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Baduanjin Exercise for Frailty Management in Frail or Prefrail Older Adults: A Systematic Review and Meta-Analysis

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ABSTRACT

Introduction: This systematic review and meta-analysis evaluated the effects of Baduanjin, a traditional Chinese mind-body exercise, on frailty and multidimensional health outcomes in older adults.

Methods: Following PRISMA guidelines, we systematically searched multiple databases for RCTs on Baduanjin in frail adults aged ≥60 years. Data were pooled using fixed- or random-effects models to calculate MDs or SMDs with 95% CIs. Heterogeneity was quantified by the I^2 statistic, with random-effects models applied if $I^2 > 50\%$. Publication bias was assessed by funnel plots and Egger's test, with the trim-and-fill method used for adjustment when indicated.

Results: Fifteen RCTs (n = 1,044) were included. Baduanjin significantly reduced frailty severity (SMD = -1.12; 95% CI: -1.59 to -0.65) and improved physical function outcomes, including grip strength (MD = 2.39 kg, 95% CI: 2.17 to 2.62, $P < 0.001$), 6-minute walking distance (MD = 33.72 m; 95% CI: 12.47 to 54.97), and short-distance walk time, although the pooled effect (MD = -0.31 s; 95% CI: -0.57 to -0.06) was moderated by test distance with significant heterogeneity. Mental health improvements encompassed reduced anxiety/depression (SMD = -0.73; 95% CI: -1.11 to -0.35) and enhanced sleep quality (MD = -2.48; 95% CI: -3.21 to -1.76). Cognitive function (MMSE: MD = 2.81; 95% CI: 0.11 to 5.51) showed a statistically significant improvement, though with wide confidence intervals. Quality of life (SF-12/SF-36: SMD = 0.75; 95% CI: 0.48 to 1.02) also improved significantly.

Conclusion: Despite methodological limitations in the included trials, pooled evidence suggests that Baduanjin may confer clinical benefits for managing frailty in older adults. Given its simplicity, safety, and adaptability, Baduanjin should be considered for integration into standard geriatric care and community health programs.

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INTRODUCTION

Frailty is characterized by a substantial depletion of physiological reserves and a disruption of homeostasis in older adults, meaning that even minor stressors can precipitate the occurrence of numerous adverse events (1). Affecting millions globally (2), frailty is recognized as the most common cause of mortality in this population (3) and serves as a precursor to various complications, including falls (4), fractures (5), loss of cognitive function (6), functional disability (7), and premature death (8). Frailty profoundly diminishes quality of life (9) and exhibits synergistic interactions with chronic diseases (10) and polypharmacy (11), thereby accelerating health deterioration. Furthermore, its psychosocial ramifications encompass depression (12), social isolation (13), and sleep disturbances (14).

Emerging evidence suggests that targeted interventions may attenuate frailty progression and partially restore physiological resilience (15), highlighting the critical importance of early detection and multimodal management. Among these interventions, studies predominantly from Chinese populations indicate that Baduanjin may offer benefits in disease prevention, clinical treatment, and rehabilitation (16). Its characteristic slow movements engage multiple muscle groups while improving postural stability (17,18). The gentle stretching inherent in Baduanjin practice has been shown to alleviate joint pain in older populations (19). Furthermore, research supports its multidimensional clinical value, including cardiovascular enhancement (20), pulmonary function improvement in chronic obstructive pulmonary disease (COPD) patients (21), and glycemic control optimization in diabetes management (22,23). Notably, regular Baduanjin practice is associated with measurable mental health benefits, particularly in reducing anxiety and depressive symptoms among older adults (24,25). Additionally, neurocognitive studies indicate its potential to enhance executive function (26) and ameliorate sleep disturbances (27,28).

Pharmacological interventions have shown limited efficacy in managing frailty in clinical settings. In contrast, long-term, low-intensity exercise represents a particularly effective non-pharmacological strategy (29). Although resistance training can significantly mitigate frailty (30), it has limited applicability for frail older adults due to safety concerns and adherence challenges. Moreover, most exercise programs proven to improve frailty are hospital-based (31), with time commitments and medical costs constituting significant barriers to participation. Baduanjin is simple, easy to learn, suitable for long-term home or community-based practice (32), and is associated with a low risk profile. Typically, only mild, transient muscle soreness has been reported (33). Given its accessibility and favorable safety profile, Baduanjin represents a promising intervention to promote health in frail older adults.

Despite the growing popularity of Baduanjin as a geriatric intervention, the current evidence base remains fragmented. Recent meta-analyses have largely focused on physical function in non-frail community dwellers (34, 35) or the specific subtype of cognitive frailty (36). Consequently, the efficacy of Baduanjin for physical frailty syndrome remains unsynthesized. This syndrome is a distinct clinical state characterized by sarcopenia, exhaustion, and vulnerability to stressors. This study aims to bridge this gap, providing clinicians with reliable, population-specific data to guide prescriptions for frail older adults.

METHOD

Search Strategy

The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. It was registered prior to the study with the Prospective Registry of International Systematic Reviews (PROSPERO) (registry number: CRD420251004822). We searched international databases (PubMed, Scopus, Web of Science, Cochrane Library, EMBASE, CINAHL, MEDLINE) and Chinese databases (China National Knowledge Infrastructure, Wanfang Data and China Biomedical Literature Database) for studies published from January 1, 2015, to January 1, 2025. The search strategy combined Medical Subject Headings (MeSH) terms and free-text keywords using Boolean operators (AND, OR), targeting the following three domains: Frailty ("Frailty" OR "Frailty Syndrome" OR "Debility" OR "Frail Elderly" OR "Frailness" OR "Frail"), Intervention ("Baduanjin" OR "Eight Brocade" OR "Eight-Section Brocade" OR "Eight Brocade Qigong" OR "Traditional Chinese Exercise" OR "Traditional Chinese Qigong"), Study design ("Randomized Controlled Trial" OR "Randomized Controlled Trials"). Two reviewers (G.Y. and W.G.F.) independently performed title and abstract screening, resolving discrepancies through consensus discussions involving the third reviewer (L.B.). Full-text articles meeting predefined inclusion criteria were subjected to standardized data extraction and quality assessment

using the Cochrane Risk of Bias Tool for Randomized Trials (RoB 2.0). The complete search syntax is provided in Appendix 1.

Inclusion criteria

Study Design

This meta-analysis exclusively included randomized controlled trials (RCTs). Studies were excluded if they were review articles, conference abstracts, study protocols, qualitative research, or pre-post studies lacking a control group.

Types of Participants

Eligible participants were adults aged 60 years and older with a confirmed diagnosis of frailty. Frailty was defined using validated assessment tools, such as the Fried Frailty Phenotype (FP), Frailty Index (FI), or other standardized instruments (e.g., Clinical Frailty Scale [CFS], Tilburg Frailty Indicator [TFI]).

Types of Intervention

Intervention group: Participants received Baduanjin exercise as the sole exercise intervention, with a duration of ⩾8 weeks. Co-interventions incorporating non-exercise elements (e.g., health education, nutritional counselling) were allowed.

Control group: Participants did not receive Baduanjin or any structured exercise interventions. They could continue routine non-exercise care (e.g., pharmacological treatments, dietary support) consistent with standard clinical practice.

