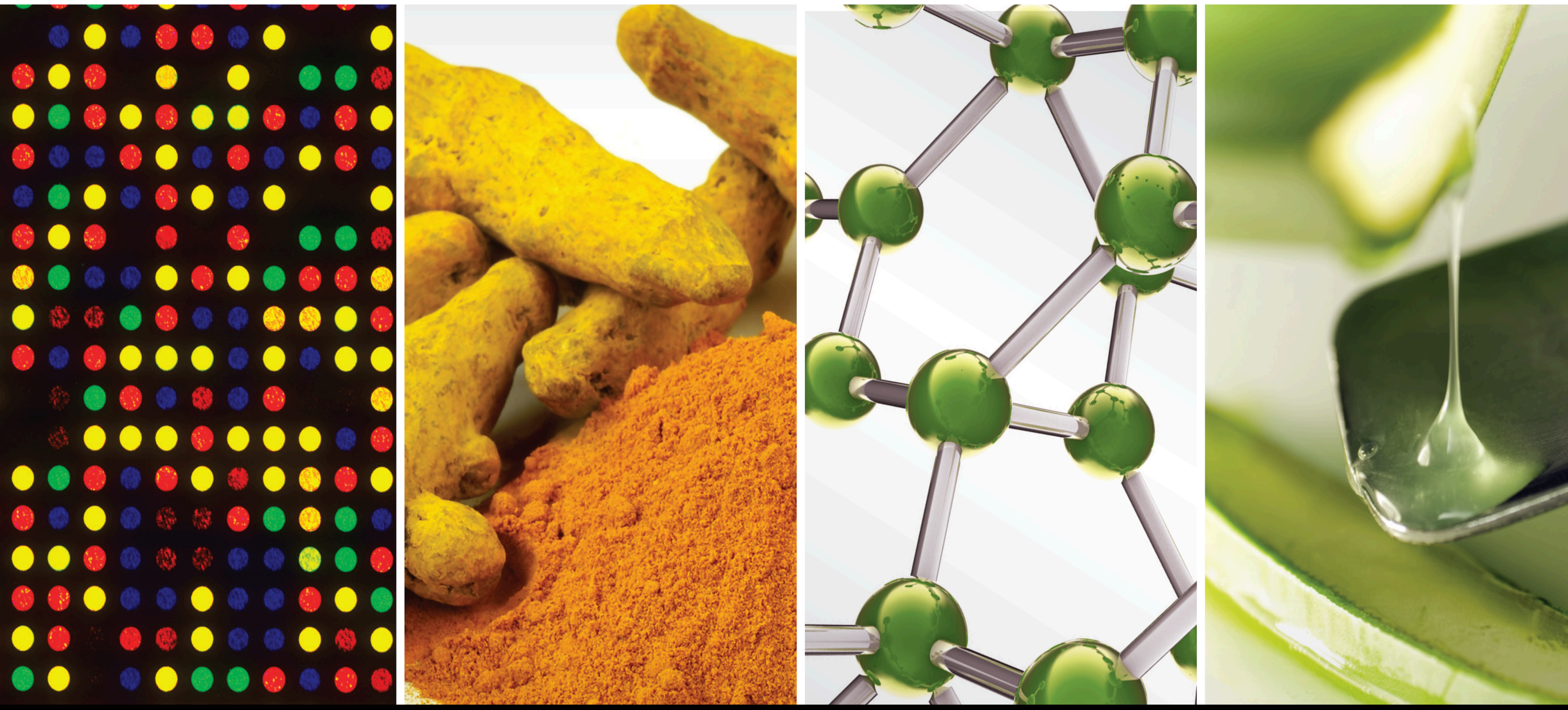
Evidence-Based Complementary and Alternative Medicine

Traditional Chinese Exercise for Chronic Diseases

Lead Guest Editor: Xue-Qiang Wang
Guest Editors: Li Li, Liye Zou, Kevin Chen, and Jiao Liu



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Editorial

Traditional Chinese Exercise for Chronic Diseases

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Chronic diseases (or noncommunicable diseases) are generally defined as human health conditions that may not have a cure, develop slowly, and require long-term medical management. Major chronic diseases include cardiovascular and cerebrovascular diseases, chronic respiratory diseases, diabetes mellitus, cancer, musculoskeletal disorders, degenerative diseases, and neurological disorders. Of note, these chronic diseases are increasingly recognized as the leading cause of death and disability worldwide and cause a substantial economic burden on healthcare and society.

Physical inactivity has been increasingly recognized as a modifiable risk factor of developing the abovepresented chronic diseases. Conversely, regular physical activity is widely accepted as an easily accessible solution that can maintain health benefits with few side effects, including preventing the onset of chronic diseases or delaying their progression. Traditional Chinese exercises (TCEs) have been utilized as part of traditional Chinese medicine for health promotion and symptomatic management of chronic diseases for thousands of years. TCEs mainly consist of Tai Chi, Baduanjin, Liuzijue, Wuqinxi, and more. These exercises possess a similar philosophy; gentle movements are performed in coordination with muscle stretching and relaxation, slow breathing, proprioceptive awareness (mental focus), and a meditative state of mind. Such unique features have gained increasing popularity worldwide, especially those suffering from chronic diseases with low exercise intolerance. Several interventional studies have shown clinically meaningful improvements associated with TCEs among individuals with Parkinson's disease (PD), fibromyalgia, and heart failure. Further investigations are needed for other chronic diseases such as lower back pain, cancer, chronic obstructive pulmonary disease (COPD), and more. In particular, research on the potential mechanisms of the beneficial effects of TCE is still in its infancy.

In this special issue, we invited researchers to contribute original research, review articles, consensus statements, and guidelines on traditional Chinese exercise in preventing and managing chronic diseases. We were particularly interested in manuscripts that investigated the physiological and psychological responses following TCE intervention among individuals with chronic diseases and their associated biological mechanisms. In total, 17 original and review articles have passed peer review and finally were considered for publication.

A study by M. Shen and others investigated the effects of a 12-week Wuqinxi program on the cognitive measures and motor functions among patients with PD. In this study, 30 PD patients were assigned into two groups (Wuqinxi and stretching training). The two exercise modalities had shared the same intervention duration in which two 90-minute sessions were arranged per week. Results indicated that PD patients demonstrated significant improvement on motor performance following the 12-week Wuqinxi training program. Furthermore, the Wuqinxi group showed significantly better cognitive performance relative to its active control group. Promising findings with small sample size need to be further substantiated.

Similarly, Wang and colleagues attempted to determine the superior effects of Wuqinxi and stretching exercise among 46 mild-to-moderate PD patients. Of note, both acute (one session) and chronic (12 weeks) effects of two exercise modalities on health outcomes were investigated. Interestingly, hand dexterity was significantly enhanced even following one Wuqinxi session. Furthermore, significant improvements on hand dexterity, mental function, and emotional well-being were observed following the 12-week Wuqinxi training. Given the physical and psychological benefits of Wuqinxi training, this unique training approach should be incorporated into part of PD treatment.

X. Yu and others evaluated the effects of Tai Chi in patients with PD through a systematic review and meta-analysis. The study included 17 RCTs with 951 participants. The results suggested Tai Chi is a relatively safe activity for patients with PD to significantly improve general motor function, bradykinesia, and balance conditions but not for their quality of life and functional mobility. The study indicates that more studies with larger sample sizes and better methodological quality are needed to provide more evidence.

X. Yu and the group investigated the effects of body weight support-Tai Chi (BWS-TC) exercise on balance control and walking function in poststroke survivors with hemiplegia. The trial divided 71 subjects into BWS-TC and control groups. The subjects in BWS-TC groups participated in 40 min rehabilitation sessions three times a week for 12 weeks. The results demonstrated that the BWS-TC group showed better performance in gait cycle time, step length, step velocity, range of motion of the joints, and dynamic balance than the control group. This study provides preliminary evidence for patients with stroke to practice Tai Chi, improving balance control and walking function.

Another meta-analysis presented by X. Zhang and colleagues included 19 RCTs aiming to explore the effects of Tai Chi on the balance function and exercise capacity among stroke patients. The Tai Chi group showed better outcomes in the Berg balance function scale, standing and walking test, the center of gravity sway area and speed, and the Fugl–Meyer assessment scale. The study indicates that Tai Chi exercise is beneficial to balance functions and exercise capacities for poststroke patients if practiced once or twice or ≥5 times/week with 30 to 60 minutes each time.

The research work by Y. Qi and coauthors recruited 20 patients with chronic complete thoracic spinal cord injury (SCI). It required them to perform five consecutive sets of 16-form Wheelchair Tai Chi (WCTC16). Researchers recorded and analyzed heart rate variability (HRV) of patients before and after the WCTC16. The results indicated that the Tai Chi exercise was beneficial to vagal activity and sympathetic activity for patients with chronic complete thoracic SCI, which allowed patients to get a balanced sympathovagal tone.

The systematic review and meta-analysis by Q. Sun and the group evaluated the enhancement effects of the combined physical-cognitive interventions on memory self-efficacy, objective cognitive function, psychological well-being, and emotion of older adults with subjective cognitive decline (SCD). The study included 11 RCTs involving 1713 participants with SCD. The interventions were physical activity combined with cognitive training. The study suggested that the combined intervention is an effective and safe method for patients with SCD to improve cognitive function and prevent the conversion of SCD to Alzheimer's disease.

The systematic review and meta-analysis by X. Chen and coworkers evaluated the existing RCTs for evidence of Tai Chi and other TCEs rehabilitation effects for chronic heart failure. The study involved 33 RCTs with 2,465 patients. Compared to the routine managements (RMs) alone, TCEs plus RMs improved peak oxygen consumption (VO_{2peak}), 6-minute walking distance (6MWD), and Minnesota Living with Heart Failure Questionnaire (MLHFQ). Compared to general exercise, the TCEs group showed superior improvements in MLHFQ but not in VO_{2peak} or 6MWD. The review suggests that TCEs is a safe and highly adherent rehabilitation therapy, which can be considered an alternative to conventional exercises for patients with chronic heart failure.

Y. Teng and colleagues reviewed 45 original articles regarding the effects of Tai Chi practice on modulating primary hypertension. The review demonstrated the significant efficacy of Tai Chi exercise in improving hypertension clinical symptoms and quality of life, compared to most of the control interventions. Meanwhile, the study also points out the methodological problems in included studies and suggests more future studies with better quality control.

The other systematic review and meta-analysis by C. Kuo and colleagues included 14 RCTs to explore the clinical effects of the Baduanjin exercise among cancer patients. A total of 10 studies were included in the meta-analysis. The meta-analysis supported that the Baduanjin exercise can alleviate the degree of cancer-related fatigue in patients and improve their quality of life and sleep quality, thereby providing preliminary evidence for further long-term follow-up RCTs.

Another research article by C. Yao and coworkers investigated the effect of 24-week Wuqinxi exercise among 72 patients with chronic low back pain (CLBP) through a randomized controlled trial (RCT). All patients who received the Wuqinxi training or general exercise showed improved pain condition and quality of life at the end of 12 weeks and 24 weeks. The Wuqinxi group showed better outcomes than the general exercise group after 24 weeks of intervention. The study results indicate that Wuqinxi can be considered a stand-alone therapy and self-management skill among people with CLBP, suitable for long-term practice.

The research article by Z. Zhang and coworkers reported a parallel control experiment involving 76 patients with amphetamine drug dependence, divided into Taijiquan and control groups. The Taijiquan group received a 6-month exercise intervention and the same routine rehabilitation exercise as the control groups. The study reported that Taijiquan exercise was beneficial to the balance control ability, overall sense of health, vitality, mental health, trait anxiety, and drug craving in the dependent patients. The study provided evidence to support exercise therapy for addicts to quit drugs and prevent relapse.

The paper lead by T. Xiao with colleagues used the design of three-arm RCT. It aimed to explore the efficacy of group-based basketball and Baduanjin exercise on problematic smartphone use and mental health in eligible Chinese college students. The study included 96 participants for three groups, basketball, Baduanjin, and control groups. They reported a significant reduction of problematic smartphone use and improved mental health, including feelings of anxiety, loneliness, inadequacy, and perceived stress after 12-week interventions of basketball and Baduanjin, respectively. Furthermore, similar improvements were still significant at two-month follow-up except for perceived stress. The study demonstrates that exercise is helpful for college students with problematic smartphone use and their mental health.

The systematic review by J. Fang and the group included 47 trials involving 3877 participants. The review investigated the reported adverse events potentially associated with Baduanjin exercise and evaluated the quality of the methods used to monitor adverse events in the trials assessed. Only two studies reported adverse events that were potentially caused by Baduanjin exercise, such as muscle ache, palpitation, giddiness, knee pain. The limited evidence suggests the future studies to monitor and record the adverse events strictly.

J. Zhou and coworkers comprehensively reviewed and summarized clinical studies on Baduanjin to provide more evidence-based evidence in support of the application of Baduanjin for healthcare. A total of 810 publications were identified, including 43 systematic reviews, 614 RCTs, 66 non-RCTs, 84 case series, and 3 case reports. The study reported that the most commonly used version of Baduanjin was the style of the State General Administration of Sport of China in 2003. There were no serious adverse events related to the Baduanjin intervention. The reviewers suggested further high-quality designed and reported studies to validate the clinical benefits of Baduanjin.

In their review, Y. Qin and coworkers updated the clinical effects of traditional Chinese exercises, such as Tai Chi, Baduanjin, Yijinjing, and Wuqinxi, in the treatment of simple obesity. The review showed beneficial clinical effects on the treatment of simple obesity with their characteristic. For example, Tai Chi is beneficial to the overall balance, while Baduanjin can increase lower limb strength and reduce fat content. Thus, the review suggests that traditional Chinese exercises can reduce fat and weight, adjust posture, and cultivate physical and mental health, which is a simple and effective way to lose weight at low cost and is environment friendly.

The protocol reported by T. Liu and the group aimed to explore the specific and nonspecific effects of Tai Chi and its responses in patients with functional constipation. The trial will recruit 40 patients with functional constipation and 40 healthy subjects and require them to receive a 10-week Tai Chi intervention. The outcomes such as motor function, respiratory function, emotional state, 24 h dynamic electrocardiogram, and the functional magnetic resonance imaging will be evaluated at the baseline, after 5-and 10-week Tai Chi practice. This study provides a new perspective for understanding Tai Chi and a new approach for investigating the mind-body exercise.

We hope that readers will be interested in understanding the physiological and psychological effects and the underlying mechanisms of traditional Chinese exercise for chronic diseases, such as stroke, SCI, PD, and chronic low back pain. We also hope the special issue can perk the interest of more researchers studying the effects of traditional Chinese exercise for chronic diseases, thereby contributing and improving further investigations and research studies with new strategies and high-quality design.

Conflicts of Interest

The editors declare no conflicts of interest regarding the publication of the special issue.

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Review Article

Effects of Combined Physical Activity and Cognitive Training on Cognitive Function in Older Adults with Subjective Cognitive Decline: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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Background. Subjective cognitive decline (SCD) is recognized as the earliest prodromal stage of Alzheimer's disease (AD). Emerging studies explored the effects of combined physical activity and cognitive training interventions on cognitive ability, psychological well-being, and emotion of older adults with SCD, but the results are now still controversial. *Objective*. This study systematically evaluated the enhancement effects of the combined physical-cognitive interventions on memory self-efficacy, objective cognitive function, psychological well-being, and emotion of older adults with SCD. *Methods*. Data sources PubMed, EMBASE, Web of Science, China National Knowledge Infrastructure (CNKI), Wanfang degree and conference papers database, Chinese Science and Technology Periodical (VIP) databases from their inception to 28 February 2020, the Cochrane Central Register of Controlled Trials (Cochrane Library, 2020, Issue 3), and the reference lists of all retrieved articles were searched. Data analysis and bias risk evaluation were conducted in 2020. Two reviewers (SG and YY) independently evaluated the risk of bias of the included studies using the RoB 2 tool. *Results*. Eleven RCTs involving 1713 participants with SCD (age 68.0 ± 6.1) were included for review and meta-analysis. The interventions in the included studies were physical activity combined with cognitive training. Multiple-modality exercise with mind-motor training, supervised strategy-based memory training sequentially after stationary cycling, Dejian Mind-Body intervention, and physical activity and cognitive stimulation were also practiced. *Conclusions*. Compared to the active or nonactive control groups, the combined interventions are effective in improving objective cognitive function in SCD which may show the potential value of combined physical-cognitive interventions in improving objective cognitive ability and preventing the conversion of SCD to MCI or AD and no adverse effects. However, owing to the limitations of the included studies, these findings should be interpreted cautiously.

1. Introduction

As the population ages, concerns about cognitive decline increase. 2020 Alzheimer's disease (AD) facts and figures described that total payments are to be $244 billion in 2019 for health care, long-term care, and hospice services for people aged ≥65 years with dementia in the United States. The average per-person Medicare payments for services to beneficiaries of age ≥65 years with (AD) or other dementias are more than three times as great as payments for beneficiaries without these conditions (more than 23 times as great) [1]. AD remains the most common cause of dementia [1, 2]. Early detection and intervention of Alzheimer's disease offer numerous medical, emotional, and financial benefits that accrue to affected individuals and their families as well as to the society at large [3].

Studies have been made to identify individuals who are at increased risk of AD and to test interventions that might delay the progression of preclinical stage prodromal to full-blown dementia [4–6]. Subjective cognitive decline (SCD) has been identified as a condition where some individuals experience subjective cognitive complaints, but the cognitive performance by neuropsychological tests and daily function shows no evidence of objective cognitive impairment. SCD is increasingly recognized as the earliest prodromal stage of AD [7–10]. 74% of people aged 70 years and older who perform normally on standard cognitive tests self-report a subjective decline in cognitive functioning [11]. SCD individuals showing the positivity of pathophysiological AD biomarkers show a risk of progression similar to MCI patients [6]. Some studies showed that amyloid and tau protein PET imaging investigations in cohorts of aging individuals (>60 years of age) who were cognitively unimpaired showed a quantitative association between the extent of either amyloid or tau pathology with the severity of cognitive concerns experienced by individuals [12–14]. Other studies have investigated markers of neurodegeneration in individuals with SCD. In particular, cross-sectional studies [15–17] have shown that these individuals have small reductions in the volume of brain regions that typically show loss of volume in the early stages of AD (e.g., the medial temporal lobe) when compared with control groups of individuals without SCD. Besides, some studies [16, 18] have identified AD-associated patterns of glucose hypometabolism in individuals with SCD, whereas other studies [19] have not. In addition, individuals with SCD who harbor the major genetic risk factor APOE $\varepsilon 4$ for AD are at an increased risk of being at individuals with SCD who do not carry the disease-associated APOE $\varepsilon 4$ [20]. It is likely that a relationship between APOE $\varepsilon 4$, SCD, and AD exists, though its exact nature remains undetermined [21].

Livingston et al. considered SCD as a critical window of opportunity to intervene and alter the trajectory of both cognitive and functional decline in seniors [22]. It would be more appropriate to prevent or postpone the AD process by intervention in the SCD stage. However, until now, the positive effect on the cognitive ability and behavioral symptoms of SCD individuals of medication was controversial [23–26]. The available evidence suggests that nonpharmacologic interventions may benefit current cognitive function in persons with SCD [27, 28]. Extensive evidence indicates that physical activity may improve cognitive health outcomes such as mental health, physical health, and quality of life for older adults with SCD. Tailored physical activity guidelines are needed to support strategies for dementia risk reduction [29]. Emerging reviews of the evidence have led international health organizations, including the World Health Organization (WHO), the American National Institutes of Health, and the British National Institute of Health and Care Excellence, to advocate for physical activity as both a primary prevention (in cognitively healthy individuals) and a secondary prevention (in individuals who have no dementia but already experience cognitive decline) strategy for reducing dementia risk [30–33]. The Canadian Physical Activity Guidelines for adults with SCD also have been developed [34].

Physical activity was associated with brain health benefits, including possible improved cognitive function, reduced anxiety, and depression risk, and improved sleep and quality of life [35]. Recent meta-analyses of randomized controlled trials show that physical activity also may be a promising intervention in the cognition of included subjects with dementia and mild cognitive impairment (MCI) [36, 37]. Cross-sectional studies, longitudinal observational studies, and prospective intervention trials also supported this evidence [38, 39].

By adding, exposure to a cognitively challenging environment could enhance the neural and cognitive benefits elicited by physical activity in humans and animals [40, 41]. A review indicated that the new generation of prevention trials is addressing some of the problems encountered in previous trials by testing interventions during the optimum window of exposure (i.e., earlier in the course of the disease, even in the preclinical phase), using multidomain rather than single-domain intervention strategies [42]. Some studies observing the synergistic effect of exercise and cognitive training interventions were associated with improved cognitive performance in older adults [43, 44]. A meta-analysis found that combined cognitive and physical exercise training can improve global cognition in older adults with MCI or AD and were beneficial for activities of daily living and mood [45].

However, for the elderly with SCD, combined physical-cognitive interventions on cognitive function are equivocal. The topic of interventions in this population has been relatively unexplored. For instance, compared with an active or nonactive control group, whether combined physical-cognitive interventions prevent cognitive decline is unclear. In the present study, we aimed to systematically evaluate the effect of combined physical-cognitive interventions on memory self-efficacy, objective cognitive function, general psychological well-being, and emotion.

2. Methods

2.1. Selection and Identification of Studies. Seven electronic databases, including PubMed, EMBASE, Web of Science (SCI, Science Citation Index), China National Knowledge Infrastructure (CNKI), Wanfang degree and conference papers database, Chinese Science and Technology Periodical (VIP) databases from their inception to 28 February 2020, and the Cochrane Central Register of Controlled Trials (Cochrane Library, 2020, Issue 3), were searched without language restrictions. Relevant keywords related to physical activity as Medical Subject Heading terms and text words (e.g., "Multiple training modalities" or "Physical activity" and "Activity") were used in combination with words related to subjective cognitive decline (e.g., "Subjective Cognitive Decline," "Subjective Cognitive Impairment," "Cognitive complaints," "Subjective Memory Decline," and "Subjective Memory Impairment"). The unpublished/grey literature was searched using ClinicalTrials.gov, the National Research

Register, the Chinese Master's Theses Full-Text Database, China Doctor Dissertation Full-Text Database, and China Proceedings of Conference Full-Text Database. Additional trials were found through the reference lists of all retrieved articles (please see the full search strategy in Table 1). Literature search, study identification, and data extraction were conducted from February to April 2020. All searched records were imported into the reference management software (Note Express V.3.2) to eliminate duplicate records. The full texts of the studies that potentially met the inclusion criteria were obtained to further evaluate their eligibility. Any disagreements were resolved by discussion with the third reviewer (QS). The review was registered at the International Prospective Register of Systematic Review, PROSPERO (Registration number: CDR42020181482, https://www.crd.york.ac.uk/prospero/).

2.2. Inclusion Criteria. The trials selected in this review met the following inclusion criteria: (1) study design: published randomized controlled trials (RCTs) were included; (2) participants should older adults (age: 55 years and older) with self-reported cognitive complaints, without objective evidence of deficits on cognitive tests and unaccounted for medical or psychiatric causes (e.g., dementia, MCI); (3) intervention: physical activities (e.g., aerobic activity, muscle-strengthening activity, bone-strengthening activity, balance activity, and multicomponent activity) combined with cognitive training (e.g., cognitive training, memory training, psychological interventions) were practiced in the experimental group for at least 2 weeks; (4) control should be memory intervention, mental training, or health education (e.g., psychoeducation, cognitive restructure, stress management, relaxation, and mindfulness); (5) outcomes: we used subjective memory measures as the primary outcome and objective cognitive function, psychological well-being, and emotion as the second outcomes. Those without available data were excluded.

2.3. Data Extraction. The data were extracted by one reviewer (SX) using the prepared form and checked for accuracy by another reviewer (QS). The extracted information from eligible studies included participants' characteristics, sample size, study design, methodological information of study quality, experimental and control intervention, duration, frequency, intensity and style of aerobic exercise, outcomes, and adverse events.

2.4. Assessment of Risk of Bias in Individual Studies. Two reviewers (SG and YY) independently evaluated the risk of bias of the included studies using the RoB 2 tool, a revised Cochrane risk of bias tool for RCTs, which is a widely used quality assessment tool for evaluating RCTs [46]. The RoB 2 tool includes domains such as randomization process, deviations from intended interventions, missing outcome data, outcome measurement, selection of the reported result, and overall bias [46]. The overall judgment of each item for each study was categorized as "low risk," "high risk," and "some concerns" according to the levels of bias. Discrepancies between reviewers were resolved by the third reviewer (JL).

2.5. Statistical Analysis. Review Manager Software V.5.3 was used for the statistical analysis which was provided by Cochrane Collaboration, and the statistical significance was defined as a two-sided P value < 0.05. Data were summarized using relative risk with 95% CI for binary outcomes and mean difference (MD) or standardized MD (SMD) with corresponding 95% CI for continuous outcomes. The pooled effect was calculated using the fixed-effect model if data were available and no significant heterogeneity was detected. Otherwise, the random-effect model was applied. Statistical heterogeneity was assessed using the I^2 statistic. However, the overall pooled analysis was not considered appropriate when the heterogeneity among studies was high ($I^2 > 75\%$); clinical or methodological heterogeneity was considered the potential causes. Heterogeneity among studies was explored using a χ^2 test and Higgins I^2 values [46]. In view of possible heterogeneity between studies, studies with different intervention types were divided into subgroups for analysis according to different factors.

Due to the diversity of the outcome measures related to objective cognitive function in the included studies, and the relatively small number of studies meeting the inclusion criteria, we chose to combine outcomes of global cognitive ability and specific domains of cognition (i.e., memory, attention, executive ability, and verbal fluency) into objective cognitive function. Moderator analyses will be used conducted to explain the variance between groups if the heterogeneity among studies was high ($I^2 > 75\%$).

3. Results

3.1. Study Selection. 2100 records were identified from preliminary searches according to the predetermined search strategy. Two reviewers (SX, GS) disregarded obviously irrelevant records based on the abstract or title. A total of 53 potential studies were further evaluated for their eligibility, and 15 studies ultimately fulfilled the inclusion criteria [47–62]. However, 4 studies did not provide the original data [49, 50, 60, 61]. We attempted to contact the original authors by e-mail but did not receive any responses. Therefore, we excluded these studies. Finally, 11 studies involving 1713 participants with SCD were included in the review. The detailed literature search and screening flow is presented in Figure 1.

3.2. Study Characteristics. The characteristics of each included study were summarized in Table 1. Eleven RCTs involving 1713 participants with SCD (age 68.0 ± 6.1) were included for review. The included studies came from Canada (two) [47, 60], Unite States (four) [51, 56, 58, 59], China (one) [52], Australia (two) [53, 57], and France (two) [54, 55]. Participants were recruited from community [47, 51, 55, 56], social centers [52], social clubs, or personal [54, 58, 59], memory clinics [57, 60], or hospitals [53]. All included studies reported clear diagnostic inclusion and

Table 1: Characteristics of included studies.

Author/Year	Mean age	N(M/F)	Intervention	Frequency, duration and intensity	Outcomes/measure
Boa et al. 2020 [47–50]	T: 67.6± 7.5 C: 67.4± 7.2	127 (37/90)	T: Physical activity combined cognitive training C: Active control	60 min/day, 3 days/week, 24 weeks 65–85% of maximum HR	Working memory/ Monkey Ladder Spatial short-term memory/Spatial Span Verbal working memory/Digit Span Visuospatial paired associate learning/ Paired Associates
McEwen et al. 2018 [51]	T: 65.4± 3.0 C: 67.0± 5.1	55 (17/38)	T: Memory training after station cycling (SEQ) C: Active control	120 min/day, 2 days/week, 4 weeks 65% HRR	Composite memory/ Verbal and Visual Memory Test Attention/Stroop Test Executive function/CNS Processing speed/CNS
Chan et al. 2017 [52]	T: 68.3± 4.4 C: 69.5± 6.9	48 (12/36)	T: Dejian Mind-Body C: Active control	150 min/day, 1 days/week, 10 weeks	Memory/HKLLT Immediate recall/WMS-III-VR delayed recall/WMS-III-VR
Lautenschlager et al. 2008 [53]	T: 68.6± 8.7 C: 68.7± 8.5	170 (84/86)	T: Physical activity C: Active control	50 min/day, 3 days/week, 24 weeks Moderate intensity	Global cognitive function/CDR, ADAS-Cog immediate recall/word list delayed recall/word list Information processing speed/DSC verbal fluency/VFT Depression/BDI Mentality/ MCS Physical fitness/ PCS
Fabre et al. 1999 [54]	AMT: 64.9± 3.9 AT: 65.4± 6.2 C: 67.5± 3.4	24	AMT: Physical activity combined cognitive training AT: Physical activity C: Control	90 min/day, 1 days/week, 2 months	Memory/WMS Depression/SQLP Mentality/SQLP Physical fitness/SQLP
Andrieu et al. 2017 [55]	T: 75.0± 4.1 C: 75.1± 4.3	770 (266/504)	T: Physical activity combined cognitive training C: Control	120 min/day, 2 days/week for the first month, and 120 min/day, 1 day/week for the second month, then 1 60 min/month, 36 months	Global cognitive function/Composite score Memory/FCSRT Executive function/ TMT-B Information processing speed/DSST Verbal fluency/COWAT Attention/Ten MMSE orientation items Depression/GDS Mentality/ Consequences of everyday life Subjective memory function/Memory functioning Physical fitness/SPPB
Zuniga et al. 2016 [56]	T 66.4± 5.7	179 (62/117)	T: Physical activity C: Active Control	60 min/day, 3 days/week, 12 months 50–75% HRR	Depression/PSS Mentality/MUNSH Subjective memory function/FOF Physical fitness/CHIPS

Table 1: Continued.

Author/Year	Mean age	N(M/F)	Intervention	Frequency, duration and intensity	Outcomes/measure
Cox et al. 2013 [57]	T: 68.2± 9.8 C: 65.6± 4.7	170 (84/86)	T: Combined C: Control	50 min/day, 3 days/week, 6 months Moderate intensity	Mentality/SCI
Small et al. 2006 [58]	T: 54± 12 C: 53± 10	17 (6/11)	T: Physical activity combined cognitive training C: Control	30-45 min/day, 7 days/week, 2 weeks	Memory/VLM Verbal fluency/Word-generation (letter-fluency) test Subjective memory function/MFQ
Barnes 2013 [59]	T: 74.8± 6.1 C: 73.9± 6.3	95 (34/61)	MA-I/EX-I: Physical activity combined cognitive activity MA-C/EX-I: Physical activity C: Active control	60 min/day, 3 days/week, 6 months 65–85% of maximum HR	Global cognitive function/Composite score Memory/RAVLT Executive function/ TMT-B Information processing speed/DSST Verbal fluency/Letter and Category
Nagamastsu et al. 2013 [60]	T: 75.6± 3.6 C: 75.1± 3.6	58	T: Physical activity C: Active control	60 min/day, 2 days/week, 6 months 40–80% HRR	Attention/UFVO Verbal Memory and Learning/RAVLT

CNS, computerized CNS Vital Signs Memory Protocol test ; HKLLT, Hong Kong list learning test; WMS-III-VR, visuospatial reproduction subtest of the Wechsler Memory Scale III; CDR, Clinical Dementia Rating; ADAS-Cog, Alzheimer Disease Assessment Scale-Cognitive Subscale; DSC, digit symbol coding; VFT, verbal fluency total; BDI, Beck Depression Inventory; MCS, Medical Outcomes 36-Item Short Form (SF-36) mental component summary; PCS, SF-36 physical component summary; WMS, Wechsler Memory Scale; SQLP, the Subjective Quality of Life Profile; FCSRT, Free and Cued Selective Reminding Test; TMT-B, Trail Making Test B; DSST, Digit Symbol Substitution Test; COWAT, Controlled Oral Word Association Test; MMSE, Mini-Mental State Examination; GDS, the Geriatric Depression Scale; SPPB, the Short Physical Performance Battery; PSS, Perceived Stress Scale; MUNSH, Memorial University of New Foundland Scale of Happiness; FOF, Frequency of Forgetting scale; CHIPS, Cohen-Hoberman Inventory of Physical Symptoms; SCI, the Stage of Change Instrument; VLM, verbal learning and memory test; MFQ, The Memory Functioning Questionnaire; RAVLT, Rey Auditory Verbal Learning Test; UFVO, Useful Field of View.

exclusion criteria for their participants. The interventions of the included studies were physical activity combined with cognitive training. Multiple-modality exercise with mind-motor training (M4) [47], supervised strategy-based memory training sequentially after stationary cycling (SEQ) [51], Dejian Mind-Body intervention (DMBI) [52], and physical activity and cognitive stimulation [55] were also practiced. The majority of interventions occurred in physical activity combined with cognitive training, except for four studies reporting the physical activity.

The frequency of intervention varied from 1 to 5 sessions weekly and 30–150 mins per session. The duration of the intervention was from 2 weeks to 36 months. Of these, 11 studies compared combined physical-cognitive interventions with stretching and/or tone exercise, cognitive training, social activities, or health education. Since the lower intensity of those activities did not significantly alter the exercise habits of the participants, we believed that those activities did not differ. A heart rate reserve [51, 56, 60] from 40% progressed to 80%; 60–85% of maximum heart rate [47, 54, 59] or "moderate intensity" [53, 57] was applied to control the intensity of physical activity in the included studies; there was no description in others [52, 55, 58]. The intervention in the control group was the very low intensity of activity/exercise such as social activities, stretching, balance and tone exercise, or health education.

The meta-analysis was conducted to analyze the cognitive outcomes and self-report outcomes, including cognitive function, psychological well-being, and emotion. There was a wide variety of measurement tools applied to evaluate the same cognitive domain within a study or among studies, including MMSE, ADAS-Cog, CDR, Logical Memory subtest of the Wechsler Memory Scale-Revised (WMS-LM), digit symbol cording (DSC), Trail Making Test (Parts A and B), Stroop test, letter verbal fluency test (LVFT), and category verbal fluency test (CVFT). Otherwise, there were kinds of scales to evaluate the mentality and physical fitness (i.e., The Short Form-12, SF-36), depression (i.e., BDI, 15-item Geriatric Depression Scale), and subjective memory impairment (i.e., Frequency of Forgetting Scale, Memory Performance).

3.3. Risk of Bias of Included Studies. The quality of the RCTs included was assessed by two reviewers independently by using the RoB 2 tool, a revised Cochrane RoB tool for randomized trials [56]. The risk of bias in each study is illustrated in Figure 2.

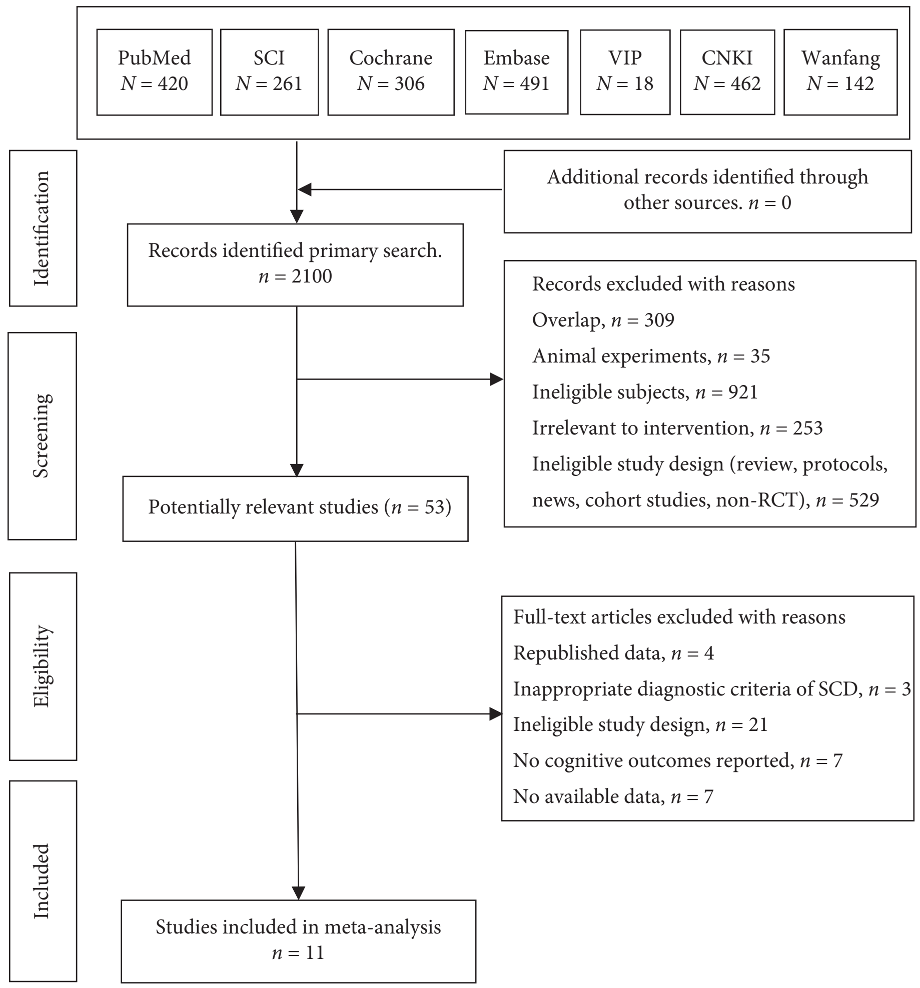

Figure 1: The literature searches and select flow diagram of the included studies. SCI, science citation index; VIP, Chinese Science and Technology Periodical database; CNKI, China National Knowledge Infrastructure; SCD, subjective cognitive decline; RCT, randomized controlled trial.

Five studies [47, 53, 55, 57, 60] were identified as having low risk in the randomization process, and six studies [51, 52, 54, 56, 58, 59] were identified as having uncertain risk. The risk of deviations from intended interventions was low in six studies [47, 53, 55, 57, 59, 60] and uncertain in five studies [51, 52, 54, 56, 58]. All studies [47, 51–60] had a low risk for missing outcome data. Seven studies [47, 53–55, 57, 59, 60] were identified as having low risk and four studies [51, 52, 56, 58] were identified as having high risk related to measurement of the outcome. Furthermore, seven studies [51, 53, 56–60] were uncertain risk and one study [52] was high risk in terms of the reported result selection. Finally, the risk of overall bias was noted as low in two studies [53, 55], uncertain in five studies [47, 54, 57, 59, 60], and high [51, 52, 56, 58] in four studies.

3.4. Effects of Interventions

3.4.1. Memory Self-Efficacy (MSE). Two studies [55, 58] involving 787 participants compared the combined cognitive-physical interventions with control groups in terms of subjective memory function measured by memory functioning [55] and the Memory Functioning Questionnaire (MFQ) [58]. Compared with the control group, no significant improvement was found in the combined physical-cognitive interventions group in the subjective memory function ($n = 787$, SMD = 0.04, 95% CI −0.10 to 0.18, $P = 0.54$; Figure 3).

3.4.2. Objective Cognitive Function. Seven studies [55, 59] reported the effects of combined cognitive-physical interventions on objective cognitive function in participants with SCD including global cognitive function, memory, executive ability, attention, and verbal fluency.

Three studies reported the effects of combined physical-cognitive interventions on composite memory, which were measured by the Free and Cued Selective Reminding Test, WMS, Verbal, and Visual Memory Test [51, 54, 55]. Two studies [47, 52] reported the effects of combined physical-cognitive interventions on immediate memory ability which was measured by Spatial Span and WMS. Three studies [51, 55, 59] involving a number of 889 participants

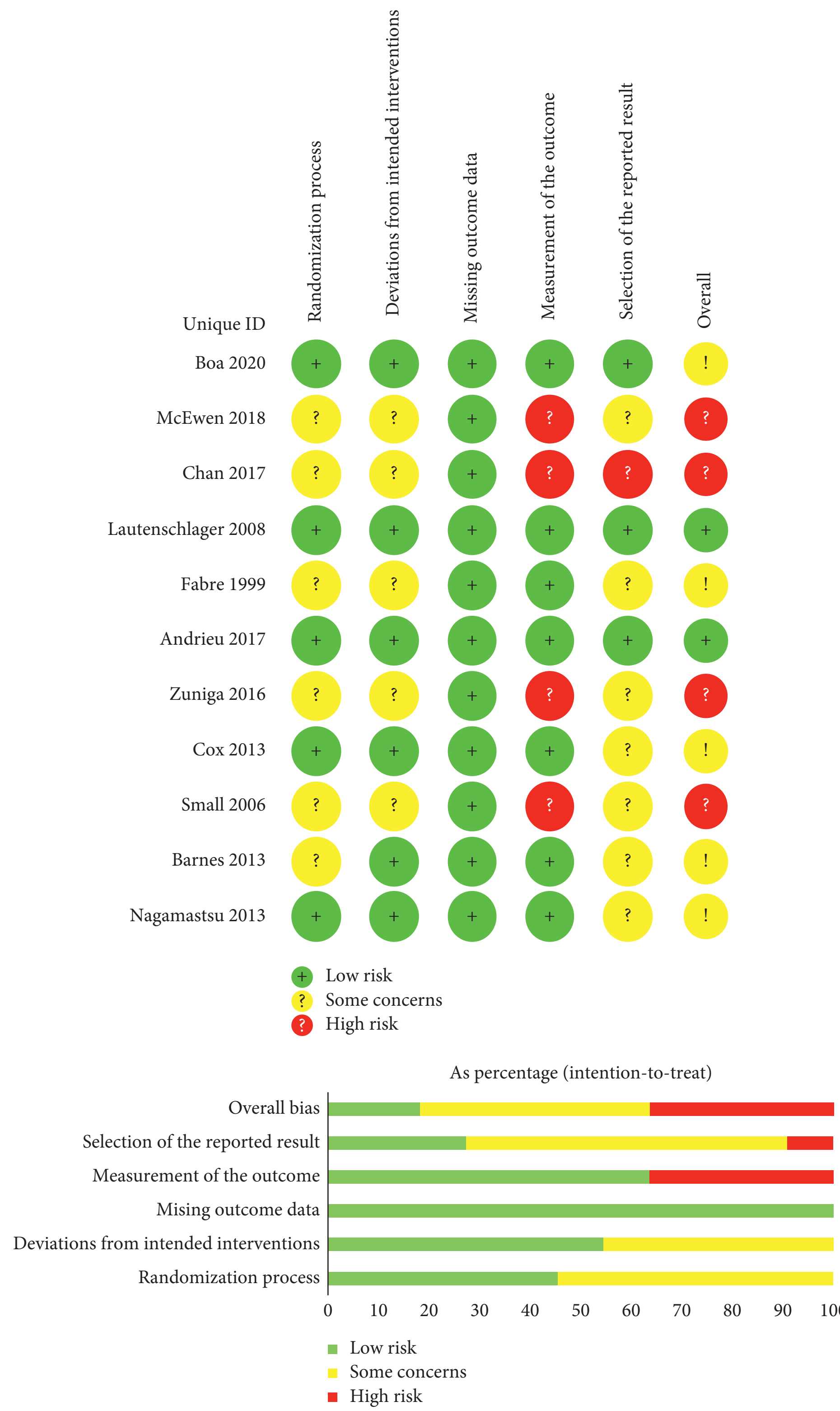

Figure 2: Summary of the risk of bias of the included studies: review authors' judgments about each risk of bias item for each included study.

compared the combined physical-cognitive interventions and control groups in terms of attention, which was measured by Stroop test [51], ten MMSE orientation items [55], and Useful Field of View (UFOV) [59]. The effects of combined physical-cognitive interventions on executive ability were evaluated in three studies [51, 55, 59] with a total of 882 participants using the Trail Making Test part B [55, 59] or CNS [51]. Three studies with 851 participants assessed verbal fluency using the COWAT [55], word-generation (letter-fluency) test [58], or verbal fluency test

Study or subgroup	Experimental group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Std. mean difference IV, fixed, 95% CI
2.4.1. combined								
Andrieu 2017	−0.23	16.428	390	−0.871	16.212	380	97.9	0.04 [−0.10, 0.18]
Small 2006	92.1	37.6	8	83.7	21.8	9	2.1	0.26 [−0.69, 1.22]
Subtotal (95% CI)			*398*			*389*	*100.0*	*0.04 [−0.10, 0.18]*
Heterogeneity: $chi^2 = 0.21$, $df = 1$ ($P = 0.65$); $I^2 = 0\%$								
Test for overall effect: $Z = 0.62$ ($P = 0.54$)								
2.4.2. physical activity								
Zuniga 2016	−48.61	9.77	90	−49.59	9.62	89	100.0	0.10 [−0.19, 0.39]
Subtotal (95% CI)			*90*			*89*	*100.0*	*0.10 [−0.19, 0.39]*
Heterogeneity: not applicable								
Test for overall effect: $Z = 0.67$ ($P = 0.50$)								

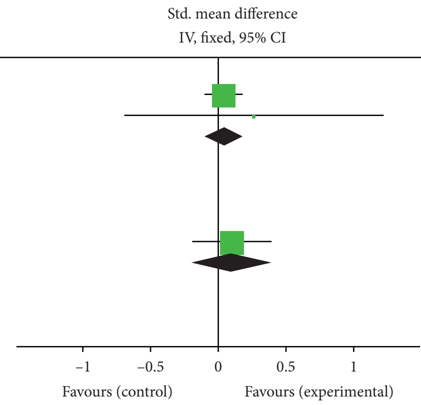

Figure 3: Forest plot for combined physical-cognitive interventions or physical activity on MSE. Combined: combined physical-cognitive interventions.

[59]. Owing to the different tools, we used SMD scores. The results showed that participants in the combined physical-cognitive interventions group had a significant improvement in SMD scores of objective cognitive function compared with the controls ($n = 5679$, $SMD = 0.12$, 95% CI 0.07 to 0.17, $P < 0.001$; $I^2 = 0\%$, the fixed-effect model; Figure 4). Moderator analyses were not conducted because of the heterogeneity statistics for the fixed-effect model confirming that there was no heterogeneity ($I^2 = 0\%$).

The effects of physical activity on objective cognitive function were evaluated in four studies [53, 54, 59, 60]. Meta-analysis showed that physical activity had a significant improvement in SMD scores of objective cognitive function compared with controls ($n = 1328$, $SMD = 0.13$, 95% CI 0.03 to 0.24, $P = 0.02$; $I^2 = 0\%$, the fixed-effect model; Figure 5).

3.4.3. Psychological Well-Being. Two studies [54, 55] reported the effects of combined physical-cognitive interventions on mentality, which was measured by SQLP [54], and the consequences of everyday life [55]. The results showed that participants in the combined physical-cognitive interventions group had no significant improvement in SMD scores compared with controls ($n = 786$, $SMD = 0.12$, 95% CI −0.02 to 0.26, $P = 0.09$; Figure 6). Four studies [53, 54, 56, 57] involving 535 participants assessed the effects of physical activity on mentality measured by SF-36 mentality component summary [53], SQLP [54], Memorial University of Newfoundland Scale of Happiness [56], and the Stage of Change Instrument [57]. Meta-analysis showed physical activity had significant improvement of mentality ($n = 535$, $SMD = 0.22$, 95% CI 0.05 to 0.39, $P = 0.01$, $I^2 = 22\%$, the fixed-effect model; Figure 6).

3.4.4. Emotion (Depression). Three studies with 851 participants assessed depression using the Subjective Quality of Life Profile (SQLP) [54], Geriatric Dementia Scale (GDS) [55], and Perceived Stress Scale (PSS) [56]. Meta-analysis showed that combined physical-cognitive interventions had no significant improvement in depression ($n = 965$, $SMD = -0.09$, 95% CI −0.21 to 0.04, $P = 0.18$; Figure 7). Compared to the usual care control group, there was no significant improvement in the Beck Depression Inventory (BDI) scores in the physical activity group in two studies involving 186 participants ($n = 186$, $SMD = -0.11$, 95% CI −0.39 to 0.18, $P = 0.47$; Figure 7).

3.4.5. Safety and Adverse Events. No serious adverse events were reported during combined physical-cognitive interventions in the included studies. One study [53] reported one participant with foot pain and gout intervention, and another study [60] reported two people with shortness of breath and four falls; however, they were without any physical injury.

4. Discussion

4.1. Some Findings. In this present review, we explore the effect of combined physical-cognitive interventions on MSE, objective cognitive ability, psychological well-being, and emotion in comparison with the usual lifestyle in the elderly with SCD. Eleven eligible studies were included, and pooled analyses were not performed, due to different assessment scales and number of participants, kinds of activities, and methodological quality of the included studies. The results indicated a positive association in the elderly with SCD intervention trials to date, including objective cognitive function and well-being, combined physical-cognitive interventions, or only physical activity intervention, and they were added to the qualitative review because only RCTs were included.

