed with Tai Chi can also be attributed to its positive effects on vestibular function (*McGibbon et al., 2005*). The vestibular organs play a crucial role in maintaining balance. Through long-term Tai Chi practice, balance receptors in these organs can be improved (*Lan et al., 2000*; *McGibbon et al., 2005*; *Tsang & Hui-Chan, 2006*), leading to reduced swaying during one-legged standing

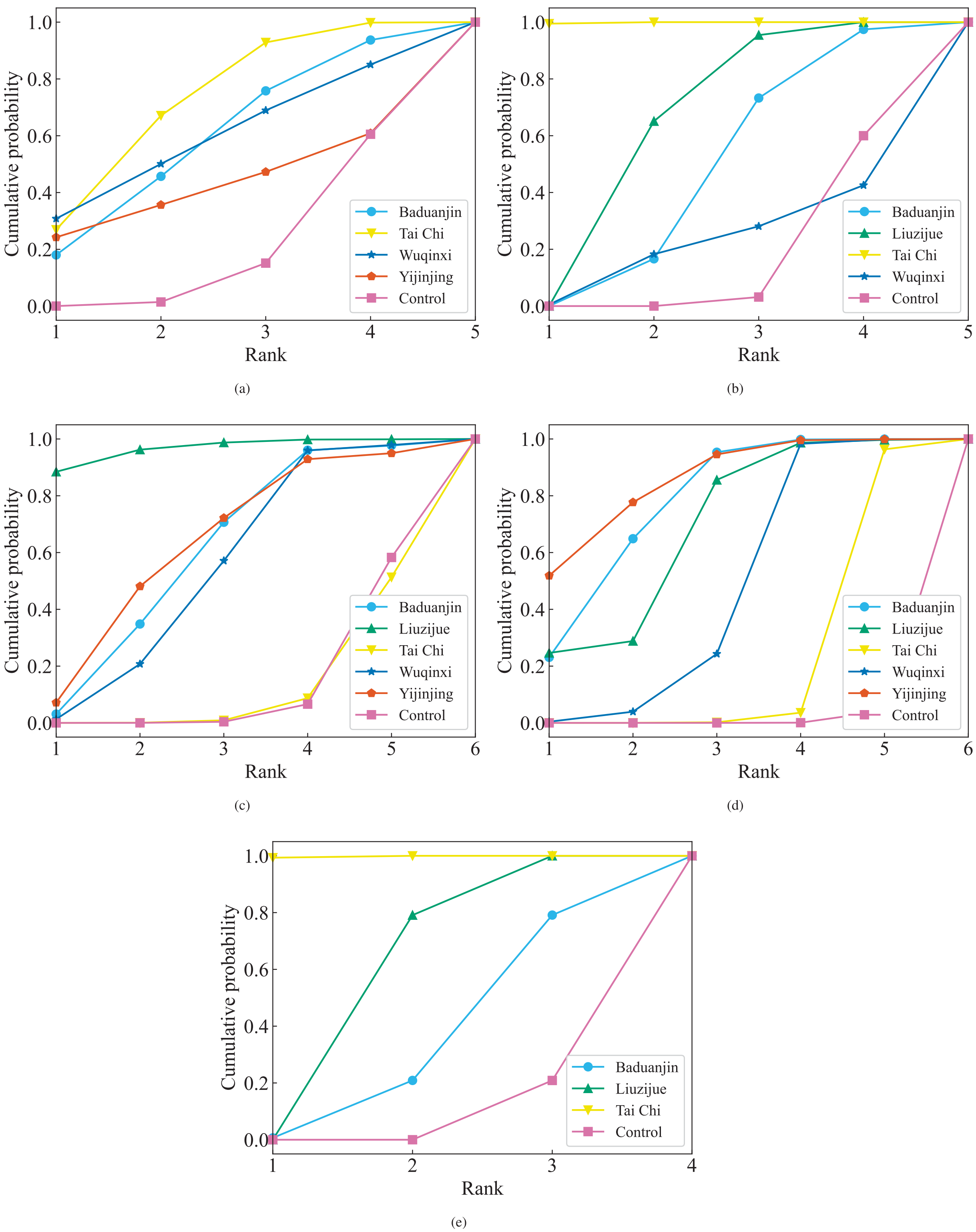

Figure 4 Ranking of different TCEs. (A) SLSC, (B) TUGT, (C) BBS, (D) 6MWT, (E) SF-36PCS. Full-size DOI: 10.7717/peerj.18512/fig-4

(*Pan et al., 2018*). In summary, Tai Chi offers a comprehensive approach to enhancing static balance (SLSC) in older adults by improving both muscle strength and vestibular function.