Types of Outcome Measures

Primary outcome: Frailty status was evaluated using validated tools, including the FP, FI, CFS, and TFI.

Secondary outcomes: Physical function, psychological outcomes, quality of life, sleep quality, and cognitive function.

Data extraction

Data extraction was performed using a standardized form covering study characteristics (first author, publication year, location), participant characteristics (baseline health status, sample size, sex distribution, mean age, and age range), intervention details (setting, specific components, provider qualifications, control protocol, frequency, and duration), and outcome measures (primary and secondary outcomes). We contacted corresponding authors via email to request missing data; if the data remained unavailable, the study was excluded from the relevant meta-analysis. Extracted data were recorded in Microsoft Excel and imported into Review Manager (RevMan) version 5.4. Two reviewers (Z.J.Q. and L.Z.C.) independently extracted the data and cross-checked the results for consistency.

Data analysis

Statistical analyses were primarily performed using Review Manager 5.4. For continuous outcomes, the weighted mean difference (MD) was calculated when measurement scales were consistent across studies, whereas the standardized mean difference (SMD) was used when measurement scales varied. Both were reported with 95% confidence intervals (CIs). Statistical heterogeneity was assessed using the Chi^2 test and the I^2 statistic. A fixed-effects model was applied when heterogeneity was not significant ($P > 0.10$ and $I^2 < 50\%$); otherwise, a random-effects model was adopted. To explore potential sources of heterogeneity, we performed subgroup analyses based on a priori selected variables derived from clinical characteristics and literature review. Furthermore, Stata 18.0 was employed to assess publication bias through funnel plots and Egger's test. If significant bias was detected, the trim-and-fill method was used to adjust the pooled results.

Risk of Bias Assessment

The risk of bias in all included studies was independently evaluated by two reviewers (G.Y. and W.G.F.) using the Revised Cochrane risk-of-bias tool for randomized trials (RoB 2) (37). The assessment covered five

domains: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of the outcome, and bias in selection of the reported result. Each domain was graded as 'low risk,' 'some concerns,' or 'high risk' of bias. Any discrepancies between the two reviewers were resolved through discussion or adjudicated by a third reviewer (L.B.). Results were synthesized and visualized using RevMan version 5.4, including risk-of-bias graphs and summary figures.

RESULTS

Results of the literature search

A systematic literature search across ten databases and registries initially identified 201 records, including Cochrane Library (n=13), CINAHL (n=2), CNKI (n=48), CBM (n=43), Embase (n=3), Medline (n=13), PubMed (n=8), Scopus (n=11), Web of Science (n=14), and Wanfang (n=46). After removing 109 duplicates, 92 unique records underwent title and abstract screening, resulting in the exclusion of 57 irrelevant studies. Thirty-five full-text articles were then assessed for eligibility. Twenty studies were excluded for the following reasons: non-randomized design (n=11), combined interventions with other exercise therapies (n=3), non-elderly populations (n=2), absence of a control group (n=2), and undefined frailty criteria (n=2). Ultimately, fifteen RCTs met the inclusion criteria and were included in the meta-analysis (Figure 1).

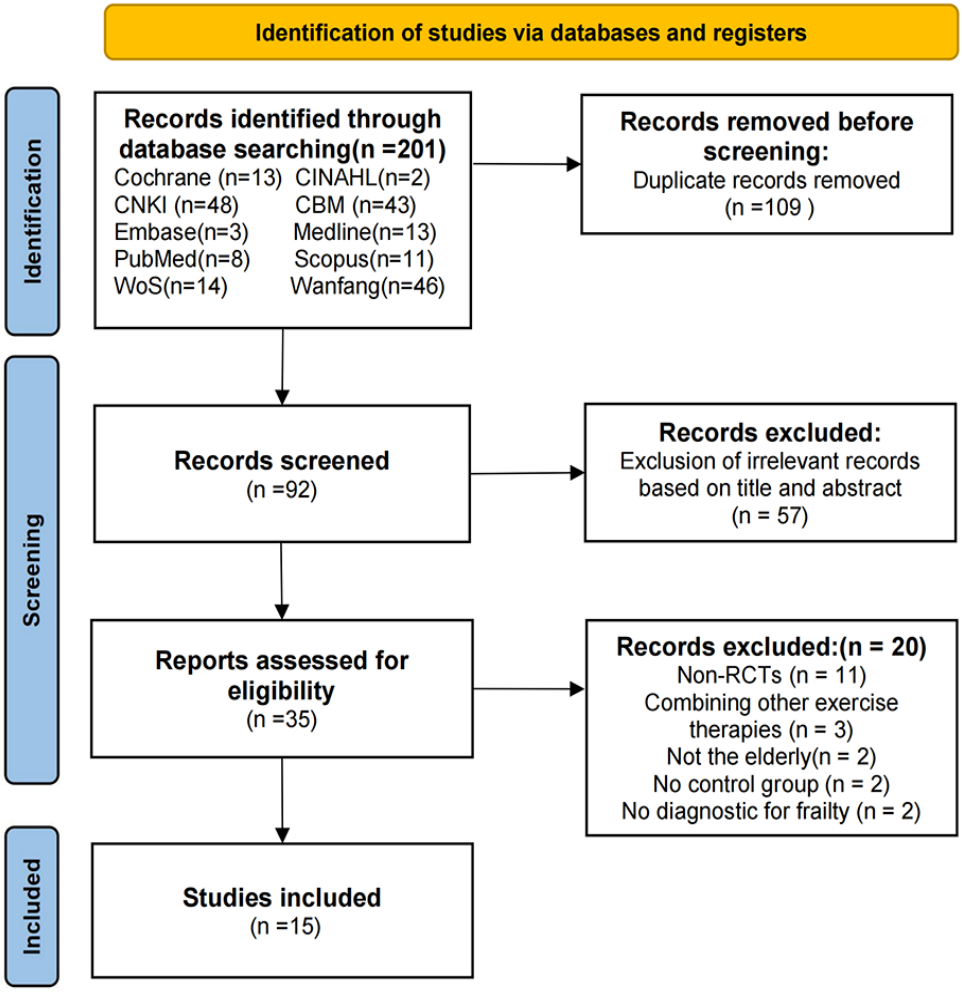

Figure 1. PRISMA Search Strategy

Characteristics of the included studies

This study included 15 RCTs involving 1,044 participants (32,38-51), all conducted in China (Appendix 2). The mean age of participants ranged from 62.9 to 85.3 years. Recruitment settings included nursing homes, healthcare institutions, and community-based home care. Intervention providers included certified Baduanjin instructors, clinical healthcare professionals, and researchers. The experimental group interventions centered on traditional Baduanjin exercises (including seated modified versions), with 5 studies (38-40,44,45) employing combined interventions integrating Baduanjin with herbal decoctions, music therapy (40), acupoint massage (44), and health education (39). Control interventions included health education (n=12), low-intensity exercise (n=2) (48,49), and music therapy (40). Intervention durations ranged from 12 to 24 weeks, with 12 weeks being the most frequent duration.