Regarding objective cognitive function, the pooled results showed that combined physical-cognitive interventions yielded significant improvements in SCD elderly in our meta-analysis. We found that combined cognitive-physical interventions conferred a significant benefit on attention, which is partly consistent with other studies. A review has shown the beneficial effects of combined cognitive and exercise training for improving cognitive functions and functional status in older adults with and without cognitive impairment. In line with this, a meta-analysis revealed

Study or subgroup	Experimental group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Std. mean difference IV, fixed, 95% CI
Andrieu 2017	0.938	5.511	390	0.251	5.43	380	13.6	0.13 [−0.02, 0.27]
Andrieu 2017	−0.056	0.725	390	−0.158	0.716	380	13.6	0.14 [−0.00, 0.28]
Andrieu 2017	−1.393	8.685	390	−1.794	8.658	380	13.6	0.05 [−0.10, 0.19]
Andrieu 2017	0.01	0.65	390	−0.07	0.64	380	13.6	0.12 [−0.02, 0.27]
Andrieu 2017	−2.316	51.074	390	−2.346	50.276	380	13.6	0.00 [−0.14, 0.14]
Andrieu 2017	0.985	6.499	390	0.501	6.415	380	13.6	0.07 [−0.07, 0.22]
Barnes 2013	0.22	1.05	32	−0.05	0.82	32	1.1	0.28 [−0.21, 0.78]
Barnes 2013	0.62	1.02	32	0.13	1.01	32	1.1	0.48 [−0.02, 0.97]
Barnes 2013	0.07	1.13	32	−0.01	0.94	32	1.1	0.08 [−0.41, 0.57]
Barnes 2013	0.25	0.75	32	0.22	0.8	32	1.1	0.04 [−0.45, 0.53]
Barnes 2013	0.22	0.28	32	0.16	0.28	32	1.1	0.21 [−0.28, 0.70]
Barnes 2013	0.15	0.49	32	0.08	0.62	32	1.1	0.12 [−0.37, 0.61]
Boa 2020	0.33	1.43	63	−0.06	1.44	64	2.2	0.27 [−0.08, 0.62]
Boa 2020	0.17	0.71	63	−0.04	0.72	64	2.2	0.29 [−0.06, 0.64]
Chan 2017	−11.27	17.83	22	−19.5	17.94	26	0.8	0.45 [−0.12, 1.03]
Chan 2017	6.73	13.01	22	3.58	12.23	26	0.8	0.25 [−0.32, 0.82]
Fabre 1999	−0.62	0.52	8	−1	0.01	8	0.2	0.98 [−0.08, 2.03]
McEwen 2018	108.2	13.5	26	105.7	8.8	29	1.0	0.22 [−0.31, 0.75]
McEwen 2018	−97.6	11.7	29	−104.6	14.8	26	0.9	0.52 [−0.02, 1.06]
McEwen 2018	−102.3	13.2	26	−106.9	17.6	29	1.0	0.29 [−0.24, 0.82]
McEwen 2018	110.1	9	26	105.9	9	29	0.9	0.46 [−0.08, 1.00]
McEwen 2018	110.7	12	26	109.2	13.5	29	1.0	0.12 [−0.41, 0.65]
Small 2006	52.4	7.7	8	46.6	13.4	9	0.3	0.50 [−0.48, 1.47]
Small 2006	123.3	7.8	8	119.1	15.1	9	0.3	0.33 [−0.64, 1.29]
Total (95% CI)			*2859*			*2820*	*100.0*	*0.12 [0.07, 0.17]*

Heterogeneity: $\chi^2 = 17.53$, df $= 23$ ($P = 0.78$); $I^2 = 0\%$
Test for overall effect: $Z = 4.56$ ($P < 0.00001$)

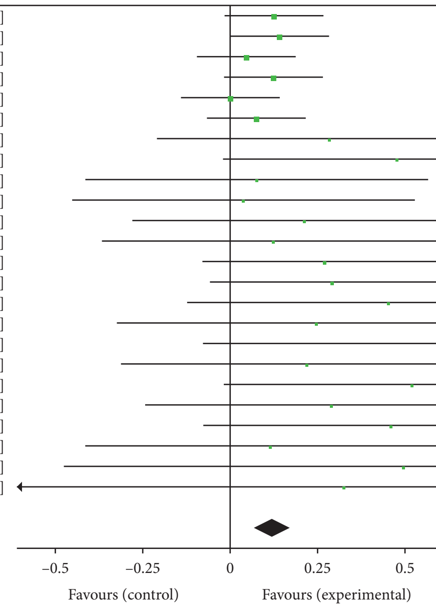

Figure 4: Forest plot for combined physical-cognitive interventions on objective cognitive function.

Study or subgroup	Experimental group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Std. mean difference IV, fixed, 95% CI
Barnes 2013	−0.08	0.22	31	0.16	0.28	32	4.7	0.31 [−0.18, 0.81]
Barnes 2013	0.08	0.82	31	−0.05	0.82	32	4.8	0.16 [−0.34, 0.65]
Barnes 2013	0.17	0.62	31	0.13	1.01	32	4.8	0.05 [−0.45, 0.54]
Barnes 2013	0.02	0.85	31	0.01	0.94	32	4.8	0.01 [−0.48, 0.50]
Barnes 2013	−0.18	0.88	31	−0.22	0.8	32	4.8	0.05 [−0.45, 0.54]
Fabre 1999	−0.5	0.53	8	−1	0.01	8	1.0	1.26 [0.16, 2.36]
Lautenschalager 2008	0.16	0.74	85	−0.03	0.74	85	12.8	0.26 [−0.05, 0.56]
Lautenschalager 2008	−2.62	6.91	85	−3.43	6.91	85	12.9	0.12 [−0.18, 0.42]
Lautenschalager 2008	1.09	3.13	85	0.91	3.32	85	12.9	0.06 [−0.25, 0.36]
Lautenschalager 2008	0.45	1.94	85	0.38	1.84	85	12.9	0.04 [−0.26, 0.34]
Lautenschalager 2008	1.88	8.3	85	0.43	6.91	85	12.8	0.19 [−0.11, 0.49]
Nagamastsu 2013	43.38	10.95	24	43	9.61	25	3.7	0.04 [−0.52, 0.60]
Nagamastsu 2013	8.13	3.7	24	8.04	3.36	25	3.7	0.03 [−0.54, 0.59]
Nagamastsu 2013	9.29	3.21	24	8.52	3.5	25	3.7	0.23 [−0.34, 0.79]
Total (95% CI)			*660*			*668*	*100.0*	*0.13 [0.03, 0.24]*

Heterogeneity: $\chi^2 = 6.80$, df $= 13$ ($P = 0.91$); $I^2 = 0\%$
Test for overall effect: $Z = 2.43$ ($P = 0.02$)

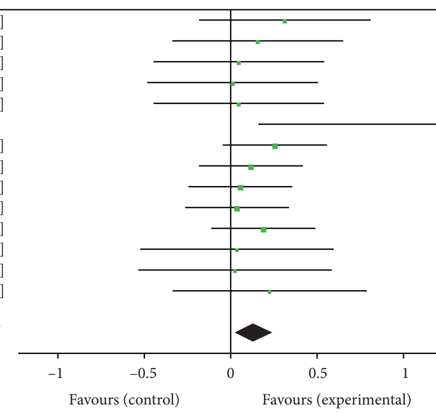

Figure 5: Forest plot for physical activity on objective cognitive function.

Study or subgroup	Experimental group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Std. mean difference IV, fixed, 95% CI
2.3.1. combined								
Andrieu 2017	3.803	25.492	390	1.212	25.406	380	98.4	0.10 [−0.04, 0.24]
Fabre 1999	1.37	0.52	8	0.5	0.76	8	1.6	1.26 [0.16, 2.37]
Subtotal (95% CI)			*398*			*388*	*100.0*	*0.12 [−0.02, 0.26]*
Heterogeneity: $\chi^2 = 4.20$, df $= 1$ ($P = 0.04$); $I^2 = 76\%$								
Test for overall effect: $Z = 1.68$ ($P = 0.09$)								
2.3.2. physical activity								
Cox 2013	18.45	4.99	85	16.75	4.89	85	31.6	0.34 [0.04, 0.65]
Fabre 1999	1.25	0.71	8	0.5	0.76	8	2.6	0.96 [−0.09, 2.02]
Lautenschalager 2008	−4.04	7.84	85	−4.4	8.02	85	32.1	0.05 [−0.26, 0.35]
Zuniga 2016	37.54	8.63	90	35.66	8.49	89	33.6	0.22 [−0.08, 0.51]
Subtotal (95% CI)			*268*			*267*	*100.0*	*0.22 [0.05, 0.39]*
Heterogeneity: $\chi^2 = 3.85$, df $= 3$ ($P = 0.28$); $I^2 = 22\%$								
Test for overall effect: $Z = 2.55$ ($P = 0.01$)								

Test for subgroup differences: $\chi^2 = 0.81$, df $= 1$ ($P = 0.28$); $I^2 = 0\%$

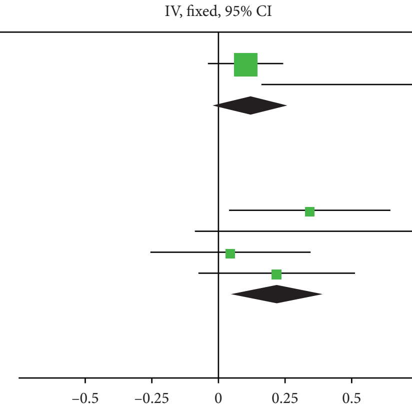

Figure 6: Forest plot for combined physical-cognitive interventions or physical activity on psychological well-being. Combined: combined physical-cognitive interventions.

Study or subgroup	Experimental group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Std. mean difference IV, fixed, 95% CI
2.2.1. combined								
Andrieu 2017	0.126	2.705	390	0.295	2.66	380	80.0	−0.06 [−0.20, 0.08]
Fabre 1999	−0.75	0.46	8	−0.25	0.46	8	1.4	−1.03 [−2 .09, 0.03]
Zuniga 2016	9.49	6.45	90	10.23	6.42	89	18.6	−0.11 [−0.41, 0.18]
Subtotal (95% CI)			*488*			*477*	*100.0*	*−0.09 [−0.21, 0.04]*
Heterogeneity: $chi^2 = 3.16$, $df = 2$ ($P = 0.21$); $I^2 = 37\%$								
Test for overall effect: $Z = 1.34$ ($P = 0.18$)								
2.2.2. physical activity								
Fabre 1999	−0.75	0.71	8	−0.25	0.46	8	7.9	−0.79 [−1.82 , 0.24]
Lautenschalager 2008	−0.94	3.87	85	−0.75	4.15	85	92.1	−0.05 [−0.35, 0.25]
Subtotal (95% CI)			*93*			*93*	*100.0*	*−0.11 [−0.39, 0.18]*
Heterogeneity: $chi^2 = 1.84$, $df = 1$ ($P = 0.17$); $I^2 = 46\%$								
Test for overall effect: $Z = 0.72$ ($P = 0.47$)								
Test for subgroup differences: $chi^2 = 0.01$, $df = 1$ ($P = 0.90$), $I^2 = 0\%$								

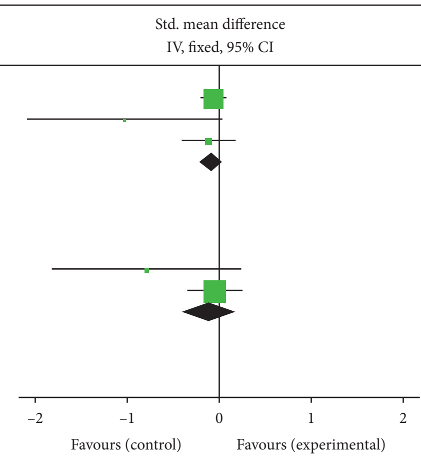

Figure 7: Forest plot for combined physical-cognitive interventions or physical activity on depression. Combined: combined physical-cognitive interventions.

significantly larger effects of combined cognitive and physical interventions, compared with both single exercise training and a control group on attention in healthy older adults [63]. McEwen's study showed that the SEQ group has a significantly increased reaction time while single stationary cycling training showed no significant changes in 55 older adults with subjective memory impairment [51].

In addition, we found a positive effect of combined physical-cognitive interventions on verbal fluency; this finding was consistent with the results of Small and colleagues which reported that a 14-day healthy longevity lifestyle program objectively demonstrated greater verbal fluency scores in older individuals with mild self-reported memory complaints but normal baseline memory performance scores [58].

In the present study, our results showed that the combined interventions are effective in improving objective cognitive function in subjective cognitive decline (SCD) older adults. As we know, SCD is identified as a condition where some individuals experience subjective cognitive complaints, but the objective examination did not show signs of cognitive decline. For the patients with SCD, the decline in cognitive function is relatively slight; therefore, the significant improvement with large SMD after the intervention may be not easy. For example, a systematic review and meta-analysis suggested that cognitive training interventions led to a small, statistically significant improvement in objective cognitive performance for SCD ($g = 0.13$, 95% CI 0.01 to 0.25; $P = 0.03$).

However, SCD is considered as the state between normal aging and (MCI) and may be the preclinical stage of (AD), with high risks of conversion to MCI or AD [52]. SCD may be a key window treatment period to delay the deterioration of cognitive function; early intervention and rehabilitation can help the reversal of cognitive decline [52]. Therefore, the effective difference may show the potential value of combined physical-cognitive interventions in improving objective cognitive ability and preventing the conversion of SCD to MCI or AD. However, due to the small SMD, the clinical importance may be not clear; further studies will be needed to explore the potential benefits of this therapy in preventing the conversion of SCD to MCI or AD.

Previous studies suggested that a cognitively challenging environment may enhance the neural and cognitive benefits that are elicited by physical activity [63, 64]. Animal studies showed that combined physical activity and environmental enrichment induce a significant enhancement in dendritic arborization of CA3 hippocampal neurons than either physical activity or an enriched environment, each on its own [41]. We consider that simultaneous physical exercise and cognitive training might increase the impact on neuroplasticity based on human and animal research, which has found that combined physical exercise and cognitive training yielded greater increases in new neurons in mice than either intervention alone [41, 43, 44]. Further study will be needed to verify the results.

Whether combined physical-cognitive interventions could improve memory ability is a controversial issue. Several studies have shown that combined physical-cognitive interventions have improved memory function, including composite memory, recent memory, and delayed memory [52–54, 59, 60]. Conversely, the remaining studies included showed combined physical-cognitive interventions to have negative results in memory ability [47, 51, 54, 65]. The changes in executive functioning differed significantly compared with the control group in only one study [52]. A meta-analysis of controlled trials with older adults presented a potential advantage at improving executive functions by physical and cognitive interventions. We speculate that there were several reasons. Firstly, the mode of combination, intervention frequency, intervention length, session length, and setting also were considered as potential moderators; secondly, the small sample size and lack of monitoring of the compliance of participants prevent any firm conclusions from being drawn; furthermore, the measures of cognition used varied across the studies that included cognitive tests, limiting its comparability. Further studies will be needed to explore the effects of combined physical-cognitive interventions on global cognitive function and the specific domains of cognition, including memory ability and executive ability.

Self-report memory complaints may predict the potential increased risk of dementia in objective cognitive performance. The English Longitudinal Study of Aging found that aged 50 years and above had a negative correlation between subjective memory complaints and objective performance in all cognitive domains [8]. In Zuniga's study, a significant main effect of subjective memory on measures of well-being indicated that individuals with the fewest memory complaints were significantly happier and lower perceived stress/physical symptoms reported across all measurement occasions [56]. However, our meta-analysis containing three studies did not show significant improvement in MSE in the combined physical-cognitive interventions [55, 56, 58]. To consider that the small sample size and the MSE were not a primary outcome for any of the combined physical-cognitive interventions studies, in these studies, further work is required to explore the role of combined physical-cognitive interventions in improving MSE.

In other cases, SCD may be associated with emotion, personality, and physical health concerns. Our findings indicated that there was a statistically significant improvement in well-being with only physical activity intervention. The present findings are comparable with a previously published meta-analysis, which conferred a small but significant benefit on psychological well-being after cognitive training interventions in older adults with SCD [66]. In Zuniga's study, a significant main effect of subjective memory on measures of well-being indicated that individuals with the fewest memory complaints were significantly happier and lower perceived stress/physical symptoms reported across all measurement occasions [56]. Significantly high importance was attributed to changes in self-efficacy in home-based physical activity programmers with older adults with memory complaints [57]. However, it is important to note that there is sometimes an unproven assumption that physical activity enhances a patient's overall well-being by preserving cognitive function [53]. The ground on these pieces of evidence, the well-being of supports that suggests cognitive impairment may have a negative impact on quality of life indicators in SCD elderly.

In the present study, we found that the combined interventions are effective in improving objective cognitive function in SCD older adults which may show the potential value of combined physical-cognitive interventions in improving objective cognitive ability and preventing the conversion of SCD to MCI or AD. However, due to the small SMD, the clinical importance may be not clear. Further studies will be needed to explore the potential benefits of this therapy in preventing the conversion of SCD to MCI or AD.

4.2. Strengths and Limitations. The strengths of this review belong to its systematic approach in which methodologically stronger study designs were used. First, we focused on types of combined physical activity and cognitive training, rather than nonpharmacologic interventions or all interventions. Furthermore, only RCTs were included in this meta-analysis. In addition, to reduce potential confounding bias, we only investigated older adults with SCD.

There are several limitations in the present study. First, the included studies with different levels of quality demonstrated methodologically heterogeneity that may have impacted our interpretation of the results. Second, the heterogeneity of intervention characteristics in the included studies should be considered, including the type and time, frequency, and duration. The type and time of combined physical-cognitive interventions used in the included studies were physical activity (e.g., walking, Dejian mind-body intervention, aerobic cycling, stretching, and jogging) and cognitive training (e.g., memory training, cognitive stimulation), which varied from 45 to 150 min per session. The intervention duration of the included studies ranged from 2 weeks to 3 years. Studies have investigated the decay after intervention cessation was less. Therefore, the optimal intervention design for the intervention effects remains unclear; more research is warranted. Third, a variety of noncompatible measurement tools were used in the included studies. Future studies should use more objective testing methods or instruments (e.g., functional MRI, event-related potential, and PET). Fourth, few studies (only two studies) reported the comparison between the combined interventions and cognitive or physical activity alone on SCD according to our current knowledge (according to the selection/identification/inclusion criteria of studies in the present study). In addition, there are no common outcomes in the two studies above; therefore, the meta-analysis of the combined interventions as compared to cognitive or physical intervention alone does not include common outcomes in the main findings. We will continue to pay attention to this issue in the future. Furthermore, most included studies were small samples. Last but not least, it is impossible to blind participants in a physical activity intervention trial; therefore, performance bias may be inevitable.

4.3. Clinical Implications and Recommendations for Future Studies. The combined interventions are effective in improving objective cognitive function in SCD older adults which may show the potential value of combined physical-cognitive interventions in improving objective cognitive ability and preventing the conversion of SCD to MCI or AD and no adverse effects. We provide clinicians with positive evidence of an effective option to recommend those older adults with SCD who would benefit from increasing combined physical-cognitive training.

Future studies in this field should use appropriate exercise modes, exercise prescriptions including training intensity, and frequency, such as the exercise training principles suggested by Bherer [63] or the global recommendations on physical activity for health provided by the WHO. In addition, if possible, the duration of training should be at least 6 months or longer [35]. Furthermore, more sensitive and objective measurement tools should be used. Finally, authors should follow the CONSORT guidelines when reporting their studies to allow better evaluation of the quality.

5. Conclusion

The combined interventions are effective in improving objective cognitive function in SCD older adults which may show the potential value of combined physical-cognitive interventions in improving objective cognitive ability and preventing the conversion of SCD to MCI or AD. However, considering the quality of included studies, discrepancies in the types, frequencies, and durations of interventions, as well as the limitations of the included studies, the findings must be interpreted cautiously. To draw specific and accurate conclusions regarding the potential enhancement effects of combined physical activity and cognitive training interventions on the objective cognitive ability, well-being, and MSE of SCD elderly, more rigorously designed and standardized training protocols of large-scale RCTs are required in future research.

Data Availability

All data analyzed during this study are included in this article. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Additional Points

Search Strategy. #1 (((((“subjective cognitive impairment”) OR “cognitive complaints”) OR “subjective cognitive decline”) OR “memory complaints”) OR “subjective memory impairment”) OR “Subjective memory decline”. #2 (((“intervention”) OR “training”) OR “exercise”) OR “activity”. #3 #1AND#2.

Disclosure

The funders have no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflicts of Interest

The authors have no conflicts of interest to report.

Authors’ Contributions

LJ conceived and designed the study and wrote and revised the manuscript; SQQ, XSR, GS, and YY were the research assistants who helped with data search, extraction, methodological assessment, and other aspects of the study; XR revised the manuscript; SQQ and XSR contributed equally to this study. All authors contributed to the writing of the manuscript and have read and approved the final manuscript version for publication.

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Review Article

Clinical Effects of Baduanjin Qigong Exercise on Cancer Patients: A Systematic Review and Meta-Analysis on Randomized Controlled Trials

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Objective. Baduanjin is a traditional Chinese Qigong exercise for health improvement. However, a few studies were examining the association between Baduanjin Qigong exercise and cancer patients. This study is conducted to explore the clinical effects of the Baduanjin Qigong exercise among cancer patients. *Methods*. We conducted a systematic review and meta-analysis using randomized controlled trials to assess the effects of the Baduanjin Qigong exercise on cancer patients. We searched Cochrane Library, PubMed, Embase, and Airiti Library for all relevant studies from inception through December 31, 2020, without language limitations. Two authors independently screened selected studies, assessed the quality of included studies, and extracted information. Any disagreement was discussed with a third senior author. Summary estimates were obtained using meta-analysis with the random effects model. *Results*. Among the fourteen articles involved in the systematic review, ten studies were included in the meta-analysis. Cancer patients with moderate-severe cancer-related fatigue were significantly less in the Baduanjin group compared with the control group (odds ratio = 0.27; 95% confidence interval (CI) [0.17, 0.42]). Three studies used the questionnaire of Functional Assessment of Cancer Therapy-Breast Cancer (FACT-B) in the assessment of quality of life, and two used the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-C30). For FACT-B, the Baduanjin group scored significantly higher than the control group (mean difference = 11.04, 95% CI [9.56, 12.53]). For EORTC QLQ-C30, the Baduanjin group scored significantly higher than the control group (mean difference = 10.57, 95% CI [7.82, 13.32]). The Pittsburgh Sleep Quality Index (PSQI) score for sleep quality of the Baduanjin group is significantly lower than the control group (mean difference = −2.89, 95% CI [−3.48, −2.30]). *Conclusion*. In conclusion, we found the Baduanjin exercise had positive clinical effects on cancer patients. This meta-analysis not only supported that the Baduanjin exercise can alleviate the degree of cancer-related fatigue in patients but also improved their quality of life and sleep quality. Further long-term follow-up randomized controlled trials are warranted.

1. Introduction

Nowadays, cancer patients live longer due to advances in cancer treatments. However, a large proportion of cancer patients could suffer from multiple physical and psychosocial complications, such as cancer-related fatigue, deterioration in quality of life (QoL), and sleep quality caused by cancer and its current therapy [1–3]. These negative conseruences may persist for months or years after the therapy [4, 5]. Therefore, more cancer care services should be developed to address the prevention of complications and assist patients in returning to the health status after treatment.

Physical activity is a potentially beneficial intervention to improve survival and QoL for people with cancer [6].

Findings from most studies have reported that exercise is a solution to pain, fatigue, and physical and mental function [7–10]. There is further evidence concerning the benefits of aerobic exercise in the rehabilitation of patients following cancer treatments [11]. A recent meta-analysis summarized that cancer patients in the aerobic training group reduced cancer-related fatigue compared to patients who received routine care [12]. Thus, aerobic exercise was suggested to be included in a part of cancer care and considered as an adjunct therapy that assists in alleviating the negative effects of cancer and its treatment [13].

Qigong is a general term for various exercises and treatments that Chinese people have performed for health [14]. Traditional Chinese medicine believes that Qigong can refine one's life and integrate mind and body [15]. Baduanjin, a branch of traditional Qigong exercise is a mild-to-moderate intensity aerobic exercise, which consists of eight effortless movements that work on specific body parts and meridians [16]. Since Baduajin is a mild and safe aerobic exercise, it is appropriate for cancer patients. Baduanjin may be a potential solution to complications undergoing cancer treatments. This present study was to examine the clinical effects of the Baduanjin Qigong exercise among cancer patients.

Table 1: Search strategy.

1	Cancer
2	Tumor
3	Tumour
4	Carcinoma
5	Neoplas*
6	Malignan*
7	1 OR 2 OR 3 OR 4 OR 5 OR 6
8	Baduanjin
9	7 AND 8
10	Fatigue
11	Tiredness
12	Quality of life
13	QOL
14	Activities of daily living
15	ADL
16	Sleep quality
17	Insomnia
18	Sleep disorder
19	10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18
20	Efficacy
21	Effect
22	Effectiveness
23	20 OR 21 OR 22
24	19 OR 23
25	7 AND 8 AND 24

2. Methods

2.1. Literature Search and Search Strategy. We conducted a systematic review and meta-analysis using randomized controlled trials (RCTs) to assess the effects of the Baduanjin Qigong exercise on cancer patients. We searched Cochrane Library, PubMed, Embase, and Airiti Library for all relevant studies from inception through December 31, 2020, without language limitations. The search string used the following: (cancer OR tumor OR tumour OR carcinoma OR neoplas ∗ OR malignan ∗)) AND (Baduanjin) AND (fatigue OR tiredness OR quality of life OR QOL OR activities of daily living OR ADL OR sleep quality OR sleep disorder OR efficacy OR effect OR effectiveness) (Table 1). We further identified other similar studies through checking the references and similar articles of screening studies.

2.2. Study Selection. These studies were involved if they met the following inclusion criteria: (1) the study design was an RCT; (2) they were original studies; (3) both experimental group and control group were diagnosed with cancer; and (4) Baduanjin Qigong exercise was the main intervention for the experimental group. The full texts of the search results were checked carefully, and we obtained the studies which had met the criteria mentioned before. Two authors (Chi-Chun Kuo and Chiao-Chen Wang) independently screened selected studies, evaluated the quality of included studies, and extracted information. Any disagreement was solved through discussion with the third author (Tao-Hsin Tung).

2.3. Data Extraction and Assessment of Potential Bias. A data extraction form was used to summarize the following information from selected studies: first author, publication year, country, study period, assigned group, randomly assigned participants (n), types of any participants, intervention time, outcome, and its measurement. An assessment of potential bias was performed independently by the authors. Two authors also used the Cochrane Collaboration Tool to assess the risk of bias of the included trials by the Review Manager version 5.3. The risk assessment tool included the following seven domains of bias risk: (1) random sequence generation, (2) allocation concealment, (3) blinding of participants and personnel, (4) blinding of outcome assessment, (5) incomplete outcome data, (6) selective reporting, and (7) other sources of bias. In the same way, any disagreement was determined to the third author.

2.4. Statistical Analysis. We used the Review Manager version 5.3 (The Nordic Cochrane Centre, The Cochrane Collaboration, 2014) to perform the quantitative synthesis. The outcomes of intervention effect were defined using questionnaires at baseline and after all interventions. The intervention effect was summarized by using the odds ratio with 95% CI or mean difference with 95% CI. If the data about means, standard deviation, or P value was unclearly reported in the articles, we would calculate by calculator tool in Review Manager or consult the Cochrane Handbook. In addition, we evaluated heterogeneity by using the I^2 statistic. A P value <0.10 was considered significantly heterogeneous. Heterogeneity was stratified as undisturbed (I^2: 0–24.9%), low (I^2: 25–49.9%), moderate (I^2: 50–74.9%), or high (I^2: 75–100%). We used the fixed-effect model when I^2 was less than 50% and would have used the random effects model if I^2 was 50% or more. For analyzing MD and 95% CI, if the standard deviation (SD) was not reported, we estimated SD by T-value and standard error. A funnel plot was used to test the symmetry of the pooled results and evaluated the publication bias of meta-analysis.

2.5. Critical Appraisal. We assessed the certainty in evidence from our three primary outcomes by using the Grading of Recommendations Assessment, Development and Evaluation (short GRADE). This system critical appraisal considered five domains: (1) overall risk of bias (randomization, allocation concealment, blinding, incomplete outcome data, selective reporting), (2) inconsistency (wide 95% CI), (3) indirectness (an indirect comparison of population, outcome, or intervention), (4) imprecision (I^2 cutoff of 50%), and (5) publication bias (commercially funding sources or study without “negative” findings). We evaluate each category rate as none, not serious, serious, or very serious; we rated the quality of evidence as very low, low, moderate, or high [17].

3. Results

3.1. Literature Search and Studies Characteristics. Figure 1 illustrates the overall study identification process by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. We acquired 44 studies from Cochrane Library, PubMed, Embase, and Airiti Library, of which 10 studies addressed the clinical effects of Baduanjin Qigong exercise on cancer patients. The characteristics of each included study are listed in Table 2. Among these studies, publication years were between 2015 and 2019, and all ten studies were conducted in China. A total of 409 participants were included in the intervention group and 402 in the controls. Figure 2 presents a summary assessment of bias risk by the Cochrane Collaboration Tool. Ying et al. clearly described how the researcher prevents selection bias by concealing the allocation sequence. The other ten trials did not clearly depict how research populations are selected. Almost all ten trials did not clearly illustrate whether the participants and outcome assessments were blinded since it was not feasible to blind the participants and Baduanjin Qigong exercise coach.

3.2. Cancer-Related Fatigue from BFI Measurement. Five of the studies examined the effect of Baduanjin Qigong exercise on cancer-related fatigue. They provided events of data on this outcome. We organized data from the selected trials using fixed models because of low heterogeneity ($\chi^2 = 0.54$, $P = 0.97$, and $I^2 = 0\%$). We found cancer patients with moderate-severe cancer-related fatigue were significantly less in the Baduanjin group compared with the control group (odds ratio = 0.27; 95% CI [0.17, 0.42]) and the test for overall effect presented ($Z = 5.81$, $P < 0.00001$) (Figure 3(a)).

3.3. QoL from EORTC QLQ-C30 Measurement. QoL was assessed on the basis of the score for various domains from the EORTC QLQ-C30. The MD was 10.57 (95% CI [7.82, 13.32]). We organized data from the selected trials using random models because of high heterogeneity. Statistical heterogeneity was observed across the trials ($Z = 7.53$, $P < 0.00001$; $\chi 2 = 12.86$, $P = 0.0003$, $I^2 = 92\%$) (Figure 3(b)).

3.4. QoL from FACT-B Measurement. Also, three studies showed that Baduanjin Qigong exercise has a positive effect on breast cancer patients. The pooled MD was 11.04 (95% CI [9.56, 12.53]), test for overall effect presented ($Z = 14.57$, $P < 0.00001$; $\chi 2 = 16.44$, $P = 0.0003$, and $I^2 = 88\%$) (Figure 3(c)).

3.5. Sleep Quality from PSQI Measurement. Two of the studies focused on the effect of Baduanjin Qigong exercise on the sleep quality of patients with cancer. For the PSQI questionnaire, the MD was −2.89 (95% CI [−3.48, −2.30]), test for overall effect presented ($Z = 9.55$, $P < 0.001$; $\chi^2 = 0.29\%$, $P = 0.59$, and $I^2 = 0\%$) (Figure 3(d)).

3.6. Publication Bias. Publication bias was viewed as the publication or nonpublication of studies relying on the direction and statistical significance of the results and the first systematic investigations of publication bias focused on this aspect of the problem. As Figures 4(b) and 4(c) show, the funnel plot was asymmetry, indicating some publication bias in this study.

3.7. Quality of Evidence Assessment. A detailed evidence assessment of study outcomes is available in Table 3. There was a low quality of evidence for the outcomes of fatigue and sleep quality due to lack of blinding the participants and outcome assessments, as well as allocation concealment; however, in the aspect of blinding, it is impractical to blind the Baduanjin intervention group and their instructors. The quality of evidence for QoL graded very low as a result of not only bias risk but also inconsistency.

4. Discussion

4.1. Clinical Implications. To the best of our knowledge, this study is the first systematic review and meta-analysis to examine the clinical effects of the Baduanjin Qigong exercise on cancer patients. There is consensus among researchers regarding the Baduanjin Qigong exercise as a potential solution to the complications of cancer and its therapy. Our results supported that Baduanjin Qigong exercise can have a positive impact on cancer-related fatigue, QoL, and sleep quality of patients with cancer. From the clinical viewpoint, common complications occurring during or after cancer treatment and lack of a gold standard for the treatment of complication are problems which should be noticed that many academic studies were conducted to find appropriate health care. After completing this systematic review and meta-analysis, we acquired an interesting outcome that continuous Baduanjin Qigong exercise might have positive effects on cancer patients.

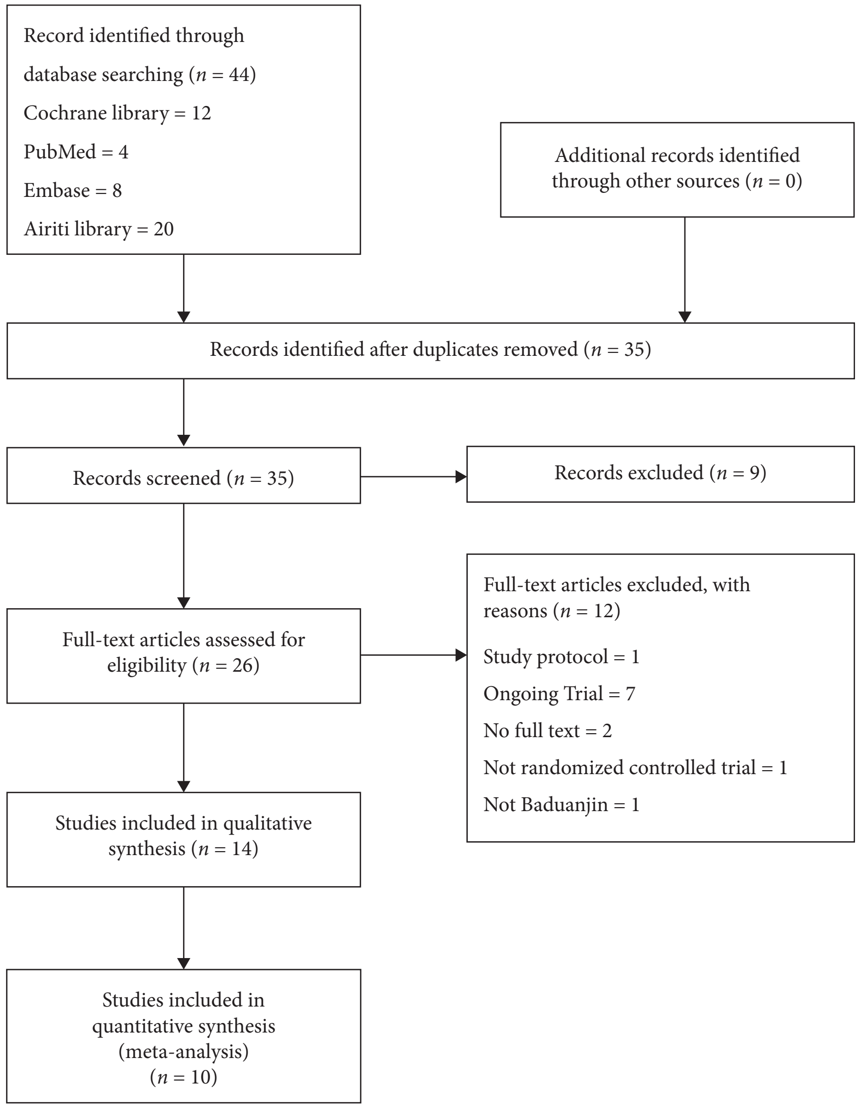

Figure 1: PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow chart.

4.2. Clinical Practice. Nonpharmaceutical treatments have experienced the stage of development, examination, and implementation. Among them, traditional Chinese medicine's nonpharmaceutical exercise treatments are constantly used for chronic health conditions in China [28, 29]. Low-intensity exercise therapies such as Tai Chi Chuan, Qigong, and Baduanjin are recommended for cancer patients and survivors, especially the easy at-home exercise program [30, 31]. Qigong exercise system like Baduanjin involves a series of movements, breath control, and meditation, which could enhance and strengthen the function of all the internal organs and bodily systems [32]. Thus, compared to traditional routine care for cancer patients suffering from complications, there is a good deal of advantages using the Baduanjin Qigong exercise as an adjunctive treatment for cancer patients.

4.3. Heterogeneity of Meta-Analysis. In the meta-analysis, heterogeneity may exist if the sample estimates for the population risk were of different magnitudes [33]. The I^2 statistic implies the percentage of variation across selected studies that is due to heterogeneity rather than chance. In this study, we used the random effect model when I^2 statistics were 92% and 88% for EORTC QLQ-C30 and FACT-B of quality of life more than 50%, respectively. For the existence of significant heterogeneity in QoL, it is important to assess heterogeneity in the meta-analysis. This problem could be caused by the fact that there were only two and three studies included in the groups, respectively, which have a kind of different effect (different level of preference in the experimental group). We aggregate studies that are different methodologies; heterogeneity in the results is still inevitable.

4.4. Methodological Considerations. Using meta-analysis study design could not only combine and synthesize multiple studies and integrate the findings, but also conduct research by combining selected studies and providing a

Table 2: Characteristics of randomized controlled trials.

Author	Publication year	Country	Study period	Assigned group	Randomly assigned participants (n)	Types of any participants	Intervention time	Outcome
Lu et al. [18]	2019	China	Unclear	Control: routine care Experimental: Baduanjin on the basis of the control group	44 43	Colorectal cancer patient with cancer-related fatigue	24 weeks	Cancer-related fatigue (BFI): (i) At 12 weeks, case (58.1%) vs. control (61.4%); $P = 0.750$. (ii) At 24 weeks, case (23.2%) vs. control (59.1%); $P < 0.01$ Sleep quality (PSQI): (i) At 12 weeks, case (5.7 ± 1.3) vs. control (7.7 ± 2.0); $P < 0.01$. (ii) At 24 weeks, case (4.1 ± 1.1) vs. control (6.9 ± 2.0); $P < 0.01$
Ying et al. [19]	2019	China	Unclear	Control: original physical activity Experimental: Baduanjin	40 46	Breast cancer survivor	6 months	Quality of life (FACT-B) case (112.00 y of l) vs. control (103.40 y of l); $P = 0.000$
Lei et al. [20]	2019	China	Unclear	Control: routine nursing Experimental: Baduanjin on the basis of the control group	60 60	Chemotherapy patients with small cell lung cancer	8 weeks	Quality of life (EORTC QLQ-C30): case (65.2 ± 10.7) vs. control (57.6 ± 6.7); $P < 0.01$
Wu et al. [21]	2018	China	Unclear	Control: routine care Experimental: Baduanjin on the basis of the control group	15 15	Chemotherapy patient with colorectal cancer	2 months	Sleep quality (PSQI): case (6.03 ± 1.47) vs. control (9.22 ± 1.95); $P = 0.000$
Huang et al. [22]	2017	China	Unclear	Control: routine rehabilitation exercise Experimental: Baduanjin on the basis of the control group	40 40	Chemotherapy patient after breast cancer radical mastectomy	4 months	Quality of life (FACT-B): Case (100.25 ± 3.89) vs. control (87.13 ± 4.36); $P < 0.01$
Li et al. [23]	2017	China	Unclear	Control: routine rehabilitation Experimental: Baduanjin and routine rehabilitation	30 31	Radiotherapy patient after breast cancer radical mastectomy	3 months	Quality of life (FACT-B): case (99.19 ± 5.218) vs. control (93.34 ± 7.247)
Xiu [24]	2015	China	Unclear	Control: routine nursing Experimental: Baduanjin and routine nursing	34 36	Patient with cancer-related fatigue	8 weeks	Cancer-related fatigue (BFI): case (52.8%) vs. control (79.4%); $P = 0.019$ Quality of life (EORTC QLQ-C30): case (70.3 ± 15.5) vs. control (51.2 ± 5.7); $P = 0.024$
Min and Yan [25]	2017	China	Unclear	Control: conventional nursing Experimental: Baduanjin combined with five-element musicotherapy on the basis of the control group	34 36	Cancer-related fatigue in patient with chemotherapy for acute myeloid leukemia	4 weeks	Cancer-related fatigue (BFI): case (52.7%) vs. control (79.4%); $P < 0.05$

Table 2: Continued.

Author	Publication year	Country	Study period	Assigned group	Randomly assigned participants (n)	Types of any participants	Intervention time	Outcome
Ping et al. [26]	2019	China	Unclear	Control: conventional nursing Experimental: Baduanjin and emotional nursing on the basis of the control group	36 35	Patient with malignancies	4 weeks	Cancer-related fatigue (BFI): case (42.86%) vs. control (69.44%); $P = 0.010$
Ping et al. [27]	2017	China	Unclear	Control: conventional nursing Experimental: moxibustion combines with Baduanjin exercise on the basis of the control group	36 36	Patient with cancer-related fatigue	8 weeks	Cancer-related fatigue (BFI): case (25.0%) vs. control (58.3%); $P < 0.05$

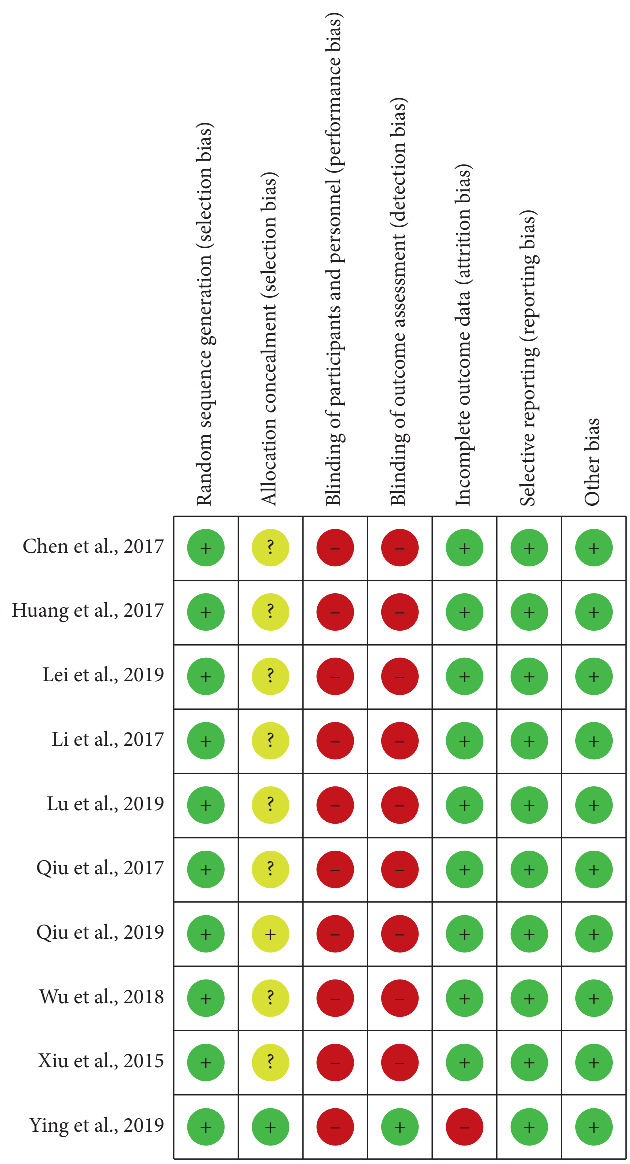

Figure 2: Risk of bias summary.

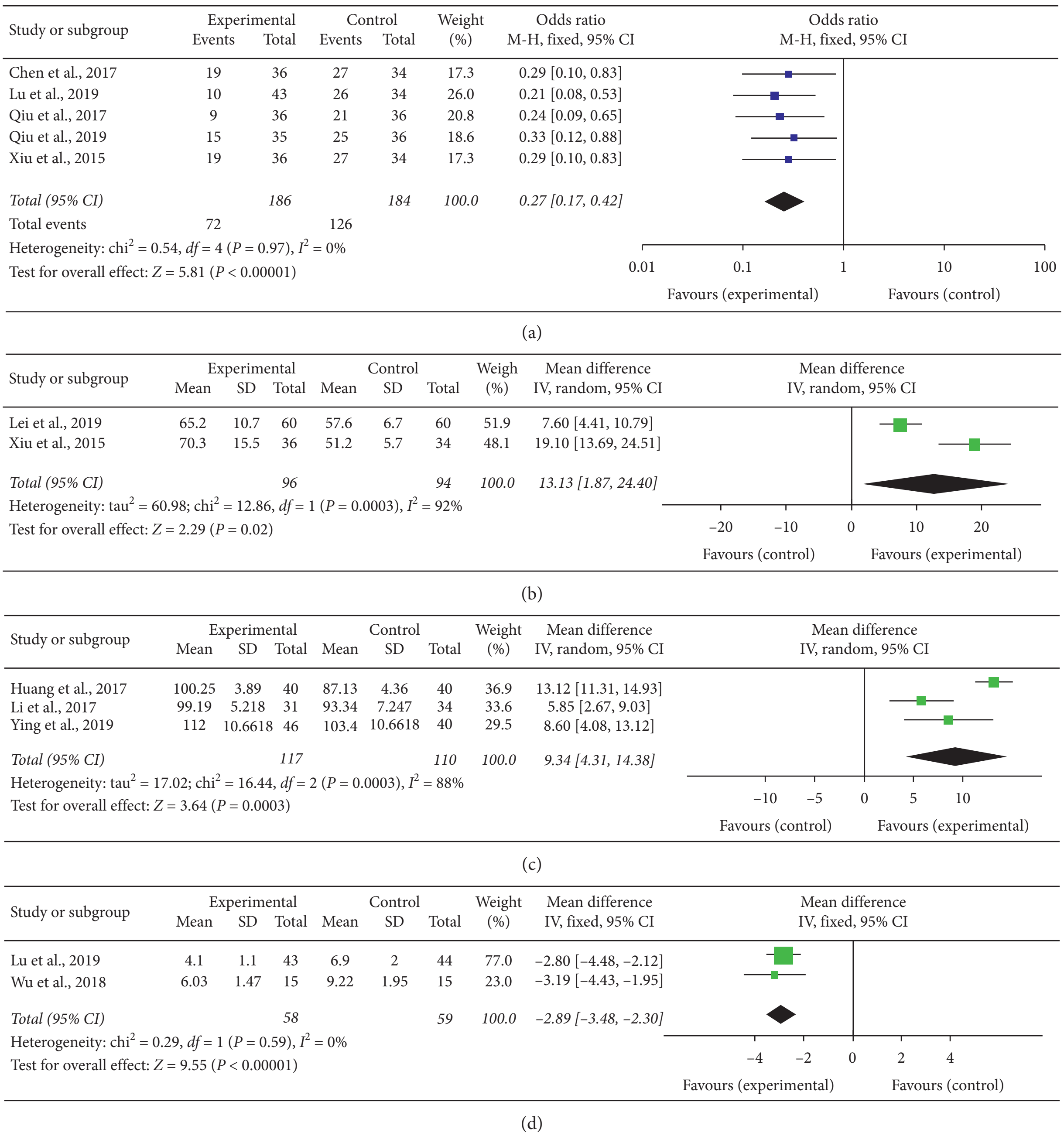

Figure 3: (a) Meta-analysis result of BFI of cancer-related fatigue. (b) Meta-analysis result of EORTC QLQ-C30 of quality of life. (c) Meta-analysis result of FACT-B of quality of life. (d) Meta-analysis result of PSQI of sleep quality.

precise estimate of the outcome [34]. However, there were some limitations in the present study. Firstly, due to fact that the number of selected studies which could be searched was insufficient, the relative lower statistical power with smaller sample sizes is not avoidable. Secondly, it is controversial of surrounding random effects model. The statistical assumption of the normal distribution for random effects does not fit the principle of randomization [35]. The variance of random effects would be only as an encumbrance variable if there are no random effects. The statistical inference of this nuisance variable to meta-analysis weights would then be to significantly increase variance estimated and consistent weights through exacting the larger studies [36]. Thirdly, most of the studies lack blinding, which may cause performance and detection bias. The biases are inevasible because the Baduanjin intervention group knows what treatment they involve. Fourthly, the usage of different outcome measurements in different studies resulted in only a few studies being included in the analysis, so the strength of the conclusions may be called into question. Fifthly, clinically, the Baduanjin intervention should be conducted on the basis of routine rehabilitation. Therefore, it is difficult to suppose whether the clinical effects were due to Baduanjin alone. Sixthly, the intervention time varies among the

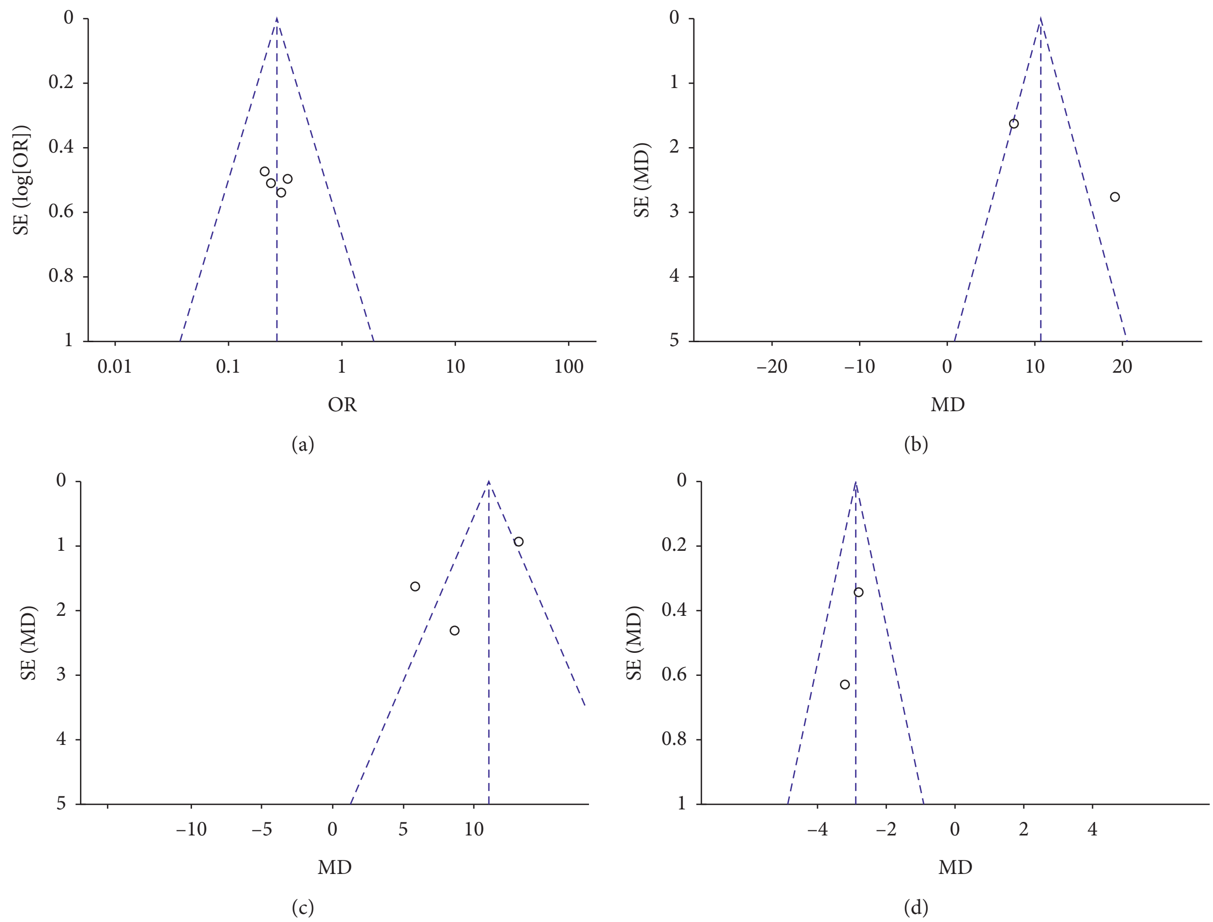

FIGURE 4: (a) Funnel plot of BFI of cancer-related fatigue. (b) Funnel plot of EORTC QLQ-C30 of quality of life. (c) Funnel plot of FACT-B of quality of life. (d) Funnel plot of PSQI of sleep quality.