Dynamic balance outcome: TUGT

Among five TCEs, Liuzijue stood out as being significantly and positively correlated with TUGT performance, ranking the highest. The performance on the TUGT is contingent upon an individual's capacity for oxygen supply (*Physiopedia, 2022*). TUGT assesses the individual's ability to transition from a stationary state to a motor state, as well as their capacity for rapid movement, both of which necessitate robust oxygen supply (*Brett, 2023*). A robust oxygen supply capacity enables the rapid delivery of sufficient oxygen to the muscles, aiding older adults to swiftly complete the TUGT (*Zhang et al., 2016*). Unlike other TCEs, Liuzijue emphasizes breathing exercises which can not only improve respiratory efficiency but also increase the body's oxygen supply, subsequently boosting endurance and stability during walking (*Xiao & Zhuang, 2015*). Moreover, Liuzijue leads to more noticeable improvements in stride length among older adults (*Wu et al., 2021*). In addition, practicing Liuzijue can promote blood circulation, which effectively alleviates muscle fatigue and diminishes lactic acid accumulation, thereby enhancing both stability and endurance during walking (*Zhang et al., 2022*). Furthermore, the abdominal muscle exercises incorporated in Liuzijue specifically target the core musculature, thereby assisting older adults in maintaining both respiratory control and trunk stability during physical endeavors. Consequently, owing to the multifaceted advantages of the Liuzijue exercise, it exhibits a potent effect in enhancing dynamic balance (*Hu et al., 2022*).

Overall balance outcome: BBS

Yijinjing displayed a significant positive correlation with BBS, and ranked the highest. BBS accurately reflects an individual's overall balance ability. As a stretching-based exercise, Yijinjing can precisely promote muscle extension and contraction, thereby enhancing muscular flexibility (*Jin et al., 2011*). Improved flexibility enables more effective absorption and dispersal of movement impacts, ultimately reducing the risk of joint wear and injury (*Tang et al., 2023*), which is particularly beneficial for maintaining balance in older adults. Moreover, Yijinjing targets connective tissues such as joint capsules and ligaments, rendering them more pliable and elastic. The enhancement in tissue elasticity can not only bolster joint stability but also mitigate imbalance stemming from joint laxity (*Fang et al., 2020*). Compared with Tai Chi, Baduanjin, and Wuqinxi, Yijinjing contains a diverse range of lumbar exercises that can stimulate acupoints around the lumbar spine, which may enhance nerve function and blood circulation in that area. This stimulation can help alleviate tension and improve muscle flexibility, leading to better posture and stability (*General Administration of Sport of China, 2012*). Therefore, the overall balance and walking stability of older adults can be improved (*Yu, 2020*). In summary, unlike other TCEs that predominantly concentrate on either static or dynamic exercise, Yijinjing uniquely integrates static and dynamic balance training, subsequently enhancing the overall balance capabilities of older adults (*General Administration of Sport of China, 2012*).

Auxiliary balance outcomes: 6MWT and SF-36PCS

Tai Chi demonstrated superior efficacy and ranked the highest in enhancing both 6MWT and SF-36PCS scores. 6MWT measures walking distance, indirectly reflecting balance ability. Enhanced balance can stabilize individuals while walking, ultimately augmenting walking distance. Tai Chi's half squat action is superior to conventional walking in strengthening lower limb muscles, which is crucial for walking stability (*Zou et al., 2019*). Moreover, during Tai Chi practice, hip and ankle joint movements contribute to balancing the body's center of gravity, refining core control, minimizing swaying in older adults, and extending walking distance (*Yue et al., 2023*).