Training frequency ranged from 2 to 7 sessions per week, with durations of 30 to 60 minutes per session; the most common regimen was three 60-minute sessions weekly. Primary endpoints were evaluated using internationally recognized frailty assessment tools, including the FI, FP, TFI, Comprehensive Frailty Assessment Instrument (CFAI), and Edmonton Frailty Scale (EFS). Secondary endpoints encompassed multidimensional health indicators: Physical function was assessed using the grip strength test, 6-minute walk test (6MWT), 4.5-meter or 6-meter walk time tests, Timed Up-and-Go Test (TUGT), Five-Times Sit-to-Stand Test (FTSST), and One-Leg Standing Test (OLST). Psychological status across the included studies was assessed using validated instruments such as the Self-Rating Depression Scale (SDS), Hospital Anxiety and Depression Scale (HADS), Geriatric Depression Scale (GDS), and the Hamilton Anxiety and Depression Rating Scales (HAMA/HAMD). Cognitive function was assessed using the Mini-Mental State Examination (MMSE). To evaluate quality of life, researchers employed standardized questionnaires including the SF-36 and SF-12 health surveys, the WHOQOL-BREF, and the EQ-5D-5L. For condition-specific assessments, the EORTC QLQ-C30 was used among cancer patients, while individuals with heart failure were evaluated using the Minnesota Living with Heart Failure Questionnaire (MLHFQ). Sleep quality was commonly measured via the Pittsburgh Sleep Quality Index (PSQI). All studies provided clear inclusion criteria and consistently reported no adverse events.

Risk of Bias Assessment

The risk of bias for the 15 included RCTs was assessed using the RoB 2 tool (Figure 2). Ultimately, all 15 studies were classified as having an overall 'high risk' of bias. This rating was predominantly driven by Domain 2 (Deviations from intended interventions). Specifically, the blinding of participants and personnel was assessed as 'high risk' across all trials. Due to the nature of Baduanjin exercise, which requires conscious participant engagement and instructor guidance, blinding is operationally impracticable. This represents an inherent methodological challenge common to non-pharmacological movement therapy research rather than a specific design flaw.

Other domains presented varying degrees of concern. Regarding Domain 1 (Randomization process), only three trials (32,45,49) adequately reported computer-generated randomization sequences with allocation concealment. The remaining studies lacked sufficient methodological detail, resulting in a judgment of 'some concerns.' Domains 3 (Missing outcome data) and 4 (Measurement of the outcome) were also frequently rated as 'some concerns.' This was primarily due to ambiguous reporting on missing data management and a heavy reliance on unblinded, patient-reported outcome measures (used in over 80% of trials). Finally, Domain 5 (Selection of the reported result) was judged to be 'low risk' across all studies, with no evidence of selective reporting detected.

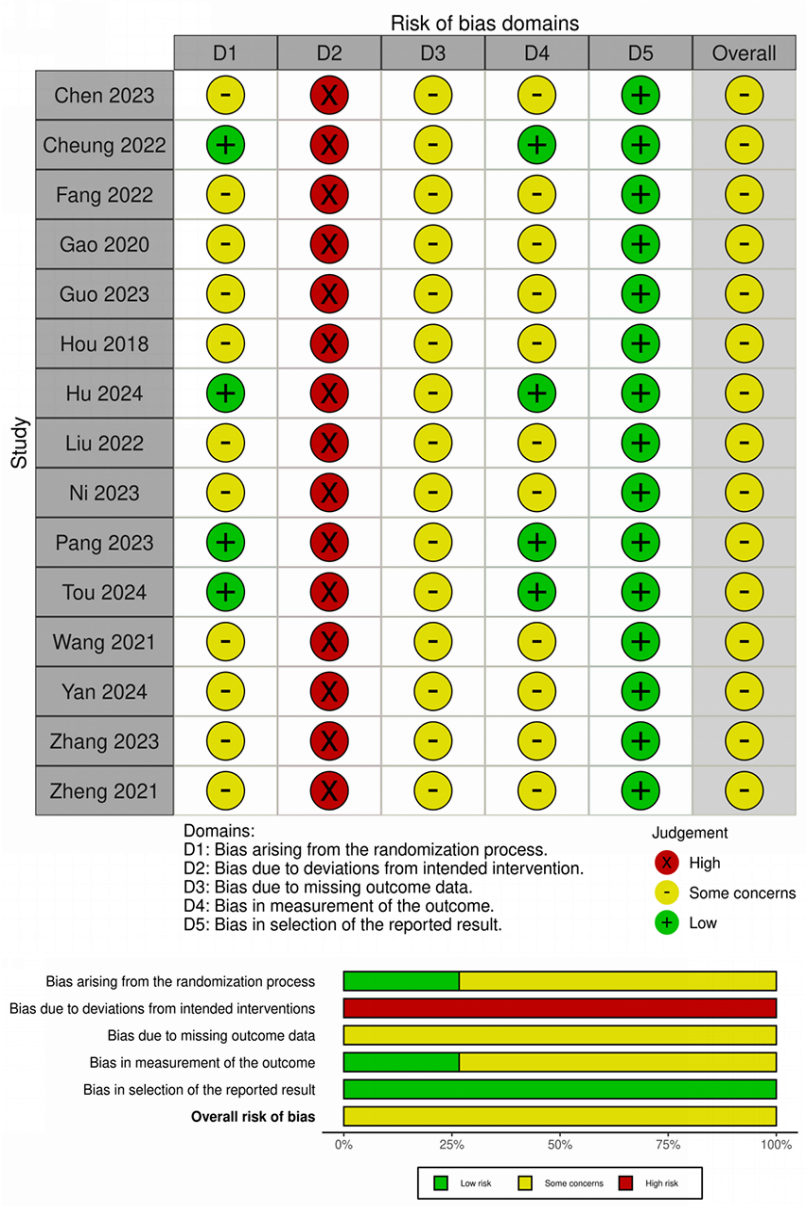

Figure 2. RoB 2.0 traffic light and summary plots of Baduanjin exercise RCTs

Meta-analysis results

Effect of Baduanjin Exercise on Frailty Status

A meta-analysis of 14 RCTs (32,38,40-51) (n = 948) evaluated the effects of Baduanjin on frailty (Figure 3A). The pooled results demonstrated that Baduanjin intervention significantly reduced frailty severity compared with control groups (SMD = -1.12; 95% CI: -1.59 to -0.65; $P < 0.001$). However, substantial heterogeneity was observed ($I^2 = 91\%$, $P < 0.001$), reflecting considerable variation across studies that warranted further investigation through subgroup analyses.