TABLE 3: Quality assessment.

Outcome (measurement)	Number of participants (trials)	Certainty assessment						Quality of the evidence (GRADE)	Recommendation
		Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias		
Cancer-related fatigue (BFI)	370 (5)	RCTs	Serious	None	None	Not serious	Undefective	⊕⊕◯◯ Low quality	Strong for using
Quality of life (EORTC QLQ-C30)	190 (2)	RCTs	Serious	Serious	None	Serious	Undefective	⊕◯◯◯ Very low quality	Strong for using
Quality of life (FACT-B)	227 (3)	RCTs	Serious	Serious	None	Serious	Undefective	⊕◯◯◯ Very low quality	Strong for using
Sleep quality (PSQI)	117 (2)	RCTs	Serious	None	None	Not serious	Undefective	⊕⊕◯◯ Low quality	Strong for using

finding studies, lasting from 4 weeks to 6 months, and we proposed that long-term effects of the exercise at a certain level need longer follow-up periods. Fifthly, all ten studies included in this meta-analysis were performance in China and the main study populations were Chinese. Therefore, whether the result can extrapolate to non-Chinese population needs further investigation. Finally, only patients of specific age and health conditions participated in these studies, which makes the effects of the Baduanjin Qigong exercise on participants with different characteristics hard to be concluded.

5. Conclusions

In conclusion, the current evidence supports that Baduanjin Qigong Exercise has positive clinical effects on cancer patients. This meta-analysis supported that the Baduanjin exercise not only can alleviate the degree of cancer-related fatigue in patients but also can improve their QoL and sleep quality. However, most of the selected studies do not mention the quality control of the practice of the Baduanjin Qigong Exercise. It is difficult to evaluate truly the practice of the Baduanjin Qigong Exercise and effectively estimate the level of each practitioner's practice for the explanation of its actual effect. If this question is not evaluated, and the comparison with the control group has no practical significance, most studies do not consider this issue, so the reliability of the conclusions reached is limited. Further long-term follow-up randomized controlled trials consider the practice of Baduanjin Qigong Exercise's action, breathing, and mind all have the problem of whether the operation in its place would make the research more discursive.

Conflicts of Interest

The authors have no proprietary interest in any aspect of this study.

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Research Article

The Feasibility and Positive Effects of Wuqinxi Exercise on the Cognitive and Motor Functions of Patients with Parkinson's Disease: A Pilot Study

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Introduction. Parkinson's disease (PD) is a chronic degenerative disease of the central nervous system common in middle-aged and elderly people, which has a serious impact on patients' cognitive and motor functions. Exercise can improve the nonmotor symptoms of PD patients, but the optimal type of exercise for the cognitive function of patients is unclear. Therefore, the purpose of this study is the impact of 12 weeks of Wuqinxi exercise on the cognitive and motor function in PD patients. *Methods*. Thirty PD patients participated in the study and were randomly assigned to two groups: Wuqinxi group ($n = 15$) or stretching group ($n = 15$). All the participants performed a 12-week exercise program twice a week, 90 min/session. The assessments were conducted before and after exercise intervention, included cognitive function (frontal assessment battery (FAB); Stroop test I and II), motor functions (Unified Parkinson's Disease Rating Scale Part III (UPDRS-III); timed up and go (TUG)). *Results*. We found the FAB and Stroop I scores were significantly higher in the Wuqinxi group than in the stretching group. Participants in the Wuqinxi group significantly improved their UPDRS-III (17.73 ± 9.88) and TUG (10.50 ± 1.79) score after 12 weeks of training intervention. *Conclusion*. The results show that the use of Wuqinxi for rehabilitation therapy for cognition is feasible, widely accepted, and effective in patients with Parkinson's disease. This study provides preliminary evidence for further large-scale and controlled studies.

1. Introduction

Parkinson's disease (PD) is a progressive neurodegenerative disease characterized by dopamine (DA) depletion [1]. The patient has characteristic motor symptoms and nonmotor symptoms such as sleep disorders, cognitive impairment, anxiety, and depression [2]. Among them, cognitive dysfunction aggravates motor symptoms. According to reports, the incidence of dementia in PD patients is about 12%–30%, which brings a huge burden to patients' lives and families [3]. Dementia is characterized by the progressive cognitive decline associated with behavior disturbances and differential in performing the activities of daily living [4]. Another common factor in this neuropathology is the impairment of executive functions [5, 6]. Notably, executive deficits can occur at any stage of the disease and can be progressive [7]. However, the question of impairment of executive function remains unresolved.

Exercise can promote the growth of brain cells and the diversity and complexity of neuronal communication and help improve the executive function of the elderly [8]. Wuqinxi exercise belongs to the healthy Qigong exercise. Previous studies have shown that Wuqinxi exercise has been used to improve osteoporosis in the elderly [9], attention concentration ability [10], immune function [11] and exercise capacity [12], and reduce cardiovascular disease and metabolic syndrome

[13]. Although more and more studies have shown the great potential of Wuqinxi, there is no research to explore the impact of Wuqinxi on the executive function of PD patients.

At present, many methods of testing executive function have been developed. For example, the Stroop color and word test studies the classic paradigm of executive function, which can measure inhibition control ability [14]. We also used the frontal assessment battery (FAB) assessment tool, which has been shown to be superior to the mini-mental state examination (MMSE), as a screening tool for neurodegenerative diseases involving the frontal lobe. It is rarely used in studies of PD patients [15].

Therefore, this study aims to systematically evaluate the process and scientific feasibility of the experimental design, compare the effects of Wuqinxi exercise and stretching exercises on PD cognition and motor function, and provide a new and effective rehabilitation exercise for Parkinson's patients. We hypothesize that the 12-week Wuqinxi exercise is effective in improving PD cognitive and motor function and is better than the stretching group.

2. Methods

2.1. Participants. PD patients were recruited through Shanghai University of Sport or Xinhua Hospital Affiliated to Shanghai Jiaotong University School of Medicine by referrals from neurologists and/or physical therapists and distribution of the study information to local support groups for persons with PD. The inclusion criteria for the study participants included a clinical diagnosis of PD, ages between 55 and 80 years, and with a disease severity from mild to moderate level (rating from 1 to 3 out 5) according to the Hoehn and Yahr scale [16]; drug treatment is stable, the patient can walk independently or with the aid of walkers. The exclusion criteria included currently involved in any behavioural or pharmacological intervention study or instructor-led exercise training program; serious organic diseases (heart disease, hypertension, tuberculosis, nephritis, etc.) in the past two years; history of alcoholism, smoking, and visual or hearing impairment; a mini-mental state examination score lower than 24 [15] and deep brain stimulation surgery (DBS). All interventions are carried out during the drug "on" phase.

2.2. Study Design. We designed a randomized clinical trial to compare the effects of exercise at 3 months in a group of patients assigned to Wuqinxi classes with the effects in groups assigned to stretching classes. Each group participated in a 90-minute class that met twice weekly for 12 weeks. The research was supported by the Ethics Committee of Shanghai Sport University and obtained written informed consent from all participants. The research was registered in China Clinical Trial Registry (ID: ChiCTR1800016570).

2.3. Screening and Randomization. Research staff screened patients by telephone; those who met prescreening criteria underwent an in-person evaluation and baseline assessment. We used stratified random sampling (H&Y period). Using computer-generated random number sorting (Stata V.12.0, Statacorp, Texas, USA), a random number is placed in a sealed envelope at a ratio of 1 : 1, and the participants are drawn by random numbers from the envelope. The participants are randomly assigned to Wuqinxi group or stretching group. Outcome assessors were unaware of group assignments.

2.4. Exercise Interventions

2.4.1. Wuqinxi Exercise. The protocol consisted of ten movements (two movements in each of the five animals). During the training, it is required to imagine the movement characteristics of the five animals (tiger, deer, bear, ape, and bird), emphasizing the coordination of body movements, breathing and mind, loosening the limbs, and relaxing the spirit. A professional trainer conducts practice guidance twice a week, 90 minutes each time. After the exercise, each patient is required to fill in the exercise log, including the heart rate, rest time, and exercise time during each training period (Figure 1).

2.4.2. Stretching Exercise. This control method is formulated by a physical therapist. It is a low-intensity activity stretching method that consists of sitting and standing stretching. The range of movement includes the upper body (neck, shoulders, upper back, chest, and arms) and lower extremities (quadriceps, triceps, calf muscles, and hips), with joint extension, bending, and trunk rotation suitable for the physical characteristics of the elderly. The main breathing method is abdominal breathing, and the emphasis is on coordination of inhalation and movement to relax the muscles. The stretching group is also conducted under the guidance of the coach, twice a week, 90 minutes each time, a total of 12 weeks.

2.5. Outcome Assessments

2.5.1. Primary Outcomes. Stroop colour and word test [17] is a neuropsychological test widely used in clinical experimental study. It is the best evidence to prove that the patient's executive function is the ability to suppress interference. The ST-I is used as a measure of processing speed, and the ST-II is used as a measure of selective attention and inhibition. The frontal assessment battery (FAB) is a short bedside screening instrument that evaluates six domains of frontal lobe function, namely, conceptualization [18]. The Montreal Cognitive Assessment Scale (MoCA) is a rapid assessment scale that covers cognitive domains such as executive function, language, orientation, calculation, conceptual thinking, memory, visuospatial perception, attention, and concentration [19].

2.5.2. Secondary Outcomes. UPDRS is an internationally used scale for assessing the degree of disease and motor function of Parkinson's patients. There are a total of four parts. UPDRS-III was selected for evaluation in this study

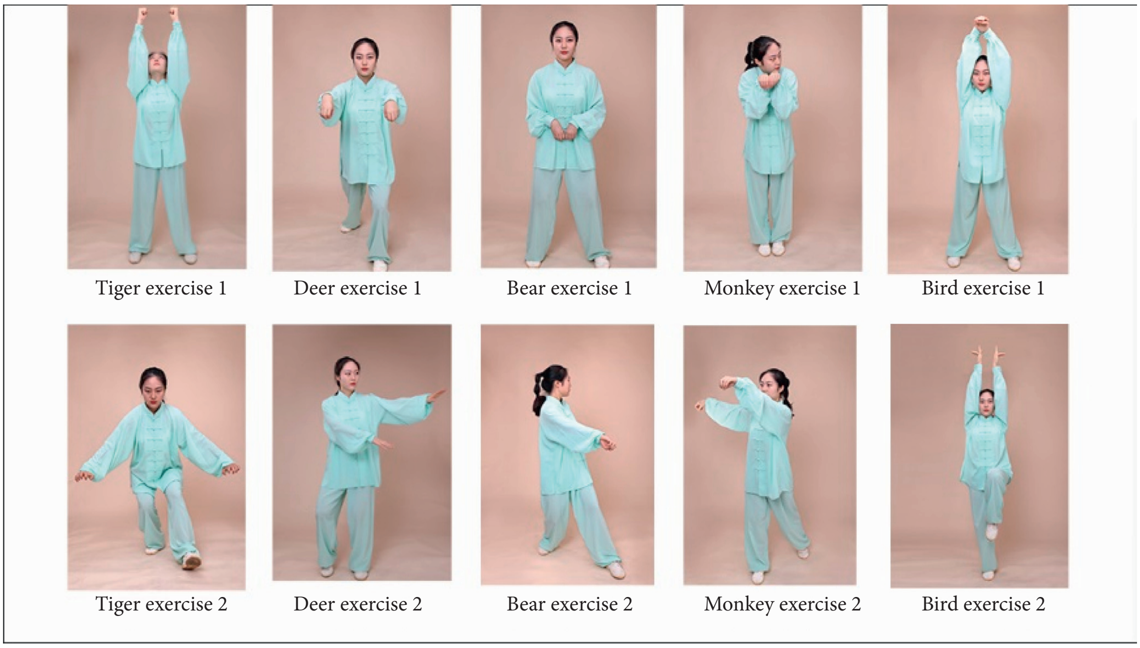

Figure 1: Illustrations of Wuqinxi exercise maneuvers. The agreement includes ten actions such as tiger raising, tiger seizing, deer colliding, deer running, bear swaying, bear rubbing, ape being alert, ape plunking, bird stretching, and bird flying.

[20] score ranging from 0 to 56, with lower values indicating less motor disability. The timed up and go (TUG) test is a well-known clinical test for assessing of mobility and fall risk [21]. The subject was instructed to stand up from the sitting position indicated by the examiner, walk 3 meters in a comfortable place, turn around, walk back to the chair, and sit down.

2.6. Statistics Analysis. Statistical data analysis was performed using IBM SPSS 25.0 (IBM Corp., Armonk, NY) software, with descriptive statistics (mean and standard deviation). The paired t-test was used to analyze the baseline and motor function data before and after the exercise intervention in the group. The normality of the data was tested using the Shapiro–Wilk test. The effects of the exercises on cognitive function were examined using two-way repeated-measures ANOVA, with the group (Wuqinxi or stretching) serving as the between-subject factor and time (baseline, 12 weeks) serving as the within-subject factor. Significant differences in ANOVA were analysed by the Bonferroni post hottest. P value <0.05 indicates significant difference; P value <0.01 indicates extremely significant difference.

3. Results

3.1. Baseline Characteristics of the Participants. Of the 121 people who were screened, 32 were registered and randomized, while 89 subjects refused to participate before randomization. In the end, 30 patients were randomly assigned to the traditional Wuqinxi exercise training group ($N = 15$) or the stretching exercise training group ($N = 15$). One person in the Wuqinxi group withdrew from training because he needed to take care of his family, and one person in the stretching group withdrew because he did not like exercise (Figure 2).

Table 1 shows the demographic and clinical characteristics of the patients. There were no significant differences in demographic and baseline variables between the two groups, indicating that randomization was acceptable. During the study, there were no reports of fall in both groups.

3.2. Exercise Intensity. In terms of exercise intensity, the target heart rate of PD patients was calculated according to the formula $\text{HRmax} = 208 - (0.7 \times \text{age})$, and it was maintained for about 20 minutes during training [22]. The heart rate of PD patients during training was monitored by Polar Team2 heart rate telemeter. Exercise intensity did not differ significantly between the Wuqinxi group and stretching group. Exercise intensity in the two groups was between 50% and 70%, which can be considered relatively comfortable aerobic exercise [23].

3.3. Outcomes

3.3.1. Cognitive Ability. For the ST-I score, after 12 weeks of intervention, there is a significant difference in time ($P = 0.011$), but the stretching group (1.69 ± 0.62) is higher than the Wuqinxi group (0.32 ± 0.33); there is a significant difference between the two groups ($P = 0.026$), the Wuqinxi group (2.47 ± 0.47) is greater than the stretching group (1.10 ± 0.47); and there is a significant interaction between time and group (F (1,28) $= 4.229$, $P = 0.049$). The Wuqinxi group is better than the stretching group (Figure 3(a)).

For the ST-II score, after 12 weeks of intervention, there is a significant difference in time ($P = 0.004$), but the Wuqinxi group (2.04 ± 0.66) is higher than the stretching

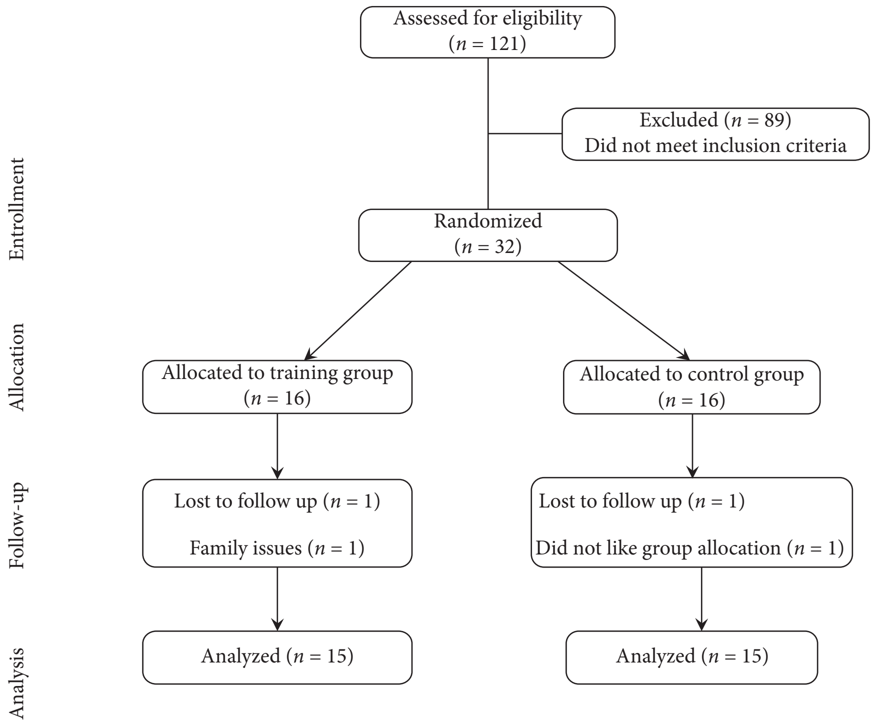

Figure 2: Patient flow diagram.

Table 1: Mean (SD) for baseline characteristics of participating patients.

	Wuqinxi	Stretching	*P* value
Number	15	15	
Age (yr)	68.67 ± 4.33	66.93 ± 3.36	0.23
Gender (M/F)	8/7	12/3	
Disease duration (yr)	6.27 ± 4.49	7 ± 3.92	0.63
H&Y scale	1.86 ± 0.83	2.2 ± 0.70	0.24
Education level	10.53 ± 1.99	10.20 ± 1.69	0.84
Antiparkinsonian medications taken (no.)			
Levodopa or carbidopa	14	14	
Pramipexole	7	10	
Others	6	4	
There is no statistical difference in any characteristic category between the two groups			

H&Y, Hoehn and Yahr.

group (1.68 ± 0.54); there is a significant difference between the two groups ($P < 0.001$); the Wuqinxi group (1.65 ± 0.40) is greater than the stretching group (1.30 ± 0.40); but there was no significant interaction between time and group (F (1,28) = 4.229, $P = 0.545$) (Figure 3(b)).

For the FAB score, after 12 weeks of intervention, there is no significant difference in time, but the stretching group (0.66 ± 0.33) is higher than the Wuqinxi group (0.60 ± 0.99); there is a significant difference between the two groups ($P = 0.023$), the Wuqinxi group (2.66 ± 0.47) is greater than the stretching group (1.13 ± 0.47), and there is a significant interaction between time and group (F (1,28) = 5.305, $P = 0.029$]). The Wuqinxi group is better than the stretching group (Figure 3(c)).

For the MOCA score, after 12 weeks of intervention, there is no significant difference in time, but the stretching group (2.40 ± 1.01) is higher than the Wuqinxi group (0.60 ± 0.99); there is a significant difference between the two groups ($P = 0.001$), the Wuqinxi group (3.40 ± 0.46) is greater than the stretching group (1.66 ± 0.46), and there is a significant interaction between time and group (F (1,28) = 7.094, $P = 0.013$). The Wuqinxi group is better than the stretching group (Figure 3(d)).

3.3.2. Motor Function. After 12 weeks of intervention, the UPDRS-III score of PD patients in the Wuqinxi group decreased from 26.67 (10.99) to 17.73 (9.88) previously measured, a 33% decrease, with a statistical difference ($P = 0.021$) (Figure 4(a)). The score before and after the TUG Wuqinxi group decreased by 16% from 12.52 (3.52) to 10.50 (1.79), and the change was statistically different ($P = 0.007$); the TUG score of PD patients in the stretching group increased from 12.80 (7.77) to 17.97 (7.88), an increase of 28%,

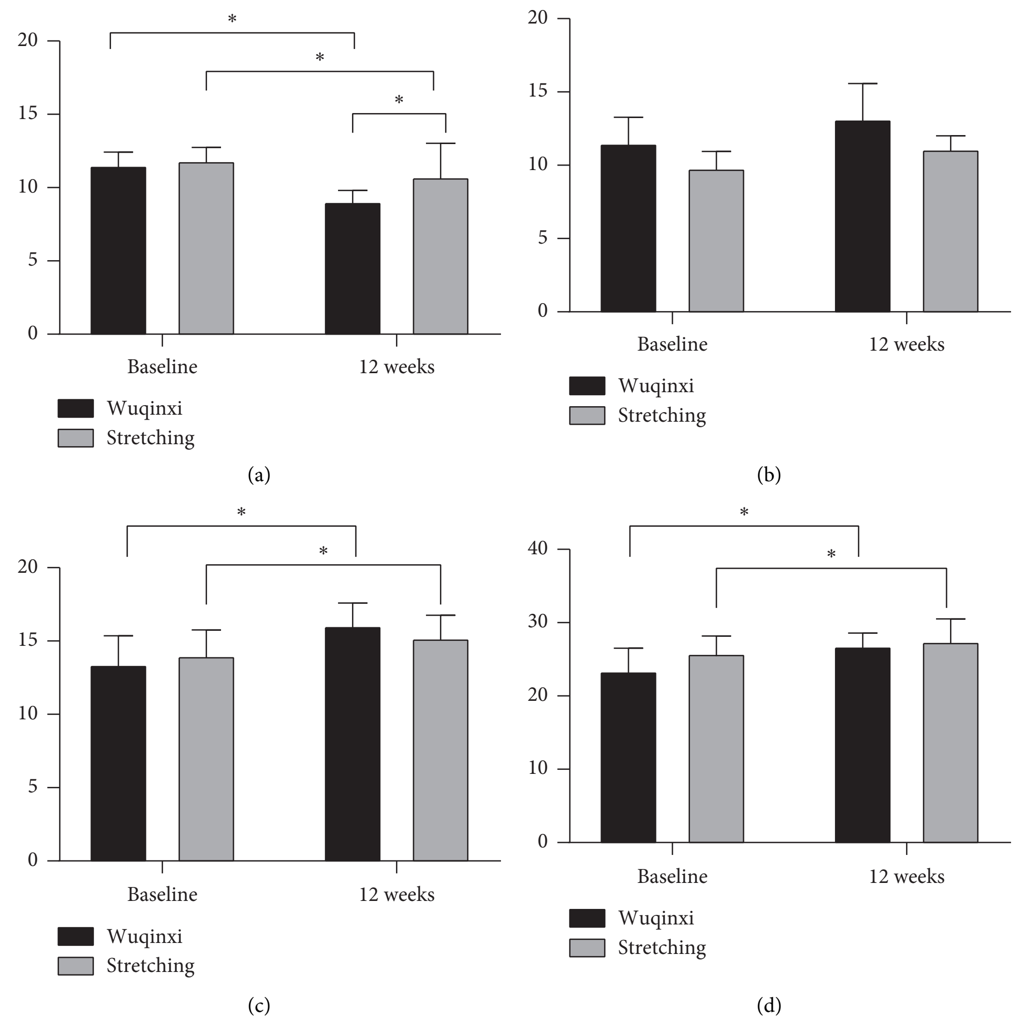

Figure 3: Changes in cognitive function after 12 weeks of intervention. (a) ST-I, part I of the Stroop test. (b) ST-II, part II of the Stroop test. (c) FAB, the frontal assessment battery. (d) MoCA, Montreal Cognitive Assessment. $^{*}P < 0.05$ for the indicated comparisons.

and the change before and after was statistically different ($P = 0.004$), indicating that the walking ability of the stretching group decreased compared with that before the intervention, which was statistically significant, but had no actual clinical significance (Figure 4(b)).

4. Discussion

Our study proved for the first time that the Wuqinxi exercise is effective in the cognitive and motor function of patients with mild to moderate PD and is better than the stretching group.

Research has shown that practising Wuqinxi can effectively improve the executive ability of middle-aged and older people [24]. This is similar to our research. The Stroop test in this study is a measure of executive function, which assesses attention control and processing speed (reaction time) during task interference (colour and word inconsistency) [25]. Impaired performance on Stroop is related to a higher risk of subsequent dementia in nonpsychotic patients [26, 27]. Therefore, 12-week Wuqinxi intervention can improve Stroop scores, indicating that Wuqinxi exercise may reduce the risk of dementia in PD patients. Liang [28] evaluated the cognitive function of middle-aged and older people by exercising four times a week for 30 minutes and found that Wuqinxi has a good effect on the cognitive function of middle-aged and older people. In addition, during the 6-month Wuqinxi exercise, the Wuqinxi group's MMSE, visual space and executive ability, naming, attention, delayed recall, orientation, and MOCA score all changed significantly [29].

Cognitive test results of MOCA and FAB show the positive effect of Wuqinxi can be attributed to its essence. As a mind-body aerobic exercise, compared with traditional exercise methods (such as resistance training, muscle endurance training, and strength training), PD patients are required to control their breathing in addition to mobilizing external muscle activities during the exercise; when the practitioner reaches a relaxed state, it can change the mental state of PD patients during practice and improve their bioelectric current and body activity so that the brain waves in various areas of the brain tend to be synchronized and the electromagnetic activity of brain cells is highly effective

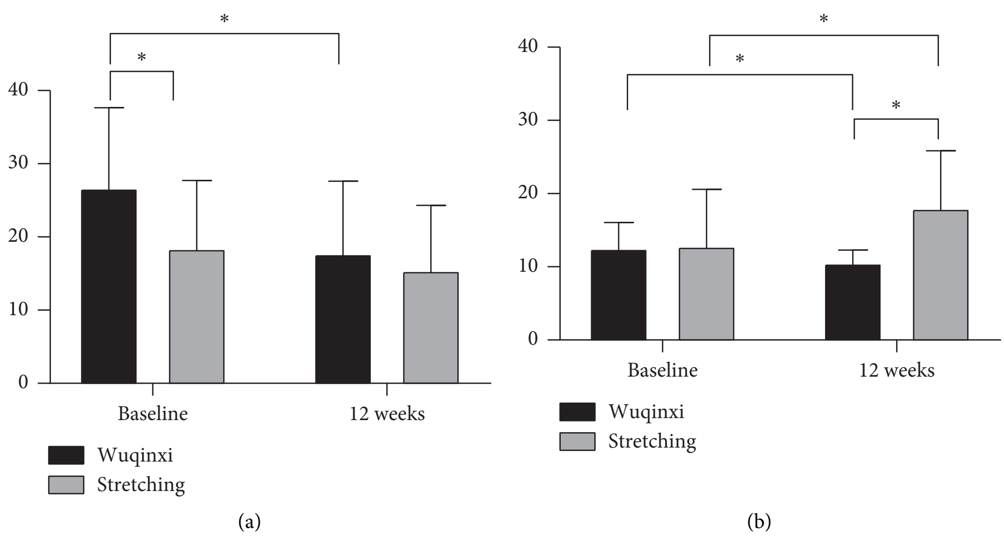

FIGURE 4: Changes in motor function after 12 weeks of intervention. (a) UPDRS-III, Unified Parkinson's Disease Rating Scale III. (b) TUG, the timed up and go. $^*P < 0.05$ for the indicated comparisons.

[30, 31]. The decline in cognitive function in patients with Parkinson's disease represents functional connectivity in the cortex-striatal network accompanied by degeneration of the nervous system other than the dopaminergic system, such as the cholinergic and noradrenaline pathways [32]. Therefore, by instructing patients to focus on their sensory feedback during Wuqinxi exercises, the function of the frontal regions involved in attention and emotional processing may be notably improved.

Another important clinical finding is that current randomized controlled trials have improved the severity of motor symptoms after exercise regimens. Specifically, from the pretest to the posttest, the UPDRS-III score of patients with ON state in Wuqinxi group dropped by 33%. As a bionic traditional movement, Wuqinxi needs to imitate the ferocity of tigers, the briskness of deer, the vigorousness of bears, the agility of birds, and the agility of apes [33]. The movement involves both upper and lower limbs and also emphasizes symmetrical posture, which can strengthen the coordinated contraction of active muscles and antagonist muscles and play a role in the recovery of patients' motor function [34]. A meta-analysis showed that Wuqinxi can reduce antagonistic muscle contraction and improve sport function [11]. After 8 weeks of intensive intervention in 16 patients with Parkinson's disease, Lee et al. found a significant improvement in UPDRS-III in the healthy qigong group compared with the stretching group, which is consistent with the results of this study. [35]

The teaching process is divided into the following: the first three weeks for the learning phase of the movement, 4–6 weeks for the consolidation phase of the campaign and gradually integrating the concepts of breathing and imagination, and 7 to 12 weeks for the collective exercise time of the change. Simple and easy-to-understand actions make it easier to increase patient participation. The gradual process enabled the patients to show good enthusiasm in the process of involvement, and there was some excellent feedback after the course.

4.1. Study Limitations and Perspectives. This study has certain limitations. First of all, due to the particularity of the disease, the Wuqinxi group and the stretching group have a small sample size, which may affect the results. Secondly, we did not follow up the patients and could not obtain the durability of the treatment effect. In the future, we can consider adding some brain function imaging technologies, such as near-infrared, EEG, and other advanced instruments, to further explore the impact of Wuqinxi exercise on specific brain areas of patients.

5. Conclusions

These preliminary data indicate that the Wuqinxi exercise for 90 minutes twice a week for 12 weeks is feasible, widely accepted, and useful for patients with mild to moderate Parkinson's disease. In the future, further large-scale and controlled studies will be needed to confirm these data to further explore the mechanism of the Wuqinxi exercise on PD improvement.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors report no conflicts of interest in this work.

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Review Article

The Influences of Tai Chi on Balance Function and Exercise Capacity among Stroke Patients: A Meta-Analysis

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Objective. This study aims to explore the influences of Tai Chi on the balance function and exercise capacity among stroke patients. *Methods*. Databases including PubMed, Embase, WOS (Web of Science), the Cochrane Library, CNKI (China National Knowledge Infrastructure), Wanfang Data, VIP (VIP database), and CBM (China Biology Medicine disc) were retrieved to gather the figures of randomized controlled trials on the balance function and exercise capacity among stroke patients. Then relevant data were input and analyzed in Review Manager 5.3. *Results*. Nineteen papers were included and analyzed in this study. According to the combined effect size, the balance function of stroke patients improved significantly: the Berg Balance Function Scale score [MD = 7.67, 95% CI (3.44, 11.90)]; standing and walking test scores [MD = 3.42, 95% CI (4.22, −2.63)]; gravity swing area [MD = 0.79, 95% CI (1.48, 0.10)]; and gravity swing speed [MD = −5.43, 95% CI (−7.79, 3.08)]. In addition, the exercise capacity improved significantly as well: the FMA (Fugl-Meyer Assessment Scale) scale score [MD = 4.15, 95% CI (1.68, 6.63)]. There are no significant influences or changes of other related results. *Conclusions*. Stroke patients are able to improve their balance functions and exercise capacities prominently when they do Tai Chi exercise once or twice a week and ≥5 times/week and >30 ≤ 60 min/time.

1. Introduction

Stroke, a common and frequently occurring disease among middle-aged and elderly people, is a disease of brain tissue damage caused by the sudden rupture of cerebral blood vessels or vascular obstruction, which has high incidence, high disability rate, and high mortality rate [1]. Hemiplegia is one of the most common sequelae of stroke, whose patients usually lose muscle strength and balance function of one limb, making them inconvenient or unable to move at all [2]. According to statistics, there are about two million new stroke patients every year in China; nowadays, there are a total of 6–7 million survival Chinese patients, whose mortality rate reaches 10%–30% and the disability rate is around 60%–70%. In addition, around 80% of stroke patients suffer from impairment of lower limb motor function [3], which severely troubles their daily activities and lowers their quality of life [4].

As a low-intensity aerobic exercise, Tai Chi is a safe, effective, and inexpensive adjuvant therapy and rehabilitation method [5] and has been reported many times in recent years for being applied in daily rehabilitation of patients with chronic diseases and the elderly [6]. The evidence of quantitative research shows that Tai Chi can relax the tense muscles of patients, enhance their flexibility and strength, inhibit the occurrence of abnormal postures and spasms, improve the balance function, enhance the normal exercise ability and control ability of stroke patients, and have many positive effects on the daily activities and psychological emotions of stroke patients [7, 8], thus improving the life quality of stroke patients.

In previous studies, none of the randomized controlled trial studies on Tai Chi intervention have been integrated to analyze the role of Tai Chi on stroke. Therefore, this study aims to clarify the effect of Tai Chi on the balance function and exercise ability among stroke patients, as well as illustrate the influences of various exercise variables among the patients, so as to provide references for the development of precise exercise programs.

2. Research Method

This study followed the requirements of the international meta-analysis writing guidelines (the PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health-care interventions: explanation and elaboration) [9] for the selection and use of research methods. The protocol for this study was registered with INPLASY (202110086).

2.1. Literature Inclusion and Exclusion Criteria

2.1.1. Research Design. A meta-analysis of randomized controlled trials (RCT) and the influences of Tai Chi on balance function and exercise capacity among stroke patients is conducted.

2.1.2. Criteria of the Included Literature. ① The subjects of the study were all stroke patients with stable conditions and were in line with the stroke diagnostic criteria formulated by the 4th Cerebrovascular Disease Academic Conference of the Chinese Medical Association [10] or the stroke diagnostic criteria regulated by the American Heart Association/American Stroke Association (AHA/ASA) [11]; ② the vital signs were stable; ③ if a study had two treatment groups, it was regarded as two studies; and ④ the type of this study is randomized controlled trial (RCT).

2.1.3. Criteria of the Excluded Literature. ① The subjects included in the experiment were normal elderly without stroke diseases; ② the subjects had dyskinesias and could not complete Tai Chi exercises; ③ there was no pure Tai Chi exercise intervention group; ④ papers with multiple releases and low-quality assessment; and ⑤ papers with unclear and incalculable experimental data.

2.2. Literature Retrieval Strategy. Databases including PubMed, the Cochrane Library, Embase, Web of Science (WOS), China National Knowledge Infrastructure (CNKI), Wanfang Data, VIP, and China Biology Medicine disc (CBM) were retrieved to gather randomized controlled trial figures on balance function and exercise mobility on stroke patients who did Tai Chi exercise. The retrieval period started from the initial period of each database to June 30, 2020. The search strategy was based on the principle of PICOS (Population, Intervention, Comparison, Outcomes, and Study design) and adopted a combination of subject words and free words, which were determined after repeated prechecks, supplemented by manual search and the references tracking of those papers when necessary. Chinese search terms include cerebral stroke (脑卒中), stroke (中风), cerebral thrombosis (脑血栓), cerebral infarction (脑梗死), Tai Chi (太极), Tai Chi Chuan (太极拳), random (随机), and experiment (试验). The English search terms used the Web of Science database as an example:

#1 TS = (stroke or apoplexy or cerebrovascular accident)

#2 TS = (Tai Ji or Tai-ji or Tai Chi or Tai Ji Quan or Taiji or Taijiquan or Tai Chi Chuan)

#3 TS = (balance or equilibrium or posture control or posture reaction or athletic ability or exercise performance or motor ability or exercise capacity or sports ability)

#4 TS = (randomized controlled trial or randomized or controlled or trial)

#5 #1 and #2 and #3 and #4

2.2.1. Intervention Measures. At least, one group only used Tai Chi exercise as the intervention method, and the control group received placebo, health education, daily activities, routine nursing, etc.

2.2.2. Outcome Indicators. Outcome indicators selected various scales and testing indicators for evaluating balance function and exercise ability, including the Berg Balance Scale (BBS), standing and walking, gravity center swing, short physical performance battery (SPPB), Fugl-Meyer Assessment Scale (FMA), and six-minute walking test (6MWT).

2.3. Literature Screening, Data Extraction, and Quality Evaluation

2.3.1. Literature Screening. Two researchers used independent double-blind methods to screen the literature based on the criteria of the included and excluded literature and extracted relevant data. If there was a disagreement on the mutual review, screening, and data extraction phases, a third researcher would join in to discuss whether to include the data.

2.3.2. Data Extraction. The data extracted from the literature mainly include the author's name, year of publication, nationality, sample size, age, exercise form, exercise cycle, exercise duration, exercise frequency, and exercise intensity. The outcome indicator data extracted from the study were the change values of outcome index included in the literature, that is, the postintervention test data subtracted the preintervention test data.

Physical exercise variables were divided based on relevant previous researches: exercise duration lasting for ≤30 min (minutes), >30 ≤ 60 min, and >60 min [12]; exercise intensity had low, medium, and high categories [13]; exercise frequency included 1-2 times/wk (times per week), 3-4 times/wk, and ≥5 times/wk, and the cycle was divided into ≤12 weeks, >12 ≤ 24 weeks, and >24 weeks [14].

2.3.3. Quality Evaluation. The risk of bias criteria of randomized controlled trials (RCT) in the Cochrane Collaborative Network were adopted to perform qualitative evaluation of seven aspects of RCT: random sequence generation, distribution concealment, blind method of subjects and researchers, blind method of outcome evaluator, incomplete outcome data, selective report, and other bias, and each index was judged by "low bias risk," "uncertain bias risk," or "high bias risk."

2.3.4. Level of Evidence. In this study, the evidence level of the included literature was graded according to the evidence level of the Oxford Center for Evidence-Based Medicine [15] (Table 1).

2.3.5. Statistical Analysis. Using Review Manager 5.3 for the literature data process, this paper had the combined effect size and heterogeneity test and drew a forest diagram. The literature outcome indicators were all continuous variables, the effect size chose Mean Difference (MD) and Standardized Mean Difference (SMD), and the effect size was MD = 95% of confidence interval. This meta-analysis strictly follows the PRISMA guidelines [8] and used the P value and I2 for the heterogeneity test. If there was no statistical heterogeneity between the results of each study (I2 ≤ 50%, $P > 0.10$), the fixed-effects model would be selected. If there was statistical heterogeneity between the studies, the source of the heterogeneity would be further analyzed, and the random effects model was used for analyses after excluding the influence of obvious clinical heterogeneity.

3. Results

3.1. Process and Results of Literature Screening. Initially, a total of 380 articles were retrieved from the database, among which 41 repeated papers were excluded. According to the inclusion and exclusion criteria, 303 papers were screened and excluded. Then, 17 articles were excluded after a full-text screening. At last, 19 articles were left (Figure 1).

3.2. The Included Literature

3.2.1. Basic Information of the Included Literature. Nineteen randomized controlled trial (RCT) literature were included, whose subjects were all stroke patients. According to the evidence level standard and recommendation level of the Oxford Center for Evidence-Based Medicine, the evidence levels of the included literature were all Ib, which stands for a relatively high evidence level and good quality (Table 2).

3.2.2. Sports Intervention Features in the Included Literature. Tai Chi, as an intervention method, was adopted in all the 19 included papers. Their selected intervention period lasted 12 weeks or less, and there were two articles that did not report the intervention period. Four papers chose the intervention frequency as twice a week, six papers chose 3-4 times/wk, and nine papers chose ≥5 times/wk. Four papers had the exercise duration ≤30 min per time, 14 papers had 30–60 min per time, and one paper had >60 min per time. The research results in the included literature were all the balance function and exercise ability among stroke patients (Table 3).

3.2.3. Bias Risk Analysis of the Included Literature. As shown in Figures 2 and 3, Review Manager software was used to analyze the risk of bias in the included literature. Among these papers, 5 papers did not explain the method of random allocation of subjects, and only 4 papers used the method of allocation and hiding to randomly divide the subjects and did not blind the subjects. Only 3 papers blinded the subjects and 6 papers conducted the blinding of evaluation, among which 2 papers conducted double-blinded experiments on both subjects and result evaluation. Data of the 19 papers were complete, and other sources of bias risk were not explained.

3.3. Meta-Analysis Results

3.3.1. The Influences of Tai Chi on the Berg Balance Scale. Six papers studied the influence of Tai Chi on Berg Scale scores. The heterogeneity analysis showed that $I^2 = 99\%$, $P < 0.01$, showing heterogeneity features in those studies. Therefore, the random effects model was used to analyze the results, and the combined effect size showed [MD = 7.67, 95% CI (3.44, 11.90)]. Compared with the control group, Tai Chi can significantly improve the Berg Balance Scale score of stroke patients (Figure 4).

3.3.2. The Influences of Tai Chi on the Standing and Walking Test. Three papers studied the influence of Tai Chi on the standing and walking test of stroke patients. The analysis of heterogeneity showed that $I^2 = 13\%$, $P = 0.32 > 0.05$. In other words, there was no statistical heterogeneity between those studies. Thus, the fixed-effects model was selected to analyze, and the meta-analysis results were [MD = −3.42, 95% CI (−4.22, −2.63)], indicating that Tai Chi can significantly improve the standing and walking ability of stroke patients (Figure 5).

3.3.3. The Influence of the 6 m Walking Test on the Patients Doing Tai Chi. Two papers studied the influences of Tai Chi on the 6 m walking experiment. The heterogeneity results showed that $I^2 = 89\%$, $P = 0.003 < 0.05$, so the random effects model was selected to conduct meta-analysis of the results, and the results showed that the combined effect size was [MD = 30.94, 95% CI (−11.34, 73.23)]. Tai Chi can significantly improve the 6 m walking

Table 1: Evidence level and recommendations grades of the Oxford Center for Evidence-Based Medicine.

Level of evidence	Contents	Recommended hierarchy
Ia	Systematic review with homogeneity of RCTs	I
Ib	Individual RCTs (with narrow confidence interval)	
IIa	Systematic reviews with homogeneity of cohort studies	II
IIb	Individual cohort study (including low-quality RCTs, e.g., <80% follow-up)	
IIc	Outcomes research	
IIIa	Systematic review of homogeneous case-control studies	III
IIIb	Individual case-control study	
III	Case series (and poor-quality cohort and case-control studies)	IV
—	Expert opinions without explicit critical appraisal	V

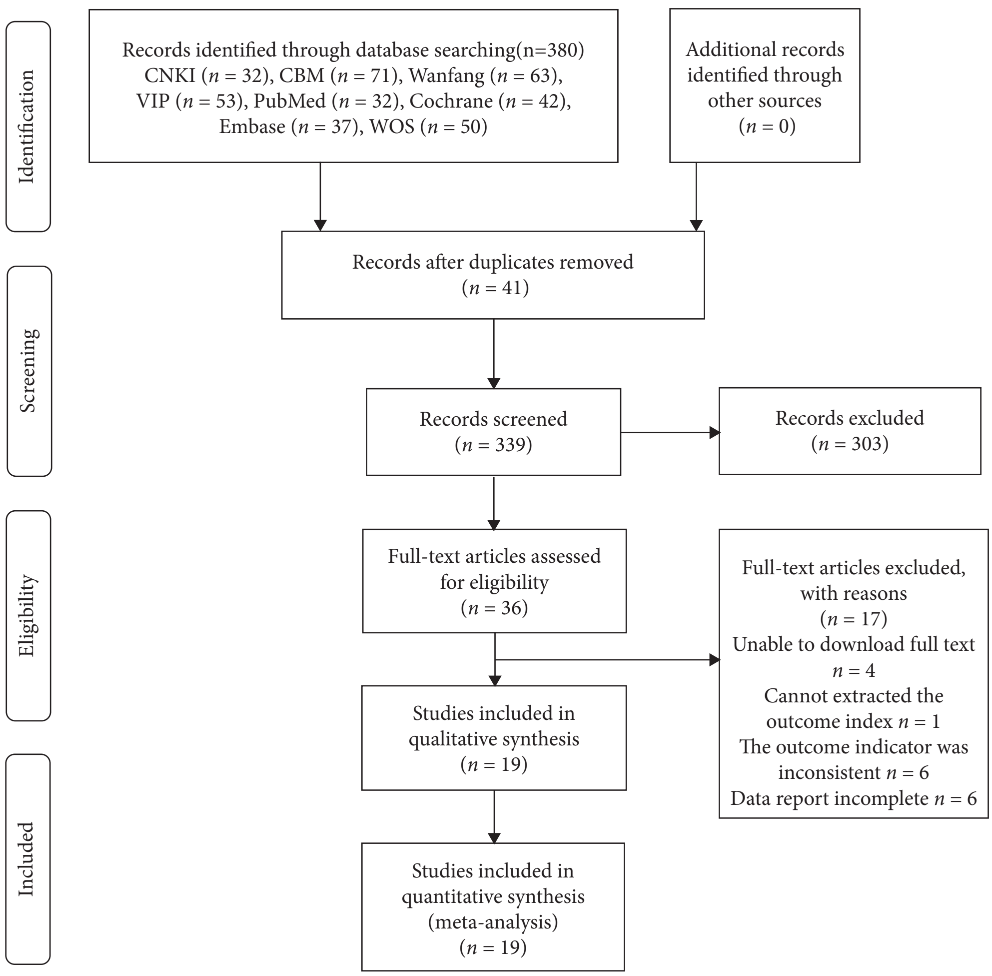

Figure 1: Literature screening process.

distance of stroke patients, but the difference is not significant (Figure 6).

3.3.4. The Influence of Tai Chi on the Swing of the Gravity Center. Two papers studied the influence of Tai Chi on the swing area of the center of gravity (Figure 7), three papers studied the effect of Tai Chi on the swing length of the center of gravity (Figure 8), and two papers studied the effect of Tai Chi on the swing speed of the center of gravity (Figure 9). The heterogeneity test results were $I^2 = 83\%$, $P = 0.02 < 0.05$; $I^2 = 97\%$, $P = < 0.01$; and $I^2 = 0\%$, $P = 0.65 > 0.05$. Therefore, the random effect model was selected in the tests of swing area of gravity center and swing length of gravity center, and the fixed-effects model was selected in the swing speed of the gravity center test to conduct meta-analysis on the results. The swing area of gravity center was [MD = −0.79, 95% CI (−1.48, −0.10)], swing length of gravity center was [MD = −0.28, 95% CI (−2.05, 1.49)], and swing speed of gravity center was [MD = −5.43, 95% CI (−7.79, −3.08)]. The results show that Tai Chi can significantly improve the area and speed of the gravity center swing of stroke patients while

Table 2: Basic information of the included literature.

No.	Included literature	Nationality	Symptom	Number of subjects (T/C)	Age (T/C)	Percentage of men (T/C) (%)	Level of evidence
1	Au-Yeung et al. [16]	China	Stroke	59/55	61.7 ± 10.5 65.9 ± 10.7	55.93 60.00	Ib
2	Chan and Tsang [17]	China	Stroke	9/9	63.9 ± 6.1 63.2 ± 6.0	55.56 44.44	Ib
3	Huang et al. [18]	China	Stroke	14/14	62.21 ± 9.74 59.93 ± 9.96	85.71 71.43	Ib
4	Kim et al. [19]	Korea	Stroke	11/11	53.45 ± 11.54 55.18 ± 10.20	63.60 54.50	Ib
5	Taylor-Piliae and Coull [20]	The U.S.	Stroke	16/12	72.8 ± 10.1 64.5 ± 10.9	62.5 58.33	Ib
6	Taylor-Piliae et al. [21]	The U.S.	Stroke	53/48	71.5 ± 10.3 68.2 ± 10.3	64.2 47.9	Ib
7	Zheng et al. [22]	China	Stroke	85/85	61.01 ± 5.20 60.73 ± 6.05	32.9 28.2	Ib
8	Fan et al. [23]	China	Stroke	43/43	63.4 ± 5.0 63.8 ± 5.3	67.44 69.77	Ib
9	Fu and Zhang [24]	China	Stroke	30/30	59.7 ± 7.6 60.3 ± 8.4	63.33 60	Ib
10	Li et al. [25]	China	Stroke	30/30	71.03 ± 8.21 71.06 ± 8.33	56.67 53.33	Ib
11	Liu et al. [26]	China	Stroke	24/24	52.13 ± 14.13 53.51 ± 12.63	58.33 45.83	Ib
12	Xiao [27]	China	Stroke	46/46	57.51 ± 1.14 57.68 ± 1.75	67.39 65.22	Ib
13	Xu et al. [28]	China	Stroke	40/40	60.14 ± 10.25 48.23 ± 12.32	55 40	Ib
14	Yang and Liu [29]	China	Stroke	28/21	51.43 ± 47.63 54.02 ± 38.41	60.71 61.90	Ib
15	Yang and Tang [30]	China	Stroke	28/21	51.43 ± 15.63 54.85 ± 11.85	60.71 66.67	Ib
16	Yang et al. [31]	China	Stroke	30/30	58 ± 11.27 60.07 ± 7.87	66.67 60	Ib
17	Zhang et al. [32]	China	Stroke	20/20	67.80 ± 12.22 66.65 ± 10.49	50 55	Ib
18	Zhao et al. [33]	China	Stroke	30/30	53.85 ± 11.69 51.38 ± 14.83	66.67 63.33	Ib
19	Yi et al. [34]	China	Stroke	66/66	48.78 ± 13.52 47.69 ± 14.91	63.64 59.09	Ib

T: treatment group; C: control group.

Table 3: Sports intervention features in the included literature.