SF-36PCS measures physical health. Through gentle and sustained motions, Tai Chi can ease muscle tension throughout the body, alleviate pain, and enhance flexibility (*You et al., 2018*), potentially bolstering SF-36PCS. Compared to Wuqinxi, Baduanjin, and Yijinjing, Tai Chi can significantly reduce joint pain and stiffness and promote improved physical function (*Ge et al., 2017*).

Optional dose to improve balance

Currently, a consensus regarding the optimal duration and intensity of TCEs for balance improvement in older adults remains elusive. There are significant differences due to age, health status, gender, and other factors. A study suggested that 45–149 min of TCEs per week had a positive effect on balance (*Wang et al., 2020*). Moreover, one RCT found that three 30-min TCEs sessions per week over 8 weeks, totaling 150 min weekly, also enhanced balance (*Yuen et al., 2021*). In addition, some scholars recommended a 12-week program of 30–35-min of low-intensity TCEs sessions five times a week to improve balance (*Zhao et al., 2022*). Despite the presence of variations, the majority of scholars advocate engaging in TCEs for a duration of 30–60 min. Notably, TCEs are typically classified as low-to-moderate intensity aerobic activities (*Duan et al., 2024*; *Liu et al., 2024*; *Ma et al., 2022*), which impose minimal demands on heart rate and ratings of perceived exertion (*Corliss, 2023*), thereby making them an optimal choice for both healthy and frail older adults.

Clinical implication

This study holds several pivotal clinical implications. Firstly, as evidenced by improved performance in SLSC, TUGT, BBS, 6MWT, and SF-36PCS, five TCEs could enhance multiple balance outcomes in older adults to diminish the risk of accidents. In particular, Tai Chi, Liuzijue, and Yijinjing exhibited the most significant improvements in static and dynamic balance in older adults. Secondly, TCEs, with their gentle nature, are particularly well-suited for older adults or those with limited athletic abilities. In light of the positive impact of various TCEs on balance improvement in this population, healthcare providers ought to engage in discussions with patients regarding exercise modalities, aiming to personalize exercise plans accordingly.

Limitations

This NMA had some limitations. First, during literature retrieval, only Chinese and English databases were searched, potentially introducing a language bias. Secondly, the RCTs encompassed within this NMA exhibited variations in terms of sample size, intervention duration, frequency, and exercise intensity, potentially contributing to heterogeneity. For instance, the longer the duration of the intervention, combined with higher frequency and intensity, tended to yield more pronounced effects. Third, this NMA focused exclusively on five balance function outcomes. Although these selected outcomes are representative, they do not preclude the exploration of additional crucial outcomes to elucidate balance ability in future studies. Additionally, the NMA included only RCTs, and the number of participants was relatively small. Finally, finding RCTs that directly compare different TCEs is difficult, and the lack of direct comparisons among various TCEs is a limitation.

CONCLUSIONS

The aforementioned TCEs had positive effects on improving balance in older adults. Tai Chi, Liuzijue, and Yijinjing best improved the static, dynamic, and overall balance outcomes, respectively. Tai Chi revealed significant intervention effects in the SLSC, 6MWT, and SF-36PCS. Liuzijue significantly improved the TUGT, BBS, 6MWT, and SF-36PCS. Meanwhile, Baduanjin, Wuqinxi, and Yijinjing showed noteworthy intervention effects on the BBS. Tai Chi ranked highest in the SLSC, 6MWT, and SF-36PCS, while Liuzijue and Yijinjing ranked highest in the TUGT and BBS, respectively. Therefore, older adults can make reasonable choices regarding TCEs based on their health status and needs. Moving forward, the validation of these results can be strengthened by the application of more rigorous research methodologies.

ADDITIONAL INFORMATION AND DECLARATIONS

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Author Contributions

- Jingyi Xie conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the article, and approved the final draft.
- Jindong Guo conceived and designed the experiments, performed the experiments, prepared figures and/or tables, and approved the final draft.
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