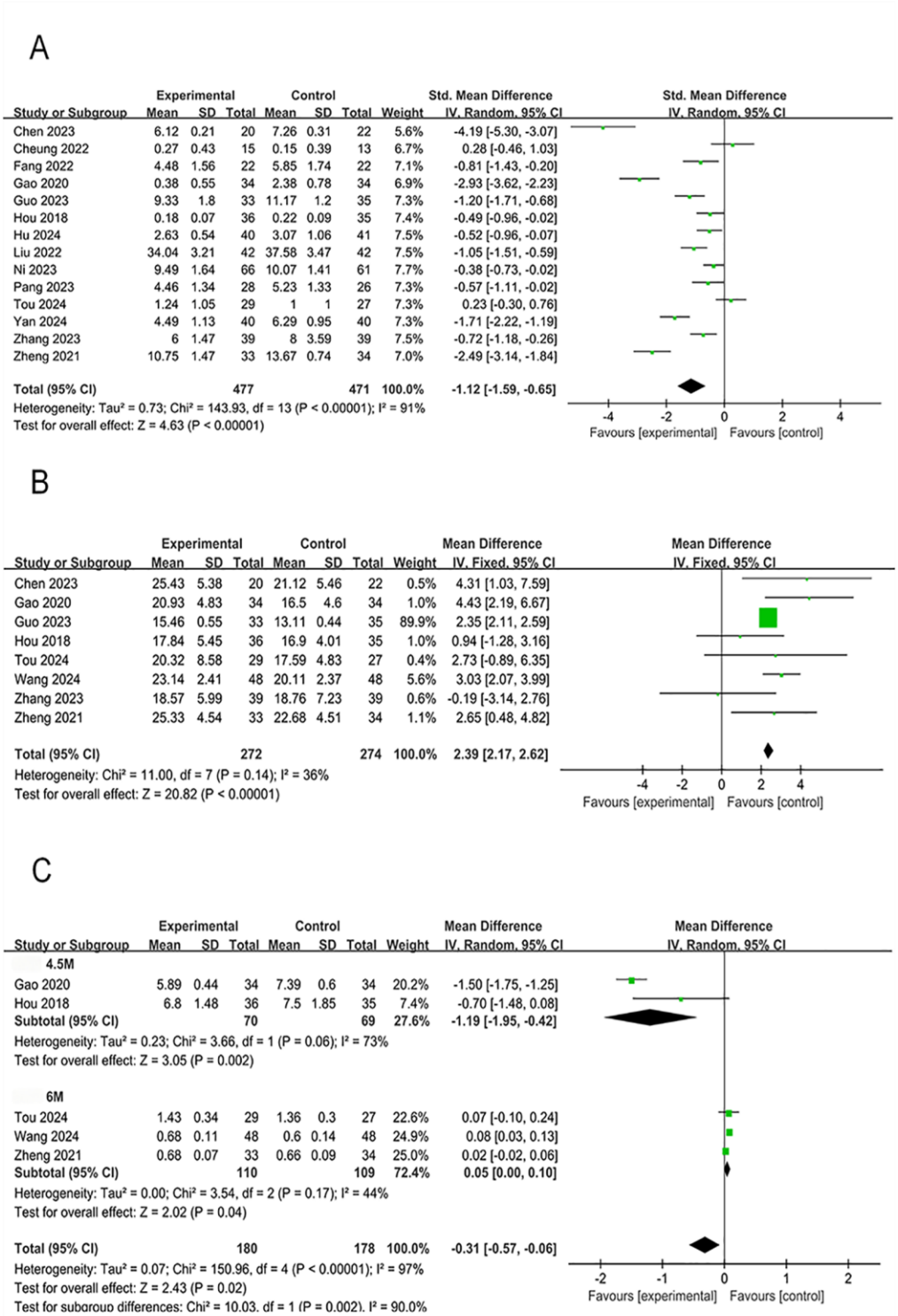

Figure 3. Forest plots of frailty status and physical function outcomes. (A) Frailty status score. (B) Grip strength. (C) Walking time (4.5-meter or 6-meter).

Subgroup Analysis of Baduanjin Exercise on Frailty

Subgroup analyses (Figure 4) identified intervention duration as the only significant moderator (P = 0.03). Benefits were significant for interventions ≤ 12 weeks (SMD = -1.37, P < 0.001) but not for those >12 weeks (P = 0.67). No significant heterogeneity was found for intervention type (P = 0.14), setting (P = 0.68), age (P = 0.39), or measurement tool (P = 0.81). However, within-group analyses revealed that significant improvements were restricted to institutional settings (hospitals/nursing homes) and participants aged 60–80 years, with no significant effects observed in home-based settings or the oldest-old (80–90 years). Similarly, while multidimensional tools (CFAI, TFI) detected significant changes (P ≤ 0.0001), physical frailty measures (FP, FI) did not yield statistically significant results.

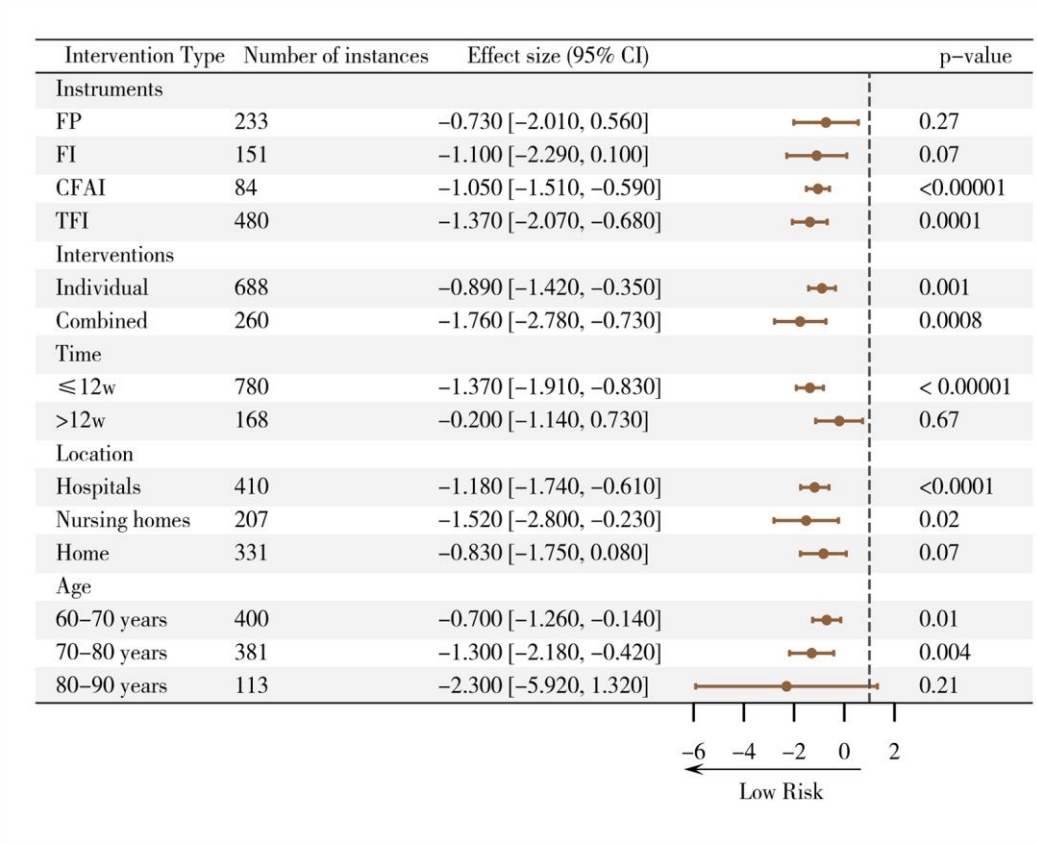

Figure 4. Forest plot of Frailty Score Subgroup Analysis

Effect of Baduanjin on Grip Strength

A meta-analysis of 8 RCTs (32,38,39,41,43,47,48,51) (n = 546) demonstrated that Baduanjin training significantly improved grip strength (MD = 2.39 kg, 95% CI: 2.17 to 2.62, P < 0.001) with low between-study heterogeneity (I^2 = 36%, P = 0.14) (Figure 3B).