No.	Included in the study	Intervention measures		Intervention elements			Outcome indicators
		Treatment group	Control group	Control group	Frequency (times/wk)	Time (min/time)	
1	Au-Yeung et al. [16]	Tai Chi	Regular activity	12	4	60	TUG
2	Chan and Tsang [17]	Tai Chi	Regular activity	12	2	60	Gravity swing test
3	Huang et al. [18]	Tai Chi	Regular activity	12	3	40	FMA
4	Kim et al. [19]	Tai Chi + physiotherapy	Physiotherapy	6	2	60	TUG, 10 mwt

Table 3: Continued.

No.	Included in the study	Intervention measures		Intervention elements			Outcome indicators
		Treatment group	Control group	Control group	Frequency (times/wk)	Time (min/time)	
5	Taylor-Piliae and Coull [20]	Tai Chi	Health education	12	3	60	SPPB
6	Taylor-Piliae et al. [21]	Tai Chi	Regular activity	12	3	60	SPPB
7	Zheng et al. [22]	Tai Chi	Regular activity	12	5	60	6 mwt
8	Fan et al. [23]	Tai Chi + conventional rehabilitation	Conventional rehabilitation	12	3	90	BBS, TUG, and FMA
9	Fu and Zhang [24]	Tai Chi + conventional rehabilitation	Conventional rehabilitation	8	6	40	BBS
10	Li et al. [25]	Tai Chi + medicine	Medicine	12	2	60	FMA
11	Liu et al. [26]	Tai Chi + conventional rehabilitation	Conventional rehabilitation	12	7	30	BBS
12	Xiao [27]	Tai Chi + conventional rehabilitation	Conventional rehabilitation	—	5	40	FMA
13	Xu et al. [28]	Tai Chi + physiotherapy	Physiotherapy	12	7	40	BBS
14	Yang and Liu [29]	Tai Chi + conventional rehabilitation	Conventional rehabilitation	8	3	40	FMA
15	Yang and Tang [30]	Tai Chi + comprehensive rehabilitation	Comprehensive rehabilitation	8	5	40	FMA and BBS
16	Yang et al. [31]	Tai Chi + traditional walking	Traditional walking	—	7	15 (Tai Chi) + 45 (traditional walking)	FMA
17	Zhang et al. [32]	Tai Chi + conventional rehabilitation	Conventional rehabilitation	3	7	30	FMA
18	Zhao et al. [33]	Tai Chi + conventional rehabilitation	Conventional rehabilitation	8	5	30	FMA
19	Yi et al. [34]	Tai Chi + conventional rehabilitation	Conventional rehabilitation	12	2	60	BBS, FMA, and swing test

"—" indicates that there is no description in the literature; TUG: timed up and go test; FMA: Fugl-Meyer motor function score scale; 10 mwt: 10 m walking test; SPPB: short physical performance battery; 6 mwt: 6 m walking test; BBS: Berg Balance Scale.

standing, but it has no statistical significance on the length of the gravity center swing.

3.3.5. The Influences of Tai Chi on FMA. Ten papers analyzed the influence of Tai Chi on the FMA scale. The heterogeneity analysis results showed that $I^2 = 98\%$, $P < 0.01$. Therefore, a meta-analysis of the results using a random effects model showed that [MD = 4.15, 95% CI (1.68, 6.63)]. Compared with the control group, Tai Chi can significantly improve the FMA scale scores of stroke patients, or the exercise ability improved significantly.

Two papers selected once-twice/wk exercise frequency for Tai Chi intervention, whose combined effect size showed [MD = 9.46, 95% CI (0.92, 17.99)]. Three studies selected 3–4 times/wk exercise frequency for Tai Chi exercise, whose combined effect size showed [MD = 3.66, 95% CI (−0.50, 7.82)]. Five papers studied exercise frequency ≥5 times/wk, whose combined effect size was [MD = 1.76, 95% CI (0.56, 2.95)]. The results show that 3–4 times/wk of Tai Chi exercises cannot significantly improve the FMA scale scores of patients, while once-twice/wk and ≥5 times/wk of Tai Chi exercises can significantly improve FMA scores and improve exercise ability of patients (Figure 10).

Three papers selected Tai Chi exercises lasting for ≤30 min/time, whose combined effect size was [MD = 2.89, 95% CI (0.03, 5.75)]. Seven papers studied 30–60 min per time Taijiquan exercises, whose combined the effect size was [MD = 4.64, 95% CI (0.70, 8.57)]. The results show that both kinds of exercise duration can improve the FMA scale score and improve exercise ability, while the improvement effect of 30–60 min/time exercise time is better (Figure 11).

3.3.6. The Impact of Tai Chi on SPPB. Two papers studied the influence of Tai Chi on the SPPB scale. The heterogeneity analysis showed that $I^2 = 0\%$, $P = 0.92 > 0.05$, that is, the two studies did not have statistical heterogeneity, so the fixed-effects model was selected for meta-analysis of the results. The combined effect size was [MD = −0.22, 95% CI (−1.00, 0.56)], that is, Tai Chi exercise has no significant improvement effect on SPPB and it cannot significantly improve the exercise capacity of stroke patients (Figure 12).

4. Discussion and Analysis

4.1. The Overall Analysis of the Impact of Tai Chi on the Balance Function and Exercise Ability of Stroke Patients. The results of this study prove that Tai Chi is able to significantly

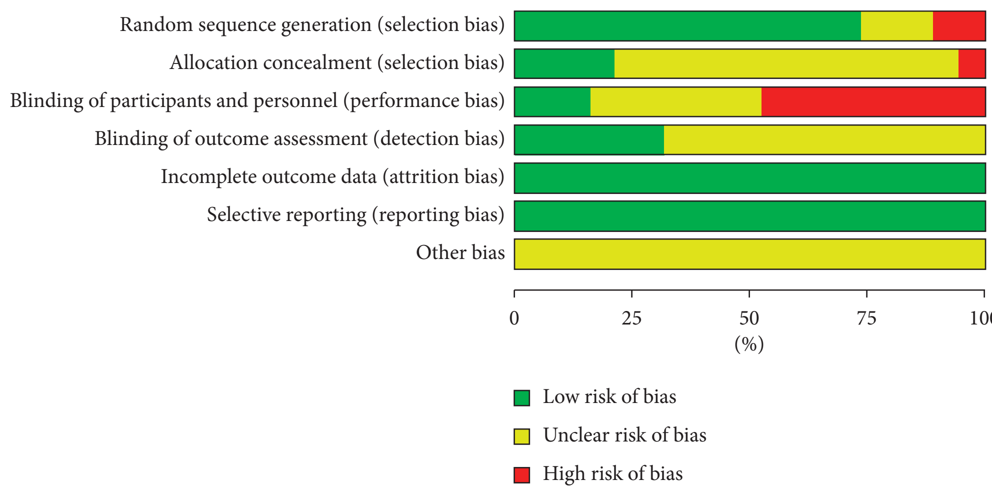

Figure 2: The overall risk of bias of the included papers.

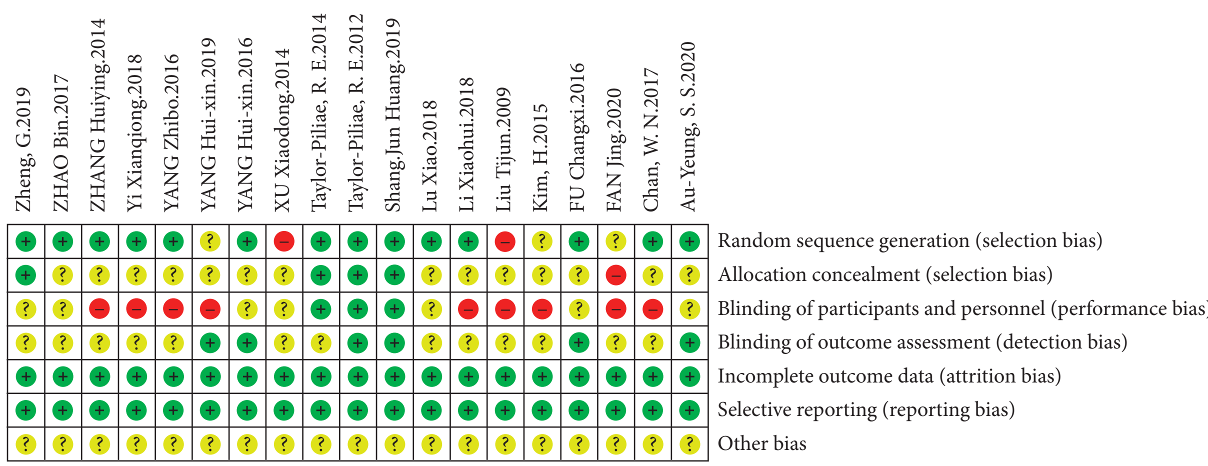

Figure 3: The risk of bias of the included papers.

Study or subgroup	Intervention group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
FAN Jing, 2020	11.85	2.96	43	7.03	2.6	0		Not estimable
FU Changxi, 2016	16.15	8.83	30	6.4	8.83	30	17.7	9.75 (5.39, 14.11)
Liu Tijun, 2009	29.4	8.09	24	14.15	8.09	24	17.4	15.25 (10.67, 19.83)
XU Xiaodong, 2014	29.77	1.25	40	22.56	1.32	40	21.7	7.21 (6.65, 7.77)
YANG Hui-xin, 2016	0.64	1.14	28	0.28	0.7	28	21.7	0.36 (−0.16, 0.88)
Yi Xianqiong, 2018	26.48	3.17	66	18.78	3.2	66	21.5	7.70 (6.61, 8.79)
Total (95% CI)			*231*			*181*	*100.0*	*7.67 (3.44, 11.90)*

Heterogeneity: $tau^2 = 21.36$; $chi^2 = 388.99$, df = 4 ($P < 0.00001$); $I^2 = 99\%$

Test for overall effect: $Z = 3.56$ ($P = 0.0004$)

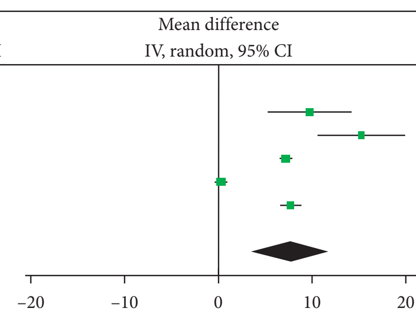

Figure 4: The forest diagram of the influences of Tai Chi on the BBS.

improve the balance function and exercise ability of stroke patients. This result is consistent with previous study results and again verifies the results of previous studies. Studies have shown that the stability of the core muscles of stroke patients is weak, and the stability of the trunk and pelvis is poor when completing antigravity activities, which leads to weakened exercise capacity [35] and decreased balance ability [36] during walking. As a low-intensity exercise method, Tai Chi can relax the tense muscles of patients, increase muscle flexibility and strength, improve the normal movement control ability of stroke patients, improve balance function, and inhibit the occurrence of abnormal postures and spasms, as well as have a positive effect on the life quality and psychological emotions of patients [7, 37, 38]. The study also found that regular Tai Chi exercises can promote the formation of functional nerve

Study or subgroup	Intervention group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Mean difference IV, fixed, 95% CI
AU-Yeung, S. S, 2009	−4.2	16.84	59	−1.7	22.52	55	1.2	−2.50 (−9.84, 4.84)
FAN Jing, 2020	−7.67	2.84	43	−3.53	2.93	43	42.2	−4.14 (−5.36, −2.92)
Kim, H, 2015	−3.73	1.27	11	−0.82	1.25	11	56.6	−2.91 (−3.86, −1.86)
Total (95% CI)			*113*			*109*	*100.0*	*−3.42 (−4.22, −2.63)*

Heterogeneity: $chi^2 = 2.30$, df = 2 ($P = 0.32$); $I^2 = 13\%$
Test for overall effect: $Z = 8.47$ ($P < 0.00001$)

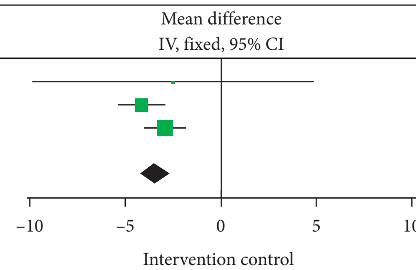

Figure 5: Forest diagram of the influences of Tai Chi on the standing and walking test.

Study or subgroup	Intervention group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
FAN Jing, 2020	102.43	50.87	43	49.88	43.96	43	49.9	52.55 (32.45, 72.65)
Zheng, G, 2019	−6.7	62.28	85	−16.1	69.41	85	50.1	9.40 (−10.42, 29.22)
Total (95% CI)			*128*			*128*	*100.0*	*−30.94 (−11.34, 73.23)*

Heterogeneity: $tau^2 = 827.24$; $chi^2 = 8.98$, df = 1 ($P = 0.003$); $I^2 = 89\%$
Test for overall effect: $Z = 1.43$ ($P = 0.15$)

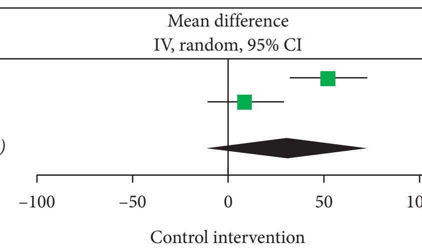

Figure 6: Forest diagram of the influences of Tai Chi on the 6 m walking experiment.

Study or subgroup	Intervention group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
FAN Jing, 2020	−95.03	38.99	43	48.38	40.67	43	47.6	−1.16 (−1.62, −0.70)
Yi Xianqiong, 2018	−642.9	590.1	66	−374.8	584.56	66	52.4	−0.45 (−0.80, −0.11)
Total (95% CI)			*109*			*109*	*100.0*	*−0.79 (−1.48, −0.10)*

Heterogeneity: $tau^2 = 0.21$; $chi^2 = 5.82$, df = 1 ($P = 0.02$); $I^2 = 83\%$
Test for overall effect: $Z = 2.24$ ($P = 0.03$)

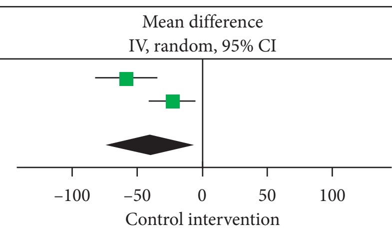

Figure 7: Forest diagram of the influences of Tai Chi on the swing area of the gravity center.

Study or subgroup	Intervention group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
FAN Jing, 2020	311.62	59.46	43	196.69	44.94	43	25.5	2.16 (1.62, 2.70)
Kim, H, 2015	−147.49	78.46	11	−39.05	67.14	11	24.2	−1.43 (−2.39, −0.47)
Kim, H, 2015	−151.75	122.53	11	−50.12	67.58	11	24.5	−0.99 (−1.88, −0.09)
Yi Xianqiong, 2018	−230.09	136.74	66	−105.28	129.24	66	25.8	−0.93 (−1.29, −0.57)
Total (95% CI)			*131*			*131*	*100.0*	*−0.28 (−2.05, −1.49)*

Heterogeneity: $tau^2 = 3.13$; $chi^2 = 99.59$, df = 3 ($P < 0.00001$); $I^2 = 97\%$
Test for overall effect: $Z = 0.31$ ($P = 0.76$)

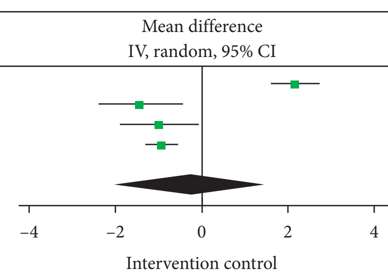

Figure 8: Forest diagram of the influences of Tai Chi on the swing length of the gravity center.

Study or subgroup	Intervention group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Mean difference IV, fixed, 95% CI
Chan, W. N, 2017	−3.8	31.3	9	−8.2	22.4	9	0.9%	4.40 (−20.75, 29.55)
Kim, H, 2015	−8.32	4.45	11	−2.31	2.57	11	60.1%	−6.01 (−9.05, −2.97)
Kim, H, 2015	−5.86	5.49	11	−1.1	3.25	11	39.0%	−4.76 (−8.53, −0.99)
Total (95% CI)			*31*			*31*	*100.0%*	*−5.43 (−7.79, −3.08)*

Heterogeneity: $chi^2 = 0.85$, df = 2 ($P = 0.65$); $I^2 = 0\%$
Test for overall effect: $Z = 4.52$ ($P < 0.00001$)

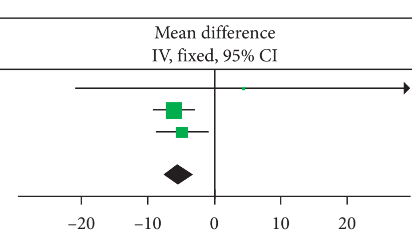

Figure 9: The forest diagram of the influences of Tai Chi on the swing speed of the gravity center.

Study or subgroup	Intervention group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
1.2.1 1-2 times/week								
Li Xiaohui.2018	6.07	4.58	30	1.03	4.75	30	9.6	5.04 (2.68, 7.40)
Yi Xianqiong.2018	32.58	3.21	66	18.83	3.44	66	10.3	13.75 (12.61, 14.89)
Subtotal (95% CI)			*96*			*96*	*20.0*	*9.46 (0.92, 17.99)*
Heterogeneity: $tau^2 = 37.04$; $chi^2 = 42.46$, df = 1 ($P < 0.00001$); $I^2 = 98\%$								
Test for overall effect: $Z = 2.17$ ($P = 0.03$)								
1.2.3 3-4 times/week								
FAN Jing.2020	13.11	3.03	43	7.37	2.64	43	10.3	5.74 (4.54, 6.94)
Shang.Jun Huang.2019	7.39	4.43	14	2.33	3.83	14	9.1	5.06 (1.99, 8.13)
YANG Hui-xin.2019	1.49	1.24	28	1.06	1.31	21	10.5	0.43 (−0.29, 1.15)
Subtotal (95% CI)			*85*			*78*	*29.9*	*3.66 (−0.50, 7.82)*
Heterogeneity: $tau^2 = 12.59$; $chi^2 = 59.10$, df = 2 ($P < 0.00001$); $I^2 = 97\%$								
Test for overall effect: $Z = 1.72$ ($P = 0.08$)								
1.2.3 > 5 times/week								
Lu Xiao.2018	42.53	3.04	46	39.87	5.16	46	10.1	2.66 (0.93, 4.39)
YANG Hui-xin.2016	0.78	1.08	28	0.91	1.16	21	10.5	−0.13 (−0.77, 0.51)
YANG Zhibo.2016	2.04	0.77	30	1.3	0.62	30	10.5	0.74 (0.39, 1.09)
ZHANG Huiying.2014	11.35	4.01	20	7.2	3.8	20	9.6	4.15 (1.73, 6.57)
ZHAO Bin.2017	11.93	5.32	30	7.2	5.1	30	9.4	4.43 (1.79, 7.07)
Subtotal (95% CI)			*154*			*147*	*50.1*	*1.76 (0.56, 2.95)*
Heterogeneity: $tau^2 = 1.25$; $chi^2 = 26.98$, df = 4 ($P < 0.0001$); $I^2 = 85\%$								
Test for overall effect: $Z = 2.88$ ($P = 0.004$)								
Total (95% CI)			*335*			*321*	*100.0*	*4.15 (1.68, 6.63)*
Heterogeneity: $tau^2 = 15.06$; $chi^2 = 569.62$, df = 9 ($P < 0.00001$); $I^2 = 98\%$								
Test for overall effect: $Z = 3.29$ ($P = 0.0010$)								
Test for subgroup differences: $chi^2 = 3.70$, df = 2 ($P = 0.16$); $I^2 = 46.0\%$								

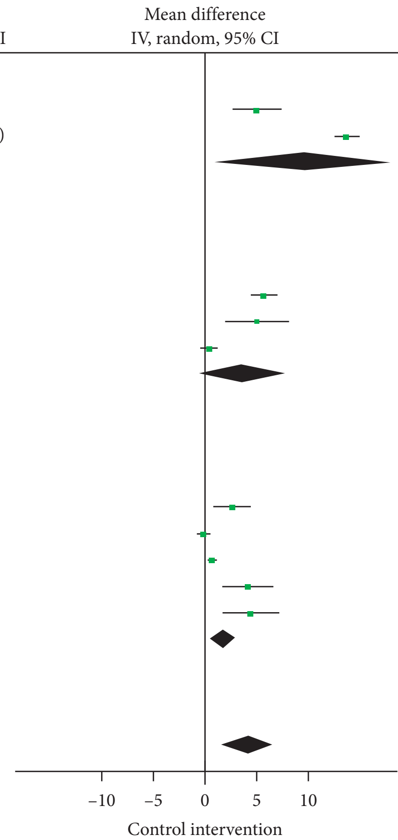

FIGURE 10: Forest diagram of the influences of different exercise frequencies on FMA.

Study or subgroup	Intervention group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Mean difference IV, random, 95% CI
1.3.1 < 30 min/time								
YANG Zhibo, 2016	2.04	0.77	30	1.3	0.62	30	10.5	0.74 (0.39, 1.09)
ZHANG Huiying, 2014	11.35	4.01	20	7.2	3.8	20	9.6	4.15 (1.73, 6.57)
ZHAO Bin, 2017	11.93	5.32	30	7.5	5.1	30	9.4	4.43 (1.79, 7.07)
Subtotal (95% CI)			*80*			*80*	*29.6*	*2.89 (0.03, 5.75)*
Heterogeneity: $tau^2 = 5.36$; $chi^2 = 14.57$, df = 2 ($P = 0.0007$); $I^2 = 86\%$								
Test for overall effect: $Z = 1.98$ ($P = 0.05$)								
1.3.2 30-60 min/time								
FAN Jing, 2020	13.11	3.03	43	7.37	2.64	43	10.3	5.74 (4.54, 6.94)
Li Xiaohui, 2018	6.07	4.58	30	1.03	4.75	30	9.6	5.04 (2.68, 7.40)
Lu Xiao, 2018	42.53	5.04	46	39.87	5.16	46	10.1	2.66 (0.93, 4.39)
Shang.Jun Huang, 2019	7.39	4.43	14	2.33	3.83	14	9.1	5.06 (1.99, 8.13)
YANG Hui-xin, 2016	0.78	1.08	28	0.91	1.16	21	10.5	−0.13 (−0.77, 0.51)
YANG Hui-xin, 2019	1.49	1.24	28	1.06	1.31	21	10.5	0.43 (−0.29, 1.15)
Yi Xianqiong, 2018	32.58	3.21	66	18.83	3.44	66	10.3	13.75 (12.61, 14.89)
Subtotal (95% CI)			*255*			*241*	*70.4*	*4.64 (0.70, 8.57)*
Heterogeneity: $tau^2 = 27.44$; $chi^2 = 508.14$, df = 6 ($P < 0.00001$); $I^2 = 99\%$								
Test for overall effect: $Z = 2.31$ ($P = 0.02$)								
Total (95% CI)			*335*			*321*	*100.0*	*4.15 (1.68, 6.63)*
Heterogeneity: $tau^2 = 15.06$; $chi^2 = 569.62$, df = 9 ($P < 0.00001$); $I^2 = 98\%$								
Test for overall effect: $Z = 3.29$ ($P = 0.0010$)								
Test for subgroup differences: $chi^2 = 0.50$, df = 1 ($P = 0.48$); $I^2 = 0\%$								

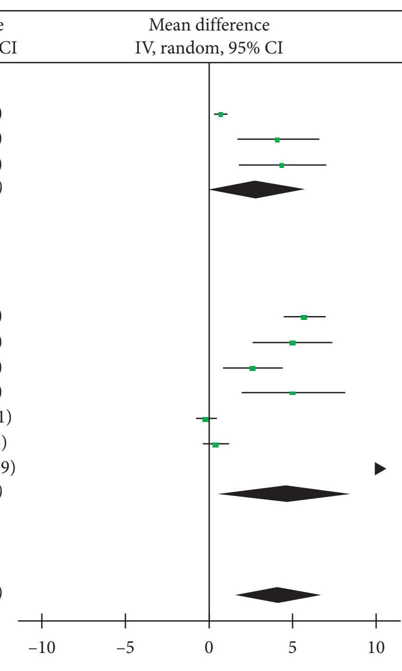

FIGURE 11: Forest diagram of the influences of different exercise durations on FMA.

Study or subgroup	Intervention group Mean	SD	Total	Control group Mean	SD	Total	Weight (%)	Mean difference IV, fixed, 95% CI
Taylor-Piliae, R. E, 2012	0.6	2.3	16	0.9	2.23	12	21.3%	−0.30 (−1.99, 1.39)
Taylor-Piliae, R. E, 2012	0.9	2.25	53	1.1	2.26	48	78.7%	−0.20 (−1.08, 0.68)
Total (95% CI)			*69*			*60*	*100.0%*	*−0.22 (−1.00, 0.56)*

Heterogeneity: $\text{chi}^2 = 0.01$, df = 1 ($P = 0.92$); $I^2 = 0\%$
Test for overall effect: $Z = 0.56$ ($P = 0.58$)

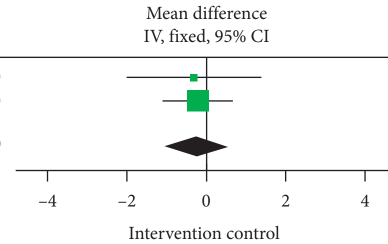

Figure 12: The forest diagram of the impact of Tai Chi on SPPB.

pathways, consolidate the efficiency of newly created or newly activated synapses, improve peripheral nerve conduction function, enhance the proprioception ability, promote exercise ability, and improve the quality of life [39].

4.2. The Effects of Physical Exercise Variables on the Balance Function and Exercise Ability among Stroke Patients. These studies show that Tai Chi exercises with different time durations all have a significant improvement on the balance function and exercise ability of stroke patients, among which $>30 \leq 60$ min/time has the best effect on the patient's exercise ability. They also show that patients have not only improved their balance function and exercise performance but also significantly promoted the life quality index [40]. Another study found that, after Tai Chi exercises, upper limb function of stroke patients improved significantly, and the coordination and balance of the lower limbs also improved to some extent. Follow-up studies also found that their exercise ability and life activity ability also improve [41].

Tai Chi exercises at different frequencies each week have different effects on the balance function and exercise ability of stroke patients. Tai Chi frequency of twice a week by Hwang et al. [42] shows that the balance ability, coordination, and walking ability have significantly improved among stroke patients, which are essential for them to take care of themselves in daily life and prevent from falling down [43]. Studies have found that Tai Chi can increase the strength of the quadriceps and hamstrings, improve flexibility, thereby enhance the stability and balance of the knee joint, and improve the exercise ability of patients [44, 45]. In another frequency study by Wang et al. [46], after 5 times/wk of Tai Chi Cloud Hand training, the Berg Balance Scale score of the experimental group improved significantly, indicating that Tai Chi can promote the balance function of stroke patients. The study by Yang et al. [47] also found that 5 times/wk of Tai Chi exercises can adjust the exercise ability of the patients, thereby promoting gait stability.

The experimental cycles included in this study are all 12 weeks or less. The results show that the balance function and exercise ability of stroke patients in the treatment group improved significantly. A large number of previous studies have also disclosed the effect of a certain period of Tai Chi exercise on stroke patients. Hart et al. conducted 12-week Tai Chi exercise training for stroke patients on a community basis, whose results showed that the stroke patients improved in terms of balance function and exercise ability [48]. In another 12-week Tai Chi "Cloud Hand" intervention for stroke patients, the control group received routine rehabilitation training, evaluating the balance function and exercise ability through the Berg Balance Scale, as well as the standing and walking test, and the balance function and exercise ability of both groups improved. In the mean time, as the intervention period extended, Tai Chi had better influences on the balance function and exercise ability. Yu et al. analyzed the effect of Tai Chi for 24 weeks on the static balance of middle-aged and elderly people and found that the total length of the gravity center movement of the subjects, the peripheral area, and the shaking index of the surrounding area significantly improved, which shows the promotion of static balance ability of Tai Chi among the middle-aged and elderly people [49, 50].

5. Limitations

This study has certain limitations. First, the research methods of some included papers are not comprehensive, which did not explain the method of random allocation or blinding the subjects or evaluator. Therefore, the results may be inaccurate. Second, certain results of meta-analyses are highly heterogeneous. As a result, the research results may have a certain degree of bias. Third, some studies have small number of subjects and a small sample size, which suggests that more experimental studies are needed to prove our point of view.

6. Conclusions

Stroke has become a prominent problem that seriously endangers the health of middle-aged and elderly people, which features high morbidity, high disability, and high mortality. Tai Chi is considered as an effective nondrug intervention against hemiplegia, which is one of the most common sequelae of stroke patients. This study used the meta-analysis method to analyze the randomized controlled study on the intervention of Tai Chi on balance function and exercise ability among stroke patients, which further proved that Tai Chi can significantly enhance balance function and exercise ability of stroke patients. This study also analyzed the dose-response relationship of balance function and exercise ability when doing Tai Chi. Study results show that regular Tai Chi exercise once to twice a week, ≥5 times/wk, and $>30 \leq 60$ min/time can improve the balance function and exercise capability of the stroke patients.

In the future, the study should consider the safety and effectiveness of Taijiquan intervention for stroke patients.

Moreover, study in this filed should adopt comprehensive randomized controlled studies as much as possible, improve the methodological quality, strengthen the research on balance function and exercise ability of stroke patients, ensure the quality of evidence in research, enrich the research on different schemes of Tai Chi intervention, and improve the dose-response relationship between exercise variables of Tai Chi and balance function and Tai Chi and exercise ability among stroke patients.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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Research Article

The Specific and Nonspecific Effects of Tai Chi and Its Possible Central Responses: A Protocol of Neuroimaging Study

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Tai Chi has been proven to be a safe and effective assistant therapy for healthcare and disease treatment. However, whether the adjuvant therapeutic effect of Tai Chi is general or disease-oriented remains uncertain. This trial focuses on exploring the specific and nonspecific effects of Tai Chi and its potential central responses. The results will deepen our understanding of the characteristics of Tai Chi exercise for adjuvant therapeutic effects and promote its application in the clinic. In this neuroimaging trial, 40 functional constipation (FC) patients and 40 healthy subjects (HS) will be recruited and will receive 10 weeks of Tai Chi exercise. The motor function, respiratory function, stool-related symptoms, quality of life, and emotional state of the participants will be evaluated at the baseline, the 5-week Tai Chi practice, and the end of practice. The potential changes in the heart rate variability and the cerebral function will be recorded by the 24 h dynamic electrocardiogram at the baseline and the functional magnetic resonance imaging at the end of practice. The possible correlations among the clinical variables, the heart rate variability, and the cerebral activity alterations in FC patients and HS will be analyzed. The healthcare and therapeutic effects of Tai Chi exercise might consist of the specific and nonspecific effects. This study provides not only a new perspective for understanding Tai Chi but also a new approach for investigating the mind-body exercise. This trial was registered in the Chinese Clinical Trial Registry (http://www.chictr.org.cn/showproj.aspx?proj=33243) on 28 November 2018 (registration number: ChiCTR1800019781; protocol version number: V1.0). This trial is currently in the stage of recruiting patients. The first patient was included on 1 December 2018. To date, 18 FC patients and 20 HS have been included. Recruitment will be completed in December 2020.

1. Introduction

Tai Chi is a traditional mind-body exercise, which originated from ancient China and widely spread all over the world. It is reported that there are 5 and 150 million Tai Chi practitioners in China and the whole world, respectively. Tai Chi has dual effects on healthcare and treatment. For healthy subjects (HS), the healthcare effects of Tai Chi in strengthening muscle strength [1], improving physical flexibility [2], enhancing the ability to balance and control [2], increasing vital capacity [3], reducing stress [4], and others have long been identified. For patients, the therapeutic effects of Tai Chi for treating multiple chronic diseases including osteoarthritis [5], hypertension [6], type 2 diabetes mellitus [7], coronary heart disease [8], and chronic obstructive pulmonary disease [9] have also been proven by a number of studies. These studies indicated that Tai Chi was widely involved in the prevention, treatment, and rehabilitation of various diseases. Does Tai Chi have different effects on the same organ/system in different practitioners? For example, a systematic review and meta-analysis showed that mind-body interventions, including Tai Chi, were effective in alleviating gastrointestinal symptoms and improving the quality of life (QOL) of patients [10]. Does Tai Chi have different gastrointestinal modulation effects between patients with gastrointestinal disorders and HS? In other words, is the gastrointestinal regulation of Tai Chi disease-oriented and influenced by individual physical condition? However, majority of the Tai Chi-related studies were performed either on patients or HS, and few studies were performed on both patients and HS to investigate the influence of physical conditions on the effect of Tai Chi.

On the basis of the characteristics of Tai Chi and previous researches, we predict that the effects of Tai Chi include two aspects: the relatively specific effects and nonspecific effects. The nonspecific effects mainly refer to the modulating effects on human motor function (muscle strength, physical flexibility, etc.) and respiratory function, especially vital capacity. The nonspecific effects might also manifest as maintaining the normal function of organs/systems, keeping the body in a relatively balanced and coordinated state. While the relatively specific effects of Tai Chi are disease-oriented, meaning that when the body is in a pathological state, Tai Chi practice might reduce the hyperactive function to improve the hypoactive function.

To test the hypothesis, we design this neuroimaging study. In this study, both functional constipation (FC) patients and HS were selected as participants to investigate the specific effects (gastrointestinal function) and nonspecific effects (motor function and respiratory function) of Tai Chi. FC is a common functional gastrointestinal disorder (FGID) with high prevalence. It is characterized by various constipation-related symptoms, including reduced defecation, defecation stress, hard stools, and uncomfortable abdominal muscle in the absence of evident organic or structural reasons for these symptoms. A randomized control trial indicated that Tai Chi practice could significantly improve the constipation symptom of patients with chronic FC [11].

This study aims to (1) investigate the nonspecific effects of Tai Chi by comparing the influence of Tai Chi practice on motor function and respiratory function between FC patients and HS using the lower-extremity muscle strength test, functional balance tests, and vital capacity test; (2) investigate the specific effects of Tai Chi from three aspects, including gastrointestinal symptom, autonomic nervous activity, and emotional state; and (3) explore the potential central responses of Tai Chi's specific and nonspecific effects by functional magnetic resonance imaging (fMRI).

2. Methods and Analysis

2.1. Study Design. The trial is designed as a neuroimaging trial that focuses on specific and nonspecific effects of Tai Chi and its potential central responses. A total of 40 FC patients and 40 HS will be recruited. Fifteen participants in each group will be randomly selected to undergo MRI scan. The study procedure is outlined in Figure 1.

2.2. Sample Size Calculation. We will investigate the therapeutic effects of Tai Chi for FC patients. According to our preliminary study from which we recruited 10 FC patients with the Tai Chi intervention, the mean improvement of weekly complete spontaneous bowel movements (CSBMs) of Tai Chi was 1.67 ± 0.89 times. A systematic review [12] focusing on the management of FC reported the mean improvement of weekly CSBMs of polyethylene glycol (the first-line medication of FC) was 1.8 times. We hypothesize that the therapeutic effects of Tai Chi are not less than the polyethylene glycol. Considering $\alpha = 0.05$, $1 - \beta = 0.8$, the study design required a sample size of 36 for each group with the one-sample noninferiority test [13], with a drop-out rate of 10%. A total of 40 patients with FC and 40 HS will be finally recruited.

$$N = \left(\sigma \frac{Z_{1-\alpha} + Z_{1-\beta}}{\mu - \mu o - \delta} \right)^2. \quad (1)$$

2.3. Patients with FC. Patients who match the inclusion criteria will be recruited. FC patients will be diagnosed by two gastroenterologists in the digestion department of the Hospital of CDUTCM, according to the Rome IV Diagnostic Criteria for FC [14]. Each FC patient will undergo a careful physical examination including a routine blood test, routine urine test, routine stool test, blood biochemical test (ALT, AST, BUN, Scr), transabdominal ultrasound, and dynamic electrocardiogram. The inclusion criteria and exclusion criteria of FC patients were as same as our previous study [15].

2.3.1. Inclusion Criteria. Patients will be included in the study if they (1) reach the Rome IV Diagnostic Criteria for FC [14], (2) are right-handers and the age range is between 18 and 35, (3) have less than three CSBMs every week, (4) the Cleveland Constipation Score (CCS) score >10, and (5) provide a written informed consent form.

2.3.2. Exclusion Criteria. Patients will be excluded from the study if they (1) are pregnant women, or plan to be pregnant within 3 months, or are breast-feeding women, (2) are incapable of sports, (3) have a history of head trauma and loss of consciousness, (4) have diabetes or serious cardiovascular, neurological, psychiatric, renal, or respiratory disease, (5) have moderate or serious depression and anxiety, (6) cannot keep silent for 20 minutes while lying down, (7) have any contraindications to fMRI scanning including the presence of metal stent, metal denture, or claustrophobia, (8) have taken other exercises (including meditation and yoga) that may improve constipation over 30 minutes every week in the last 3 months, (9) have taken gastrointestinal motility medicine, nonsteroidal anti-inflammatory medicine, and steroids in the last 15 days, (10) have received other treatments (including surgery, diet modification, biofeedback, or probiotics) in the last month, or (11) have participated in any other clinical trials in the past 3 months.

2.4. Healthy Subjects. Those who match the inclusion criteria will be recruited and will receive the same physical examination with the FC patients.

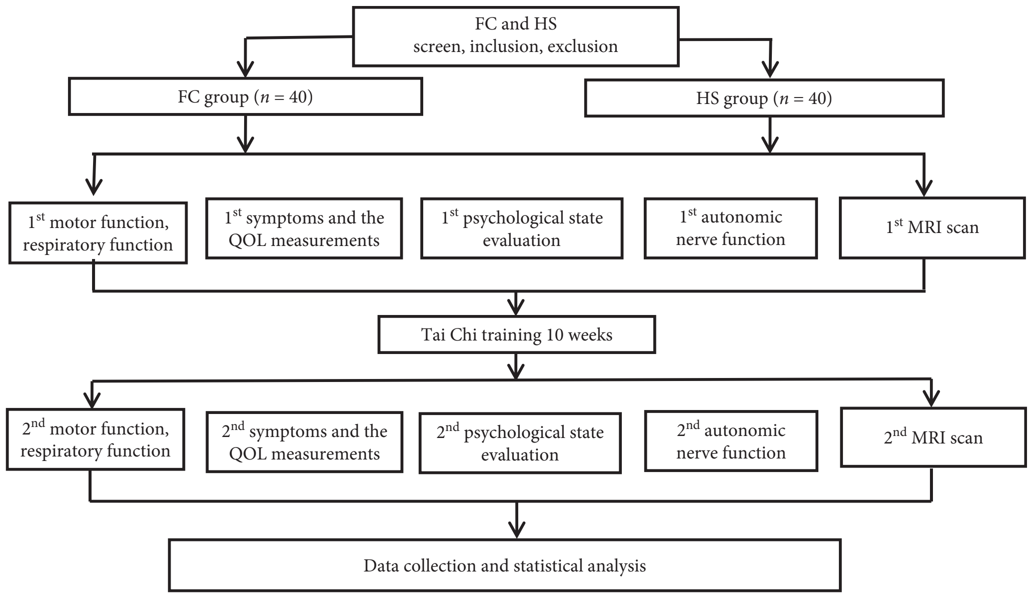

Figure 1: Study flowchart. This is a neuroimaging trial which focuses on specific and nonspecific effects of Tai Chi and its potential central responses. Totally, 40 eligible FC patients and 40 HS will be recruited. Fifteen participants in each group will be randomly selected to undergo functional magnetic resonance imaging (fMRI) scan.

2.4.1. Inclusion Criteria. Subjects will be included if they (1) are right-handers and aged 18–35 years, (2) have no abnormalities during the physical examinations, (3) have passed the National Student Physical Health Standard test, and (4) provide written informed consent.

2.4.2. Exclusion Criteria. The exclusion criteria for HS are the same as the criteria for FC patients (see Section 2.3.2). Moreover, those who have possible organic diseases, psychological disorders, and gastrointestinal symptoms and signs are also excluded.

2.5. Recruitment Strategy. The participants will be recruited from the Chengdu University of Traditional Chinese Medicine (CDUTCM) by delivering leaflets inside the campus, posting advertisements in billboards, posting at Acupuncture and Brain Science Research Center and CDUTCM (http://cdutcm.edu.cn/) websites, and posting in our WeChat public account.

2.6. Intervention. The participants will undergo 40 sessions with 24-style Tai Chi. The exercise of Tai Chi will be performed four times a week (Monday, Tuesday, Thursday, and Friday) and will last for 10 weeks [15]. Each exercise session lasts for an hour, including 10-minute warm-up, 40-minute Tai Chi exercise, and 10-minute relaxation.

Before the formal intervention, participants were involved in motor learning and strength training under the guidance of two professional Tai Chi instructors. During the intervention, they exercise strictly under the 24-style Tai Chi exercise standard operating procedure (SOP), which was formulated by two Tai Chi experts. In each session of the exercise, the instant heart rate will be counted both at the pre- and posttrial, and the sports self-rating scale will also be filled out. Participants who did not come will be recorded. The training will be considered effective when the rating of perceived exertion (RPE) of the subjects reaches 4–6 levels in each session, and training times must not be less than 80% (32 times) of total training times.

During the treatment period, participants are usually not recommended to use concomitant care or interventions. However, if required (such as, aggravation of the patient's condition), participants will be permitted to use extra osmotic laxatives. The type and dosage of medication used should be recorded in the case report forms (CRFs).

2.7. Outcome Measurements. Measurements will be evaluated by independent assessors who have been trained prior to the study. All results will be recorded whether or not the participants completed the study. The outcome assessors will be independent of the research team and will not be told about group allocation, so as to ensure the object evaluations of the trial.

2.7.1. General Information Collection. Same as our previous study [15], general information including the demographic data and vital signs will be collected. The demographic data include age, gender, education level, nationality, and body mass index (BMI). The vital signs include body temperature, heart rate, respiratory rate, and blood pressure. Among them, the BMI will be calculated at the baseline and the end of the invention, whereas the vital signs of each patient will be immediately recorded after every training.

According to our hypothesis, the nonspecific effects of Tai Chi include motor function, vital capacity, and psychological state regulation and the specific effects of Tai Chi for FC patients reflects in relieving gastrointestinal symptoms and modulating autonomic nerve function.

2.7.2. Nonspecific Effects: Motor Function, Vital Capacity, and Psychological State. The lower-extremity muscle strength, functional balance tests, and the vital capacity test will be collected at the baseline, the median of intervention (after 5 weeks of exercise), and at the end of the intervention. The lower-extremity muscle strength will be measured using a hand-held isometric dynamometer (Micro FET3; Hoggan Health Industries, Draper, UT, United States). Functional balance tests include the Berg Balance Scale (BBS) [16], timed up-and-go (TUG) test, and functional reach test [17].

During the vital capacity test, the forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and FEV1/FVC ratio will be measured using a Super Spiro spirometer (MicroMedical, Rochester, Kent, UK) in resting status. The peak expiratory flow rate (PEFR) will be assayed using a peak flow meter.

To assess the psychological state of all participants, we collected the following metrics at the baseline, the median of intervention, and the end of intervention: the self-rating depression scale (SDS) [18], the self-rating anxiety scale (SAS) [19], and the Eysenck Personality Questionnaire (EPQ) [20].

2.7.3. Specific Effects: Gastrointestinal Symptoms and Autonomic Nerve Function. To evaluate the changes of the gastrointestinal symptoms and QOL of participants, we performed the following measurements at the baseline, the median of intervention, and the end of intervention: CCS [21], patient assessment of constipation symptoms (PAC-SYM) [22], patient assessment of constipation QOL questionnaire (PAC-QOL) [23], RPE [24], and MOS 36-item short-form health survey (SF-36) [25]. Also, the evaluation of constipation diary, including CSBMs per week, the fecal character, and the difficulty degree of defecation, will be measured once a week for 10 times.

To evaluate the autonomic nervous function, we selected the heart rate variability (HRV). All participants will be assessed during the 24-h HRV at the baseline and the end of the intervention. The metrics of HRV include standard deviation of NN intervals (SDNN), standard deviation of sequential 5-min RR interval means (SDANN), and root mean square successive difference (RMSSD). The device used is a dynamic electrocardiogram (ct-086S; BENE WARE, Hangzhou, China).

2.8. MRI Data Acquisition. MRI data will be collected on 15 participants in each group at the baseline and the end of intervention. The acquisition parameter will be consistent with our previous article [15].

The MRI scan includes three sequences: a high-resolution 3-dimensional T1-weighted imaging (3D-T1W1), a blood oxygenation level-dependent functional MRI (BOLD-fMRI), and a diffusion tensor imaging (DTI) sequence. Scanning will start in the morning after overnight fasting. Subjects who are selected will undergo MRI scan with a 3.0 T magnetic resonance scanner (Siemens, Germany). The 3D-T1WI scan parameters will be as follows: repetition time/echo time: 1900 ms/2.26 ms; slice thickness: 1 mm, slice number: 176, matrix size: 128×128, and the view field: $256 \times 256\ mm^2$. The BOLD-fMRI scanning parameters are as follows: repetition time/echo time: 2000 ms/30 ms; flip angle: 90°; slice number: 30; matrix size: 128×128; view field: $240 \times 240\ mm^2$; slice thickness: 5 mm; and total volume: 240. DTI data are as follows: view field: $240 \times 240\ mm^2$; repetition time/echo time: 6800 ms/93 ms; matrix size: 128×128; and slice thickness: 3 mm, seamless. Two diffusion-weighted sequences will be acquired using gradient values b: 1000 s/mm^2 and b: 0, with diffusion-sensitizing gradients used in 64 noncollinear directions.

2.9. Data Management. The clinical data will be managed with printed and electronic CRFs. CRFs will be entered parallelly and will only be available to the outcome assessors. The Evidence-based Medicine Center of the CDUTCM will be responsible for monitoring the study and data every 3 months.

2.10. Statistical Analysis

2.10.1. Clinical Data Analysis. Clinical data will be analyzed by independent statisticians who do not know the test procedure based on the principles of intention to treat (ITT) and per protocol. The statistical significance threshold has p value <0.05. The results of the participants who failed to complete the study will be considered no different from the baseline data in ITT analysis. All continuous variables will be presented as mean ± standard deviation. The categorical variables will be described in percentage (%). The clinical data in the two groups (FC group and HS group) will be compared with two-sample t-tests, and the comparisons of the baseline and after intervention in each group will be compared with a paired sample t-test. Nonparametric tests (Mann–Whitney U test) will be used to compare non-normally distributed clinical data, and the χ^2 test or Fisher's test will be used to compare categorical variables.

2.10.2. Functional MRI Data Analysis. For fMRI scans, all preprocessing steps will be performed using DPABI software based on MATLAB. The main analytical methods include the amplitude of low-frequency fluctuation amplitude (ALFF) and seed-based functional connectivity.

After preprocessing the data, the ALFF will be calculated to compare the whole-brain spontaneous activity pattern before and after intervention in each group, as well as between patients with FC and HS following 10-week Tai Chi practices. The different regions obtained at ALFF analysis will be selected as the region of interest (ROI), also called seed, to perform the seed-based functional connectivity analysis and to explore the functional synchronization of ROI and other regions. The thresholds of $p < 0.05$ with a false discovery rate correlation will be applied to all analyses.

2.10.3. Correlation Analysis. To investigate the associations between nonspecific effects and central responses under different physical conditions, we performed the correlation analysis between the clinical data, including motor function, respiratory function, psychological state, and cerebral function in patients with FC and HS. In order to further explain the regulation mechanism of Tai Chi on the brain-gut interaction disorder, the correlation analysis among gastrointestinal symptoms, heart rate variability, and brain function activities in FC patients will also be carried out.

2.10.4. Safety Assessments. Adverse events might happen during Tai Chi practice, including strain, sprain, nausea, and dizziness. If any these adverse events occur, the instructor will take appropriate treatment according to clinician's advice and record the processing detail in the CRFs. The safety assessments will be monitored by the Ethics Committee.

The schedule of the study, including enrollment, interventions, assessments, and visits for participants, is shown in Table 1.

3. Discussion

As a popular physical–mind exercise, Tai Chi is widely used in the prevention, treatment, and rehabilitation of various diseases. On the basis of the characteristics and related studies on Tai Chi, we put forward the original hypothesis that Tai Chi practice can produce relative specific effects and nonspecific effects on the human body.

The main purposes of this study include two aspects. First, this study tries to explore the physiological and psychological existence of the specific and nonspecific effects of Tai Chi by comparing the differences in the motor function, respiratory function, gastrointestinal symptoms, psychological manifestations, and HRV between FC patients and HS after Tai Chi practice. Second, this study tries to explore the potential central mechanism of the specific and nonspecific effects of Tai Chi practice by analyzing the potential cerebral activity changes induced by Tai Chi and their correlation with clinical variables. The study will provide a new approach for investigating the mind-body exercise, and the results might deepen our knowledge about Tai Chi.

3.1. Specific and Nonspecific Effects of Tai Chi. Tai Chi is a complex sport that requires the coordination of spirit, breathing, postures, and movements. It can produce a significant impact on almost all human systems such as motor system, cardiovascular system, respiratory system, and digestive system. The impact is far beyond the physiological and psychological changes brought by a simple physical exercise. Thus, Tai Chi is not only widely used in public healthcare but also involved in disease treatment and rehabilitation.

On the basis of the characteristics of Tai Chi and related studies, we put forward that there are two types of effects of Tai Chi. One is the specific effect, which mainly indicates the therapeutic effects of Tai Chi practice on the pathological status and has obvious disease orientation. For instance, Tai Chi practice could produce a specific-regulating effect on the abnormal gastrointestinal (GI) function of patients with GI disorders, specifically improve the cognitive function of patients with Alzheimer's disease [26], and significantly relieve the depression symptoms of patients with depression [27]. A systematic review and meta-analysis demonstrated that Tai Chi and other mind-body interventions were effective in alleviating GI symptoms and improving several aspects of the disease-related QOL including interference with activity, body image, health worry, food avoidance, and social reaction [10].