Effects of Baduanjin on Short-Distance Walk Time

Pooled analysis of 5 RCTs (n = 358) indicated a reduction in walk time (MD = -0.31 s; 95% CI: -0.57 to -0.06; P = 0.02) (Figure 3C). However, significant heterogeneity was explained by the test distance (interaction P = 0.002; I^2 = 90%). Specifically, Baduanjin significantly reduced completion time for the 4.5-meter walk (MD = -1.19 s; 95% CI: -1.95 to -0.42; P = 0.002) (47,48), whereas a marginal increase was observed for the 6-meter walk (MD = 0.05 s; 95% CI: 0.00 to 0.10; P = 0.04) (32,39,41).

Effects of Baduanjin on 6-Minute Walk Distance(6MWD)

Pooled analysis of 4 RCTs (n = 249) demonstrated a significant improvement in functional exercise capacity (MD = 33.72 m; 95% CI: 12.47 to 54.97; P = 0.002; Figure 5A), though substantial heterogeneity was present (I^2 = 77%; P = 0.004). Sensitivity analysis identified one study (Pang et al., 2023) as the source of variation; its exclusion eliminated heterogeneity (I^2 = 0%; P = 0.40) while confirming a robust positive effect (MD = 20.08 m; 95% CI: 10.29 to 29.88; P < 0.0001; Figure 5B).

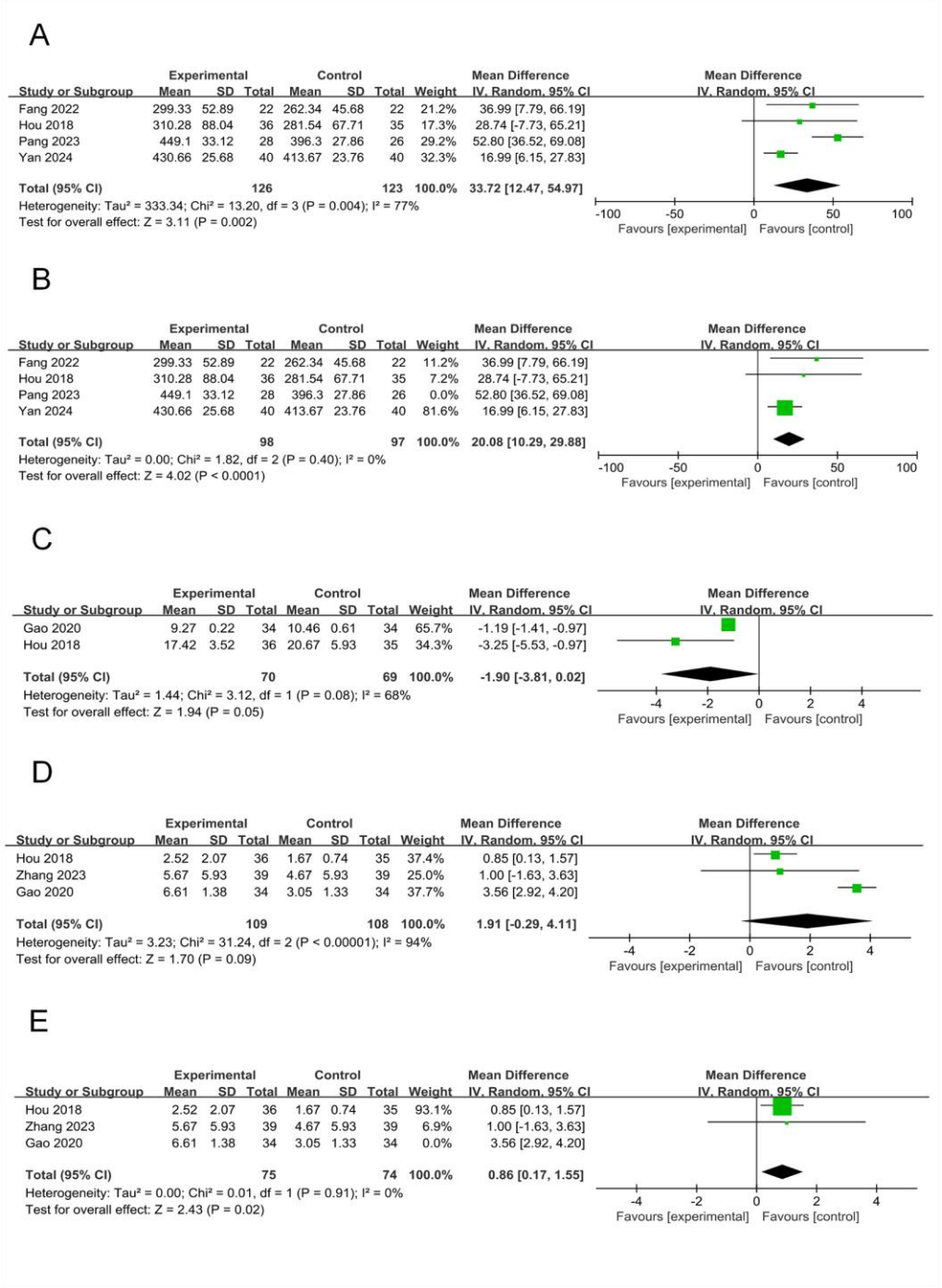

Figure 5. Forest plots representing the meta-analysis of functional test scores. (A) 6-minute walk distance (6MWD). (B) Sensitivity analysis of 6MWD. (C) Five-times-sit-to-stand test (FTSST). (D) One-leg standing test (OLST). (E) Sensitivity analysis of OLST.

Effects of Baduanjin on FTSST

A meta-analysis of 2 RCTs (47,48) (n = 139) suggested that Baduanjin training may improve lower extremity function (Figure 5C), showing a non-significant trend towards reduction in FTSST completion time (MD = -1.90 s, 95% CI: -3.81 to 0.02, P = 0.05) with moderate heterogeneity (I^2 = 68%, P = 0.08).

Effects of Baduanjin on OLST

A meta-analysis of 3 RCTs (43,47,48) (n = 217) initially showed no significant improvement in OLST (MD = 1.91 s, 95% CI: -0.29 to 4.11, P = 0.09) with substantial heterogeneity (I^2 = 94%, P < 0.001) (Figure 5D). Sensitivity analysis identified one study (47) as the primary source of variation. Its exclusion eliminated heterogeneity (I^2 = 0%; P = 0.91) and revealed a statistically significant improvement in balance (MD = 0.86 s; 95% CI: 0.17 to 1.55; P = 0.02; Figure 5E).

Effects of Baduanjin on TUGT

Pooled analysis of 3 RCTs (32,47,48) (n = 195) revealed no statistically significant reduction in TUGT completion time (MD = -1.58 s; 95% CI: -3.33 to 0.18; P = 0.08; Figure 6A). Substantial heterogeneity was observed across the included studies (I^2 = 85%).