The second aspect is the nonspecific effects, which mainly refers to the benefits for the motor system, respiratory system, and others. No matter Tai Chi practice or other forms of physical exercises can produce it. The nonspecific effects might be a promoting effect on the motor system and respiratory system for not only the patients but also the HS. For example, studies demonstrated that Tai Chi exercises could increase the muscle strength in the lower extremities, improve balance control, and reduce the risk of falls for both healthy elderly people [28, 29] and Parkinson's and stroke patients [30, 31]. However, it should be emphasized that the specific effects of Tai Chi are relative and conditional. The nonspecific effects are the more widely used and fundamental effect of Tai Chi.

3.2. Potential Central Responses of Tai Chi. As a typical physical and mental exercise, Tai Chi not only emphasizes physical movement but also requires the state of unity of body and mind. The positive effects of meditation and aerobic exercise on cognitive function, including memory and decision-making abilities, have been widely accepted [32, 33]. Recent studies further identified the influence of Tai Chi practice on the cerebral structure and function of practitioners [34]. For example, MRI studies showed that Tai Chi training evoked significant changes in the brain white matter network [35], brain volume [36], and spontaneous brain functional activities [37] in older people. These studies indicated that Tai Chi practice could influence not only the cerebral function but also the brain structure. It might be the central mechanism of the specific and nonspecific effects of Tai Chi.

In this study, FC patients will be enrolled to investigate the specific effects of Tai Chi-modulating GI function. FC, as a typical FGID, the dysfunction of the gut-brain axis plays an essential role in its pathogenesis [38]. Recent neuroimaging studies identified the abnormality in the cerebral function and structure in FC patients compared with the healthy controls. For example, an fMRI study demonstrated that FC patients showed significant differences in baseline brain activities in several brain regions implicated in emotional process modulation, somatic and sensory processing, and motor control regions [39]. Considering the existence of cerebral structural and functional abnormalities in FC patients, it is

Table 1: Study period.

Timepoint**	Study period: Enrollment −14 days	Allocation −7 days	Postallocation: 0 day (baseline)	35 days (middle of intervention)	70 days (after intervention)	Etc.
Enrollment						
Eligibility screen	✗					
Informed consent	✗					
Demographics	✗					
Diagnosis	✗					
Past medical history	✗					
Physical examination		✗				
Allocation		✗				
Interventions						
Group A (FC patients)			✗	✗	✗	
Group B (HS)			✗	✗	✗	
Assessments						
BMI		✗			✗	
HRV		✗			✗	
Lower-extremity muscle			✗	✗	✗	
Functional balance			✗	✗	✗	
Vital capacity			✗	✗	✗	
Exercise self-rating scale			✗	✗	✗	
CCS			✗	✗	✗	
PAC-QOL			✗	✗	✗	
PAC-SYM			✗	✗	✗	
Stool diary			✗	✗	✗	
SDS, SAS			✗	✗	✗	
EPQ			✗	✗	✗	
SF-36			✗	✗	✗	
MRI			✗		✗	
Safety observation						
Blood routine test			✗			
Urine routine test			✗			
Stool routine test			✗			
Adverse events					✗	

This is a neuroimaging trial that includes a 2-week baseline period and a 10-week treatment period. In the baseline period, recruited patients will be screened according to the inclusion criteria and exclusion criteria, and then, eligible FC patients and HS will sign an informed consent form and receive a physical examination. After allocation, the FC patients and HS will be recruited and will receive 10 weeks of Tai Chi exercise. Schedule of enrollment, interventions, and assessments: at the baseline, the median of intervention (5 weeks of exercise), and the end of the intervention (10 weeks of exercise). Among them, lower-extremity muscle strength was measured using a hand-held isometric dynamometer (Micro FET3; Hoggan Health Industries). Functional balance tests include BBS, TUG test, and functional reach test. During the vital capacity test, FEV1, FVC, and FEV1/FVC ratio were measured using a MicroMedical Super Spiro spirometer in resting status. PEFR was assayed using a peak flow meter. The stool diary, CCS, and PAC-SYM will be used to evaluate the clinical efficacy of different interventions; the PAC-QOL will be used to assess the health-related QOL; the SDS, SAS, EPQ, and Mini-Mental State Examinations will be used to consider the effect of psychological factors on the patients' symptoms. All participants will be assessed during the 24 h HRV to evaluate the autonomic nervous function at the baseline and the end of the 10-week intervention. fMRI scans will be performed to detect the cerebral functional changes in 15 patients in each group both at the baseline and the end of the intervention.

feasible to explore the mechanism of Tai Chi's specific effects on GI function of FC patients.

In this study, fMRI will be selected as the neuroimaging technique to investigate the cerebral activity changes elicited by Tai Chi practice. fMRI is the most commonly used brain imaging technique and has been widely used in the studies on the central mechanism of Tai Chi intervention [35, 40, 41]. For example, using fMRI, people found that influencing the resting-state functional connectivity alteration between the cognitive control network and rostral anterior cingulate cortex and medial prefrontal cortex might be the central mechanism of Tai Chi intervention for fibromyalgia [41]. These studies indicated that it was reliable to use fMRI to explore the central mechanism of Tai Chi intervention for FC.

Furthermore, to ensure the reliability and repeatability of the results, we will establish a strict quality control program, which includes the participant selection, the SOP of Tai Chi practice, the SOP of neuroimaging scan, and the outcome measures. For example, for the selection of participants, the freshmen who never practice Tai Chi and have no physical exercise frequently will be taken into consideration. In the implementation of Tai Chi intervention, the SOP of 24-style Tai Chi is established, which covers the requirement on the movements, breathing, and ideas of the participant.

4. Conclusions

In conclusion, Tai Chi is a safe and effective assistant therapy for many diseases. However, whether the therapeutic effects of Tai Chi are disease-oriented remains uncertain. This trial is the first to investigate the existence of the specific and nonspecific effects of Tai Chi and to explore their potential central responses. It will provide a new perspective for understanding Tai Chi and a new approach for studying mind-body exercise.

Abbreviations

HS:	Healthy subject
FC:	Functional constipation
FGID:	Functional gastrointestinal disease
QOL:	Quality of life
GI:	Gastrointestinal
fMRI:	Functional magnetic resonance imaging
CDUTCM:	Chengdu University of Traditional Chinese Medicine
CSBMs:	Complete spontaneous bowel movements
CCS:	Cleveland Constipation Score
RPE:	Rating of perceived exertion
PAC-SYM:	Patient Assessment of Constipation Symptom
PAC-QOL:	Patient Assessment of Constipation Quality of Life Questionnaire
RPE:	Rating of perceived exertion
SF-36:	The MOS 36-item short-form health survey
BBS:	Berg Balance Scale
TUG:	Timed up-and-go
FEV1:	Forced expiratory volume in one second
FVC:	Forced vital capacity
SDS:	Self-Rating Depression Scale
SAS:	Self-Rating Anxiety Scale
EPQ:	Eysenck Personality Questionnaires
HRV:	Heart rate variability
3D-T1WI:	3-dimensional T1-weighted imaging
BOLD-fMRI:	Blood oxygenation level-dependent fMRI
DTI:	Diffusion tensor imaging
CRF:	Case report form
ITT:	Intention to treat
PP:	Per protocol
ReHo:	Regional homogeneity
ALFF:	Amplitude of low-frequency fluctuation amplitude.

Data Availability

This is a protocol for a clinical trial, and no original data are included.

Ethical Approval

The procedures have been approved by the Sichuan Regional Ethics Review Committee on Traditional Chinese Medicine (no. 2018KL-047) and conformed to the Declaration of Helsinki. In addition, all researchers were trained and signed a pledge to protect the confidentiality of study participants.

Consent

All enrolled subjects signed an informed consent form.

Disclosure

Tianyu Liu, Yuke Teng, and Sha Yang are the co-first authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Tianyu Liu, Yuke Teng, and Sha Yang contributed equally to this article. FZ and JW were responsible for this study. TL, YT, SY, FZ, JW, ZH, and SY conceived and designed the study. TL, YT, and SY participated in drafting the trial protocol and preparing the manuscript. YG, TY, JC, and RY participated in data collection and were in charge of recruitment and treatment of patients. All authors read and approved the final manuscript.

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Research Article

Effects of Basketball and Baduanjin Exercise Interventions on Problematic Smartphone Use and Mental Health among College Students: A Randomized Controlled Trial

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Problematic smartphone use (PSU) has become a prevalent issue worldwide. Previous studies suggest that physical exercising may effectively reduce smartphone users' addiction levels. Comparisons and further evaluations on the long-term effects of different types of exercise-based interventions on treating PSU remain to be investigated. *Objective*. We investigated if group-based basketball and Baduanjin exercise (a type of Qigong) would reduce PSU and improve the mental health of college students and whether such effects would be sustained. A twelve-week experiment was conducted, where 96 eligible Chinese college students with PSU were randomly assigned to two intervention arms (i.e., basketball and Baduanjin exercises) and a control arm. Outcome measures, including PSU (measured by the Mobile Phone Addiction Index in Chinese (MPAI)) and mental health indices for anxiety (measured by Self-Rating Anxiety Scale (SRAS)), loneliness (measured by the short-form of the UCLA Loneliness Scale (UCLA-LS)), inadequacy (measured by the revised Janis and Field's Feelings of Inadequacy Scale (FIS)), and stress (measured by the Chinese version of Perceived Stress Scale (CPSS)) were collected at the baseline, the end of week 12, and the two-month follow-up. A Generalized Estimating Equations (GEE) model for longitudinal data was utilized in analyses. *Results*. Both exercise interventions demonstrated significant effects on decreasing PSU (basketball: $p < 0.01$; Baduanjin: $p < 0.01$), feelings of anxiety (basketball: $p < 0.01$; Baduanjin: $p = 0.04$), loneliness (basketball: $p < 0.01$; Baduanjin: $p < 0.01$), inadequacy (basketball: $p < 0.01$; Baduanjin: $p < 0.01$), and perceived stress (basketball: $p < 0.01$; Baduanjin: $p = 0.04$), at the end of interventions. At two months after interventions, both exercise interventions demonstrated significant effects on decreasing PSU (basketball: $p < 0.05$; Baduanjin: $p < 0.05$), feelings of anxiety (basketball: $p < 0.01$; Baduanjin: $p = 0.03$), loneliness (basketball: $p < 0.01$; Baduanjin: $p < 0.01$), and inadequacy (basketball: $p < 0.01$; Baduanjin: $p = 0.01$), but not for feeling of stress. Furthermore, group-based basketball demonstrated larger improvements for all these significant results on reducing PSU and meanwhile improving their related mental health parameters among college students.

1. Introduction

With the development of smartphone technology in recent decades, the number of smartphone users has grown dramatically throughout the world. However, the availability of smartphones also brought about the increasingly prevalent issue of problematic smartphone use (PSU), which displays common signs related to addiction, such as craving, lack of control, and withdrawal symptoms [1]. Recent studies reported that individuals with PSU encountered various physical, psychological, and social problems that could do great harm to their lives [2–4], particularly for vulnerable youths (including college students) who account for a significant proportion of the affected population worldwide [5, 6]. For example, 20% of teenagers in Spain, up to 36% in the UK [7], and 21% in China [8] were found to have PSU, while the prevalence rates were reported with 62.3% and 64.9% for female and male college students, respectively [9, 10].

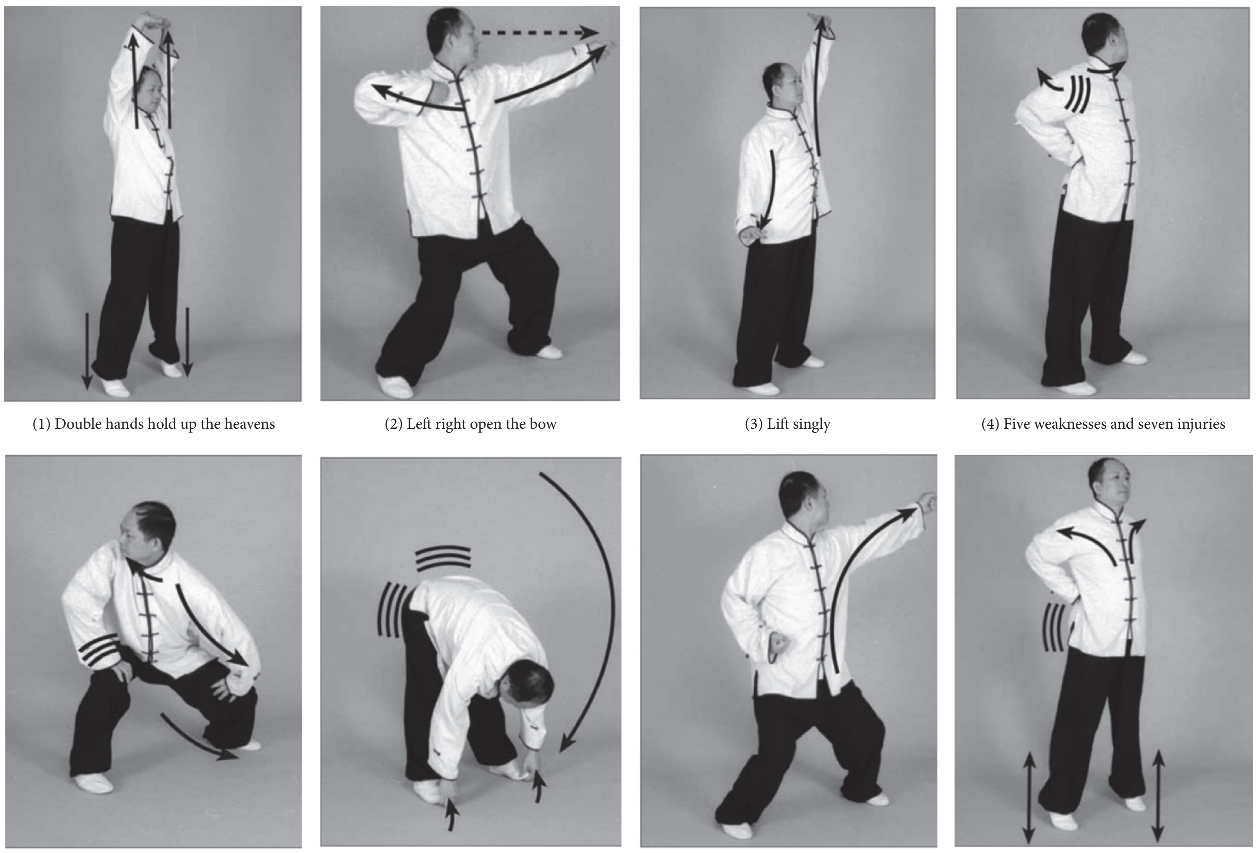
Tackling PSU is still under investigation; however, given the commonalities with other addictive behaviors, it may benefit from therapeutic approaches focused primarily on prescription medication and cognitive behavioral therapy. Alternatively, exercise interventions are also gaining popularity given findings reporting the effectiveness in treating individuals with substance abuse [11, 12]. Physical exercise is a safe and feasible treatment alternative that is likely to reduce PSU and improve comorbid mental health problems. As frequent smartphone use is associated with less physical activity, time spent exercising can both reduce the time of phone use and meanwhile induce similar reward-based effects as phones. Furthermore, as exercise is often a social activity, promoting more social encounters, it may also contribute to overall mental wellness. According to a recent meta-analysis of randomized controlled trials [7] on exercise interventions including typical aerobic exercises such as running, bicycling, basketball, badminton, football, tennis, and dancing, as well as aerobic exercises containing mindful movements such as Baduanjin and Taichi, doing physical exercising was found with evidence to effectively reduce the smartphone users' addiction levels, and prolonged engagement in exercise was associated with fewer withdrawal and mood-related symptoms.

These findings are promising, but with further demand to investigate the comprehensive healing effects of exercise interventions on PSU. First, people with PSU were often found to be more socially anxious and lonelier and have lower self-esteem and higher stress levels [13, 14]; hence, understanding changes in the mental wellness, alongside changes of absolute levels of addictive smartphone use [7, 15], can add more insights. Second, research is needed to confirm the long-term effects of physical activities on reducing PSU, as most of the existing studies did not have postintervention follow-up assessments. Third, it is worthy of further investigation on whether and how different types of exercise interventions for mental health (e.g., [16–26, 27]) can address these psychological problems and maintain the influence, in order to assist the development of more tailored programs with personalized feasibility considered to better help people in different mental health states. In particular, evaluating and comparing oriental exercise interventions containing mindful movements (e.g., Tai Chi, Yoga, or other types of Qigong exercises) and other widely played sports which originated in the West (e.g., basketball) with regard to treating PSU can be very valuable in consideration of their mechanism differences.

Baduanjin (or Eight Pieces of Brocade), created more than one thousand years ago during the Chinese Southern Song dynasty, is a Qigong exercise containing eight components of mindful movements and is easy to learn. These eight pieces are, namely, (1) Double Hands Hold up the Heavens, (2) Left Right Open the Bow, (3) Lift Singly, (4) Five Weaknesses and Seven Injuries, (5) Sway the Head and Swing the Tail to get rid of the Heart Fire, (6) Two Hands Hold the Feet, (7) Screw the Fist with Fiery Eyes, and (8) Seven Disorders and Hundreds of Illnesses Disappear. Snapshots of these eight movements (postures may vary stylewise) illustrated by Yang are provided in Figure 1 [28]. On the other hand, basketball, invented relatively much recently (1891) by Canadian-American gym teacher James Naismith in the United States, has evolved to become one of the world's most popular sports [29]. As a valuable comparison of mental health healing effects by different types of exercise interventions, the present study aimed to examine the impacts of these two typical exercises on reducing PSU of college students, who are at a higher risk for developing lifelong unhealthy habits. Both 12-week intervention effects and follow-up assessments were to be quantified, in order to assess the strength and sustainability of such effects. Another objective was to determine psychological changes measured by indicators of anxiety, loneliness, inadequacy, and stress, as a result of exercise interventions. Aligning such mental health aspects with smartphone use, this study sought to confirm the overall positive influences of exercising on youth with PSU, as well as exploring psychological pathways to reduce their addictive behaviors.

2. Methods

2.1. Participants. A total of 762 students were recruited from a comprehensive university in central China via advertisement and social media, China, to complete the Mobile Phone Addiction Index (MPAI), which was used to identify PSU [30]. Those with MPAI scores above 40 accounted for 22.2% of all respondents and were considered as potential candidates for the interventions. To be finally included, these potential candidates were evaluated against the inclusion criteria. Firstly, given the exercise training requirement, they must be able to independently ambulate without any assisting device. Secondly, they had no major disease (cardiovascular disease, respiratory illness, and musculoskeletal disorder) that can affect them to participate in exercise training. Thirdly, they were not diagnosed with any psychiatric (e.g., depression, anxiety, bipolar disorder, obsessive-compulsive disorder, eating disorder, and



(1) Double hands hold up the heavens (2) Left right open the bow (3) Lift singly (4) Five weaknesses and seven injuries

(5) Sway the head and swing the tail to get rid of the heart fire (6) Two hands hold the feet (7) Screw the fist with fiery eyes (8) Seven disorders and hundreds of illnesses disappear

Figure 1: Snapshots of eight components of movements of Baduanjin.

posttraumatic stress disorder) and attention disorders. Fourth, they did not attend any structured exercise training in the past three months, including no basketball and mindful exercise training experience prior to this study. Eventually, 100 qualified candidates were randomly assigned to three groups using the Excel RAND function: basketball ($N = 33$), Baduanjin ($N = 33$), and the control group ($N = 34$). However, due to scheduling conflict ($N = 2$), injury caused by other things ($N = 1$), and studying abroad ($N = 1$), only 96 participants were involved in the whole intervention period and therefore Per Protocol analysis was used.

2.2. Measures. The main outcomes of interest in this study were problematic smartphone use and related psychological indicators including anxiety, loneliness, inadequacy, and stress, which were measured with widely used instruments. The questionnaire is divided into 6 parts, which are basic information (age, gender, profession, whether or not they are the only children, etc.), mobile phone addiction index, self-rating anxiety scale, loneliness scale, feelings of inadequacy scale, and perceived stress scale, totaling about 25 minutes to occupy your time.

2.2.1. Primary Outcomes (Problematic Smartphone Use (PSU)). PSU was measured by the MPAI in Chinese [14, 30]), which includes 17 items addressing four aspects of addictive behavior, that is, inability to control cravings, anxiety and feeling lost, withdrawal and escape, and productivity loss. All questions are rated on a 5-point scale, and a higher total score indicates a more severe level of problematic use.

2.2.2. Secondary Outcomes. Anxiety was measured by the Self-Rating Anxiety Scale or SRAS [31], which is a norm-referenced scale commonly used to identify the presence of anxiety. According to the norms in China, scores above 50 indicate anxiety, with 50–59 as minor anxiety, 60–69 as moderate anxiety, and 70 and above as severe anxiety [32]. Loneliness was measured using the short-form of the UCLA Loneliness Scale (UCLA-LS), which includes 8 items and has been validated among Chinese college students [33]. A higher total score indicates a higher level of perceived loneliness. Inadequacy refers to low self-esteem and absence of self-confidence in various social contexts and was measured by the revised Janis and Field's Feelings of Inadequacy Scale (FIS) [34]. It should be noted that higher scores on this scale refer to lower levels of inadequacy. As one of the most frequently used tools to quickly measure perceived stress, the original Perceived Stress Scale (PSS-14), as well as its Chinese version (CPSS), proved to have satisfactory psychometric properties [35]. Therefore, respondents were asked to complete the CPSS and report their stress levels regarding different life aspects.

2.3. Procedure. This study was a twelve-week randomized controlled study with two experimental conditions (i.e., basketball exercise and Baduanjin exercise). Participants in the experimental arms were engaged in either basketball or Baduanjin exercise sessions for twelve weeks, which lasted 90 minutes each time and occurred three times each week. In comparison, the control group members maintained their routines and received no intervention. As mentioned earlier, four participants did not complete the interventions due to different reasons and therefore were not able to receive postintervention assessment (i.e., two drop-outs from each of the two experimental arms in Figure 2). The other 96 study participants were assessed at the baseline, immediately after the intervention (12 weeks later), and at the follow-up (two months later). Prior to this intervention, all eligible participants had signed the consent forms approved by the ethical committee of the university.

Participants in the basketball group received basketball training taught by one professional basketball coach from the university. They participated in exercise three times per week for 12 weeks. Each session included 10 minutes of warm-up, 70 -minutes of basketball exercise (moderate intensity: 120–150 b/min), and 10 minutes of cooldown. The training program consisted of basic movements, basketball skills (lay-ups, dribbling, and shooting), and games. Basketball was played as 3 versus 3 (or 2 versus 2) on half court. Given that the beneficial effects of Baduanjin on mental health have been well documented [26, 36, 37], its form was arranged in the other experimental group. A certified instructor from the university taught and supervised the participants, who participated in exercises three times per week for 12 weeks. Each session included 10 minutes of warm-up, 70 minutes of Baduanjin practice, and 10 minutes of cooldown. The whole set of Baduanjin included eight postures, consisting of the starting and ending postures.

2.4. Statistical Analysis. For each outcome of interest, a population average model using generalized estimating equations or GEE [38] was built with the Stata16 software [39], to assess the intervention effects of the two exercise interventions comparing with control over time, while adjusting for potential confounders. Correlations among the three repeated measures of each outcome variable taken within each participant were assumed to be exchangeable, and parameter estimates and their robust standard errors were obtained with the Stata command *xtgee* for the GEE approach, for which the distribution assumption of the dependent variable is not required [40]. Main and interaction effect terms for both the repeated measure time factor and the group factor were included in the GEE model for each outcome at first, and then we assessed the significance of the time-arm interaction for each outcome. If the time-arm interaction effects for an outcome were significant, we report estimated coefficients and their *p*-values for both the main effects and the interaction effects for this outcome. Distribution inequality among the three RCT arms was detected for each baseline variable, and baseline variables that turned out to be significant would be included as main effect terms in all GEE models to control for their confounding effects. Statistical significance was set at type I error level of 0.05. For each of all the five outcome variables (i.e., MPAI and four mental health indices), means and standard deviation ranges of raw values at different time points in each of the three RCT groups are illustrated in interaction plots. Also given in each interaction plot are "×" symbols at different postintervention time points, which indicate the significance of the corresponding "time × intervention" interaction effect for that time point by the Walt test of the GEE model, representing a significant intervention effect across the time span from baseline to that postintervention time point as compared to the control group. That is to say, each "time × intervention" interaction term measures the difference between "the change of outcome from the baseline to the corresponding time in the corresponding intervention group" and "the change of outcome from the baseline to the corresponding time in the control group," and thus a significant interaction term indicates a significant change of outcome induced by the intervention during this time span (from the baseline to the corresponding time) as compared to the control group.

2.5. Ethics. The study procedures were carried out in accordance with the Declaration of Helsinki. The Institutional Review Board of the university approved the study. All subjects were informed about the study and all provided informed consent.

3. Results

3.1. Demographic Information. Distribution inequality among the three randomized arms was tested for each of baseline variables, that is, age, gender, grade/college level, major, family, class role, dating, monthly mobile phone fee, daily mobile phone use, purpose of mobile phone use, main social use of mobile phone, and awareness of harm of mobile radiation. Only major turned out to have group difference ($p < 0.05$), and thus major was included as a main effect term in all GEE models to control for its confounding effect. Detailed demographic information is presented in Table 1.

3.2. Respondent Characteristics across Groups. For each of the three groups, Table 2 displays respondents' average scores on smartphone use and the four psychological measures at the three time points. All three groups started at similar levels of PSU, anxiety, stress, inadequacy, and loneliness, yet there were improvements across all indicators at the end of the interventions in the two experimental groups. For example, the MPAI scores of Baduanjin participants dropped from 51.13 to 42.74 after 12 weeks, suggesting a moderate reduction in their PSU levels. In comparison, the control group only witnessed small fluctuations in scores of all five measures from the baseline to week 12. Furthermore, when comparing baseline against the 2-month follow-up scores, positive changes in smartphone

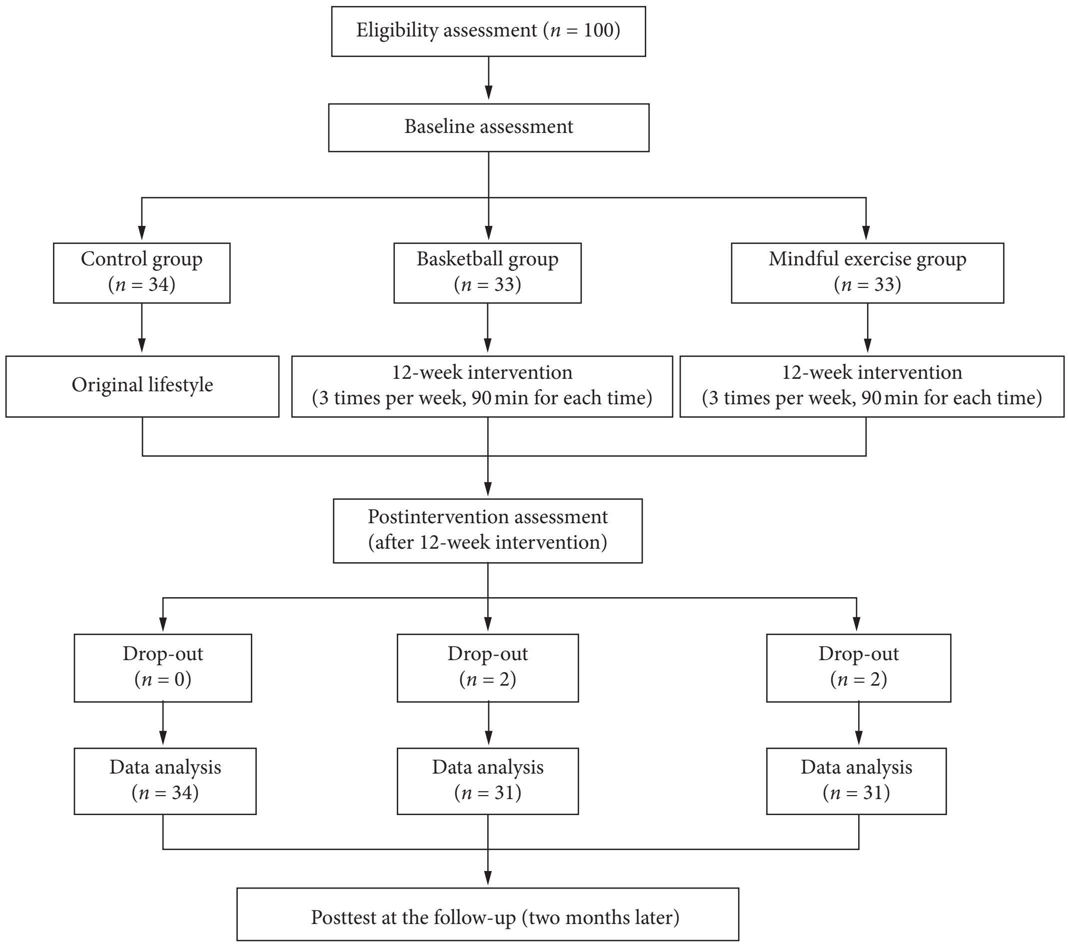


FIGURE 2: Flowchart displaying the process of randomization, intervention, and follow-up assessment.

use and psychological indicators were still evident among the Baduanjin and basketball groups.

3.3. Effects of Exercise Interventions. The regression coefficient estimation results by the GEE model for all of the five outcomes are organized in Table 3. Since this is a randomized controlled trial, the group means can be assumed to be equal at baseline and the test of the intervention effect is subsumed within the test of the "time × intervention" interaction. As can be seen in the "Interaction effect" section of Table 3, significant effects for all outcomes right after intervention were observed for both Baduanjin and basketball groups. These significant effects stayed for at least two months beyond the intervention period, with the only exception of stress. These trends with corresponding significance indicators are also illustrated in the interaction plots of all five outcome variables in Figures 3 and 4. Quantitative interpretations of significant intervention effects for the five outcome variables in Table 3 are given next, categorized by short-term or long-term effects with regard to the two postintervention time points, respectively.

3.3.1. Short-Term Effects of Exercise Interventions. PSU: both Baduanjin and basketball contributed to significantly larger reductions of PSU level as compared to the control group at the end of the intervention period; see Table 3 and Figure 3. Specifically, the MPAI scores dropped 8.47 more among basketball participants (95% CI −12.34 to −4.61, $p < 0.01$) and 7.15 more among Baduanjin participants (95% CI −10.48 to −3.82, $p < 0.01$) than those receiving no intervention, suggesting a strong short-term effect of both exercising interventions on reducing PSU; see Table 3 and Figure 3.

Psychological outcomes: all four mental health indicators were found to be positively influenced by both Baduanjin and basketball interventions significantly; see Table 3 and Figure 4. Participants' levels of anxiety, loneliness, inadequacy, and perceived stress dropped noticeably from baseline to week 12 as a result of exercising, comparing to the control group. Specifically, from baseline to week 12, those who played basketball regularly has a reduction of 9.56 (95% CI −12.87 to −6.25, $p < 0.01$) on anxiety score (SRAS), a reduction of 10.33 (95% CI −13.79 to −6.88, $p < 0.01$) on loneliness score (UCLA-LS), an increase of 25.14 (95% CI 17.43 to 32.85, $p < 0.01$) on inadequacy score (FIS), and a reduction of 5.05 (95% CI −7.52 to −2.57, $p < 0.01$) on stress score (UCLA-LS), more than that among the control group. Similarly but to less extent, from baseline to week 12, Baduanjin participants witnessed drops in these four mental health indices as well: those who played Baduanjin regularly

Table 1: Summaries of baseline variables in the three groups ($N = 96$).

		Baduanjin	Basketball	Control
Age		19.21 ± 1.02	18.95 ± 0.89	19.71 ± 1.77
Gender	Male	24	23	24
	Female	7	8	10
Grade	Freshmen	29	30	28
	Sophomore	2	1	5
	Junior	0	0	1
Major*	Science	24	22	34
	Social science	7	9	0
Family	Single child	22	16	22
	Sibling	9	15	12
Class role	Leader	10	4	10
	Nonleader	21	27	24
Dating	Yes	6	5	11
	No	25	26	23
Monthly mobile phone fee (Yuan)	<20	1	2	5
	20–50	12	17	14
	51–100	6	6	9
	101–150	3	0	1
	150–200	9	6	5
Daily mobile phone use (hours)	3-4	0	5	2
	4–6	1	2	4
	6–8	23	18	19
	8–10	3	5	8
	>10	4	1	1
Main use of mobile phone	Social (chatting)	13	16	16
	Study and work	14	13	16
	Personality	0	2	0
	Entertainment	4	0	1
	Killing time	0	0	1
Main social use of mobile phone	Internet surfing	16	14	15
	Movie and music	12	14	18
	Phone and messaging	1	0	0
	Photograph	2	3	0
	Playing game	0	0	1
Awareness of harm of mobile radiation	Know	26	23	30
	Do not know	5	8	4

Note. *A significant baseline difference, which was added to the analysis models as the main effect terms to adjust for their potential confounding effects.

have a reduction of 4.27 (95% CI −8.23 to −0.31, $p = 0.04$) on anxiety score (SRAS), a reduction of 7.63 (95% CI −11.29 to −3.96, $p < 0.01$) on loneliness score (UCLA-LS), an increase of 18.01 (95% CI 9.46 to 26.56, $p < 0.01$) on inadequacy score (FIS), and a reduction of 2.89 (95% CI −5.61 to −0.16, $p < 0.01$) on stress score (UCLA-LS), more than that among the control group. Overall, both basketball and Baduanjin proved to be most beneficial in alleviating loneliness and feelings of inadequacy, as indicated by the strongest changes in the two measures in Table 3 ($p < 0.01$) and Figure 4.

3.3.2. Long-Term Effects of Exercising Interventions. PSU: even after the interventions were over, participants still benefited from both exercise interventions, whose MPAI scores two months later remained significantly lower than their baseline scores. As Table 3 and Figure 3 display, MPAI scores of basketball and Baduanjin participants were, respectively, reduced 4.42 (95% CI −7.86 to −0.98, $p < 0.05$) and 4.67 (95% CI −8.23 to −1.12, $p < 0.05$) more than those in the control group, proving the lasting effect of exercising in the long run. Compared with Week 12 scores, MPAI scores of Baduanjin participants were somewhat more stable than those of basketball participants at the two-month follow-up, suggesting that the influence of Baduanjin on PSU might be more enduring.

Psychological outcomes: significant effects of exercise interventions on participants' mental health were carried over two months later after the end of interventions, with the only exception of perceived stress. Loneliness and feelings of inadequacy were still improved to the greatest extent in both exercising groups. Specifically, from baseline to 2-month follow-up after intervention, those who played basketball regularly has a reduction of 10.08 (95% CI −13.02 to −7.14, $p < 0.01$) on anxiety score (SRAS), a reduction of 8.74 (95% CI −12.05 to −5.44, $p < 0.01$) on loneliness score (UCLA-LS),

Table 2: Mean and standard deviation (Mean ± SD) of the raw data values for MPAI, anxiety, stress, inadequacy, and loneliness at the baseline, week 12, and 2-month follow-up in the Baduanjin, basketball, and control groups.

Variable	Baduanjin			Basketball			Control		
	Baseline	Week 12	2-month follow-up	Baseline	Week 12	2-month follow-up	Baseline	Week 12	2-month follow-up
MPAI	51.13 ± 8.66	42.74 ± 6.87	43.48 ± 5.05	48.42 ± 7.80	38.71 ± 4.60	41.03 ± 3.23	47.82 ± 5.83	46.59 ± 5.03	44.85 ± 3.96
Anxiety	51.29 ± 6.00	45.58 ± 5.12	46.42 ± 4.83	52.84 ± 5.05	41.84 ± 4.43	41.58 ± 4.67	54.03 ± 5.31	52.59 ± 5.04	52.85 ± 4.13
Stress	34.23 ± 5.10	29.52 ± 4.3	30.35 ± 4.65	33.87 ± 5.00	27 ± 4.21	32.03 ± 4.05	34.5 ± 5.82	32.68 ± 5.08	31.94 ± 4.79
Inadequacy	76.87 ± 7.71	108.32 ± 15.12	100.52 ± 21.19	78.68 ± 8.23	117.26 ± 15.03	110.81 ± 12.58	77.41 ± 7.88	90.85 ± 14.76	88.18 ± 11.4
Loneliness	50.1 ± 4.82	40.68 ± 2.82	42.45 ± 3.06	50.55 ± 4.51	38.42 ± 2.91	40.13 ± 3.32	48.79 ± 5.76	47 ± 6.2	47.12 ± 4.71

* $p < 0.05$; ** $p < 0.01$.

Table 3: Parameter estimation of time, group, and their interaction effects in the GEE models.

Effect			MPAI	Anxiety	Loneliness	Inadequacy	Stress
		Coef.	47.54	52.80	49.15	75.59	33.93
Intercept		95% CI	(44.41, 50.67)	(50.24, 55.36)	(46.96, 51.33)	(70.40, 80.79)	(31.14, 36.72)
		p	0.00**	0.00**	0.00**	0.00**	0.00**
		Coef.	−1.24	−1.44	−1.79	13.44	-1.82
	Time 2	95% CI	(−2.95, 0.48)	(−4.26, 1.38)	(−4.77, 1.18)	(8.03, 18.86)	(-3.94, 0.29)
Time effect		p	0.16	0.32	0.24	0.00**	0.09
		Coef.	−2.97	−1.18	−1.68	10.76	-2.56
	Time 3	95% CI	(−4.75, −1.19)	(−3.41, 1.06)	(−4.27, 0.91)	(5.81, 15.72)	(-4.77, -0.35)
		p	0.00**	0.30	0.20	0.00**	0.02*
		Coef.	3.24	−3.02	1.38	-0.95	-0.40
	Baduanjin	95% CI	(−0.40, 6.88)	(−5.78, −0.25)	(−1.19, 3.96)	(-4.97, 3.07)	(-3.08, 2.28)
		p	0.08	0.03*	0.29	0.64	0.77
		Coef.	0.51	−1.55	1.86	0.74	-0.79
Group effect	Basketball	95% CI	(−2.98, 4.00)	(−4.14, 1.05)	(−0.66, 4.38)	(-3.18, 4.66)	(-3.56, 1.97)
		p	0.77	0.24	0.15	0.71	0.57
		Coef.	0.28	1.23	−.3515483	1.81694	.5701275
	Major	95% CI	(−2.17, 2.74)	(−0.62, 3.08)	(−1.41, 0.71)	(-2.67, 6.30)	(-1.44, 2.58)
		p	0.82	0.19	0.51	0.43	0.58
		Coef.	−7.15	−4.27	−7.63	18.01	-2.89
	Time 2* Baduanjin	95% CI	(−10.48, −3.82)	(−8.23, −0.31)	(−11.29, −3.96)	(9.46, 26.56)	(-5.61, -0.16)
Interaction effect		p	0.00**	0.04*	0.00**	0.00**	0.04*
		Coef.	−8.47	−9.56	−10.33	25.14	-5.05
	Time 2* basketball	95% CI	(−12.34, −4.61)	(−12.87, −6.25)	(−13.79, −6.88)	(17.43, 32.85)	(-7.52, -2.57)
		p	0.00**	0.00**	0.00**	0.00**	0.00**
		−4.67	−3.69	−5.97	12.88	-1.31	
	Coef.	95% CI	(−8.23, −1.12)	(−6.92, −0.46)	(−9.17, −2.76)	(3.73, 22.03)	(-3.80, 1.18)
Time 3* Baduanjin		p	0.01*	0.03*	0.00**	0.01**	0.30
		Coef.	−4.42	−10.08	−8.74	21.36	0.72
	Time 3* basketball	95% CI	(−7.86, −0.98)	(−13.02, −7.14)	(−12.05, −5.44)	(13.64, 29.09)	(-1.73, 3.17)
		p	0.01*	0.00**	0.00**	0.00**	0.56

*$p < 0.05$; **$p < 0.01$; Time 1: the postintervention time (week 12); Time 2: the 2-month follow-up time after the postintervention time.

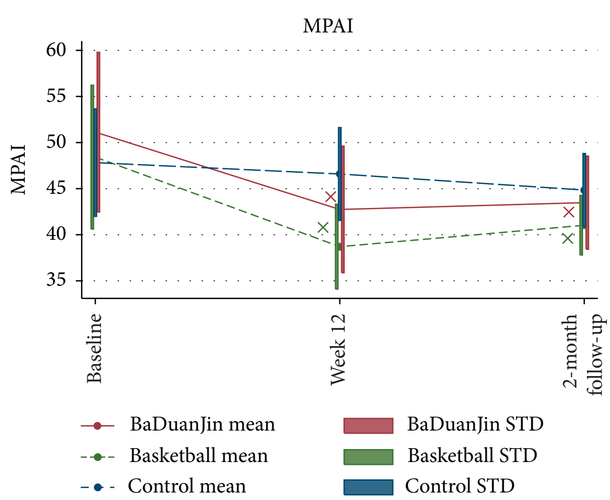


Figure 3: Interaction plots for comparisons of intervention effects on mobile phone addiction index.

and an increase of 21.36 (95% CI 13.64 to 29.09, $p < 0.01$) on inadequacy score (FIS), more than that among the control group. Similarly but to less extent, from baseline to week 12, Baduanjin participants witnessed drops in these four mental health indices as well: those who played Baduanjin regularly has a reduction of 3.69 (95% CI −6.92 to −0.46, $p = 0.03$) on anxiety score (SRAS), a reduction of 5.97 (95% CI −9.17 to −2.76, $p < 0.01$) on loneliness score (UCLA-LS), an increase of 12.88 (95% CI 3.73 to 22.03, $p < 0.01$) on inadequacy score (FIS), more than that among the control group. On the other hand, no significance was found regarding the improvements in perceived stress at the two-month follow-up as

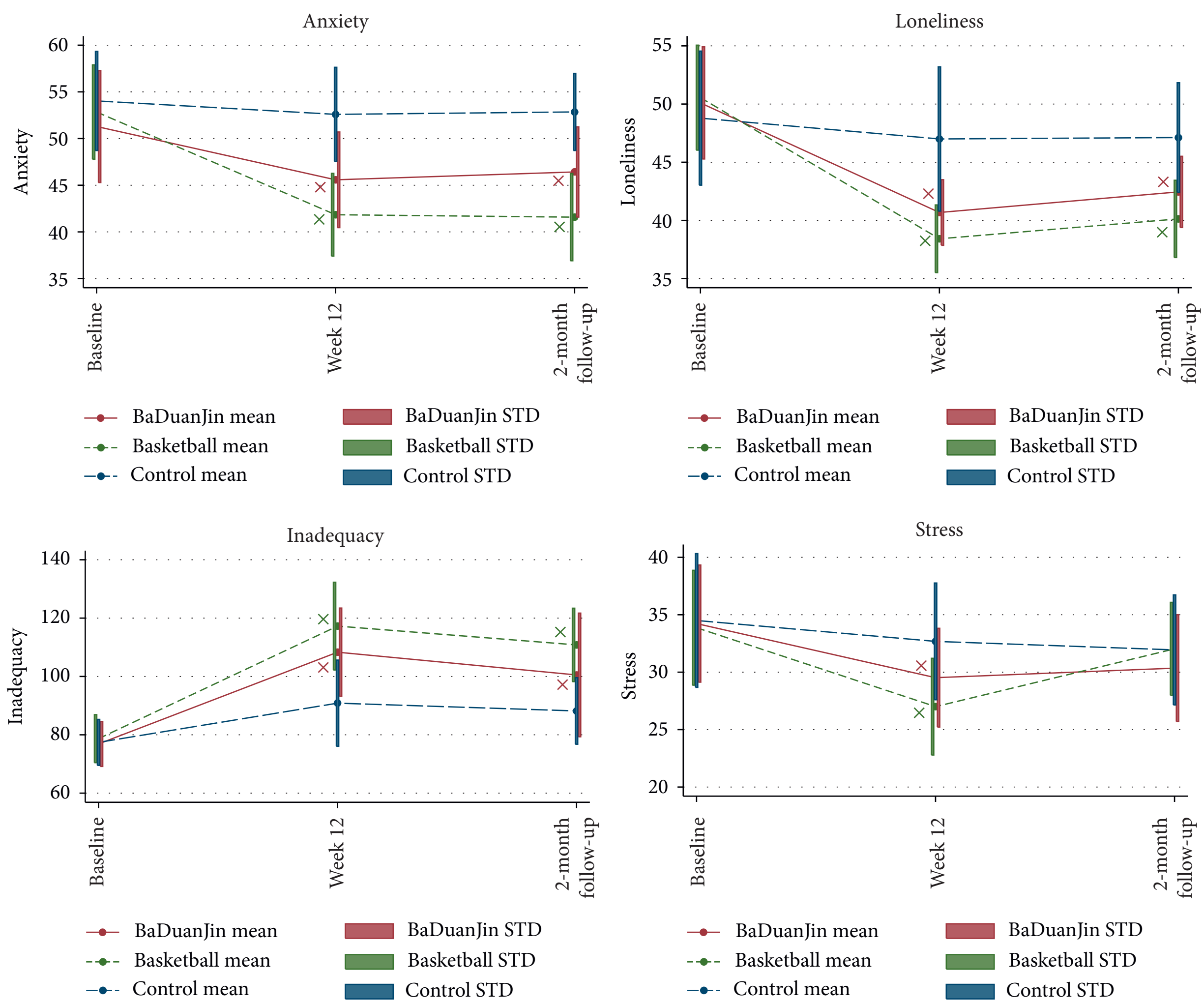


FIGURE 4: Interaction plots for comparisons of intervention effects on mental health indices.

compared to baseline for both exercising groups ($p = 0.30$ for Baduanjin group and $p = 0.56$ for the basketball group), when the reduction in stress levels from the baseline was no longer stronger than that in the control group.

4. Discussion

As demonstrated by previous experimental research, exercise engagement for at least 12 weeks was effective in reducing addictive smartphone use and withdrawal symptoms [7]. What remained unclear was the lasting effect of exercise beyond the end of intervention, as well as differences in the effectiveness of different types of exercises, especially those between traditional oriental exercises containing mindful movements and team sports such as basketball.

The results of this study showed that PSU of the participants in both intervention groups were reduced after the intervention and such beneficial effects were sustained for two months. These findings confirm the importance of exercising as an alternative approach for alleviating PSU, which also contributed to the improvement of mental health outcomes, particularly on anxiety, inadequacy, and loneliness. These findings also accord with previous researches that attendance of both team sports (e.g., [41]) and exercises containing mindful movements (e.g., [16, 20, 21, 23, 25]) are significantly associated with mental health.

The beneficial effects varied between the two intervention types based on our data, which is worthy of some notes and further investigations. Group-based basketball intervention was observed to have a greater effect on reducing PSU and improving mental health outcomes. Part of the reason might be that social activities involved in the group-based basketball help relieving mental health burden than exercise such as Baduanjin without interacting with others. In addition, group-based basketball intervention is generally more vigorous and involved with more competition as compared to Baduanjin, and hence group-based basketball might be associated with a higher level of dopamine increase to combat with addiction of smartphone use [42]. However, Baduanjin seems to yield more enduring effect on lowering PSU, with potential reason that the training of mindful movements typically in accords with rhythmic deep breaths could help improve one's discipline and activity endurance for a longer run [43].

Other than the effects of interventions, the feasibility is also an important factor for exercise intervention promotion among people with PSU. Comparing to basketball, Baduanjin is a convenient (practice time can be as less as 10 to 20 minutes) and noninvasive exercise that attracts many peoples' attention in real life [28]; recommending Baduanjin exercise to people with addictive smartphone use appears to be more feasible than basketball. In particular, while practicing Baduanjin exercise, these participants may improve their confidence and pleasant moods to make greater efforts. As it positively cultivates the ability of self-control in their moods and helps them enjoy this exercise mode, their mental health issues such as anxiety and loneliness will possibly disappear. Collectively, Baduanjin exercise seems to be an available approach that could be effectively used for alleviating mood disorders in people with PSU.

Although both Baduanjin and basketball interventions in our study are effective in reducing smartphone use of college students and improving their mental health, the main limitations of this study are stated as follows. Firstly, a limited sample was obtained from only one regional university in China. Therefore, the results may not be generalizable before we replicate the study among other Chinese students or student populations in other countries, especially without culture-related confounders in consideration. We encourage researchers to examine the effects of culture-specific physical exercise on population of different regions globally to adjust for such a confounder effect [44]. Secondly, follow-up positive effects were observed, but two months may be too short to determine and compare the long-term effect of Baduanjin and basketball. Relapse seems to be common for PSU and hence research designs with longer follow-up time are in demand and better equipped with state-of-the-art tracking technologies [45]. Thirdly, PSU-related outcome measures are based on self-reporting and brain changes in structure and function between baseline and postintervention were not measured in this study, so potential neurological mechanisms of the beneficial effects of exercise interventions on PSU and the related mental health outcomes remain unclear. There is substantial evidence that many mental illnesses including behavioral addictions are associated with the dopamine-involved brain reward process [46, 47] and that dopamine is also involved in the rewarding aspects of exercise and ultimately the motivation to exercise [48]. The effects of chronic exercise on the dopaminergic system have been extensively verified in animal models at a genetic level [49, 50]. In the context of this research, the larger improvements of PSU and the mental health outcomes introduced by group-based basketball intervention as compared to Baduanjin intervention might be explained as that college students got more dopamine rewards from basketball play which is a more intense, competitive, and game-like than Baduanjin. Future studies should pay attention to changes in dopaminergic functioning introduced by exercise interventions among people with PSU. Fourthly, future studies may include the optimal exercise type or "dose" required for reducing PSU with researches of more exercise interventions in depth. Lastly, it would be of a great value to put more focus on exercise preference patterns among people with PSU for better exercise promotion among them to lower their PSU levels more effectively.