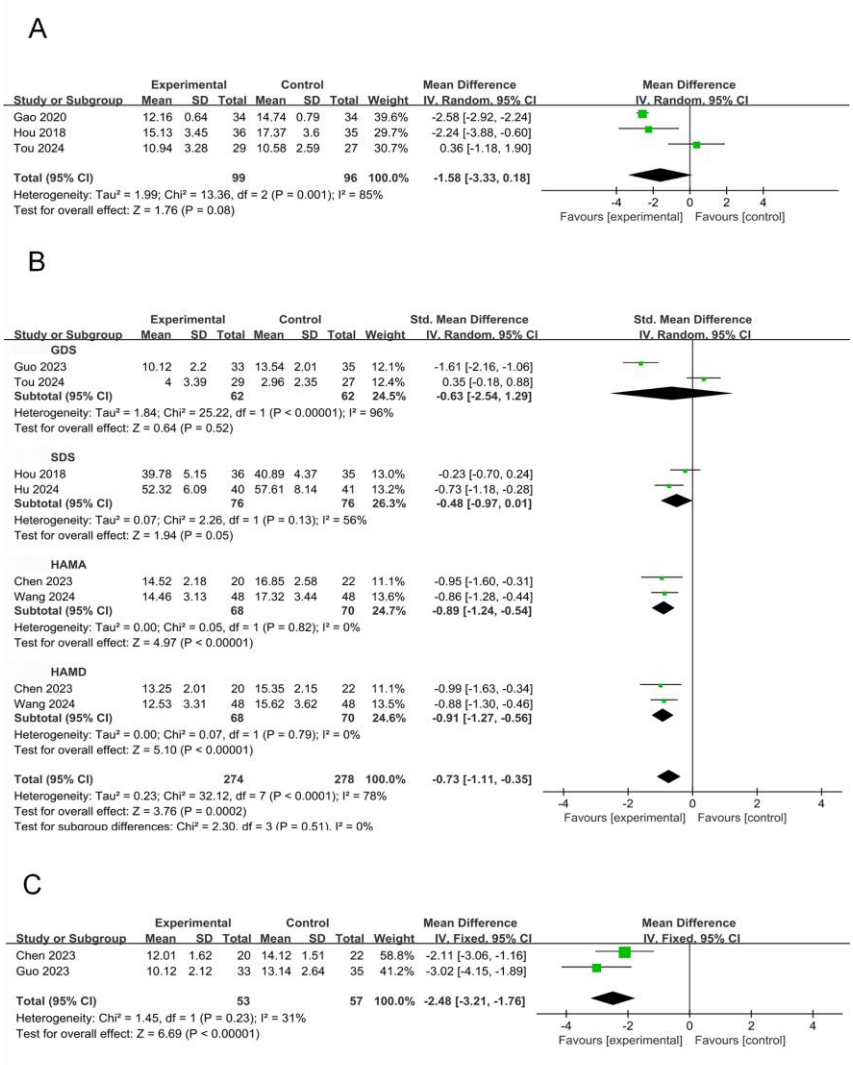

Figure 6. Forest plots of functional mobility and neuropsychiatric outcomes. (A) Timed Up and Go Test (TUGT). (B) Anxiety and depression scores. (C) Pittsburgh Sleep Quality Index (PSQI).

Effect of Baduanjin on Anxiety and Depression Scores

Pooled analysis of eight RCTs (n = 552) demonstrated that Baduanjin significantly alleviated symptoms of emotional distress (SMD = -0.73; 95% CI: -1.11 to -0.35; P = 0.0002; Figure 6B), though substantial heterogeneity was present (I^2 = 78%). Subgroup analyses by assessment scale revealed distinct patterns of consistency. Significant and homogenous benefits were observed in trials utilizing the HAMA (38,39) (SMD = -0.89; I^2 = 0%; P < 0.001) and HAMD (38,39) (SMD = -0.91; I^2 = 0%; P < 0.001). In contrast, results for the GDS (32,51) and SDS (42,48) did not reach statistical significance (P = 0.52 and P = 0.05, respectively) and exhibited moderate-to-extreme heterogeneity (I^2 = 56% – 96%). The test for subgroup differences was not statistically significant (P = 0.51).

Effect of Baduanjin on PSQI Scores

A meta-analysis of 2 RCTs (38, 51) (n = 110) assessed sleep quality using PSQI (Figure 6C). Low heterogeneity was observed between studies (I^2 = 31%, P = 0.23). Baduanjin significantly reduced PSQI scores (MD = -2.48, 95% CI: -3.21 to -1.76; P < 0.001), indicating improved sleep quality.

Effects of Baduanjin on MMSE Scores

A meta-analysis of 2 RCTs (48,51) (n = 139) evaluated Baduanjin's effect on MMSE scores (Figure 7A). Results indicated a marginally significant improvement (MD = 2.81, 95% CI: 0.11 to 5.51; P = 0.04), however, the analysis was limited by extreme heterogeneity (I^2 = 93%, P = 0.0002).

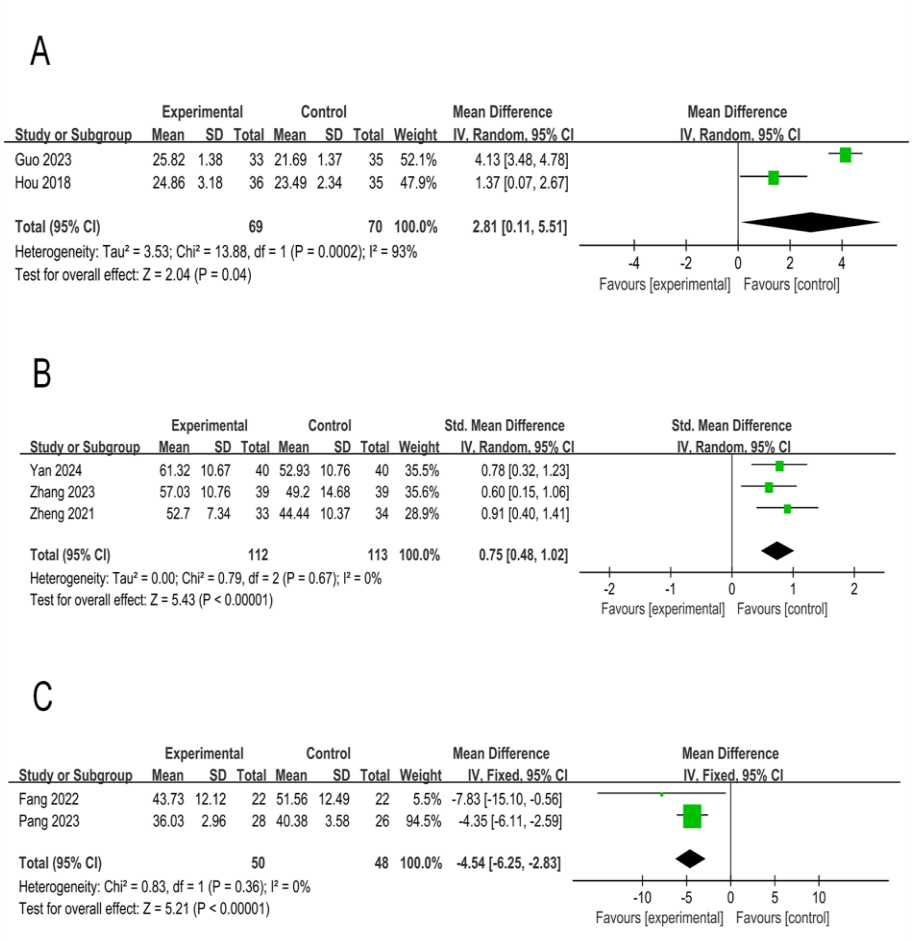

Figure 7. Forest plots of cognitive function and quality of life outcomes. (A) Mini-Mental State Examination (MMSE). (B) Short Form (SF)-12 and SF-36 health surveys. (C) Minnesota Living with Heart Failure Questionnaire (MLHFQ).