5. Conclusions

In conclusion, our interventions demonstrate that both Baduanjin and basketball exercises can effectively reduce PSU of college students and improve their mental wellness with regard to reducing anxiety, loneliness, inadequacy, and stress. Furthermore, such positive effects on all these indices introduced by the two exercises can be sustained for two months after intervention except for the perceived stress index. Future studies might benefit from comparing exercise interventions on this domain with more confounders considered, longer follow-up time designed, and more objective indices measured and from tailoring treatment programs to address the needs of different populations.

Data Availability

The data used in the study are available upon request to the corresponding author.

Conflicts of Interest

The authors declare no conflicts of interest.

Authors' Contributions

Tao Xiao and Can Jiao contributed equally to the paper. Jie Yao and Tao Xiao conceptualized the study; Shijie Liu contributed to data collection; Tao Xiao, Lin Yang, and Jie Yao contributed to data analysis; Tao Xiao, Jie Yao, Lin Yang, Jane Jie Yu, and Yanjie Zhang contributed to manuscript writing; Jiao Can, Shijie Liu, Zhaowei Kong, Igor Grabovac, Jieting Zhang, and Qian Yu provided critical feedback. All authors have read and agreed to the published version of the manuscript.

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Review Article

The Safety of Baduanjin Exercise: A Systematic Review

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Objectives. Baduanjin exercise is a form of Qigong exercise therapy that has become increasingly popular worldwide. The aims of the current systematic review were to summarize reported adverse events potentially associated with Baduanjin exercise based on currently available literature and to evaluate the quality of the methods used to monitor adverse events in the trials assessed. *Methods*. The English databases PubMed, Cochrane library, and EMbase were searched from inception to October 2020 using the keywords "Baduanjin" or "eight session brocade." Only studies that included Baduanjin exercise therapy were included. *Results*. Forty-seven trials with a total of 3877 participants were included in this systematic review. Twenty-two studies reported protocols for monitoring adverse events, and two studies reported the occurrence of adverse events during training. The adverse events reported included palpitation, giddiness, knee pain, backache, fatigue, nervousness, dizziness, shoulder pain, chest tightness, shortness of breath, and muscle ache. *Conclusions*. Only two studies reported adverse events that were potentially caused by Baduanjin exercise. Adverse events related to Baduanjin exercise in patients with chronic fatigue syndrome may include muscle ache, palpitation, giddiness, knee pain, backache, fatigue, nervousness, dizziness, shoulder pain, chest tightness, and shortness of breath. Further studies conducted in accordance with the Consolidated Standards of Reporting Trials statement guideline incorporating monitoring of adverse events are recommended. Additional clinical trials in which Baduanjin exercise is used as a main intervention are needed, and further meta-analysis may be required to assess its safety and reach more informed conclusions in this regard in the future.

1. Introduction

Qigong exercise is a core part of traditional Chinese medicine therapy that has existed for more than 2000 years [1]. Baduanjin is one of the traditional Chinese Qigong exercise therapies of mild to moderate intensity, and it is considered to be an effective approach to promoting health [2]. It emphasizes the mind-body connection, slow movements while breathing deeply, and muscle stretching with mental concentration; it also has profound therapeutic effects in patients with various medical conditions [3–8]. Although Baduanjin has been practiced for thousands of years in China, globally it is not as popular as Tai Chi [1, 9]. To date, no review has systematically investigated the safety of Baduanjin.

The reporting of adverse events (AEs) is vital when introducing and evaluating a new therapy. An AE has been defined as any unwanted experience during a study regardless of whether the AE was directly related to an intervention [10]. Standard reporting of AEs is suggested in the Consolidated Standards of Reporting Trials (CONSORT) statement [11]. It is strongly recommended that AEs should be described in the Results sections of published reports [12]. Despite existing guidelines on the reporting of AEs [11], the degrees to which AEs are described in experimental studies are still inadequate [13, 14]. Insufficient reporting of AEs may lead to skepticism, criticism, and even rejection of a therapy.

To address the above-described research gaps with respect to Baduanjin exercise, a systematic review of the available evidence on its safety is needed. Accordingly, the main purpose of the present systematic review was to investigate and summarize the AEs reported in previous studies that included Baduanjin exercise. A secondary aim was to evaluate the quality of the methods used to monitor AEs in the studies assessed.

2. Methods

2.1. Guideline Adherence and Eligibility Criteria. The current analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Only studies published in English were included. Studies involving patients with medical conditions and studies using healthy participants were included. No restrictions on sociodemographic characteristics were applied. Experimental studies that included any type of Baduanjin exercise were included. No restrictions on the types of Baduanjin interventions or control interventions were applied.

2.2. Types of Outcome Measures. The definition of an AE was any undesirable experience during the study period. AEs were categorized as serious, non-serious, and intervention-related using a prior meta-analytic review as a guide [15]. Serious AEs were defined as those associated with hospitalization or medical or surgical needs, and those that were potentially life-threatening or resulted in death. Other AEs were defined as non-serious.

2.3. Search Methods. The PubMed, Cochrane library, and Embase electronic databases from inception to October 2020 were searched. The search string used to search PubMed and Embase was Baduanjin [Title/Abstract] OR eight session brocade [Title/Abstract]. The search string used to search the Cochrane library was Baduanjin [Title/Abstract/Keyword] OR eight session brocade [Title/Abstract/Keyword].

Initial screening to exclude duplicate and irrelevant studies based on article titles was conducted by the first author (Fang). The abstracts of the remaining studies were then independently reviewed by two authors (Fang and Zhang). The remaining full texts were then reviewed by two different independent authors with reference to the eligibility criteria (Wu and Ye). Only research articles that met the selection criteria were included in the subsequent review and assessment. The References sections of relevant articles were also reviewed by the authors. Consensus was reached via discussion if there were disagreements between two reviewers. Only reports published in English were included in the analysis [16].

2.4. Data Extraction and Management. Data extraction from the reports identified included characteristics of the timing, frequency, and types of AEs reported based on the Extension of the CONSORT statement [11], and it was performed by both Fang and Zhang independently. All authors participated in discussion to reach a consensus in cases of disagreements. In two cases in which researchers had not clearly described AEs in their published articles, we emailed the corresponding authors seeking further details on intervention-related AE data and baseline data. Only one of these corresponding authors emailed us back in response to our questions. All of the authors of the current study discussed the AEs that remained unclear in the second study due to the lack of a response from the corresponding author, and made collective judgments with respect to those AEs.

3. Results

3.1. Reports Identified. A total of 322 records were initially identified. Of these, 112 full-text articles were subsequently obtained based on the predetermined selection criteria, and a total of 47 articles were ultimately included in the current review. The flow of the literature search is presented in Figure 1.

3.2. Characteristics of Participants and Settings. A combined total of 3877 participants were included in the trials assessed in the final analysis, 2343 women and 1234 men; 3 studies did not report the exact number of males and females [17–19]. The mean ages in individual studies ranged from 20.8 to 83.0 years, and the median mean age was 60.1 years (interquartile range 49.9–65.5 years). The percentages of female participants in the studies ranged from 0% to 100%, and the median was 66.1% (interquartile range 38.7–80.2%).

The sample sizes in the reports ranged from 1 to 271, and the median was 68 (interquartile range 42–110). Most of the studies were conducted in China, including ten in Fujian [20–29], six in Beijing [19, 30–34], five in Taiwan [35–39], five in Guangdong [7, 40–43], four in Hong Kong [6, 44–46], three in Shanghai [18, 47, 48], two in each of Hebei [49, 50], Jiangsu [51, 52], Sichuan [53, 54], and Hubei [17, 55], and one in each of Tianjin [4], Shanxi [56], Jiangxi [57], and Macau [58]. One study was conducted in Singapore [59], and one study was conducted in the USA [60].

Eleven trials included healthy participants only [17, 20, 22, 30, 33, 36, 37, 39, 49, 55, 60], and the remaining 36 included participants with a variety of physical and mental health conditions [4, 6, 7, 18, 19, 21, 23–29, 31, 32, 34, 35, 38, 40–48, 50–54, 56–59].

3.3. Characteristics of Intervention Groups and Control Groups. The Baduanjin exercise regimes used in the studies varied in content, frequency, duration, and intensity. The majority of studies used standing Baduanjin exercises as an

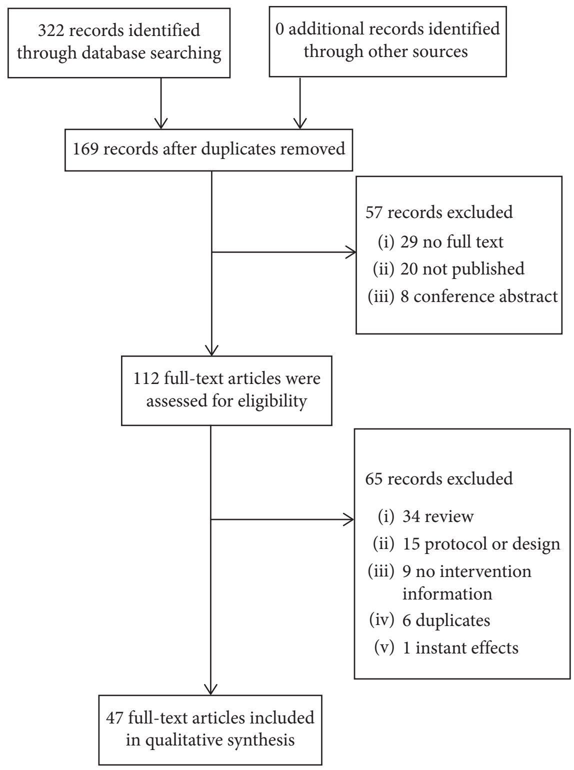

Figure 1: The flow of the literature search.

intervention [4, 6, 17–39, 41–59], two studies used a mixed model including standing and sitting Baduanjin exercises [40, 60], and one study used sitting Baduanjin exercises only [7]. The duration of Baduanjin exercise ranged from 12 minutes to 120 minutes. The frequency of sessions varied from once per week to 14 times per week, with overall exercise programs lasting from 8 weeks to 1 year. Five studies did not report the qualifications of instructors [17, 34, 40, 57, 58].

Of the 47 eligible studies, 8 evidently did not include controls [7, 28, 38, 39, 48, 58–60], and 5 used more than two control groups [21–24, 49]. Three studies used walking as a control [34, 42, 54], and other control measures used in single studies were muscle relaxation training [30], reading [6], physical therapy [19], and an aerobic exercise [43]. Twenty-seven studies used non-interventional controls, including usual care [4, 17, 18, 20, 25–27, 29, 31–33, 35–37, 40, 41, 44–47, 50–53, 55–57]. Further details of the characteristics of the studies are presented in Table 1.

3.4. Patterns of AEs. Of the 47 studies assessed, 22 reported protocols used to monitor AEs [4, 6, 17, 20, 21, 26, 27, 29, 32, 35, 37, 38, 40, 41, 43, 44, 46–48, 52, 55, 59], but only 2 reported the actual occurrence of AEs during the trial [44, 52]. Of these two studies, one reported muscle ache only [52] and the other reported muscle ache, palpitation, giddiness, knee pain, backache, fatigue, nervousness, dizziness, shoulder pain, chest tightness, and shortness of breath [44] (Table 2).

4. Discussion

Baduanjin exercise is becoming increasingly popular around the world as it has been associated with therapeutic benefits for various medical conditions. It is now offered in hospital and community settings across China to reduce clinical symptoms and improve quality of life. The risk of harm from Baduanjin exercise may be minor, as suggested by the current systematic review, and older adults or patients with chronic illness are more likely to experience benefits associated with its clinical effects and affordability.

In the present systematic review, the reporting of AEs in Baduanjin exercise studies was insufficient, and this limits the conclusions that can be drawn to date about its safety [10]. A total of 47 studies with a combined total of 3877 participants were included in the current systematic review. Of the 47 studies, 22 reported the utilization of protocols to monitor AEs, and 2 reported the actual occurrence of AEs. The AEs reported included palpitation, giddiness, knee pain, backache, fatigue, nervousness, dizziness, shoulder pain, chest tightness, shortness of breath, and muscle ache. Some studies reported AEs at the end of the study, which may have resulted in recall bias. More frequent measures to identify AEs, and the incorporation of multiple modalities via which to report AEs throughout the study (interviews, questionnaires, and tests), may contribute to the generation of more reliable evidence [12].

None of the studies in the current systematic review reported any serious AEs. The most commonly reported AE related to Baduanjin exercise was muscle ache [44, 52], which is consistent with previous observations in other exercise studies [61–65]. Notably, some Baduanjin exercises entail a semi-squat position, for example, "Session 2, Open the Arms as an Archer Shooting Both Left- and Right-Handed"; "Session 5, Sway the Head and Shake the Tail"; and "Session 7, Grip the Palms to Improve Strength" [25]. In such sessions, participants are required to coordinately move upper limbs and trunks while in a semi-squat position, which may greatly improve muscle strength, particularly that of the lower extremities. These types of Baduanjin exercises may have contributed to the mild muscle aches reported during the first 2 weeks of practice [44, 52].

In one trial that included participants with chronic fatigue syndrome (CFS), 24 AEs were reported after Baduanjin exercise [44], which is consistent with other physical exercise studies in individuals with CFS [66]. This suggests that patients with CFS may experience some non-serious AEs after standard Baduanjin exercises. Notably however, that report [44] only mentions the monitoring of AEs in the intervention group, and there is no information regarding AEs in the control group. Further research is needed that incorporates the monitoring and reporting of all AEs in both intervention and control groups based on the CONSORT statement, to facilitate informative conclusions in patients with CFS.

The current study had several limitations. Only reports published in English were included. Additional potentially

Table 1: Characteristics of included studies.

Source	Area	Average age (age range)	Study population	No. of men/ women	Intervention group	Control group
An et al. [47]	Shanghai	65 ± 7.36	Patients with KOA	0/28	$N = 14$ Baduanjin 30 min; 5 times/w; 8 w	$N = 14$ keep routine as usual 8 w
An et al. [48]	Shanghai	65.2 ± 7.3	Patients with KOA	3/19	$N = 22$ Baduanjin 30 min; 5 times/w; 1y	—
Bao et al. [60]	American	83	Older adults	3/13	$N = 16$ Baduanjin (mixed) 45–50 min; 12 w	—
Chan et al. [44]	HK	39 ± 7.93	Women with chronic fatigue syndrome-like illness	42/108	$N = 75$ Baduanjin 90 min; 16 times/9 w (group training) + ≥30 min; 7 times/ w; 9 w (self- practice)	$N = 75$ keep routine as usual 9 w
Chan et al. [45]	HK	32.5–47.0	Persons with chronic fatigue syndrome-like illness	0/108	$N = 46$ Baduanjin 90 min; 16 times/9 w (group training) + ≥30 min; 7 times/ w; 9 w (self-practice)	$N = 62$ keep routine as usual 9 w
Chen et al. [36]	Taiwan	45.16 ± 5.78	Healthy middle-aged women	0/87	$N = 44$ Baduanjin 3 times/w; 12 w	$N = 43$ keep routine as usual 12 w
Chen et al. [37]	Taiwan	71.75 ± 8.13	Community-dwelling older people	19/36	$N = 27$ Baduanjin 30 min; 3 times/w; 12 w	$N = 28$ keep routine as usual 12 w
Chen et al. [53]	Sichuan	60.10 ± 7.06	Patients with chronic obstructive pulmonary disease	147/85	$N = 117$ usual care + Baduanjin 30 min; 7 times/w; 3 m	$N = 115$ usual care 3 m
Chen et al. [7]	Guangdong	62	Patients with dysfunctional ventilatory weaning response	1/0	$N = 1$ usual care + Baduanjin (sitting Baduanjin) 30 min; 2 times/d; 19 d	—
Chen et al. [38]	Taiwan	38.9 ± 9.6	People with severe mental illness	8/3	$N = 11$ Baduanjin 90 min; 2 times/w; 8 w	—
Chen et al. [30]	Beijing	22.5 ± 2.0	Healthy college students	16/26	$N = 21$ Baduanjin 90 min; 5 times/w; 8 w	$N = 21$ muscle relaxation training 90 min; 5times/w; 8 w
Chen et al. [35]	Taiwan	70.29 ± 13.53	Patients with stable heart failure	42/38	$N = 39$ Baduanjin 35 min; 3 times/w; 12 w	$N = 41$ keep routine as usual 12 w
Chen et al. [40]	Guangdong	60.7 ± 11.12	Patients with AMI after PCI	59/23	$N = 43$ usual care + Baduanjin (mixed) 30 min; 2 times/d; 3 d (sitting Baduanjin) 30 min; 5 times/w; 4 d-24 w (standing Baduanjin)	$N = 39$ keep routine as usual 24 w
Cheung et al. [46]	HK	41.75 ± 8.99	Women survivors of intimate partner violence	0/271	$N = 136$ Baduanjin 120 min; 2 times/w; 6 w (group training) + 60 min; 1 time/w; 7–22 w (group follow-up) +30 min; 7 times/w; 1–22 w (self-practice)	$N = 135$ keep routine as usual 22 w
Dong et al. [57]	Jiangxi	30–65	Patients with phlegm-dampness hypertension	26/21	$N = 23$ Baduanjin 60 min; 5 times/w; 16 w	$N = 24$ usual care 16 w
Fan et al. [41]	Shenzhen	71.1 ± 6.3	Elderly patients with sleep disturbances	34/105	$N = 67$ Baduanjin 45 min; 5 times/w; 24 w	$N = 72$ keep routine as usual 24 w
Han et al. [31]	Beijing	56 ± 8.86	Postoperative non-small cell lung cancer patients	28/32	$N = 30$ Baduanjin 60 min; 3 times/w; 1 w (training); 30 min; 10 times/w; 2 w-3 m (self-practise)	$N = 30$ keep routine as usual 3 m
Hsu et al. [39]	Taiwan	49.93 ± 4.38	Middle-aged women	0/31	$N = 31$ Baduanjin 20 min; 3 times/w; 12 w	—

Table 1: Continued.

Source	Area	Average age (age range)	Study population	No. of men/ women	Intervention group	Control group
Jin et al. [17]	Wuhan	34.2 ± 14.57	Physically healthy people	Not mentioned	$N = 55$ Baduanjin 30–60 min; ≥3 times/w; 16 w	$N = 55$ keep routine as usual 16 w
Jing et al. [49]	Tangshan	75.08 ± 5.26	Elderly housebound	40/78	$N = 39$ Baduanjin 60–90 min; 2 times/m; 3 m 1times/m; 3–6 m	$N = 79$ control group1: CBT 6 m control group2: Baduanjin + CBT 60–90 min; 2 times/m; 3 m 1 time/m; 3–6 m
Li et al. [55]	Wuhan	34.2 ± 14.6	Physically healthy adults	36/74	$N = 55$ Baduanjin 30–60 min; 3 times/w; 16 w	$N = 55$ keep routine as usual 16 w
Li et al. [20]	Fuzhou	20.78 ± 1.1	Healthy college students	36/170	$N = 101$ Baduanjin 60 min; 5 times/w; 12w	$N = 105$ keep routine as usual 12w
Li et al. [54]	Sichuan	50.98 ± 7.76	Patients with schizophrenia	47/14	$N = 30$ Baduanjin 40 min; 5 times/w; 24 w	$N = 31$ brisk walking 40 min; 5 times/w; 24 w
Liang et al. [42]	Guangdong	55.25 ± 9.38	Patients with essential hypertensive	38/22	$N = 30$ usual care + Baduanjin 20 min; 10 times/w; 6 m	$N = 30$ usual care + walking 20 min; 10 times/w; 6 m
Liao et al. [32]	Beijing	18–60	People with fatigue-Predominant subhealth	33/96	$N = 62$ Baduanjin 30 min; 14 times/w; 6 w	$N = 67$ keep routine as usual 6 w
Liu et al. [56]	Shanxi	57.2 ± 5.4	Women with diabetes	0/35	$N = 17$ Baduanjin 90 min; 6 times/w; 24 w	$N = 18$ keep routine as usual 24 w
Liu et al. [21]	Fuzhou	59.17 ± 7.36	Patients with KOA	25/83	$N = 29$ Baduanjin 60 min; 5 times/w; 12 w	$N = 79$ control group1: Taichi 60 min; 5 times/w; 12 w control group2: cycling 60 min; 5 times/w; 12 w control group3: health education 60 min; 1 time/w; 12 w
Liu et al. [59]	Singapore	77.1 ± 5.9	Frail older adults	3/9	$N = 12$ Baduanjin 90 min; 2 times/w; 4 w (training) 90 min; 3 times/w; 5–16 w (self-practise)	—
Lu et al. [51]	Nanjing	55.11 ± 11.51	Patients with colorectal cancer undergoing chemotherapy	56/31	$N = 43$ Baduanjin 20–40 min; ≥5 times/w; 24 w	$N = 44$ usual care 24 w
Mao et al. [43]	Beijing	60.86 ± 10.63	Patients after acute myocardial infarction	73/37	$N = 56$ Baduanjin 30 min; 2 times/w; 12 w	$N = 54$ aerobic exercise 30 min; 2 times/w; 12 w
Tao et al. [22]	Fuzhou	61.29 ± 4.85	Older adults	20/41	$N = 15$ Baduanjin 60 min; 5 times/w; 12 w	$N = 46$ control group1: Taichi 60 min; 5 times/w; 12w control group2: keep routine as usual 12 w
Tao et al. [23]	Fuzhou	65.55 ± 4.40	Patients with mild cognitive impairment	18/39	$N = 20$ Baduanjin 60 min; 3 times/w; 24 w	$N = 37$ control group1: brisk walking 60 min; 3 times/w; 24w control group2: health education 30 min/w; 24 w
Tsang et al. [6]	HK	80.11 ± 5.63	Chinese depressed elders with chronic illness	12/26	$N = 21$ Baduanjin 45 min; 3 times/w; 12w	$N = 17$ reading 45 min; 3 times/w; 12 w
Wang [33]	Beijing	59.35 ± 1.6	Old people	42/71	$N = 55$ Baduanjin 60 min; 5–7 times/w; 6 m	$N = 58$ keep routine as usual 6 m
Wang et al. [18]	Shanghai	65.19 ± 4.88	Patients with essential hypertensive	Not mentioned	$N = 61$ usual care + Baduanjin 20–30 min; 4-5 times/w; 1 y	$N = 61$ usual care 1 y
Wang et al. [4]	Tianjin	54.09 ± 7.76	Breast cancer survivors	0/86	$N = 46$ Baduanjin ≥20 min; 7 times/w; 6 m	$N = 40$ Keep routine as usual 6 m

Table 1: Continued.

Source	Area	Average age (age range)	Study population	No. of men/ women	Intervention group	Control group
Xia et al. [24]	Fuzhou	65.51 ± 4.35	Older adults with mild cognitive impairment	23/46	$N = 23$ Baduanjin + health education Baduanjin:60 min; 3 times/w; 24w + Health education:30 min; 1 time/8 w; 24 w	$N = 46$ control group1: brisk walking + health education brisk walking: 60 min; 3 times/w; 24w + health education: 30 min; 1 time/8 w; 24 w control group2: keep routine as usual + health education 30 min; 1 time/ 8 w; 24 w
Xiao et al. [19]	Beijing	67.8 ± 9.4	Patients with Parkinson's disease	Not mentioned	$N = 35$ Baduanjin 60 min; 4 times/w; 6 m	$N = 33$ physical therapy 6 m
Xiao et al. [34]	Beijing	67.53 ± 8.56	Patients with idiopathic Parkinson's disease	67/29	$N = 48$ Baduanjin + walk Baduanjin:12–15 min; 4 times/ w; 6m + walk: ≥30 min; 7 times/w; 6 m	$N = 48$ walk ≥30 min; 7 times/w; 6 m
Xiao et al. [50]	Hebei	Not mentioned	Adults with cardiovascular diseases	50/79	$N = 66$ Baduanjin 24 min; 5 times/w; 16 w	$N = 63$ Keep routine as usual 16 w
Xie et al. [52]	Nanjing	37.39 ± 11.35	Patients with ankylosing spondylitis	35/11	$N = 23$ Baduanjin 2times/w; 4 w (instruction) ≥3 times/w; 5–12 w (self-practise)	$N = 23$ Keep routine as usual 12 w
Ye et al. [25]	Fuzhou	63.78 ± 6.39	Patients with KOA	25/25	$N = 25$ Baduanjin 40 min; 3 times/w; 12 w	$N = 25$ Keep routine as usual 12 w
Ye et al. [26]	Fuzhou	64.36 ± 5.34	Older adults with KOA	19/37	$N = 28$ Baduanjin 40 min; 3 times/w; 12 w	$N = 28$ Keep routine as usual 12 w
Zhang et al. [58]	Macau	24 ± 7	Women with premenstrual syndrome	0/40	$N = 40$ Baduanjin (8 sessions) 14 times/w; 3consecutive menstrual cycles	—
Zheng et al. [28]	Fuzhou	60	Elderly Population at risk for Ischemic stroke	11/9	$N = 20$ Baduanjin 30 min; 3-5 times/w; 12 w	
Zheng et al. [27]	Fuzhou	60.14 ± 6.3	Community adults at risk of ischamic stroke	61/109	$N = 85$ Baduanjin 60 min; 5 times/w; 12 w	$N = 85$ keep routine as usual 12 w
Zheng et al. [29]	Fuzhou	62.19 ± 7.87	Patients with post-stroke cognitive impairment	41/7	$N = 24$ usual care + Baduanjin 40 min; 3 times/w; 24 w	$N = 24$ usual care 24 w

HK: Hong Kong; KOA: knee osteoarthritis; CBT: cognitive behavioral therapy; min: minutes; w: week; m: month; y: year; N/No: number; AMI: acute myocardial infarction; PCI: percutaneous coronary intervention.

Table 2: The types of adverse events in both groups.

Source	Tre	Tse	Tnon	Cre	Cse	Cnon	Tdropout	Cdropout	F-U
An et al. [47]	0	0	0	0	0	0	3	4	4 m
An et al. [48]	0	0	0	—	—	—	6	—	No
Bao et al. [60]	Unclear	Unclear	Unclear	—	—	—	9	—	No
Chan et al. [44]	24 muscle ache	0	4 palpitation; 3 giddiness; 2 knee pain; 2 backache; 2 fatigue; 2 nervousness; 2 dizziness; 1 shoulder pain; 1 chest tightness; 1 shortness of breath	0	0	0	18	17	No
Chan et al. [45]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	0	0	3 m

Table 2: Continued.

Source	Tre	Tse	Tnon	Cre	Cse	Cnon	Tdropout	Cdropout	F-U
Chen et al. [17]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	1	2	No
Chen et al. [37]	0	0	0	0	0	0	1	0	No
Chen et al. [53]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	3	5	No
Chen et al. [7]	—	—	—	—	—	—	—	—	No
Chen et al. [38]	0	0	0	—	—	—	5	—	8 w
Chen et al. [30]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	0	0	No
Chen et al. [35]	0	0	0	0	0	0	9	8	No
Chen et al. [40]	0	0	0	0	0	0	5	9	No
Cheung et al. [46]	0	0	0	0	0	0	16	8	No
Dong et al. [57]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	2	3	No
Fan et al. [41]	0	0	0	0	0	0	5	9	No
Han et al. [31]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	No	No	No
Hsu et al. [39]	Unclear	Unclear	Unclear	—	—	—	0	—	No
Jin et al. [17]	0	0	0	0	0	0	0	0	No
Jing et al. [49]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	1	1	No
Li et al. [55]	0	0	0	0	0	0	9	0	No
Li et al. [20]	0	0	0	0	0	0	8	4	12 w
Li et al. [54]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	0	0	0
Liang et al. [42]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	No	No	No
Liao et al. [32]	0	0	0	0	0	0	2	0	12
Liu et al. [56]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	3	2	No
Liu et al. [21]	0	0	0	0	0	0	6	26	No
Liu et al. [59]	0	0	0	—	—	—	1	—	No
Lu et al. [51]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	2	1	No
Mao et al. [43]	0	0	0	0	0	0	2	3	No
Tao et al. [22]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	10	4	No
Tao et al. [23]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	3	9	No
Tsang et al. [6]	0	0	0	0	0	0	2	2	No
Wang [33]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	No	No	No
Wang et al. [18]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	No	No	No

Table 2: Continued.

Source	Tre	Tse	Tnon	Cre	Cse	Cnon	Tdropout	Cdropout	F-U
Wang et al. [4]	0	0	0	0	0	0	0	0	No
Xia et al. [24]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	3	6	No
Xiao et al. [19]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	14	16	No
Xiao et al. [34]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	3	4	No
Xiao et al. [50]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	1	4	No
Xie et al. [52]	7 muscle ache	0	0	0	0	0	7	7	No
Ye et al. [25]	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	0	0	No
Ye et al. [26]	0	0	0	0	0	0	0	0	No
Zhang et al. [58]	Unclear	Unclear	Unclear	—	—	—	9	—	No
Zheng et al. [28]	Unclear	Unclear	Unclear	—	—	—	0	—	No
Zheng et al. [27]	0	0	0	0	0	0	6	16	No
Zheng et al. [29]	0	0	0	0	0	0	5	8	4 w

Abbreviations. Tre: related adverse events of intervention group; Tse: serious adverse events of intervention group; Tnon: non-serious adverse events of intervention group; Cre: related adverse events of control group; Cse: serious adverse events of control group; Cnon: non-serious adverse events of control group; Tdropout: dropouts of intervention group; Cdropout: dropouts of control group; F-U: follow-up; m: month; w: week.

relevant studies may have been conducted that were published in other languages. Secondly, the number of trials included in the review was small, and they only employed descriptive statistics and summaries of AEs. Further meta-analyses assessing AEs potentially associated with Baduanjin exercise may be conducted.

5. Conclusion

Estimation of any potential harm related to a novel therapy is a vital consideration when promoting that therapy. Poor reporting of AEs may substantially limit the conclusions that can be drawn relating to Baduanjin exercise. The number of trials with strict reporting of AEs is small. One of the studies in the current analysis suggests that AEs related to Baduanjin exercise in patients with CFS may include muscle ache, palpitation, giddiness, knee pain, backache, fatigue, nervousness, dizziness, shoulder pain, chest tightness, and shortness of breath. It is recommended that in future studies AEs are rigorously monitored and strictly reported in accordance with the CONSORT guideline. Further meta-analysis may enhance understanding of the safety of Baduanjin exercise in the future.

Data Availability

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Disclosure

The funder had no role during the entire process of this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Authors' Contributions

Jiajia Ye, Fangzhen Wu, and Shuhe Cai contributed to conceptualization; Jianqi Fang, Fangzhen Wu, and Liying Zhang contributed to data curation; Jianqi Fang and Fangzhen Wu contributed to formal analysis; Jiajia Ye and Shuhe Cai contributed to funding acquisition; Jiajia Ye and Liying Zhang contributed to investigation; Jianqi Fang and Liying Zhang contributed to methodology; Jiajia Ye and Shuhe Cai contributed to project administration; Jiajia Ye and Shuhe Cai contributed to resources; Jianqi Fang and Fangzhen Wu contributed to software; Jiajia Ye, Xiaowen Lian, and Shuhe Cai contributed to supervision; Jiajia Ye, Xiaowen Lian, and Shuhe Cai contributed to validation; Jiajia Ye and Shuhe Cai contributed to visualization; Jianqi Fang and Jiajia Ye prepared original draft; Jiajia Ye, Liying Zhang, Xiaowen Lian, and Shuhe Cai partcicpated in review and editing.

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Supplementary Materials

The supplementary data file includes the comparison list of PRISMA Checklist. (*Supplementary Materials*)

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Review Article

The Impact of Tai Chi on Motor Function, Balance, and Quality of Life in Parkinson's Disease: A Systematic Review and Meta-Analysis

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Objective. Parkinson's disease adversely affects function and quality of life, leading to increased mortality. The practice of Tai Chi has been associated with multifaceted improvements in health-related fitness. Considering the limited number of clinical studies included in previous reviews, inconsistent methodological quality, and inconclusive results, this meta-analysis aims to assess the effects of Tai Chi in patients with Parkinson's disease. *Method.* Four English language databases and four Chinese databases were systematically searched for existing randomized controlled trials (RCTs) of Tai Chi in Parkinson's disease from database inception through August 1, 2020. Methodological quality was appraised with the Cochrane Risk of Bias tool. A meta-analysis of comparative effects was performed using the Review Manager v.5.3 software. *Results.* Seventeen published RCTs totaling 951 subjects were included. Results showed that Tai Chi has a statistically significant effect on the outcomes of gait velocity, unified Parkinson's disease rating scale (UPDRS) motor score, activities-specific balance confidence (ABC) score, and Berg Balance Scale (BBS). The effects on the Timed Up and Go Test (TUGT) and Parkinson's Disease Questionnaire-39 (PDQ-39) were not statistically significant. *Conclusions.* This systematic review and meta-analysis of Parkinson's disease and Tai Chi suggests Tai Chi is a relatively safe activity that can result in gains in general motor function and improve bradykinesia and balance. It has no statistically significant advantage for quality of life and functional mobility. Further randomized trials with larger sample sizes and of higher methodological quality are needed to confirm these results and to assess the feasibility of Tai Chi intervention for potential different clinical applications.

1. Introduction

Parkinson's disease (PD) is globally the second most common elderly neurodegenerative disease, characterized pathologically by degeneration of dopaminergic neurons in the substantia nigra and the formation of Lewy bodies [1]. Parkinson's patients have gait and posture disorders, resting tremor, bradykinesia, muscle stiffness, and other characteristic motor symptoms [2]. As the disease progresses, patients lose postural stability and the ability to maintain standing balance (including frequent falls), have gait dysfunction, have difficulty managing activities of daily living, and have worsened function and quality of life [3, 4]. Pharmacological treatment is the mainstay of current clinical management. Despite optimal medication, loss of independence, gait dysfunction, and frequent falls persist in patients with PD, which lead to a reduced quality of life and increased mortality [5]. Thus, the Movement Disorder Society Evidence-Based Medicine Panel recommends exercise and physical therapy as an efficacious adjunct to levodopa [6].

Tai Chi is a popular exercise in Chinese society, consisting of slow, gentle, and flowing movements that involve strengthening, balance, postural alignment, mind concentration, relaxation, and breath control [7]. Tai Chi has multifaceted benefits to improving health-related fitness, such as lower extremity muscle strength, balance, flexibility, and cognitive problems [8, 9]. These benefits show potential for improvement of the long-term symptoms of Parkinson's disease [10]. Many studies have previously reported the safety and effectiveness of Tai Chi in Parkinson's disease [10–12].

However, considering the limited number of clinical studies included in previous reviews, inconsistent methodological quality of the published studies, and mixed and inconclusive results, this meta-analysis aims to assess the effects of Tai Chi in patients with Parkinson's disease.

2. Methods

This study was designed following the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions and Preferred Reporting Items for Systemic Review and Meta-Analyses (PRISMA) [13].

2.1. Search Strategy. The following electronic databases were searched from their inception until 1 August 2020: PubMed, Embase, Cochrane Library, and Web of Science (for relevant English literature) and China National Knowledge Infrastructure (CNKI), Wanfang Database, China Science and Technology Journal (VIP), and Chinese Biomedical Literature Database (CBM) (for relevant Chinese literature). Search strategies were combined as follows: for English databases, free text terms ((Tai Chi) OR (tai ji) OR (tai ji quan) AND (Parkinson's Disease OR Parkinson) were applied and for the Chinese databases, the terms were ((tai ji) OR (tai ji quan) AND pajinsen). Only Chinese and English articles were considered for this meta-analysis. The complete search strategy is shown in the Supplementary Material.

2.2. Study Selection. The inclusion criteria for each study were as follows: (1) population consisting of participants with or without Parkinson's disease; (2) using any form of Tai Chi as an intervention; (3) having a control group, other treatments, or another exercise intervention as a comparison group; (4) reporting outcomes of symptoms related to Parkinson's disease or outcomes of exercise training; and (5) using a randomized controlled trial (RCT). Exclusion criteria were as follows: (1) not writing in English/Chinese; (2) having insufficient data or irrelevant outcomes; (3) and having no available full text.

2.3. Data Extraction and Quality Assessment. The data were extracted by two independent reviewers (Wu and Hou), who assessed all the studies based on the predesigned standards. Data were checked by a third investigator (Yu). Extracted data from the included studies contained the following information: author name, year of publication, sample size, mean age, interventions (type, duration, and control details), and main outcome measures. We assessed the included studies' quality on the basis of Cochrane Collaboration's risk of bias tool. There were three scores for each item (low risk, unclear, and high risk) according to the following criteria: (1) random sequence generation, (2) allocation concealment, (3) blinding of participants and personnel, (4) incomplete outcome data, (5) selective reporting, and (6) other biases.

2.4. Statistical Analysis. All data and statistical analyses were combined and performed using Review Manager v.5.3 software (Cochrane Collaboration, Oxford, UK). The mean difference (MD) with 95% confidence interval (CIs) was used to analyze continuous outcomes. We calculated the mean and standard deviation according to the calculation method mentioned in Cochrane Handbook version 5.1.0, chapter 16.1.3.2: imputing standard deviations for changes from baseline. Heterogeneity across studies was tested with the chi-square test and the Higgins I^2 statistic [14]. The fixed-effects model was applied when statistical heterogeneity was low ($I^2 \leq 50\%$ or Chi^2test $P < 0.10$); otherwise, a random-effects model was employed. Potential sources of heterogeneity were identified using sensitivity analyses conducted by omitting one study in turn and investigating the influence of a single study on the overall pooled estimate. A P value <0.05 was considered statistically significant. Publication bias was detected by Egger's regression asymmetry test.

3. Results

3.1. Study Selection and the Basic Documents. Database searching retrieved a total of 711 studies (486 English literature studies and 225 Chinese literature studies). After removing duplicate entries, 385 studies were screened. 339 studies were excluded based on the abstract and title because of (1) being irrelevant to the theme; (2) no RCT; (3) no relevant outcomes; (4) meeting reports; and (5) no complete report. 46 potentially relevant studies were identified for full-text analysis. 29 were excluded due to (1) no available data; (2) incorrect random method; (3) subjects having other complications; and (4) intervention combined with other methods. After screening, a total of 17 studies were included [4, 11, 12, 15–28]; the flow chart of the study selection is shown in Figure 1. The mean age of the included participants ranged from 53 to 74 years with the intervention duration in the range of 8–24 weeks, exercise time was 40–60 min per session, and the sample sizes varied from 16 to 195. The control groups consisted of usual care, Qi-Gong, Resistance exercise, Stretching, and Routine exercise. The main characteristics of the selected studies are presented in Table 1.

3.2. Quality Assessment and Publication Bias. Figures 2 and 3 show the quality assessment of the included studies using Cochrane Collaboration. Among the 17 RCTs included, 11 studies (65%) [4, 12, 15–19, 21, 23, 24, 27] reported the random sequence generation. One study (5%) [18] reported the use of allocation concealment methods. Five studies (30%) [4, 15–18] described the implementation of blinding of participants and outcome assessment. Twelve studies (80%) [14–19, 21–24, 26] had complete outcome data. Only five studies (30%) [4, 15, 17, 18, 22] reported complete data;

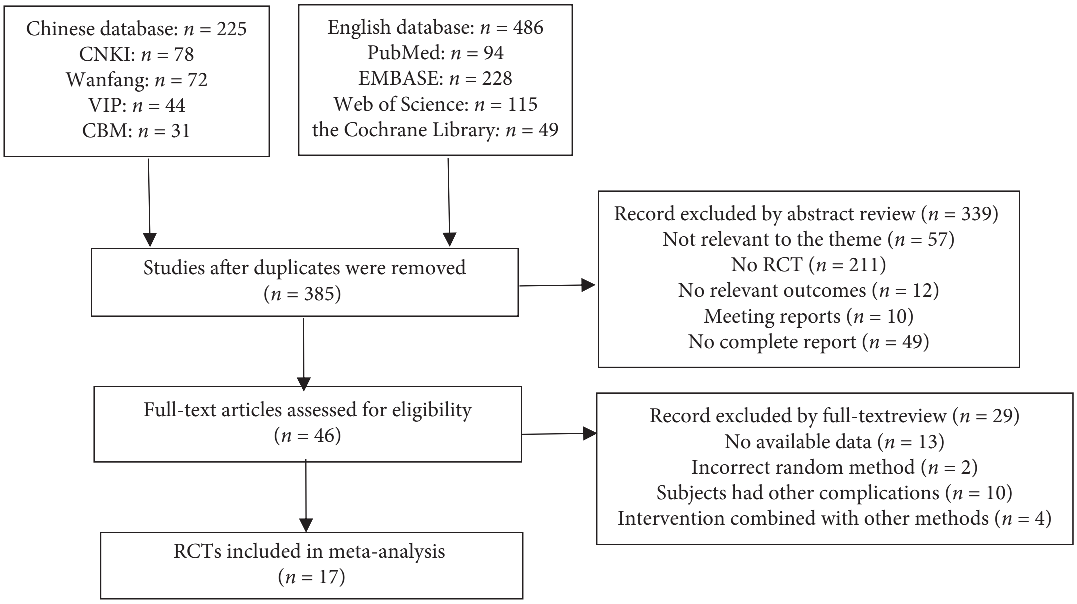

Figure 1: Flow diagram of screening literature studies.

Table 1: Characteristics of randomized controlled trials included in the meta-analysis.

Study, year	Number of patients (M/F)	Age (T/C)	Study group (n)	Outcomes	Tai Chi group Duration/exercise time	Tai Chi group Frequency/week	Control group intervention	Study design
Vergara-Diaz et al., 2018 [15]	32(16/16)	65.7 ± 3.86/ 62 ± 7.77	T(16)/ C(16)	2, 3, 4, 5	6 M/60 min	3	Usual care	2-arm RCT
Choi et al., 2013 [16]	20	60.81 ± 7.6/ 65.54 ± 6.8	T(11)/ C(9)	2	12 W/60 min	3	Usual care	2-arm RCT
Amano et al., 2013 [17]	45(28/17)	P1:64 ± 13/68 ± 7	T(12)/ C(9)	1, 2	16 W/60 min	P1: 2	P1 : Qi-Gong	P1:2-arm RCT
		P2:66 ± 11/66 ± 7	T(15)/ C(9)			P2: 3	P2 : usual care	P2:2-arm RCT
Li et al., 2012 [4]	195(122/73)	(T)68 ± 9/(R) 69 ± 8/(S)69 ± 9	T(65)/ R(65)/ S(65)	1, 2, 5	24 W/60 min	2	Resistance exercise/ Stretching exercise	3-arm RCT
Hackney and Earhart, 2012 [18]	26(21/5)	64.9 ± 8.3/ 62.6 ± 10.2	T(13)/ C(13)	2, 5, 6	10–13 W/ 60 min	2	Usual care	2-arm RCT
Xihong et al., 2018 [19]	80(44/36)	69.46 ± 5.45/ 68.61 ± 6.22	T(40)/ C(40)	1, 4, 5, 6	24 W/60 min	4	Usual care	2-arm RCT
Tingting et al., 2018 [20]	52(37/15)	62.42 ± 5.37/ 64.66 ± 5.47	T(30)/ C(25)	3	16 W/40 min	4	Routine exercise	2-arm RCT
Guan et al., 2017 [21]	80	No report	T(40)/ C(40)	6	24 W/60 min	5	Usual care	2-arm RCT
Li, 2016 [22]	16(10/6)	67.75 ± 6.84/ 68.20 ± 7.32	T(8)/ C(8)	2, 6	8 W/ 40–60 min	5	Usual care	2-arm RCT
Mingze et al., 2017 [12]	16(5/11)	63.50 ± 6.78/ 61.50 ± 5.63	T(8)/ C(8)	2, 3	24 W/60 min	2	Routine exercise	2-arm RCT
Lin, 2017 [23]	80(44/36)	65.25 ± 6.37/ 67.78 ± 5.36	T(42)/ C(38)	1, 2	16 W/60 min	3	Usual care	2-arm RCT
Li(2) et al. 2017 [24]	60	No report	T(30)/ C(30)	6	12 W/60 min	4	Usual care	2-arm RCT

Table 1: Continued.

Study, year	Number of patients (M/F)	Age (T/C)	Study group (n)	Outcomes	Tai Chi group		Control group intervention	Study design
					Duration/ exercise time	Frequency/ week		
Xihong et al., 2016 [25]	62(33/29)	70.23 ± 4.24/ 69.71 ± 4.13	T(31)/ C(31)	1, 4, 5, 6	12 W/60 min	4	Usual care	2-arm RCT
Ji et al., 2016 [11]	32(17/15)	56.06 ± 11.16/ 59.13 ± 11.22	T(16)/ C(16)	1, 6	3 M/60 min	Not specified	Usual care	2-arm RCT
Yi et al., 2010 [26]	40(23/17)	63.35 ± 8.72/ 64.83 ± 9.29	T(20)/ C(20)	2, 6	3 M/ 60–90 min	5	Walking exercise	2-arm RC
Li, 2011 [28]	47(22/25)	68.28 ± 6.62/ 67.13 ± 6.73	T(24)/ C(23)	3, 6	8 W/ 60–90 min	5	Walking exercise	2-arm RCT
Caifeng and Daohonget, 2015 [27]	68(37/31)	67.1 ± 1.5/ 65.2 ± 1.3	T(34)/ C(34)	2, 6	2 M/ 60–65 min	5	Usual care	2-arm RCT

T, Tai Chi group; C, control group; R, resistance training; S, stretching exercise; outcome 1, gait velocity; outcome 2, unified Parkinson's disease rating scale motor score (UPDRS motor score); outcome 3, Parkinson's Disease Questionnaire-39 (PDQ-39) score; outcome 4, activities-specific balance confidence (ABC) score; outcome 5, Timed Up and Go Test (TUGT); outcome 6, Berg Balance Scale (BBS); M, months; W, weeks.

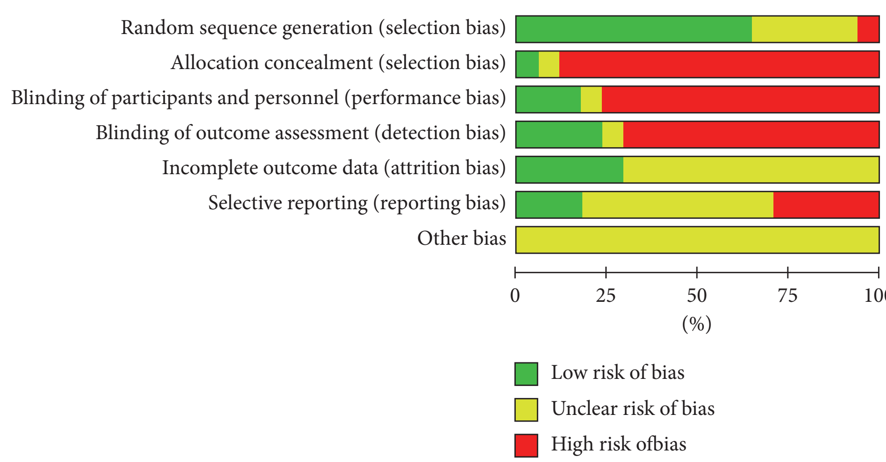

Figure 2: Risk of bias.

others were uncertain. Three studies (17%) [4, 17, 22] described the low risk of selective reports bias; others were uncertain (Figures 2 and 3). No significant publication bias was found from the funnel plot of the 10 studies (Figure 4).

3.3. Sensitivity Analysis. Sensitivity analyses were performed based on excluding studies with low quality, small sample sizes, and trials with different control groups to explore potential sources of heterogeneity. For each of these results with high heterogeneity, a separate sensitivity analysis was performed.

3.4. Analysis of Outcomes

3.4.1. Gait Velocity. Six studies [4, 11, 17, 19, 23, 25] reported the gait velocity of the Tai Chi group and the control group before and after the trial. Pooled results showed a significant increase of gait velocity in the Tai Chi group after intervention (random-effects model: SMD: 0.47; 95% CI: 0.12~0.83; $P = 0.009$; P for heterogeneity = 0.0004; $I^2 = 74\%$) (shown in Figure 5). Sensitivity analyses were performed. First, two studies [11, 25] with low quality were excluded. The pooled results showed that this exclusion did not materially alter results and statistical heterogeneity (random-effects model: SMD: 0.48; 95% CI:0.04~0.92; $P = 0.03$; P for heterogeneity = 0. 0002; $I^2 = 79\%$). Second, one study [17] with a small sample size was excluded, but this exclusion did not materially alter results and statistical heterogeneity (random-effects model: SMD: 0.66; 95% CI:0.14~1.17; $P = 0.01$; P for heterogeneity = 0.0002; $I^2 = 85\%$). Finally, one study [4] that did not use usual care as a control group was excluded, and the pooled results showed that it did not materially alter results and statistical heterogeneity (random-effects model: SMD: 0.98; 95% CI:0.30~1.66; $P = 0.005$; P for heterogeneity = 0.04; $I^2 = 76\%$). A total of three sensitivity analyses reached similar results, reflecting that the results presented here are stable.

3.4.2. UPDRS Motor Score. Ten studies [4, 12, 15–18, 22, 23, 26, 27] reported the UPDRS motor score of the Tai Chi group and the control group before and after the trial. The pooled results showed no significant difference between

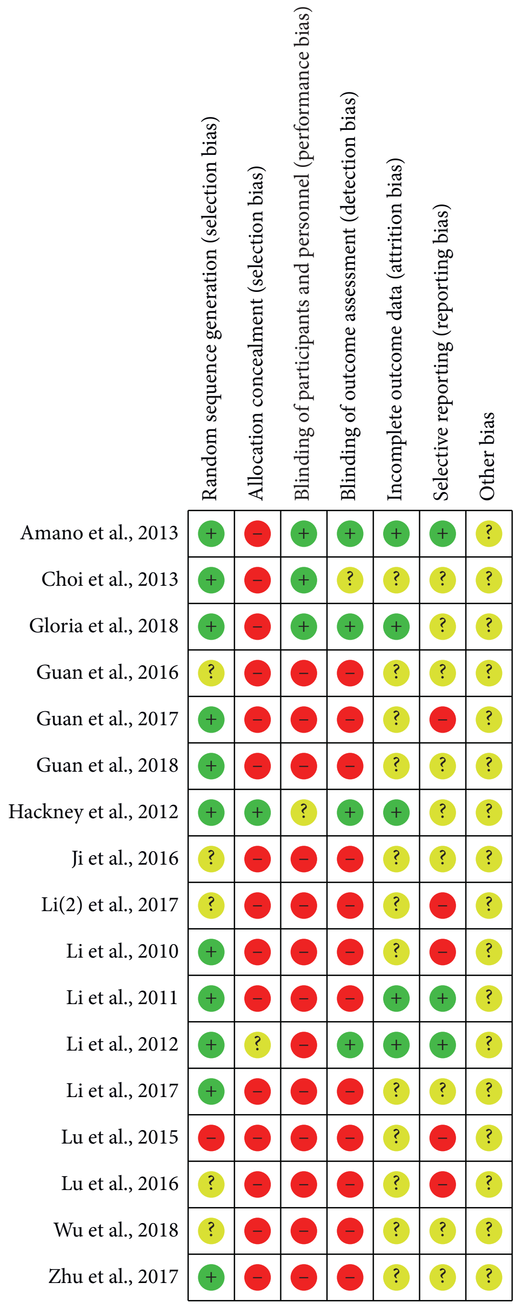

Figure 3: Risk of bias summary.

groups after intervention (random-effects model: MD: −1.58; 95% CI: −3.60~0.43; $P = 0.12$; P for heterogeneity <0.001; $I^2 = 75\%$). First, two studies [22, 27] with low quality were excluded. The pooled results showed that it did not materially change statistical heterogeneity, but that overall results changed (random-effects model: MD: −2.88; 95% CI: −4.67~−1.09; $P = 0.002$; P for heterogeneity = 0.03; $I^2 = 56\%$). Then, one study [12] with a small sample size was excluded. The pooled results showed this step did not materially alter results and statistical heterogeneity (random-effects model: MD: −2.54; 95%CI: −0.84~−4.24; $P = 0.003$, P for heterogeneity = 0.05; $I^2 = 53\%$). Finally, three studies [4, 17, 26] that did not use usual care as a control group were excluded. The pooled results showed that it did not materially alter results but the statistical heterogeneity disappeared (MD: −4.84; 95% CI: −2.83~−6.85; $P = 0.001$, P for heterogeneity = 0.89; $I^2 = 0\%$). Therefore, studies [22, 27] with low quality were excluded from the final results (Figure 6).

3.4.3. PDQ-39 Score. Four studies [12, 15, 20, 28] reported PDQ-39 score to assess the quality of life. The pooled results showed no significant difference between the Tai Chi group and the control group after intervention (random-effects model: MD: −5.59; 95% CI: −11.39~0.21; $P = 0.06$; P for heterogeneity = 0.02; $I^2 = 69\%$) (Figure 7). After excluding one study [20] with low quality (random-effects model: MD: −4.54; 95% CI: −8.63~−0.45; $P = 0.03$; P for heterogeneity = 0.12; $I^2 = 53\%$) or one study [15] with a small sample size (random-effects model: MD: −4.73; 95% CI: −10.11~0.64; $P = 0.06$; P for heterogeneity = 0.05; $I^2 = 74\%$), the pooled results showed no change in statistical heterogeneity, but results for both changed.

3.4.4. Activities-Specific Balance Confidence. Three studies [15,19,25] reported on the activities-specific balance confidence score in the Tai Chi group and the control group before and after the trial. The pooled results showed a significant increase in the Tai Chi group (fixed-effects model: MD: 5.08; 95% CI:2.91~7.26; $P < 0.001$; P for heterogeneity = 0.15; $I^2 = 48\%$) (Figure 8).

3.4.5. Timed Up and Go Test. Five studies [4, 15, 18, 19, 25] reported the Timed Up and Go Test of the two groups before and after the trial. The pooled results showed a significant increase in the Tai Chi group after intervention (random-effects model: MD: −1.05; 95% CI: −2.06~−0.05; $P = 0.04$; P for heterogeneity = 0.04; $I^2 = 59\%$) (Figure 9). First, one study [25] with low quality was excluded, and the pooled results showed that it did not materially alter statistical heterogeneity, but results changed (random-effects model: MD: −0.83; 95% CI: −1.79~0.14; $P = 0.09$; P for heterogeneity = 0.06; $I^2 = 59\%$). Second, one study [18] with a small sample size was excluded. The pooled results showed that it did not materially alter results and statistical heterogeneity compared with step 1 (random-effects model: MD: −1.11; 95% CI: −2.97~0.75; $P = 0.24$; P for heterogeneity = 0.04; $I^2 = 69\%$). Finally, one study [4] that did not use usual care as a control group was excluded. The pooled results showed that it did not materially alter results and statistical heterogeneity compared with step 2 (random-effects model: MD: −2.23; 95% CI: −5.91~1.45; $P = 0.24$; P for heterogeneity = 0.04; $I^2 = 76\%$).

3.4.6. Berg Balance Scales. Ten studies [11, 18, 19, 21, 22, 24–28] reported Berg Balance Scale scores in the Tai Chi group and the control group before and after the trial. The pooled results showed significantly increased scores in the Tai Chi group after intervention (random-effects model: MD: 2.74; 95% CI: 2.14~3.34; $P < 0.001$; P for heterogeneity = 0.09; $I^2 = 40\%$) (Figure 10).

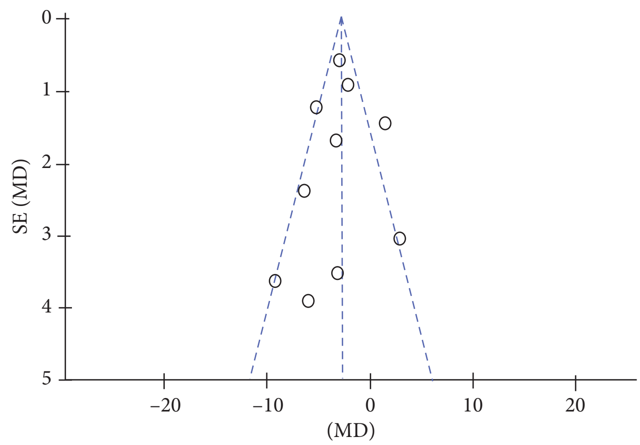

Figure 4: Funnel plot of publication bias.

Study or subgroup	Tai chi Mean	Tai chi SD	Tai chi Total	Control Mean	Control SD	Control Total	Weight (%)	Std, mean difference IV, random, 95%CI
Amano et al., 2013	0.01	0.18734994	12	0.04	0.29206164	9	8.7	−0.12 [−0.99, 0.74]
Amano et al., 2013	0.01	0.27622455	15	0.02	0.16522712	9	9.1	−0.04 [−0.87, 0.79]
Guan et al., 2016	0.202	0.18000833	31	0.052	0.19451478	31	13.1	0.79 [0.27, 1.31]
Guan et al., 2018	0.234	0.14663219	40	0.141	0.14176477	40	14.0	0.64 [0.19, 1.09]
Ji et al., 2016	0.12	0.33060551	16	0.11	0.28160256	16	10.7	0.03 [−0.66, 0.72]
Li et al., 2012	0.105	0.21254411	65	−0.045	0.20990236	65	15.3	0.71 [0.35, 1.06]
Li et al., 2012	0.105	0.21254411	65	0.099	0.24729739	65	15.5	0.03 [−0.32, 0.37]
Li et al., 2017	0.202	0.1617869	42	−0.035	0.19095287	38	13.5	1.33 [0.84, 1.82]
Total (95% CI)			286			273	100	0.47 [0.12, 0.83]

Heterogeneity: $tau^2 = 0.18$; $chi^2 = 26.74$, $df = 7$ ($P = 0.0004$); $I^2 = 74\%$
Test for overall effect: $Z = 2.62$ ($P = 0.009$)

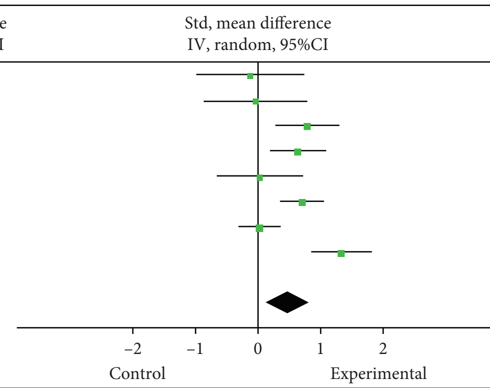

Figure 5: Forest plot of the Tai Chi group versus the control group-gait velocity.

Study or subgroup	Tai chi Mean	Tai chi SD	Tai chi Total	Control Mean	Control SD	Control Total	Weight	Mean difference IV, random, 95% CI
Amano et al., 2013	0.9	7.47261668	12	−3.4	6.44903093	9	6.9	4.30 [−1.67, 10.27]
Choi et al., 2013	−6.72	8.8110896	11	−1.23	8.67777045	9	4.6	−5.49 [−13.19, 2.21]
Gloria et al., 2018	3.04	9.23379099	12	5.58	8.37512388	13	5.5	−2.54 [−9.47, 4.39]
Hackney et al., 2012	−1.5	6.6	13	4.3	5.6	13	9.7	−5.80 [−10.51, −1.09]
Li et al., 2010	−2.369	1.96010178	19	−0.316	1.80523489	19	26.3	−2.05 [−3.25, −0.85]
Li et al., 2012	−6.42	5.01913339	65	−5.07	5.53509711	65	22.8	−1.35 [−3.17, 0.47]
Li et al., 2017	−4.4	5.56776436	42	0.4	5.66303805	38	19.0	−4.80 [−7.27, −2.33]
Lu et al., 2015	−0.74	3.0599183	8	−3.49	2.82065595	8	0.0	2.75 [−0.13, 5.63]
Lu et al., 2016	−0.74	3.0599183	8	−3.49	2.82065595	8	0.0	2.75 [−0.13, 5.63]
Zhu et al., 2017	−8.82	6.43578278	8	0.07	8.01623977	8	5.2	−8.89 [−16.01, −1.77]
Total (95% CI)			182			174	100	−2.88 [−4.67, −1.09]

Heterogeneity: $tau^2 = 2.81$; $chi^2 = 15.90$, $df = 7$ ($P = 0.03$); $I^2 = 56\%$
Test for overall effect: $Z = 3.15$ ($P = 0.002$)

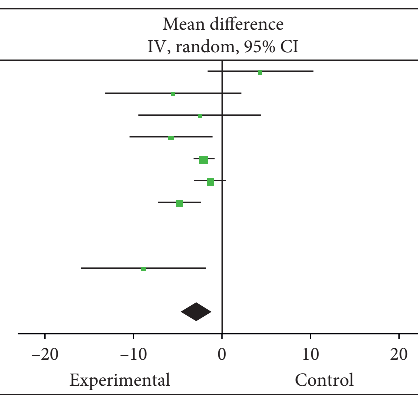

Figure 6: Forest plot of the Tai Chi group versus the control group-UPDRS motor score.

Study or subgroup	Tai chi Mean	Tai chi SD	Tai chi Total	Control Mean	Control SD	Control Total	Weight (%)	Mean difference IV, random, 95% CI
Gloria et al., 2018	−4.91	11.10449909	12	−2.14	11.40474901	15	22.5	−2.77 (−11.30, 5.76)
Li et al., 2011	−3.08	8.72243659	30	−1.54	9.81458608	25	33.1	−1.54 (−6.49, 3.41)
Wu et al., 2018	−34.75	24.76715365	8	2.75	29.25593444	8	4.3	−37.50 (−64.06, −10.94)
Zhu et al., 2017	−7.23	4.54457919	24	−0.14	4.54445816	23	40.1	−7.09 (−9.69, -4.49)
Total (95% CI)			*74*			*71*	*100*	*−5.59 (−11.39, 0.21)*

Heterogeneity: $tau^2 = 20.06$; $chi^2 = 9.73$, $df = 3$ ($P = 0.02$); $I^2 = 69\%$
Test for overall effect: $Z = 1.89$ ($P = 0.06$)

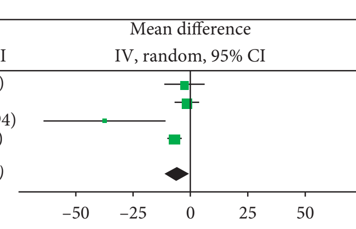

Figure 7: Forest plot of the Tai Chi group versus the control group-PDQ-39.

Study or subgroup	Tai chi Mean	Tai chi SD	Tai chi Total	Control Mean	Control SD	Control Total	Weight (%)	Mean difference IV, fixed, 95% CI
Gloria et al.2018	5.6	15.13274595	12	−3.2	13.09503723	15	4.0	8.80 (-2.03, 19.63)
Guan et al.2016	9.08	6.28556282	31	2.1	6.27015151	31	48.4	6.98 (3.85, 10.11)
Guan et al.2018	6.93	6.48187473	40	4.1	7.84959235	40	47.5	2.83 (-0.32, 5.98)
Total (95% CI)			*83*			*86*	*100*	*5.08 (2.91, 7.26)*

Heterogeneity: $chi^2 = 3.83$, $df = 2$ ($P = 0.15$); $I^2 = 48\%$
Test for overall effect: $Z = 4.58$ ($P < 0.00001$)

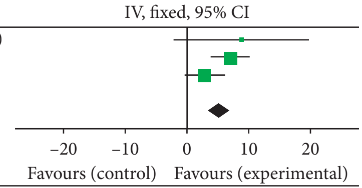

Figure 8: Forest plot of the Tai Chi group versus the control group-activities-specific balance confidence.

Study or subgroup	Tai chi Mean	Tai chi SD	Tai chi Total	Control Mean	Control SD	Control Total	Weight (%)	Mean difference IV, random, 95%CI
Gloria et al., 2018	−0.58	2.62463331	12	0	1.78429258	14	18.3	−0.58 (−2.33, 1.17)
Guan et al., 2016	−4.69	6.22759183	31	−1.29	6.9002826	31	7.7	−3.40 (−6.67, −0.13)
Guan et al., 2018	−6.84	7.00147842	40	−2.47	7.57595539	40	8.0	−4.37 (−7.57, −1.17)
Hackney et al., 2012	−1	0.1	13	−0.1	1.1	13	35.8	−0.90 (−1.50, −0.30)
Li et al., 2012	−1.05	2.80091057	65	−1	2.6620293	65	30.2	−0.05 (−0.99, 0.89)
Total (95% CI)			*161*			*163*	*100*	*−1.05 (−2.06, −0.05)*

Heterogeneity: $tau^2 = 0.64$; $chi^2 = 9.83$, $df = 4(P = 0.04)$; $I^2 = 59\%$
Test for overall effect: $Z = 2.05(P = 0.04)$

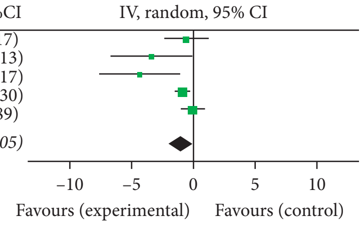

Figure 9: Forest plot of the Tai chi group versus the control group-activities-Timed Up and Go Test.

Study or subgroup	Tai chi Mean	Tai chi SD	Tai chi Total	Control Mean	Control SD	Control Total	Weight (%)	Mean difference IV, fixed, 95% CI
Guan et al., 2016	6.18	4.96559161	31	2.25	5.20025961	31	5.7	3.93 (1.40, 6.46)
Guan et al., 2017	3.17	3.7639474	40	0.22	4.27968457	40	11.6	2.95 (1.18, 4.72)
Guan et al., 2018	5.6	7.37768934	40	3.42	8.37661626	40	3.0	2.18 (-1.28, 5.64)
Hackney et al., 2012	3.3	3	13	0.5	2.1	13	9.1	3.80 (1.81, 5.79)
Ji et al., 2016	2.81	1.19862421	16	1.12	1.4027473	16	44.3	1.69 (0.79, 2.59)
Li(2) et al., 2017	6.1	4.8490927	30	1.24	5.17587674	30	5.6	4.86 (2.32, 7.40)
Li et al., 2010	4	3.48020272	20	0.635	3.57404827	20	7.6	3.37 (1.18, 5.55)
Li et al., 2011	5.78	4.55026373	24	0.16	4.54445816	23	5.4	5.62 (3.02, 8.22)
Lu et al., 2015	6.5	5.45618915	34	4	5.4	34	5.4	2.50 (-0.08, 5.08)
Lu et al., 2016	2.72	3.94003807	8	0.52	4.16129787	8	2.3	2.20 (-1.77, 6.17)
Total (95% CI)			*256*			*255*	*100*	*2.74 (2.14, 3.34)*

Heterogeneity: $chi^2 = 15.08$, $df = 9$ ($P = 0.09$); $I^2 = 40\%$
Test for overall effect: $Z = 8.93$ ($P < 0.00001$)

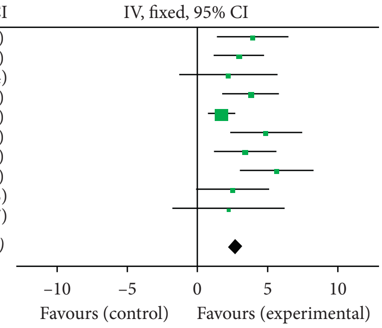

Figure 10: Forest plot of the Tai chi group versus the control group-activities-Berg Balance Scale.

4. Discussion

Here, we presented a systematic review and meta-analysis that included 17 published RCTs totaling 951 subjects. This work aimed to address the effect of Tai Chi in the management of PD through the evaluation of Tai Chi on motor function, balance, and quality of life. The results provide a new level of evidence for clinical professionals.

4.1. Motor Function. The UPDRS motor scale is one of the most commonly used indicators of motor function for Parkinson's disease and was therefore chosen for our meta-analysis to determine the improvement of the general motor function after Tai Chi intervention [1]. Previous studies have shown that the minimal clinically relevant difference (MCRD) of UPDRS III is an improvement of 2.3–2.7 points [29]. The results of this meta-analysis show that the effect of Tai Chi on motor function showed significant improvement in PD patients compared to the control group after excluding studies with low quality (MD: −2.88, $P < 0.002$), which is consistent with previous work [5,10]. After eliminating heterogeneity using a sensitivity analysis, the UPDRS motor scores increased up to 4.84 (MD: −4.84; $P < 0.001$), which surpasses the MCRD. This suggests there is stable evidence that Tai Chi is effective in improving motor function in patients with Parkinson's disease.

Tai Chi is often classified as a low-to-moderate intensity physical activity and is a suitable exercise for individuals in the general population [10, 24] especially those who are middle-aged or older [10, 30]. The Tai Chi protocol stresses weight shifting and ankle sway to effectively improved postural control and walking ability [4]. This focus on balance indicates that Tai Chi would be effective in enhancing neuromuscular rehabilitation and shows that Tai Chi is safe and effective when put in a clinical rehabilitation program.

4.2. Balance and Functional Mobility. With the progression of Parkinson's disease, patients have muscle stiffness, lose postural stability, and have gait dysfunction, leading to frequent falls, reduced quality of life, and increased mortality [3–5]. We conducted a meta-analysis of consistent methodological quality of randomized controlled trials and included gait velocity, activities-specific balance confidence (ABC) score, Timed Up and Go Test (TUGT), and Berg Balance Scale (BBS) as indicators to evaluate balance and functional ability.

Many previous studies have reported that the abnormal walking pattern observed in people with PD is characterized by short, shuffling steps [31]. Individuals with PD have a slower gait velocity than those of healthy controls, which is found to be a significant predictor of the first fall [5, 32]. Our meta-analysis demonstrated significant improvement of Tai Chi in gait velocity than in controls (SMD: 0.47; $P = 0.009$), and sensitivity analysis stability in the results. Tai Chi improves lower extremity muscle strength, a decisive factor of gait velocity [8]. Thus, an increase in gait velocity may indicate increased muscular strength of the lower limb. Previous studies have also suggested that gait velocity alone may not fully capture the influence of Tai Chi on the Parkinson deficits affecting gait performance [33]. Furthermore, inconsistent results of Tai Chi in improving locomotor control and gait performance have been reported [5, 33]; the clinical application value of Tai Chi in improving the gait velocity needs further research.

Previous studies suggest that BBS and ABC are reliable indicators to measure generic balance performance [34]. Our meta-analysis showed a significant improvement from Tai Chi in BBS (MD: 5.08; $P \leq 0.001$) and ABC (MD: 2.74; $P < 0.001$) than in controls, consistent with previous work [10]. Sensitivity analysis showed low heterogeneity and stable results. Significantly improved BBS in Tai Chi has been previously reported [10]. These include weight shift, body rotation, slow strides, and single-leg standing in different positions and require delicate joint control with muscle coordination [35]. We augmented these results by adding ABC, which may predict future falls [15, 36], to the meta-analysis of balance function. In general, our results provide stable and homogeneous evidence for Tai Chi in improving the balance ability of Parkinson's patients.

TUGT is a functional mobility balance assessment tool that accurately predicts recurrent falls [37] and is related to the sequencing of several important dynamic stability skills. Our study did not find a stable and reliable result of Tai Chi in improving TUGT for Parkinson's patients (MD: −2.23, $P = 0.24$). This is because the studies included in our meta-analysis have high heterogeneity and inconsistent results. The severity of Parkinson's disease may lead to a potential ceiling effect precluding larger magnitude improvements [15]. Therefore, more evidence is needed to explore the effect of Tai Chi on the stability of dynamic balance in patients with Parkinson's disease.

4.3. Quality of Life. PD-related quality of life reflects the overall influence of a disease on patients' physical mobility, daily activity, social functioning, psychological wellbeing, and cognition [38]. Stable results were not observed to indicate that Tai Chi could improve the quality of life of patients with Parkinson's disease, which is inconsistent with a previous review report [10]. Previous studies have shown that mind-body exercises such as Tai Chi can have a positive impact through targeting different brain systems that are involved in the regulation of attention, emotion, mood, and executive cognition and improve QOL [9]. Our meta-analysis showed that the results were not stable and highly heterogeneous. While previous studies have shown that Tai Chi can improve gait velocity, it may not fully capture the influence of Tai Chi on Parkinson's deficits affecting the quality of life [39], including gait performance, gait dysfunction, and postural instability [33]. More studies are needed to determine the effect of Tai Chi on the quality of life of Parkinson's patients.

4.4. Limitations. This meta-analysis has several limitations. First, the sample sizes of some included RCTs were quite small, and the relatively small number of eligible RCTs in the analysis may lead to limited power and the precision of the findings. Second, blinding of participants or care providers may be difficult in exercise interventions, and the high risk of performance and detection bias might weaken the strength of the evidence. Finally, the diversity of the type and parameters of Tai Chi in the included RCTs also limits the ability to make firm conclusions regarding the specific recommended Tai Chi exercise prescription for each chronic condition.

5. Conclusion

In conclusion, this systematic review and meta-analysis article of Parkinson's patients suggests that there exists stable evidence to suggest Tai Chi is a relatively safe program resulting in gains in general motor function and improvements in bradykinesia and balance. However, no statistically significant advantage for quality of life and functional mobility was observed. These results provide new evidence for PD management. Further randomized trials with larger sample sizes and of higher methodological quality are needed to confirm these results and to assess the feasibility of Tai Chi intervention for different clinical application purposes.

Disclosure

Xinze Wu and Guozhen Hou should be considered the co-first authors.

Conflicts of Interest

The authors declare no conflicts of interest in this work.

Authors' Contributions

Qi Guo and Liying Jiang were responsible for the study concept and design. Xing Yu, Xinze Wu, and Guozhen Hou acquired data. Guozhen Hou, Peipei Han, and Xing Yu performed the statistical analysis. Xinze Wu and Xing Yu interpret the data. Xing Yu wrote the report. Xinze Wu and Guozhen Hou contributed equally to this work.

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Supplementary Materials

The complete search strategy is shown in the Supplementary Materials. (*Supplementary Materials*)

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Review Article

Review of Clinical Trials on the Effects of Tai Chi Practice on Primary Hypertension: The Current State of Study Design and Quality Control

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The modulation of Tai Chi in physiological function and psychological status attracts sustaining attention. This paper collected original articles regarding the effects of Tai Chi practice on modulating primary hypertension from 7 electronic databases (PubMed, Excerpta Medica Database, Cochrane Library, Web of Science, Chinese Knowledge Resource Integrated Database, Wanfang Database, and China Science and Technology Journal Database) from their dates of origin to October 1st, 2020. A total of 45 articles were included. The literature analyses have shown that the benefits of Tai Chi practice for blood pressure management have been identified in all of the included 45 studies, and Tai Chi exercise has shown significant efficacy in improving hypertension clinical symptoms and quality of life, compared to the majority of control interventions, though there are also some methodological issues, including small sample sizes, lack of exact randomization methods and quality control criteria, and lack of specific standards used to measure the characteristics of Tai Chi practice. In the future, the inclusion of additional design standards, stricter quality controls, and evaluation measures for the features of Tai Chi practice is required in trials evaluating its effects on hypertension.

1. Introduction

As a classical mind-body exercise originating from ancient China, Tai Chi has become an important health-preserving approach. It emphasizes the coordination of motor skills, breathing, and mental awareness to keep the body and environment in harmony in order to preserve health and prevent and treat diseases. Clinical trials and systematic reviews have shown that Tai Chi practice is beneficial for both healthy subjects and patients with chronic diseases. On the one hand, Tai Chi practice is effective for keeping the dynamic balance of physical and psychological states for healthy people [1, 2]. On the other hand, it is also effective for improving symptoms, health-related quality of life (QoL), and emotional disorders of patients with chronic diseases as well as people with suboptimal health [3–5].

After analyzing original papers published between 1990 to 2020 on the health and therapeutic effects of Tai Chi practice, it was found that most papers focused on the efficacies of Tai Chi practice for chronic diseases, such as hypertension, type 2 diabetes, and osteoarthropathy disorders. It is noteworthy that 45 original papers centered on the efficacy of Tai Chi for hypertension, and the top-ranked original papers on the topic of Tai Chi practice were those examining the relationship between Tai Chi practice and chronic diseases. Most of the original papers on Tai Chi practice for hypertension have proven its benefits for blood pressure (BP) management and QoL improvement.

In the 2020 International Society of Hypertension Practice Guidelines [6], hypertension was defined based upon the following criteria: (1) systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg, for blood pressure (BP) measured while in the office; (2) SBP ≥ 135 mmHg and/or DBP ≥ 85 mmHg, for BP measured while at home; or SBP ≥ 130 mmHg and/or DBP ≥ 80 mmHg, for BP measured during 24-hour ambulatory monitoring; or SBP ≥ 135 mmHg and/or DBP ≥ 85 mmHg, for BP measured during the daytime; or SBP ≥ 120 mmHg and/or DBP ≥ 70 mmHg, for BP measured during the night. As a major risk factor of cardiovascular disease (CVD), hypertension significantly impacts QoL for patients and carries with it remarkable healthcare cost burdens [7], with estimated global prevalence ranges between 30–45% [7, 8]. Currently, pharmacotherapy is the main treatment option for hypertension, and the majority of hypertension patients use two or more drugs in combination in order to achieve the desired BP range [6, 8–10]. However, the therapeutic effects of pharmacotherapy is unsatisfactory [7, 10], and their side effects include increased risk of skin cancer [11], erectile dysfunction [12], electrolyte disturbances [13], and worsening glucose intolerances [14]. The importance of lifestyle measures for BP management has become gradually recognized, so regular exercising is recommended as a form of lifestyle therapy for combating hypertension by the International Society of Hypertension (ISH) [6], European Society of Cardiology/European Society of Hypertension (ESC/ESH) [8], and American College of Cardiology/American Heart Association (ACC/AHA) [9]. However, Tai Chi practice has not yet been recommended for BP management due to limited amounts of clinical evidence.

After searching the original articles that are available to date, this paper investigated the research status of Tai Chi practice for hypertension and analyzed specific methodological issues, including issues with study designs, protocols of Tai Chi exercise, and its quality control criteria, in order to provide references for future studies and promote applications of Tai Chi practice for chronic disease.

2. Methods

2.1. Search Strategy. Data research was conducted in four electronic databases in English (PubMed, Excerpta Medica Database, Cochrane Library, and Web of Science) and three electronic databases in Chinese (Chinese Knowledge Resource Integrated Database, Wanfang Database, and China Science and Technology Journal Database). The publication time range was set from date of origin to October 1st, 2020. The full search strategy for each electronic database was listed in Supplementary Table 1. Then, screenings of the titles and abstracts were performed to identify eligible records. After screening, the full-text assessment was conducted according to the inclusion and exclusion criteria (Figure 1).

2.2. Inclusion Criteria. The studies were eligible if (1) participants were adults who were at least 18 years of age; (2) Tai Chi practice was explicitly established as the main or only intervention therapy other than control therapy; (3) the changes in BP from baseline to the end of intervention were reported in both Tai Chi and control groups.

2.3. Exclusion Criteria. The studies were excluded if (1) they were reviews, protocols, editorials, letters, or other studies of nonoriginal papers; or (2) there was no control group in the trials; or (3) there was no description of Tai Chi exercise protocol; or (4) the study only investigated the immediate effects resulting from a single session of Tai Chi exercise; or (5) subjects with chronic diseases (e.g., cardiovascular disease, diabetes mellitus, and cancer) were included in studies.

2.4. Data Extraction and Analysis. The data were extracted with regards to the following categories: (1) basic information including publishing time, title, author, language, and country of authorship; (2) information on study design including participants, sample size, randomization, control, and outcome measures; (3) protocol of Tai Chi exercise including the style, period, frequency, and number of sessions; (4) results of the study; (5) quality control criteria. Any inconsistencies or questions about data extraction were discussed and reconsidered until consensus was reached in our group. Data analysis was performed after data extraction.

3. Results

3.1. Basic Information. A total of 45 studies were eventually included, numbered from S1 to S45. The basic information about them is listed in Supplementary Table 2. The first study of Tai Chi on hypertension was published in 1990 [S1] and peaked in 2018, when eight papers were published in the same year [S36–S43] (Figure 2). Among them, 44 studies were conducted in China (including one in Taiwan [S4] and one in Hong Kong [S40]), and one study was conducted in the United States[S2]. The academic disciplines of authors mainly included physical education, medicine, and nursing professions.

3.2. The Study Design. The study design details and results of the 45 included studies are listed in Supplementary Table 3.

3.3. Participants. Among the 45 studies, forty-two studies recruited only hypertension patients [S1–S12, S14–S20, S22–S26, S28–S45], while the remaining 3 studies recruited both hypertension patients and healthy subjects [S13, S21, S27]. The 31 studies explicitly described the hypertension grade which have enrolled the mild and moderate hypertension patients [S1–S5, S7, S10–S18, S21–S22, S24, S26–S28, S30, S32–S35, S37, S39, S42–S43, S45]. Of the 31 studies, four studies also included patients with severe hypertension [S3, S7, S11, S13].

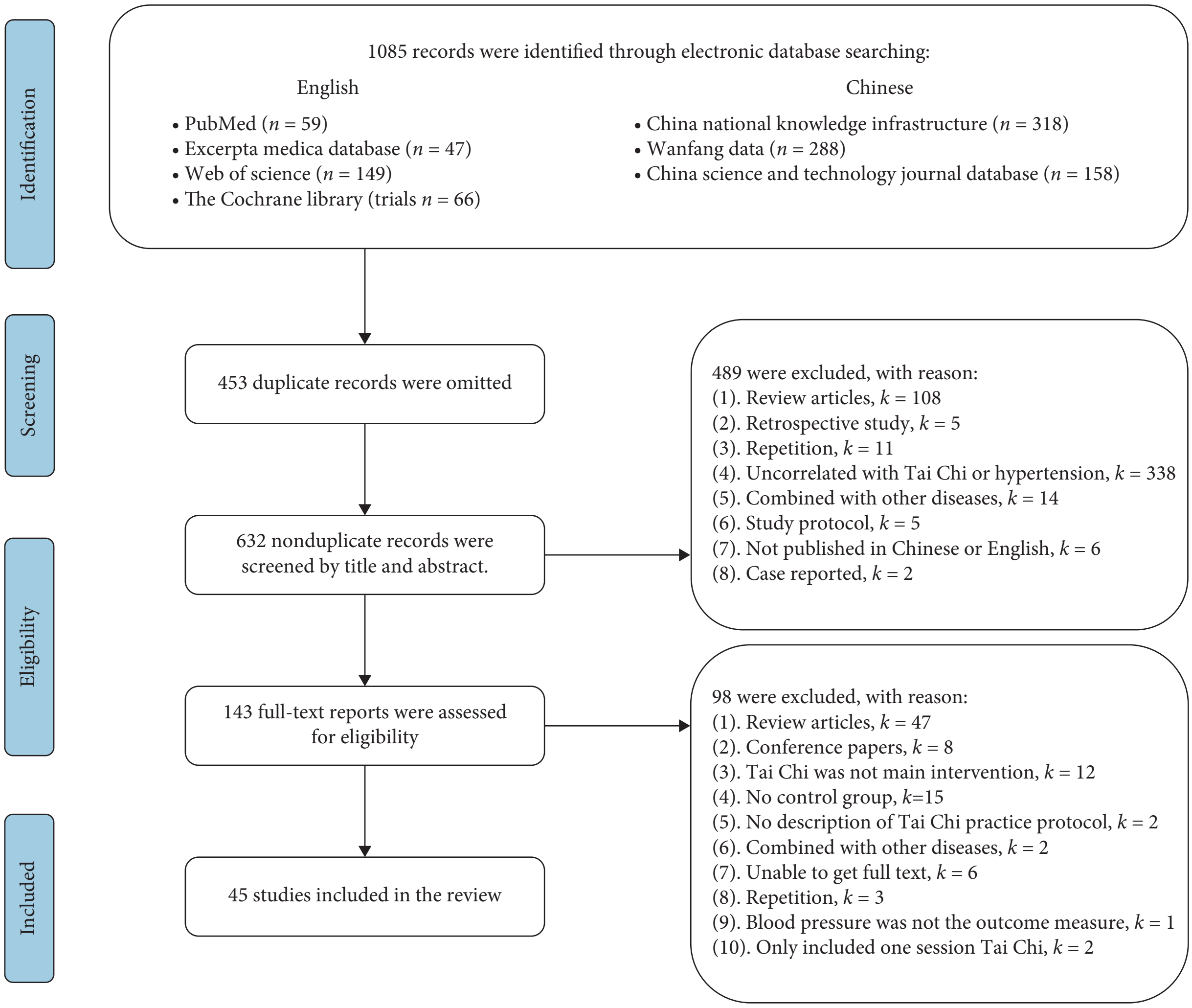

Figure 1: Flow chart detailing the systematic search of potential studies and selection process of included Tai Chi trials.

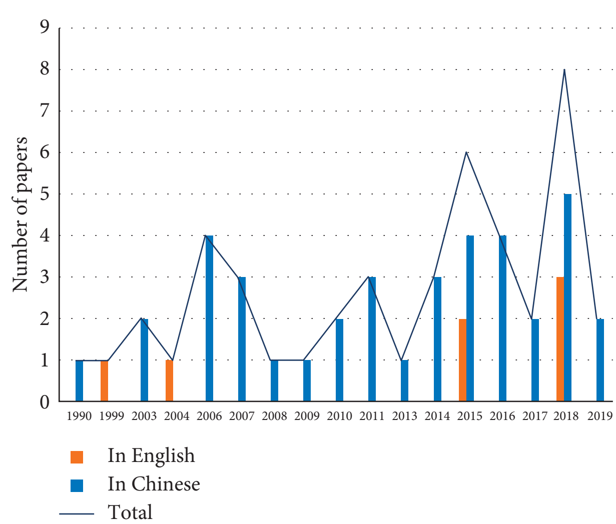

Figure 2: Annual and published quantity distribution of the 45 included studies.

3.4. Randomization. Among the 45 studies, thirty-two mentioned randomizations as part of their methodologies [S2, S4, S6–S8, S12, S14–S17, S20–S23, S25, S28–S35, S37–S45]. However, only 11 studies explicitly described their randomization methods [S6, S15, S25, S31–S32, S34, S38–S40, S43–S44], including simple random methods (nine studies in total [S25, S31, S32, S34, S38–S40, S43–S44], of which seven studies [S31, S32, S34, S38–S39, S43–S44] used a random number table and two studies [S25, S40], computer random method) and stratified random methods (two studies [S6, S15]).

3.5. Sample Size. The sample sizes of 35 studies were equal to or less than 100 cases [S1–S9, S11, S13–S18, S20–S28, S31–S34, S37–S39, S43–S45], while ten studies were designed to have more than 100 cases [S10, S12, S19, S29–S30, S35–S36, S40–S42]. The average sample size was 43 cases per group.

3.6. Control Group. Within our study population of 45 studies, twenty-seven studies had participants engage in Tai Chi practice combined with other therapies, including medication, jogging, health education, usual care, and diet control as the intervention groups [S5–S10, S12, S14–S15, S18–S20, S25–S27, S31, S33–S37, S39, S41–S45]. Within twenty-seven studies, eight studies established a usual care intervention group [S15, S20, S25, S27, S31, S41, S42, S44], six studies established a medication treatment intervention group [S6–S8, S18, S36, S39], seven studies set up a medication and exercise intervention group [S5, S9–S10, S14, S26, S37, S43], two studies established a medication and health education intervention group [S33, S35]. Furthermore, a medication and exercise and health education intervention group [S34], a usual care and exercise intervention group [S45], a health education intervention group [S19], and a diet control intervention group [S12] were established as the control group in four studies, respectively (Figure 3(a)).

Eighteen studies established Tai Chi practice as the only intervention therapy [S1–S4, S11, S13, S16–S17, S21–S24, S28–S30, S32, S38, S40]. Within these studies, seven studies only established a waiting list as the control group [S4, S16–S17, S21, S23, S24, S28], five studies established participants engaging in other exercises as various control groups [S2, S3, S11, S38, S40], three studies established participants taking medication as various control groups [S1, S30, S32], and three studies used other intervention methods as control groups [S13, S22, S29] (Figure 3(b)).

3.7. The Protocol of Tai Chi Exercise

3.7.1. Style of Tai Chi. Within our study population, 35 studies selected Yang-style Tai Chi as intervention therapy [S1–S6, S8–S10, S14–S18, S20–S24, S26–S28, S31–S34, S37–S45], and four studies selected Chen-style Tai Chi [S7, S12, S30, S35], while the other 6 studies did not report which Tai Chi styles were chosen [S11, S13, S19, S25, S29, S36]. Among the 35 studies which selected Yang-style Tai Chi, 26 studies chose 24-form Tai Chi [S3, S6, S8–S9, S15–S17, S20–S24, S26–S27, S31–S34, S37, S39–S45], one study chose eight-form Tai Chi [S38], one study chose 13-form Tai Chi [S2], one study chose 48-form Tai Chi [S10], one study chose 108-form Tai Chi [S4], one study chose Jiang Ya Gong Tai Chi [S28], and four studies allowed the participants to freely choose the form of Tai Chi according to their preference [S1, S5, S14, S18] (Figure 4(a)).

3.7.2. Intervention Period. The intervention period was designed to be equal to or less than three months for 26 studies [S2, S4, S6–S7, S9, S12–S13, S15–S17, S20–S24, S27, S30–S34, S38, S42–S45], more than three months and equal to or less than six months for nine studies [S5, S8, S10, S14, S18, S28, S35, S37, S41], more than six months and equal to or less than 12 months for seven studies [S1, S3, S11, S25, S29, S36, S40], and more than 12 months for two studies [S19, S39]. One study did not mention the intervention period [S26] (Figure 4(b)).

3.7.3. Exercise Frequency. The intervention frequency of Tai Chi was designed to be equal to or less than three times per week for 8 studies [S4, S11, S17, S28, S34, S37, S43, S44], four to seven times (including seven times) per week for 27 studies [S2–S3, S6–S9, S12–S14, S16, S18–S22, S24–S27, S32–S33, S36, S38–S41, S45], and more than seven times per week for 8 studies [S1, S10, S15, S23, S30–S31, S35, S42]. In one study, participants were free to choose either of the two intervention frequencies based on their preference (twice per day, or once every other day) [S5]. In addition, one study did not mention the intervention frequency [S29] (Figure 4(c)).

3.7.4. Length of Each Session. Two studies designated less than 30 minutes for each session [S23, S31]. Thirty-three studies designated session lengths ranging from 30 to 60 minutes [S1–S2, S4–S8, S10–S14, S18–S21, S24–S28, S30, S32–S35, S38–S41, S43–S45], and eight studies designated more than 60 minutes for each session [S3, S9, S16–S17, S22, S36–S37, S42]. One study reported a slightly different design, requiring participants to practice in the group setting for three hours per week and then to practice individually for two hours per week at home [S29], and one study did not report the length of time for each session[S15] (Figure 4(d)).

3.8. Study Results

3.8.1. Outcome Measures. All 45 studies selected BP changes as the measure of primary outcome. Additionally, the blood glucose levels, QoL, body mass index, serum nitric oxide levels, serum endothelin levels, blood lipid levels, total cholesterol, and waist circumference measures were also used to evaluate the efficacy of Tai Chi practice for hypertension.

3.8.2. Study Results. All 45 studies reported that Tai Chi exercise is effective in combating hypertension symptom and/or increasing QoL, when compared to baseline measures. Compared with control groups, thirty eight of the 45 studies demonstrated the superiority of Tai Chi practices on its own, or of combining Tai Chi practices with other therapies for BP management [S1, S3–S12, S15–S17, S20–S29, S31, S33–S45]. One study reported that the efficacy of combining Tai Chi practices with medication for hypertension was less

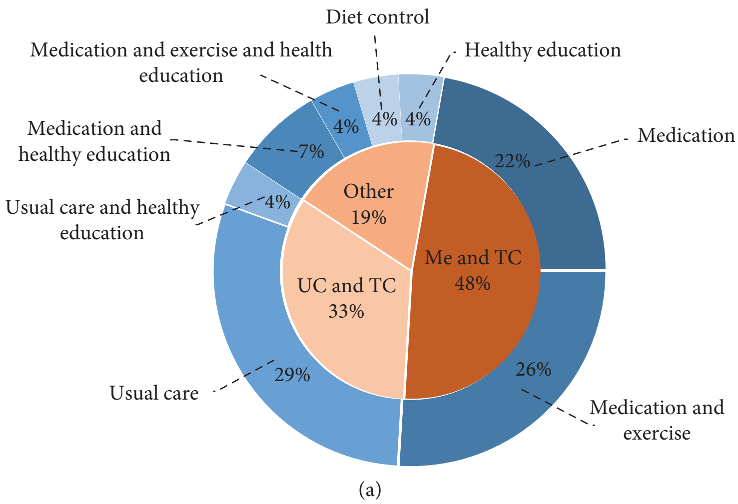

Figure 3: The control group aggregations of the 45 studies: (a) chart A lists the 27 studies that combined Tai Chi practice with other therapies as intervention groups; (b) chart B lists the 18 studies with Tai Chi exercise as the only intervention group. Me denotes medication; TC denotes Tai Chi; UC denotes usual care.

effective than combining Qigong practice with medication [S14]. Five studies [S2, S18, S19, S30, S32] reported that Tai Chi practice was similar to other therapies intended to regulate BP, including three studies comparing Tai Chi practice to medication [S18, S30, S32], one study comparing Tai Chi practice to moderate aerobic exercise [S2], and one study comparing Tai Chi practice to health education [S19]. One study demonstrated that after Tai Chi exercise, the BP of the hypertension patients tended towards that of healthy subjects [S13].

3.8.3. Adverse Reactions. No adverse reactions or side effects of Tai Chi practice were reported in the 45 studies.

4. Discussion

Tai Chi practice has been widely accepted as an effective approach for health care [15], an adjunctive treatment for chronic disorders [16], and a form of rehabilitation therapy during the recovery period from diseases [17, 18]. In the past three decades, the modulation of Tai Chi practice towards physiological function and psychological state for chronic diseases attracted global attention, especially with regards to primary hypertension. Hundreds of studies on the efficacies of Tai Chi practices for chronic diseases were conducted in more than a hundred institutions spread across 24 countries. However, the methodologies of these studies vary drastically, especially in terms of the design of Tai Chi exercise schemes and in terms of the evaluation of exercise efficacies, which in turn affects the objective evaluation in determining the efficacy of Tai Chi towards chronic diseases, as well as its clinical applications. Therefore, based on the original articles published in English and Chinese, this study aimed to summarize and analyze the data on the efficacies of Tai Chi practices for primary hypertension by examining the study design, protocols, results, and quality control criteria for Tai Chi practices, so as to provide a foundation for further studies and to promote the application of Tai Chi practice for chronic diseases, including hypertension.

4.1. The Study Design of Tai Chi for Hypertension

4.1.1. Participant Inclusion. Grade I or grade II hypertension patients were involved in all 45 studies, and only four studies included grade III patients. In fact, mild and/or moderate patients were included in the majority of studies of Tai Chi on chronic diseases [19, 20] due to its modulating and low-risk characteristics.

Due to its relatively limited therapeutic effects, Tai Chi is usually used as a complementary therapy for chronic disease. Despite being relatively low-risk, sometimes Tai Chi practice may lead to falls or subsequent injuries, especially for the elderly and for those in poor physical condition. Consequently, the participants of Tai Chi studies were predominantly patients suffering from mild and moderate grades of hypertension. In the future, a possible direction of study may be on the demographic population that is best suited to practicing Tai Chi so as to maximize its applications in BP control.

4.1.2. Sample Sizes and Randomization. The analysis showed that a total of 4236 subjects were included in the 45 studies. The minimum single-group sample size was 10, and the maximum was 238. In general, the sample sizes of these studies were relatively small. Among these studies, 32 studies mentioned randomization, while only 11 studies explicitly described the method of randomization. The small samples and lack of rigorous randomization are possible causes for poor quality and repeatability of the studies [21, 22]. Future studies should fully take these factors into consideration.

4.1.3. Controls. Evaluating the therapeutic effects and investigating the advantages of Tai Chi practices for hypertension were the main purposes of these studies. For example, twenty-four studies [S1, S6–S8, S12–S13, S15, S18–S20, S22, S25, S27, S29–S33, S35, S36, S39, S41–S42, S44] aimed to verify the effectiveness of Tai Chi practice intervention by comparing it to positive drug or nondrug therapies, and fourteen studies [S2, S3, S5, S9–S11, S14, S26, S34, S37, S38, S40, S43, S45] were performed to investigate the advantages of mind-body modulation of Tai Chi over the other exercises. In the future, the control groups can be set up according to the following aspects so as to investigate the characteristics of Tai Chi for hypertension: firstly, Tai Chi practice can be compared with psychological intervention or exercise alone in order to observe the integrative effects of Tai Chi on BP control along with meditation or aerobic exercise. The effects of meditation, as a classical psychological method of intervention, on stress relief and BP reduction have been evaluated and confirmed in the past [23]. Furthermore, aerobic exercise is the primary exercise modality that professional organizations throughout the world recommend in terms of preventing and treating hypertension [6, 8, 9]. Therefore, since Tai Chi is a commonly used form of mind-body exercise, exploring the differences between effects of Tai Chi, psychotherapy, and aerobic exercise in hypertension control may yield great value. In the future, it may be possible to design clinical studies comparing Tai Chi with meditation or aerobic exercise in the intervention of hypertension. Secondly, both hypertension and hypotension patients can be included simultaneously to investigate the bidirectional effects of Tai Chi practices on BP modulation. Thirdly, both patients with hypertension (pathological state) and healthy subjects (physiological condition) can be included simultaneously to observe the benign modulating effects of Tai Chi practices on BP regulation.

4.1.4. Selection of Outcome Measures. In most studies, the BP value was used as the main indicator, along with blood biochemical indices (serum glucose, blood lipid, cholesterol, nitric oxide endothelin levels, etc.) and biometric factors (body mass index and waist circumference). As the 2020 International Society of Hypertension Global Hypertension Practice Guidelines [6] suggested, the treatment of hypertension does not only focus on controlling BP but also emphasizes its prevention and reduction of risk factors and overall cardiovascular risk. So other than BP, these blood biochemical indices and biometric factors are also used to evaluate the effects of Tai Chi practice for hypertension. Furthermore, because Tai Chi is a type of mind-body exercise, some studies selected emotional scores, psychological scores, or QoL scores as outcome measures. Examples included the QoL Short Form 36-Item Health Survey, World Health Organization Quality of Life Brief Version, Pittsburgh Sleep Quality Index, Self-Rating Anxiety Scale, Self-Rating Depression Scale, and Geriatric Depression Scale. These indicate that the efficacy assessment of Tai Chi consists of multidimensional evaluations [24] due to its overall adjustment function. This feature can be found in almost all clinical studies on Tai Chi [25, 26]. However, we found that there is a lack of specific scale to reflect the physical and mental regulation of Tai Chi. Therefore, it will be necessary to establish specific scale of Tai Chi based on its characteristics.

4.2. Protocol of Tai Chi Exercise. The protocol of Tai Chi exercise can be analyzed in terms of four aspects: the style of Tai Chi, the period and the frequency of exercise, and the length of each session.

4.2.1. Style and Form of Tai Chi. At present, Tai Chi styles mainly include the Yang-style, Chen-style, Wu-style, and Sun-style. In the 45 studies analyzed, 35 studies (78%) chose Yang-style, 4 studies (9%) chose Chen-style, and 6 studies (13%) did not specify the exact style.

Yang-style Tai Chi has the characteristics of smooth rhythms and gentle movements and requires a moderate volume of exercise, which renders it easy to practice. Comparatively, Chen-style Tai Chi is characterized by alternating rhythms, complex movements, larger exercise volume requirements, and higher demands on the physical condition. Therefore, most of the studies and clinical trials chose Yang-style Tai Chi as intervention [27–29].