Effects of Baduanjin on Quality of Life (SF-12/SF-36)

A meta-analysis of 3 RCTs (41,43,44) (n = 225) showed significant improvements in generic quality of life (measured by SF-12/SF-36 questionnaires) after Baduanjin (SMD = 0.75, 95% CI: 0.48 to 1.02, P < 0.001), with homogeneous effects across studies (I^2 = 0%, P = 0.67) (Figure 7B).

A meta-analysis of 2 RCTs (45,46) (n = 98) in heart failure populations demonstrated that Baduanjin significantly reduced MLHFQ scores (MD = -4.54, 95% CI: -6.25 to -2.83, P < 0.001). The negligible heterogeneity (I^2 = 0%, P = 0.36) reinforces intervention consistency (Figure 7C).

Certainty of Evidence (GRADE)

The certainty of evidence was evaluated using the GRADE framework (Appendix 4). High-certainty evidence supports the efficacy of Baduanjin for improving grip strength, sleep quality (PSQI), and generic quality of life (SF-12/SF-36). Evidence for the primary outcome (frailty status), functional exercise capacity (6MWD), and heart failure-specific quality of life (MLHFQ) was graded as moderate certainty.

In contrast, evidence regarding short-distance walk time, lower limb function (FTSST), mobility (TUGT), cognitive function (MMSE), and psychological symptoms (anxiety/depression) was rated as low certainty. Evidence for balance (OLST) was deemed very low certainty. The primary reasons for downgrading included inconsistency (e.g., high heterogeneity in frailty and mental health outcomes), imprecision (wide confidence intervals or small sample sizes for FTSST/TUGT), and risk of bias.

Reporting biases

Publication bias and the robustness of the primary findings were rigorously evaluated using a combination of visual inspection, statistical testing, and sensitivity analyses. Visual assessment of the funnel plot revealed mild asymmetry (Figure 8), a finding statistically supported by a significant Egger's test (p = 0.002). However, to determine the actual impact of this potential bias on the study conclusions, the trim-and-fill method was applied. Notably, this analysis identified zero missing studies requiring imputation. Consequently, the pooled effect size remained identical before and after adjustment, suggesting that the observed asymmetry, which is likely attributable to the substantial heterogeneity or small-study effects rather than selective reporting, did not materially bias the meta-analytic point estimate. Furthermore, leave-one-out sensitivity analysis confirmed the stability of the results; the recalculated effect sizes consistently remained within the original confidence intervals upon the sequential removal of each individual study, affirming that the overall findings were robust against outliers.

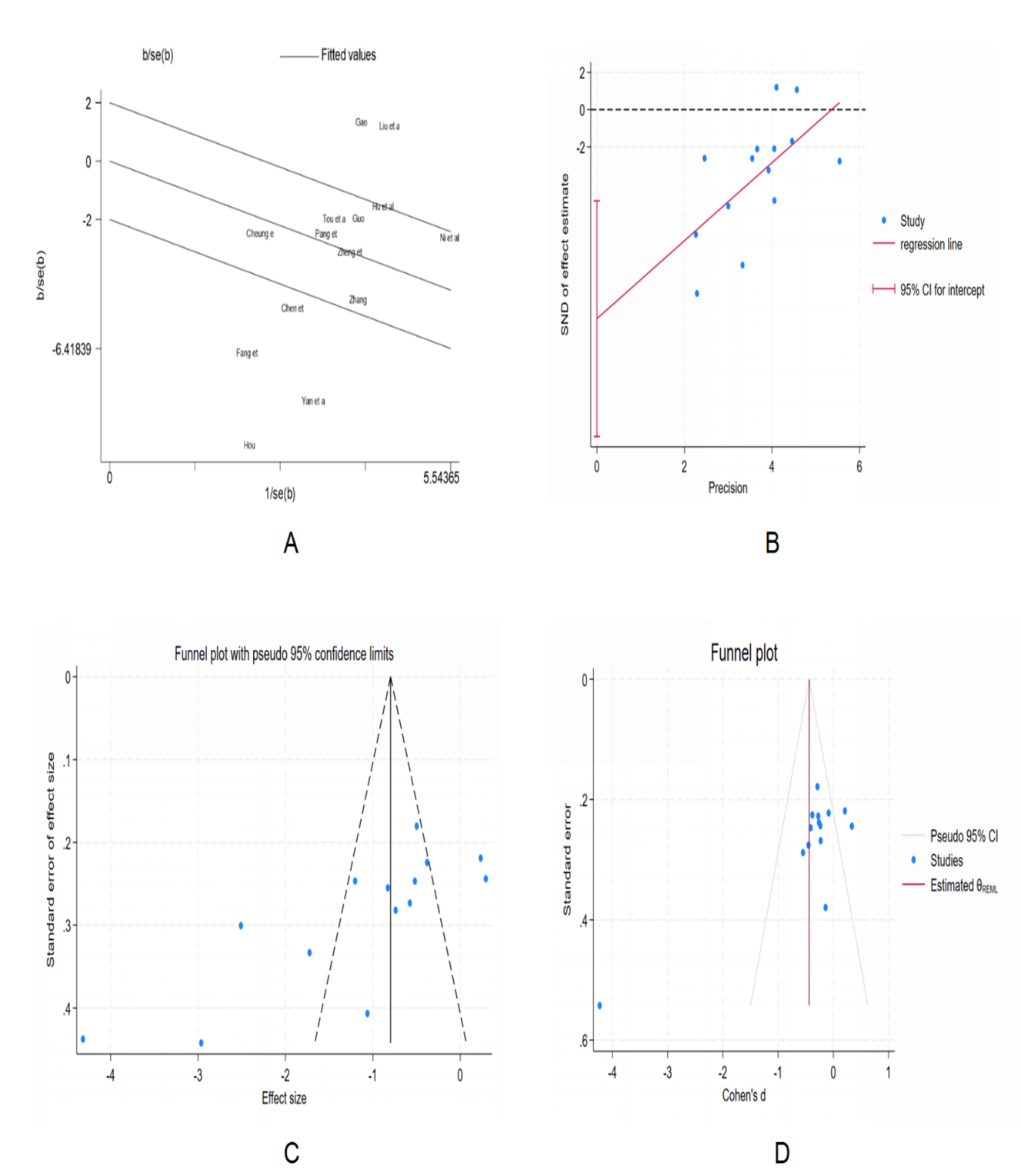

Figure 8. Assessment of heterogeneity and publication bias for frailty levels. (A) Galbraith radial plot. (B) Egger's test. (C) Funnel plot. (D) Trim-and-fill analysis.

DISCUSSION

This systematic review and meta-analysis synthesizes current evidence regarding the potential of Baduanjin exercise in managing geriatric frailty. Pooled analyses suggest that Baduanjin practice is associated with a reduction in frailty severity (SMD = -1.12) and improvements in physical performance. However, these findings must be interpreted with caution, given that the certainty of evidence ranges from high to very low, and the risk of bias was rated as high across all included trials.

In terms of specific outcomes, high-certainty evidence supports the efficacy of Baduanjin for improving upper-limb muscle strength, as evidenced by a 2.39 kg increase in handgrip strength. Evidence for the primary outcome of frailty reduction, as well as functional exercise capacity (33.72-meter gain in 6MWD), was graded as moderate certainty. Conversely, findings regarding lower-limb function and balance were supported by low to very low certainty evidence, indicating that while positive trends were observed, the therapeutic robustness for these specific parameters requires further verification through rigorous investigation.

Baduanjin may enhance balance and physical function, possibly via mechanisms such as improved muscle strength, though these pathways remain speculative and warrant further mechanistic research. This improvement is reflected in measurable gains across standardized tests, including the 6MWT, and short-distance walk times, with handgrip strength demonstrating the most pronounced effect. The mechanism by which Baduanjin relieves frailty syndrome seems to be similar to that of Tai Chi (52-54). Although Tai Chi is well-established in improving physical fitness among older populations, standardized routines like the 48-form often involve complex maneuvers-such as single-leg stances and dynamic shifts-that may limit participation among frail individuals (55). Baduanjin, by contrast, offers specific clinical advantages: its structured eight-movement sequence requires less coordination and cognitive effort and can be adapted for seated practice in those with substantial physical limitations (56).

Resistance-based movements in Baduanjin, such as progressive squats, can improve muscle strength and coordination in the lower body (17). Multi-axial joint movements in ordinary stretching manoeuvres relieve age-dependent stiffness in joints and increase flexibility in soft tissues, subsequently minimizing fall risk by enhancing optimal postural control (18). Baduanjin is also known to relieve symptoms of anxiety and depression, as well as promote better quality sleep and cognition. With guided mental concentration, it helps older adults redirect their focus from complicated thinking to simple positive mental activity, resulting in feeling relaxed and decreasing negative emotions (22). Some studies note better improvements in the quality and efficiency of sleep following practice in Baduanjin for over one month than following pharmaceutical therapy (57,58). Research shows Baduanjin's meditational practice enhances the secretion of neurotransmitters, neurotrophic factors, and cerebral blood circulation. It also causes stronger activation of the fronto-prefrontal cortex and increased blood oxygen concentration (59). These mechanisms, in turn, enhance brain operational efficiency and reaction time, consequently enhancing cognition (60).

Current studies suggest that Baduanjin yields better therapeutic outcomes when combined with other interventions, such as resistance band training (61), five-elements music (62), and cognitive-behavior therapy (63). However, the subgroup analysis in this study did not reveal statistically significant differences between combined therapy and monotherapy. This finding implies that Baduanjin, as a standalone intervention, possesses sufficient therapeutic potency to elicit clinical improvements in frail older adults. It is possible that the "ceiling effect" of exercise benefits in this vulnerable population masks the added value of combined therapies, or that the current number of combined-intervention trials is insufficient to detect a significant interaction.

Strengths and Limitations

This systematic review demonstrates methodological robustness through strict adherence to PRISMA guidelines and a comprehensive synthesis of 15 RCTs encompassing 1,044 participants, providing enhanced statistical power to detect intervention effects. The analytical framework was further strengthened by a priori sensitivity and exploratory subgroup analyses, which systematically investigated sources of heterogeneity and confirmed the stability of the results.

However, three principal limitations warrant consideration. First, methodological biases were prevalent across studies, primarily stemming from inadequate documentation of randomization procedures and operational challenges in maintaining blinding protocols, a constraint inherent to mind-body intervention research. Although the

risk of bias was judged as high, this is a common phenomenon in non-pharmacological intervention trials and does not necessarily reflect poor study quality. Second, limited statistical precision affected specific subgroup analyses, particularly those involving specialized assessments, such as the FTSST, which included only two studies. Third, substantial heterogeneity emerged for certain endpoints, likely reflecting variability in measurement protocols and intervention delivery rather than inconsistency in therapeutic efficacy.

Clinical implications and recommendations

To maximize the clinical utility of Baduanjin, we propose its systematic integration into community health initiatives, elderly care facility protocols, and digitally assisted home-based rehabilitation programs (e.g., video tutorials or mobile applications) to enhance accessibility and adherence. Age-tailored instructional materials should emphasize visual demonstrations of biomechanical precision and delineate evidence-based dosing parameters (e.g., three weekly sessions, 40-60 minutes). A multidisciplinary collaborative framework-involving physiotherapists, geriatric specialists, and psychologists-is critical for designing integrated interventions that synergistically improve physical function and psychological well-being. Concurrently, health policymakers should advocate for Baduanjin's inclusion in national chronic disease management strategies and resource allocation for standardized instructor training and community implementation infrastructure to ensure scalability and sustainability.

Future Research Directions

Baduanjin appears to offer therapeutic benefits for older adults; however, many existing studies are limited by methodological flaws that warrant further scrutiny. To strengthen the evidence base, future studies should prioritize rigorously designed, large-scale, multicenter RCTs with computerized allocation concealment and blinded outcome assessment protocols. This approach will strengthen the study's validity. In mechanism studies, high-density surface electromyography (sEMG) (64) can be combined with functional magnetic resonance imaging (fMRI) (65) to investigate the neuromuscular effects of Baduanjin. VR-based training systems and wearable monitoring platforms can also assess movement accuracy and participant compliance (66). For people with anxiety and depression, future studies could investigate the combination of Baduanjin and mindful breathing (67), particularly for managing comorbid symptoms. Furthermore, future trials should evaluate the efficacy of seated Baduanjin for populations with frailty or poor balance, as this modification may avoid the risk of falls caused by unstable standing (56,68).

CONCLUSIONS

The findings of this meta-analysis suggest that regular Baduanjin practice serves as a promising, multidimensional intervention for managing geriatric frailty. It appears to enhance physiological resilience, alleviate psychological distress, and improve health-related quality of life. However, the robustness of these conclusions is currently constrained by methodological heterogeneity and the limited statistical power of existing trials. Consequently, future research must prioritize the implementation of standardized intervention protocols and in-depth interdisciplinary mechanistic inquiries. Large-scale, rigorous RCTs are essential to validate these preliminary observations, ultimately contributing to scalable, evidence-based strategies for addressing the global challenge of population aging.

AUTHOR'S CONTRIBUTION STATEMENT

Z.J.Q. and S. Shafinaz Sh Abdullah were responsible for conceptualizing and designing the review framework. G.Y., L.B., and W.G.F. conducted the literature search, data extraction, and methodological quality assessment. Data analysis was jointly performed by Z.J.Q. and L.Z.C., with Z.J.Q. subsequently drafting the manuscript. All authors reviewed and approved the final version of the manuscript prior to submission.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

Not applicable.

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