Yang-style Tai Chi consists of 8-form, 13-form, 24-form, 42-form, 48-form, and 108-form. Within the 35 studies of Yang-style Tai Chi, 74% of these selected the 24-form for the following reasons: Firstly, the 24-form Yang-style Tai Chi was established and published in the form of a standardized exercise video by the General Sports Administration of China; secondly, Yang-style Tai Chi has a large practice following worldwide due to its high popularity and ease-of-acceptance [30]; lastly, the difficulty of 24-form Yang-style Tai Chi is moderate and it is easy to master. In the 45 studies analyzed, the average age of participants is around 60 years old. When they practiced Tai Chi, the complex motions would increase the learning curve and increase the risk of falls, strains, and sprains. Therefore, the 24-form Yang-style Tai Chi was most commonly selected in these studies. It is believed that 24-form Yang-style Tai Chi would be the best choice in future studies, evaluating the therapeutic effects of Tai Chi, except when investigating the differences in different styles/forms of Tai Chi.

4.2.2. Exercise Volume of Tai Chi. The exercise volume of Tai Chi is primarily decided by three factors: the intervention period, exercise frequency, and length of each session. The volume of exercise is mainly based on its effectiveness and feasibility [31–33].

In 45 studies, the longest intervention period was two years, while the shortest was six weeks. The majority periods of these studies were equal to or less than three months. For the exercise frequency, eight studies (18%) reported exercise frequencies equal to or less than three times per week, twenty-seven studies (60%) reported exercise frequencies that were between four to seven times per week, eight studies (18%) reported exercise frequencies that were more than seven times per week, and one study (2%) allowed

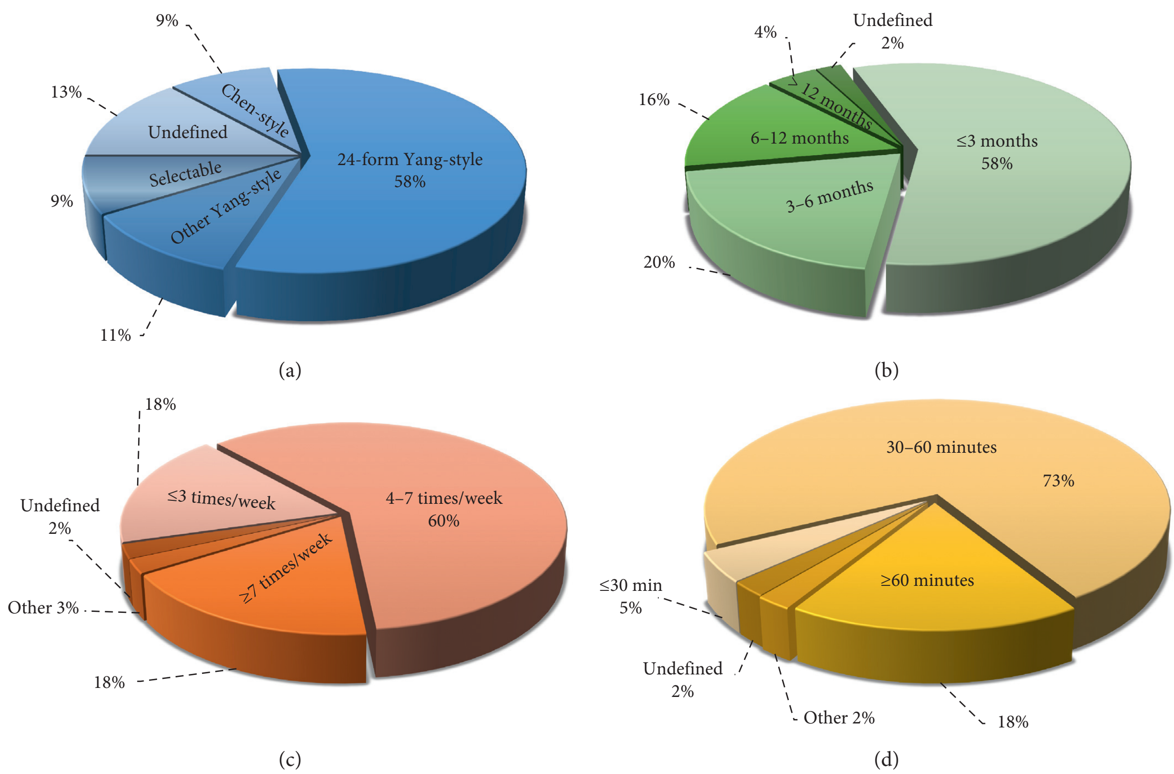

Figure 4: The protocol of Tai Chi exercise in the 45 studies: (a) for the style of Tai Chi; (b) for the intervention period; (c) for the exercise frequency; (d) for the length of each session.

participants to freely select one of the two intervention frequencies based on their preference (twice per day or once every other day), while one study (2%) did not report the exercise frequency. In summary, the periods of equal to or less than three months and the fixed frequency of between four to seven times per week were the most commonly selected in these studies.

It is noteworthy that other than fixed exercise frequencies, some studies designated variable frequencies. For example, in one study investigating effects of Tai Chi exercise on arteriosclerosis [34], the variable frequency was established as once a week for the first three months and twice a week for the following nine months. In another study involving lower back pain [35], the variable frequency was designated as twice per week for eight weeks and once per week for the remaining two weeks. Among the 45 included studies, the length of each session ranged from 30 to 60 minutes in 33 studies (73%), to more than 60 minutes in 8 studies (18%), to less than 30 minutes in only 2 studies (5%). This indicates that moderate exercise volume may be more suitable for patients with hypertension. However, only nineteen studies described the specific time distribution, such as stretching and relaxing for 5–15 minutes and then practicing Tai Chi for 30–50 minutes. Based on the different exercise guidelines for fitness-improving activities, a 60-minute exercise is beneficial for muscular recovery [36] and risk reduction of motor impairment [37]. Therefore, it is recommended that each session be around 60 minutes, with 20 minutes of warm-up exercises and 30–40 minutes of Tai Chi exercises.

4.3. Quality Control. It is known that stricter quality control is key to improving the reliability and reproducibility of studies. In the 45 studies analyzed, 23 studies (51%) mentioned quality control criteria, including evaluation of Tai Chi teaching/training and exercise intensity. In fact, the normative movements of exercise are closely related to its therapeutic effects [38–40]. Therefore, it is necessary to prepare a detailed Tai Chi teaching protocol before formal study to maintain the quality of Tai Chi exercise. With regards to exercise intensity evaluation, 20 studies (44%) had mentioned some form of exercise intensity evaluation. It is essential to analyze and evaluate the body condition, especially in cases where patients are suffering from severe hypertension, for more elderly participants, in cases where a complex style/form of Tai Chi was selected, or in cases with large exercise volume. Most of the studies established heart rate or oxygen uptake as exercise intensity evaluation metrics. Furthermore, it should be noted that Tai Chi, as a classical mind-body exercise, requires the coordination of motor skills, breathing, and mental awareness in order to maintain the quality of exercise. However, specific methods of evaluating the coordination of motor skills, breathing, and mental awareness in Tai Chi exercise remain unclear. With the popularization of Tai Chi and the extensive number of Tai Chi studies being conducted globally, it is essential to develop relevant benchmarks and guidelines to evaluate the physical and mental effects of Tai Chi in a scientific manner.

In conclusion, Tai Chi practice for primary hypertension has been highlighted for its therapeutic values over the past 30 years. Reviewing these studies not only helps us to grasp the research status of Tai Chi practices for hypertension but also helps us to recognize the methodological issues to design better studies in the future. In the future, the benefits of Tai Chi practices for BP control should be further verified by multicenter and large sample RCTs, and the characteristics of Tai Chi practices for BP modulation should be clarified by investigating its integrity and bidirectional and benign regulation; a proper evaluative scale in accordance with the features of Tai Chi also needs to be developed, and the therapeutic mechanism of Tai Chi also needs to be explored.

Data Availability

The information of the included 45 studies used to support the findings of this study are included within the supplementary information files.

Disclosure

Yuke Teng, Sha Yang, and Yuan Chen are co-first authors and contributed equally to this paper.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Yuke Teng, Sha Yang, and Yuan Chen designed the study and drafted the manuscript. Fang Zeng and Tianyu Liu revised the study design and the manuscript. Yuyi Guo, Pan Zhang, Jingya Cao, Xinyue Zhang, Yalan Chen, and Caili Jiang participated in the design of the search strategy and data extraction. Yuke Teng, Sha Yang, and Yushi Hu formed the data synthesis and analysis plan. All authors have read and approved the publication of the final manuscript.

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Supplementary Materials

Supplementary Table 1: the full search strategy for each of the electronic databases queried, including the electronic databases name, vendor/platform, coverage, searches strategy, and hits number. Supplementary Table 2: the basic information of the 45 included studies, including study number, paper title, author name, author major, publish time, paper language, and author perform place. Supplementary Table 3: the study design, intervention protocol, and results of the 45 included studies, including the study design (participants, whether random, sample size, hypertension grade, intervention group, and control group), intervention protocol (Tai Chi-style, period, frequency, and time), and result (outcome measure and conclusion). (*Supplementary Materials*)

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Research Article

Effects of Body Weight Support-Tai Chi Footwork Training on Balance Control and Walking Function in Stroke Survivors with Hemiplegia: A Pilot Randomized Controlled Trial

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Background. Tai Chi (TC) is known to enhance balance control and walking function in stroke survivors. However, motor disorders in stroke patients may limit the implementation of TC exercise and increase the risk of falling. The body weight support (BWS) device can provide protection during the early rehabilitation of stroke survivors using an overhead suspension system. Theoretically, combining TC with BWS may be an effective intervention for stroke survivors. This study aimed to examine the effects of body weight support-Tai Chi training on balance control and walking function in stroke survivors with hemiplegia. *Methods*. Seventy-one stroke survivors with hemiplegia aged 30–75 years were randomly allocated to the control group ($N = 35$) or the BWS-TC group ($N = 36$). During BWS-TC training, the subjects performed 7 Tai Chi footwork forms, and gradual easy-to-difficult progression (from 40% to 0% body weight) was followed. The subjects participated in 40 min rehabilitation sessions three times per week for 12 weeks. The primary outcome was dynamic balance in the limits-of-stability test. The secondary outcomes, which reflect improvements walking function, included spatiotemporal parameters, the joint range of motion in the affected limb during the swing phase, the Berg Balance Scale score, and the Fugl-Meyer Assessment score. Evaluations were performed at baseline and 12 weeks and compared between groups. *Results*. After training, significant between-group differences were observed in the scores for overall, forward, left, right, forward-left, and forward-right directional control in the limits-of-stability test ($P < 0.05$). Furthermore, the scores for gait cycle time, step length, step velocity, and range of motion of the joints were better in the BWS-TC group than in the control group ($P < 0.05$). *Conclusions*. The 12-week BWS-TC training may enhance dynamic balance and walking function in stroke survivors with hemiplegia.

1. Introduction

Stroke is the second most common cause of death and a leading cause of long-term disability among middle-aged and elderly adults worldwide [1, 2]. An epidemiological study reported that 70–80% of stroke survivors develop functional disabilities [3, 4]. Chronic paralysis and motor control deficits contribute to significant limitations in physical and social functioning and impose a huge public health burden [5]. Exercise intervention is an integral part of the rehabilitation for motor impairments caused by stroke and has been shown to improve the walking function, balance control, and functional independence [6–8]. However, most exercise interventions, such as resistance-based exercises [6], body weight support treadmill training [9], virtual reality [10], and passive robots [11], require safety monitoring and are equipment-dependent. Therefore, the study and development of alternative forms of exercise that could improve motor function of stroke survivors are necessary.

Tai Chi (TC) is an ancient form of exercise that has been applied in stroke rehabilitation for over 10 years worldwide [2, 12]. As a balance-based exercise, TC has been demonstrated to improve strength, balance, and physical function and prevent falls in older adults [13, 14]. Recent system reviews and meta-analyses suggest that it may also improve postural control and balance ability of stroke survivors [2, 15]. However, for those who do participate in TC rehabilitation programs, various exercise-related impairments such as spasticity, weakness, proprioceptive deficit, abnormal agonist-antagonist coactivation, and fear of falling can pose significant barriers to compliance [16, 17]. Consequently, functional gains are not commonly achieved, leading most stroke patients to feel discouraged and to discontinue treatment [18].

Body weight support (BWS) treadmill training has shown promise in providing improvements in motor function, locomotion ability, and balance in stroke survivors [19]. The BWS treadmill system consists of an over suspension system (i.e., BWS) and a treadmill. A certain percentage of the subject's body weight is supported by the overhead suspension system via a harness worn by the subject during walking [20]. BWS can provide stroke survivors with confidence in starting rehabilitation early after surgery or trauma to regain balance and locomotion without the fear of falling [21]. In addition, BWS reduces lower extremity load, thus facilitating step initiation [22]. However, BWS treadmill training is a fixed system that can only be used for gait training and cannot be combined with other exercise interventions. Additionally, BWS gait training focuses on the improvement of function in the sagittal plane, while TC requires the subject to execute symmetric and diagonal movements, controlling the center of gravity around and over the edge of the base of support [23]. TC and BWS have unique advantages and their individual application in rehabilitation has been confirmed to provide positive effects for stroke survivors. Theoretically, combining TC with BWS may be an effective intervention for improving balance control and gait function in stroke survivors.

Therefore, we propose a novel intervention using combined TC and BWS and herein aimed to examine the effects of BWS-TC training on balance control and gait function in stroke survivors with hemiplegia. Because this exercise program emphasized weight shifting in different footwork and lower extremity control movements near the limits of stability (LOS) [24], we hypothesized that the BWS-TC footwork training could improve balance control. In addition, a previous study reported that BWS decreases the lower extremity load and facilitates step initiation [22]. Therefore, we further hypothesized that the BWS-TC footwork training could improve lower limb function and gait spatiotemporal pattern.

2. Materials and Methods

2.1. Study Design and Participants. This assessor-blinded randomized controlled clinical trial included stroke patients recruited from the Shanghai Seventh People's Hospital and community centers in the vicinity (Gaoqiao, Pudong District, Shanghai, China) using flyers, posters, and referrals from neurologists and physical therapists between March 2019 and November 2019. The inclusion criteria were as follows [25–27]: clinical diagnosis of cerebral hemorrhage or infarction by computed tomography/magnetic resonance imaging, aged 30–75 years, ≥3 months since stroke onset, a score of >24 on the Mini-Mental State Examination, able to stand unaided and walk without an assistive device, and no prior experience of TC. The exclusion criteria included current involvement in any other clinical study or instructor-directed exercise program, vision disorders, severe hypertension or cardiopulmonary diseases, and lower extremity joint or muscle injuries [27]. The flowchart of subject recruitment and retention is shown in Figure 1. This study was approved by the institutional review board of Shanghai Seventh People's Hospital (2018-IRBQYYS-012). Informed consent was obtained from all participants enrolled in the study. The trial was registered with the ClinicalTrials.gov (ChiCTR1900020758).

2.2. Sample Size. The sample size was calculated using G * power software (v3.1.9.2, University Dusseldorf, Germany; available for download from http://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower.html) based on a comparison of outcome measures between the BWS-TC and control groups, represented by improvement in dynamic balance in the LOS as the primary outcomes. During the preliminary study, we randomly assigned 26 subjects with stroke to the control group and the BWS-TC group. The subjects participated in 40 min rehabilitation sessions three times per week for 4 weeks. Our preliminary test data indicated that the means ± standard deviations of the scores were 9.62 ± 4.16 points and 5.05 ± 4.62 points in the BWS-TC and control groups, respectively. According to a prior two-way analysis of variance (ANOVA) *F*-test, with a power of 0.80, an alpha level of 0.05, and a fall rate of 20%, an estimated 40 participants were required for this study.

2.3. Randomization and Allocation Concealment. The participants were screened through in-person evaluation to determine if they met the inclusion and exclusion criteria. After completing baseline testing, each participant received a sealed envelope containing a random allocation sequence number to either the BWS-TC group or control group. The sequence numbers were generated by an independent statistician using Excel (Microsoft, USA). The statistician, outcome assessors, and data analyzers were blinded to study recruitment, intervention, and evaluation.

2.4. Interventions. The BWS-TC group received a combination of BWS-TC footwork training and conventional rehabilitation therapies, while the control group received conventional rehabilitation therapies. Ten junior level physical therapists with >5 years of clinical experience

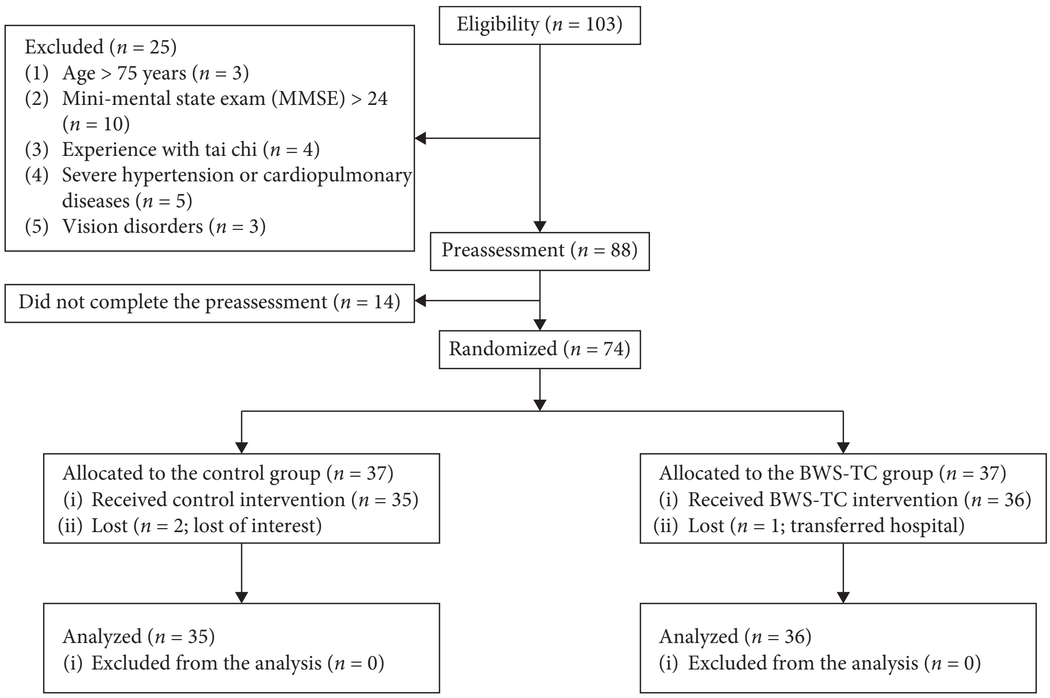

Figure 1: Flowchart illustrating the process of subject recruitment and retention. MMSE: mini-mental state examination; BWS-TC: body weight support-Tai Chi.

performed routine physical therapy and TC intervention. The subjects participated in 40 min rehabilitation sessions three times per week for 12 weeks.

2.4.1. BWS-TC Group. The TC intervention applied in this study was chiefly based on BWS training. As shown in Figure 2, each patient was asked to wear a harness, and a specific percentage of their body weight was supported by an overhead suspension system (LiKorallTM, 250 ES, Hill-Rom, Sweden). The TC intervention was developed based on the 24-form simplified TC promoted by the State Sports General Administration of China [28]. From the 24 forms of the simplified TC, we selected seven step forms: forward steps, backward steps, shuffle steps, empty steps, lunge steps, single-leg support, and turning around (Figure 2). The footwork is the foundation and precursor of TC exercise [29], and these seven typical step forms comprise most TC movements. The BWS-TC footwork training program was designed to minimize the effect of motor impairment for TC rehabilitation. We aimed to improve their insufficient support capacity to preserve motor function as well as balance control. This was achieved by asking the subjects to implement both symmetric and diagonal movements, including weight shifts, controlled displacement of the center of gravity over their base of support, ankle sways, and anterior-posterior and lateral stepping. Therefore, this training did not focus on the movements of the upper limbs and mainly emphasized endurance among different movements as well as weight shifts.

In the present study, two martial art coaches were hired to teach TC footwork. These two coaches had national second-level athlete certifications from the National Traditional Sports Major of Shanghai University of Sports. Previous studies reported a significant reduction in energy cost and quadriceps activation at a BWS of 40% [19, 30]. As the level of BWS increased, lower limb and muscle activity progressively decreased. Therefore, the initial BWS was set as at 40% in the current study. During the 12-week BWS-TC program, a gradual easy-to-difficult progression was followed, which was divided into five stages corresponding to BWS: week 1, 40%; weeks 2-3, 30%; weeks 4–6, 20%; weeks 7–9, 10%; and weeks 10–12, 0%. The BWS-TC group was required to undergo a 40 min session (20 min conventional rehabilitation programs and 20 min TC) three times per week for 12 weeks.

2.4.2. Control Group. The control group received conventional rehabilitation programs, including active mobilization of the limb muscles and joints, proprioceptive neuromuscular facilitation, muscle resistance training, stretching training, sit-to-stand training, and walking. The control group was required to undergo a 40 min rehabilitation session three times per week for 12 weeks.

2.5. Outcome Measures. All evaluations were performed before and 12 weeks after intervention by a rehabilitation assessor who was not part of the clinical study team. The primary outcome was dynamic balance in LOS, as measured by computerized dynamic posturography (Biodex Balance System, USA). The secondary outcomes included spatio-temporal parameters; the range of motion (ROM) of the ankle, knee, and hip during the affected limb swing phase of the gait cycle; Berg Balance Scale (BBS) score; and Fugl-

(a) (b) (c)

Figure 2: Schematic diagram of body weight support-Tai Chi (BWS-TC) footwork training. (a) Sketch map of BWS-TC. (b) Example diagram of BWS-TC. (c) Seven step forms of Tai Chi footwork (forward steps; backward steps; shuffle steps; lunge steps; empty steps; turn around; single-leg support).

Meyer Assessment (FMA) score of the lower limbs. Thus, the subjects were evaluated on five outcome measures at baseline and 12 weeks. A single evaluator with significant assessment experience performed the evaluations to eliminate variability in assessment results and to ensure assessment accuracy.

2.5.1. Primary Outcomes. The LOS was defined as the farthest distance in eight directions where a subject could lean from an upright position within their base of support without taking any steps [24]. A number of studies have demonstrated that the LOS test is a sensitive measure of dynamic balance control, and the reliability of evidence shows moderate test-retest reliability for directional control [31]. In this study, the LOS test was set to the easy level (50%) due to the physical impairment of the stroke survivors. All BBS procedures were performed according to the manufacturer's guidelines. The LOS score ranged from 0 to 100%, with higher scores indicating better balance control. Only one successful trial was collected to disregard learning effects and avoid muscle tiredness.

2.5.2. Secondary Outcomes

(1) Gait Analysis. The ODONATE gait analysis system (ODONATE, Maver, Shanghai, China) was used to evaluate the temporospatial parameters and ROM of the lower limb joints in the sagittal plane during walking.

The ODONATE gait analysis system was used to collect the point cloud on the human body surface and to automatically analyze the walking performance. In the supplementary attachments (available here), we submitted the comparative results of gait biomechanical between ODONATE and the gold standard in the motion capture system (Vicon Motion Systems, Oxford, United Kingdom). Furthermore, the interclasses correlation coefficient (ICC) results indicated that the ODONATE system has high reliability and validity in gait analysis (ICC Hip: 0.990; Knee: 0.997; Ankle: 0.982; see the Supplementary Materials).

Previous studies demonstrated that a self-selected walking speed is a good indicator of overall gait performance and is commonly used to assess locomotor ability [32]. Thus, subjects were instructed to walk at a self-selected speed on a 10 m walkway, and the temporospatial parameters and angle of the lower limb joints in the sagittal plane were collected. The gait cycle was defined as the period beginning with the unaffected limb's heel contact to its next heel contact [33]. Step length was measured from heel to heel in the anterior-posterior direction. The affected limb single support time (SST) was calculated from the unaffected limb toe-off to the ipsilateral heel contact [33]. The double support time (DST) was measured as follows: the first from the heel contact of the unaffected limb heel to the toe-off of the affected limb and the second from the heel contact of the affected limb to the toe-off of the unaffected limb. Furthermore, the ROM of the ankle, knee, and hip during the affected limb swing phase of the gait cycle was determined [34]. Each variable from the three trials for each subject was then averaged for subsequent statistical analysis.

(2) Lower Limb Motor Function Assessment. The motor function of lower limbs was measured by simplified Fugl-Meyer Assessment (FMA) scale, which has demonstrated excellent interrater and intrarater reliability and construct validity and is often used in stroke rehabilitation research [35, 36]. The aggregate score of scale is 34, with higher scores indicating less motor damage.

(3) Berg Balance Assessment. The Berg Balance Scale (BBS) was used to measure the balance score of the subjects in this study. Recent systematic review reported that the BBS has high intra- and interrater relative reliability in balance assessment for the poststroke population [37]. Each of these items is scored from 0 to 4, which are summed to make a total score between 0 and 56, with a higher score indicating better balance.

2.6. Statistical Analysis. All statistical analyses were performed using IBM SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). The primary and secondary outcomes analyses were performed on an intention-to-treat basis. Between-group differences in demographic and baseline variables were tested using the chi-square test for categorical variables and a one-way ANOVA for continuous variables. A two-way repeated measures ANOVA with group as a group factor and time factor was used to calculate the effects of the interventions on all outcome measures. Simple effect analysis was conducted using SYNTAX grammar, where the time-× group interaction effect was significant. An alpha level of 0.05 was considered as statistically significant.

3. Results

3.1. Baseline Characteristics of the Subjects. The demographic and baseline characteristics of the 71 subjects are presented in Table 1. There were no significant differences between the two groups ($P > 0.05$). During the study period, no adverse events were observed.

3.2. Primary Outcomes. Table 2 presents the between-group differences in dynamic control at baseline and 12 weeks. Significant group × time interactions were observed in complete time, right, forward-left, and forward-right directional control during the LOS test ($P < 0.05$). There was no significant preintervention difference between the two groups, as per the simple effect result of the group factor ($P > 0.05$). However, significant group differences were observed in complete time, right, and forward-left directional control during postintervention ($P < 0.05$). Furthermore, we also observed significant between-group changes in the scores for overall, forward, left, right, forward-left, and forward-right directional control ($P < 0.05$). Additionally, we found a significant time effect in the score of overall, right, forward-left, forward-right, and backward-right directional control and complete time between the two groups ($P < 0.05$).

3.3. Secondary Outcomes. Table 3 shows the comparison of spatiotemporal parameters and joint ROM of the affected limb during gait between the two groups at baseline and 12 weeks. We observed significant group × time interactions in the gait cycle time, step length, and hip swing range between the two groups ($P < 0.05$). The simple effect results showed that the group differences in the gait cycle time, step length, and hip swing range were statistical significant during postintervention ($P < 0.05$). In addition to the SST and DST, significant group and time differences were observed between the two groups in other spatiotemporal parameters and the joint ROM of the affected limb during walking ($P < 0.05$).

Table 4 shows the comparisons of FMA and BBS scores between the two groups at baseline and 12 weeks. Significant interactions were found in the FMA and BBS between the two groups. We observed the significant differences in both indices during postintervention between the two groups, as per the simple effect result of the group factor ($F = 4.764$, $P = 0.046$; $F = 15.213$, $P = 0.000$). Additionally, the main effect of group in BBS was significant between the two groups ($F = 6.561$, $P = 0.039$). Although the two groups exhibited a mean increase of 56.77% and 34.02% between baseline and 12 weeks, respectively, no significant group difference was found.

4. Discussion

Stroke survivors do not commonly achieve functional gains in the traditional TC rehabilitation programs due to the presence of various motor-related impairments [17]. In the present study, we proposed a novel intervention strategy that combined TC and BWS and examined the effects of BWS-TC training on balance control and walking function in stroke survivors with hemiplegia. As hypothesized, the BWS-TC footwork training program improved balance control and walking function. Furthermore, no adverse events were observed during the study period. These results indicate the safety and utility of this combined intervention for improving balance control and walking function in stroke survivors with hemiplegia.

Balance control for the dual purposes of maintaining postural stability and orientation is critical to the functional performance of activities of daily living and preventing falls [13, 24]. In the present study, we observed significant between-group differences in overall, forward, left, right, forward-left, and forward-right directional control of dynamic balance. Although the magnitude of change in the other indices in the BWS-TC group was greater than that in the control group, the between-group differences were not significant. These results suggest that 12-week BWS-TC footwork training was beneficial and effective in improving dynamic balance in stroke survivors. Previous studies have also reported similar findings [4, 13, 27]. In addition, the BBS score, which reflects balance, was significantly improved in the BWS-TC group compared to the control group. However, the beneficial rehabilitation effects of TC were not consistent in previous studies. Takeshima et al. [38] reported that 12 weeks of TC exercise had no significant effect on balance and functional fitness parameters in older Japanese adults (average age, 72 years). One of the reasons for the lack of improvement may be that TC is complex and difficult for older Japanese adults who are not accustomed to this activity to perform. During TC training without protection, the degree of functional improvement and increased incidence of adverse events, such as falling, are interdependent [39]. Therefore, another possible explanation for no improvement might be that the subjects selected a moderate or lower TC exercise intensity (e.g., higher center of gravity), based on their functional level, fear of falling, and risk control.

From the perspective of exercise training, a moderate or nonstimulating exercise load may have no significant effect on improving muscle strength and balance control [40]. However, the incidence of adverse events will increase during training when the focus is on the pursuit of functional enhancement. Adverse event reporting within clinical trials is an important source for evaluating the safety of new therapies [39]. A number of TC studies have provided evidence of its clinical efficacy and cost effectiveness, particularly among older adults and those deconditioned by chronic illness, but some adverse events have also been

Table 1: Demographic and clinical characteristics of the study subjects at baseline.

Characteristic	BWS-TC ($n = 35$)	Control ($n = 36$)	F/χ^2	P
Age (years)	63.03 ± 8.92	58.69 ± 9.72	3.872	0.054
Body mass (kg)	67.81 ± 8.66	65.06 ± 8.15	1.976	0.164
Time after onset (months)	11.38 ± 5.21	9.41 ± 4.82	2.241	0.143
MMSE (score)	27.52 ± 1.88	28.19 ± 2.04	1.743	0.191
Sex (male/female)	21/14	20/16	0.705	0.445
Hemiparesis side (left/right)	18/17	21/15	0.559	0.365
Stroke type (Isc/Hem)	25/10	22/14	0.358	0.252

Continuous variables are presented as mean ± SD; BWS-TC: body weight support-Tai Chi; MMSE: mini-mental state examination; Isc: Ischemic; Hem: hemorrhagic.

Table 2: Comparison of dynamic control between two groups.

Index	Preassessment		Postassessment		Group × time (F/P)	Group (F/P)	Time (F/P)	Simple effect (F/P)	
	BWS-TC	Control	BWS-TC	Control				Pre	Post
Overall	29.94 ± 7.87	27.71 ± 9.92	46.54 ± 14.12	33.14 ± 12.02	N.S.	8.365/0.009	6.726/0.024	N.S.	N.S.
Complete time	65.74 ± 13.94	64.67 ± 11.18	45.06 ± 10.3	49.07 ± 7.89	6.612/0.024	N.S.	14.234/0.000	N.S.	4.215/0.046
Forward	40.87 ± 7.01	36.98 ± 10.89	57.36 ± 8.63	44.98 ± 11.78	N.S.	5.368/0.041	N.S.	N.S.	N.S.
Backward	18.15 ± 6.34	16.65 ± 6.22	27.57 ± 9.37	19.76 ± 6.28	N.S.	N.S.	N.S.	N.S.	N.S.
Left	37.04 ± 8.86	37.78 ± 15.51	53.82 ± 7.32	40.10 ± 14.08	N.S.	9.951/0.008	N.S.	N.S.	N.S.
Right	36.14 ± 12.99	37.41 ± 19.62	58.21 ± 8.60	41.24 ± 12.54	4.566/0.048	12.324/0.000	5.212/0.038	N.S.	12.258/ 0.000
Forward-left	42.12 ± 10.65	45.92 ± 9.56	54.93 ± 6.05	49.37 ± 16.41	6.235/0.027	5.522/0.037	4.967/0.047	N.S.	4.962/0.044
Forward-right	45.66 ± 9.61	46.43 ± 7.87	56.23 ± 11.34	52.49 ± 14.76	5.623/0.033	4.868/0.044	4.268/0.049	N.S.	N.S.
Backward-left	21.15 ± 7.10	19.27 ± 7.34	26.12 ± 6.12	25.61 ± 10.23	N.S.	N.S.	N.S.	N.S.	N.S.
Backward-right	23.41 ± 8.43	22.42 ± 10.32	34.54 ± 11.56	26.12 ± 6.12	N.S.	N.S.	5.298/0.034	N.S.	N.S.

BWS-TC: body weight support-Tai Chi; N.S.: no significant difference.

reported [24, 41, 42]. In the present study, no adverse events were observed. Thus, the significant positive rehabilitation effects on balance control and lack of adverse events observed herein may be related to simple footwork training under the protection of BWS, which can gradually improve function with the challenge of the LOS without fear of falling.

The recovery of walking function is the primary focus of stroke rehabilitation [3, 43]. As functional measures of walking, we used the gait spatiotemporal variables and lower limb joint ROM referring to the previous literature [34]. Our results revealed that the improvements in the cycle time, step velocity, step length, and lower limb joint ROM were greater in the BWS-TC group than in the control group. Similarly, Yang [44] reported significant differences in measures such as step length (from 0.33 to 0.42 m) and walking speed (from 0.44 to 0.57 m/s) after a 4-week modified TC intervention. A number of previous studies also observed improvements in walking speed on the 10 m walking test and timed-up-and-go after TC intervention [45]. Zou et al. [46] demonstrated that the practice of TC has a positive effect in improving joint ROM in healthy older women. Although our findings are similar to those of previous studies, it is difficult to discuss the additional gains in BWS via comparison with previous studies due to differences in the baseline characteristics, duration of intervention, and outcome measures in the above studies. In future research, TC training without BWS should be included as an additional control intervention.

The current study demonstrated that BWS-TC footwork training can improve balance control and walking function in stroke survivors with hemiplegia. Furthermore, our lower extremity function results revealed significant differences between the two groups. This partially explains the possible reasons for the enhanced balance control and walking function of stroke survivors in the BWS-TC group. Such significant positive rehabilitation effects may be related to the unique rehabilitation program. BWS-TC footwork training is practiced on each side to improve movement coordination and symmetry through repetitive bilateral and reciprocal limb movements. The program translates the dualities into a dynamic exchange of stability (movements within the base of support) and instability (movements on the periphery of the base of support). As such, training involves voluntarily controlled TC postural movement excursions of the center of gravity over and/or around the edge of the base of support, with the goal of increasing the sway envelope and thereby expanding the LOS [23]. In addition, the presence of BWS makes it easier in footwork self-initiated

Table 3: Comparison of spatiotemporal parameters and joint range of affected limb during gait between two groups.

Index	Preassessment		Postassessment		Group × time (F/P)	Group (F/P)	Time (F/P)	Simple effect (F/P)	
	BWS-TC	Control	BWS-TC	Control				Pre	Post
Gait cycle time (s)	1.38 ± 0.24	1.31 ± 0.26	1.13 ± 0.19	1.18 ± 0.24	8.968/0.011	4.996/0.041	10.268/0.004	N.S.	4.024/0.047
Step velocity (m/s)	0.45 ± 0.11	0.42 ± 0.12	0.67 ± 0.18	0.51 ± 0.21	N.S.	9.62 2/ 0.007	8.695/0.010	N.S.	N.S.
Step length (m)	0.25 ± 0.14	0.28 ± 0.12	0.38 ± 0.15	0.32 ± 0.11	13.368/0.000	4.368/0.049	7.102/0.014	N.S.	5.196/0.034
SST_{AL} (%)	33.68 ± 9.62	31.36 ± 10.23	39.26 ± 11.23	35.77 ± 10.96	N.S.	N.S.	N.S.	N.S.	N.S.
DST (%)	26.16 ± 15.42	27.29 ± 14.27	22.12 ± 14.39	24.36 ± 13.83	N.S.	N.S.	N.S.	N.S.	N.S.
Hip swing range (°)	37.26 ± 11.23	38.52 ± 12.45	47.87 ± 12.88	43.74 ± 11.57	15.336/0.000	4.522/0.047	9.217/0.010	N.S.	5.961/0.032
Knee swing range (°)	32.21 ± 13.25	31.85 ± 11.98	45.33 ± 14.26	39.55 ± 12.03	N.S.	6.462/0.021	12.011/0.000	N.S.	N.S.
Ankle range (°)	13.22 ± 4.26	12.38 ± 5.12	21.64 ± 5.36	19.98 ± 7.62	N.S.	7.987/0.015	14.368/0.000	N.S.	N.S.

BWS-TC: body weight support-Tai Chi; N.S.: no significant difference; AL: affected limb; SST: single support time; DST: double support time.

Table 4: Comparison of FMA and BBS between the two groups.

Index	Group	Pre	Post	Change (%)
FMA$^{*‡\#}$	BWS-TC	15.91 ± 6.54	25.17 ± 5.35	56.77
	Control	16.17 ± 5.92	21.78 ± 7.83	34.02
BBS$^{*‡\#\$}$	BWS-TC	33.40 ± 8.83	48.03 ± 9.59	44.62
	Control	34.50 ± 8.41	39.64 ± 12.39	14.51

FMA: fugl-meyer assessment; BBS: berg balance Scale; BWS-TC: body weight support-Tai Chi; Pre: preassessment; Post: postassessment. *Statistically significant interaction between group and time. ‡Statistically significant group difference in the postassessment based on simple effect test. #Statistically significant time difference. $Statistically significant group difference.

and control movement for stroke patients to create postural sway at the ankle and/or hip to engage participants in adaptive training of balance control [20]. More importantly, external protection devices provide a basis for stroke survivors to perform various types of training without fear of falling [29]. The enhancement of the ROM and control of the ankle and hip joints not only were conducive to balance control, but also had a positive effect on improving gait and walking function. These results indicate the safety and utility of this combined intervention strategy in improving balance control and walking function in stroke survivors with hemiplegia and provide insight into the design of rehabilitation interventions for fall prevention.

This study also has some limitations. First, we only used routine rehabilitation treatment as a control and did not investigate any other types of exercise interventions. Second, a previous study has recommended that stroke patients self-practice either with their family or in their community once the interventions are complete [21, 47]. However, due to the lack of BWS equipment in these locations, we did not conduct any follow-up after the interventions were completed. Third, the synergistic movement and spasticity level of lower limb muscles of subjects were not assessed. However, during the intervention, no apparent synergistic movement or spasticity of the lower limb muscles was observed. This may be related to the longer time after onset (average 11.36 months in the BWS-TC group and 9.38 months in the control group) and reduced load and requirement of lower limb muscle activation due to BWS. Finally, the proprioceptive input and sensory integration system may play an important role in balance control and walking function [27]. However, we did not assess the change in sensory integration. Nevertheless, our study suggests that BWS-TC footwork training is useful for improving dynamic balance and walking function in stroke survivors.

5. Conclusion

Twelve weeks of body weight support-Tai Chi footwork training improved dynamic balance control and walking function of stroke survivors with hemiplegia. The future work should be to set Tai Chi training without body weight support as the control and to explore the effect of body weight support in function improvement.

Data Availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation, to any qualified researcher.

Disclosure

Xiao-Ming Yu and Xue-Ming Jin are co-first authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Xiao-Ming Yu and Xue-Ming Jin contributed equally to this work. Xiao-Ming Yu and Xue-Ming Jin conceived and designed the study. Xiao-Ming Yu and Xue-Ming Jin recruited subjects and collected the basic characteristics of subjects. Yan Lu and Xin Xue Performed clinical intervention. Yang Gao and Hai-Chen Xu performed the outcome measures assessment. Xiao-Ming Yu and Xue-Ming Jin wrote this paper. All authors read and approved the manuscript.

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Supplementary Materials

The comparative results of gait biomechanical between ODONATE and the gold standard in the motion capture system (Vicon Motion Systems, Oxford, United Kingdom) are provided. Furthermore, the interclasses correlation coefficient (ICC) results indicated that the ODONATE system has high reliability and validity in gait analysis (ICC Hip: 0.990; Knee: 0.997; Ankle: 0.982). (*Supplementary Materials*)

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Research Article

Tai Chi and Qigong Practices for Chronic Heart Failure: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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Background. Several randomized controlled trials (RCTs) have assessed the role of Tai Chi and Qigong Practices (TQPs) in managing chronic heart failure (CHF). They have included broad variations in comparators, sample sizes, and results. This study evaluates existing RCTs for evidence of TQPs rehabilitation effects for CHF. *Methods*. Both English and Chinese databases were searched from their inception to October 23, 2019. RCTs were included if they compared the addition of TQPs into routine managements (RMs) to RMs alone or compared TQPs to general exercise, with RMs as a consistent cointervention in both groups. Data were screened and extracted independently using predesigned forms. RCT quality was assessed with the Cochrane tool. The primary outcomes were peak oxygen consumption (VO_{2peak}), 6-minute walking distance (6MWD), and Minnesota Living with Heart Failure Questionnaire (MLHFQ). Mean differences (MDs) and 95% confidence intervals (CIs) were calculated, and heterogeneity was assessed with an I^2 statistic. *Results*. A total of 33 RCTs with 2,465 patients were included in the systematic review. Compared to the RMs alone, TQPs plus RMs improved VO_{2peak} (MD: 1.24 mL/kg/min, 95% CI, 0.91 to 1.57; $I^2 = 0\%$), 6MWD (MD: 59.63 meters, 95% CI, 43.35 to 75.90 $I^2 = 88\%$), and MLHFQ (MD: −8.63 scores; 95% CI, −10.60 to -6.67; $I^2 = 94\%$). Compared to general exercise, superior improvements were found in the TQP group; they were significant in MLHFQ (MD: −9.18 scores; 95% CI, −17.95 to −0.41; $I^2 = 86\%$), but not in VO_{2peak} or 6MWD. Evidence was also found of TQPs' safety and high adherence. *Conclusions*. Considering that there are low costs, multiple physical benefits, and no equipment required, TQPs are a promising rehabilitation therapy, as an adjunct to routine pharmacotherapies or as an alternative to conventional exercises, especially in home-based settings.

1. Introduction

Heart failure is a global pandemic affecting at least 26 million people worldwide, and its prevalence is increasing [1]. Although pharmacological therapy is the primary treatment, exercise-based cardiac rehabilitation (EBCR) has become an important recommendation in clinical guidelines. Unfortunately, few patients with chronic heart failure (CHF) participate in EBCR, due to the lack of resources [2]. Those patients who do participate in supervised cardiac rehabilitation programs show low adherence [3]. Therefore, finding a cheap, convenient form of EBCR with high compliance is of growing importance [4].

Qigong is an adaptable form of exercise that can be practiced at any place, any time, without any specialized equipment, and with minimal time investment. Hence, it is easily incorporated into daily routines and could be integrated into a comprehensive cardiac rehabilitation program. Qigong is an ancient Chinese martial art; it is an umbrella term, covering a spectrum of exercises including Dao-Yin-Shu (physical and breathing exercises), Wu-Qin-Xi (five animals play), Baduanjin (eight silken movements), and Yi-Jin-Jing (changing tendons exercises) [5]. Tai Chi is a well-known exercise that has grown from the Qigong tradition. Tai Chi and Qigong Practices (TQPs) typically involve slow movements synchronized with meditation and regulated breathing techniques [5]. Moreover, all TQPs share the principle that any form of Qigong has an effect on the cultivation of balance and the harmony of vital energy (qi), which functions as a holistic, coherent, and interactive system [5].

In recent years, the rehabilitating effects of TQPs for CHF patients have received increasing recognition and attention. An earlier systematic review of TQPs in cardiac rehabilitation, including seven randomized or nonrandomized controlled trials, suggested that TQPs enhance physical health and promote overall quality of life among patients with chronic heart disease [6]. This has been corroborated by a recent systematic review which included 35 randomized controlled trials (RCTs) with 2,249 patients to evaluate TQPs' effect on cardiovascular diseases [7]. However, these two reviews included studies without subgroup analysis by varying cardiovascular diseases. Therefore, the rehabilitating effects of TQPs for heart failure remain unclear.

In light of the growing number of RCTs of TQPs used for rehabilitation in CHF patients, and the ensuing need for critical evaluation, we conducted a systematic review and meta-analysis of the available evidence to inform clinical practice. The research questions were as follows: (1) Does the addition of TQPs into routine managements (RMs) improve clinical outcomes, as compared to RMs alone? (2) What is the difference between TQPs and general exercise in terms of improving CHF patients' clinical outcomes? (3) What is TQPs' safety profile and how is adherence?

2. Methods

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (Supplementary Materials: PRISMA 2009 Checklist) [8] and the Cochrane Handbook for Interventional Reviews [9]. The study protocol has been published previously in PROSPERO (CRD42018081982).

2.1. Search Strategy. The electronic databases PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, CINAHL, and China National Knowledge Infrastructure were searched from their inceptions until October 23, 2019. Searches were restricted to English and Chinese. Search strategy details are provided in the Supplemental Materials-Search strategy.

2.2. Study Selection. One reviewer (XC) scanned all titles and abstracts to exclude irrelevant citations which were checked by a second reviewer (YC). Two reviewers (XC and YC) independently assessed the eligibility of the remaining citations after retrieving the full texts of potentially relevant articles. Randomized controlled trials (RCTs) were included, and selection criteria conformed to the PICOS approach, as described hereinafter.

2.2.1. Populations. Patients diagnosed with heart failure that were in a stable phase of the disease with no acute exacerbations were included. There were no restrictions regarding heart failure subtypes.

2.2.2. Intervention. RCTs that applied an intervention group receiving any form of Qigong practice (e.g., Tai Chi, Liu-Zi-Jue, Baduanjin, Wu-Qin-Xi, and Yi-Jin-Jing) were included. However, studies were excluded if TQPs had been used in combination with other oral traditional interventions such as Chinese herbal decoctions.

2.2.3. Comparators. No exercise or general exercise is planned, structured, and repetitive for the purpose of conditioning the body (such as walking, cycling, swimming, or running). RMs were provided according to clinical guidelines and as a consistent cointervention to both groups.

2.2.4. Outcomes. Primary outcomes included (1) peak oxygen consumption (VO_{2peak}), (2) 6-minute walking distance (6MWD), and (3) disease-specific quality of life using total scores according to the Minnesota Living with Heart Failure Questionnaire (MLHFQ). Secondary outcomes included left ventricular ejection fraction (LVEF), B-type natriuretic peptide (BNP), and other clinically relevant outcomes, as well as adverse events and participant's adherence to TQPs.

2.3. Data Extraction. The data extraction form was drafted based on the reporting guidelines from the extended CONSORT statement for randomized trials of nonpharmacologic treatment [10] and the TIDieR (Template for Intervention Description and Replication) [11]. One reviewer (XC) used a standardized form to extract data from the included articles. The following data were extracted: study characteristics (e.g., author, year, and country), participant characteristics such as age, sex, sample size, New York Heart Association (NYHA) functional class, LVEF subtype, TQPs interventions (e.g., TQP types, frequency, durations, and target intensity), and controls, as well as outcomes measured.

Attempts were made to contact the original investigators regarding any missing data. The extracted data was checked by a second reviewer (YC). Any discrepancies were resolved by agreement after rechecking the source papers and further discussion with a third reviewer (LM).

2.4. Quality and Certainty of Evidence. In accordance with recommendations in the Cochrane Handbook, the trials' methodological quality was independently evaluated by two reviewers (XC and YC) using the Cochrane risk-of-bias assessment tool. Any discrepancies were resolved by agreement after rechecking the source papers and further discussion with a third reviewer (LM). The following domains were considered: (1) random sequence generation, (2) allocation concealment, (3) blinding of patients and personnel, (4) blinding of outcome assessors for primary outcomes, (5) incomplete outcome data, and (6) selective reporting. The overall evidence and certainty of evidence were evaluated with the Grading of Recommendations Assessment, Development, and Evaluation approach.

2.5. Data Analysis. RevMan 5.3 (Cochrane Collaboration) and STATA 12 (StataCorp) were used to analyze the data from the included studies. The outcome measures from the individual trials were combined through meta-analysis, when possible. For each outcome measure, studies were pooled separately according to comparators: (A) TQPs plus RMs vs. RMs: to evaluate add-on effects of TQPs; and (B) TQPs plus RMs vs. general exercises plus RMs: to contrast TQPs and general exercise. For studies with multiple control groups [12, 13], such as TQPs plus RMs vs. general exercise plus RMs control vs. RMs control, the results were split into pairwise comparisons by the different comparators. For the study which had two TQP groups using the same exercise but with different practice times (30 minutes or 60 minutes) [14], the results of these two TQPs groups were combined and used as the mean effects of the TQP group.

Given that all variables in the included studies consisted of continuous data, we used the mean difference (MD) when the same instrument was used, or the standardized mean difference (SMD) when different instruments were used, with 95% confidence intervals (CIs) to analyze the outcomes. A p value <0.05 was considered statistically significant. For trials that had missing information for outcome means or standard deviations (SD), data was first sought from the original investigators. If it was not available from the author, then imputations were performed using the recommended statistical approaches mentioned in the Cochrane Handbook (session 6.5.2.3). For those studies using the median and interquartile range (IQR) instead of means and SD, the medians were used as a substitute for the means, and the SD was approximated as SD = IQR/1.35. For those studies with only missing SD, SD was imputed from a reported standard error, CI, t-statistic, Z-statistic, or p value that was correlated with the difference between the two groups' means.

Heterogeneity was assessed with a chi-square test ($p < 0.10$ was considered indicative of statistical significance) and an I^2 statistic (where $I^2 > 30\%$, 50%, and 75% indicated moderate, substantial, or considerable heterogeneity, respectively) [9]. A random-effects model was employed where there was formal evidence of statistical heterogeneity (I^2 statistic > 50%). Otherwise, a fixed-effects model was used. Potential publication bias was evaluated by visual examination of funnel plot asymmetry and Egger's test (p value <0.05 was considered statistically significant). When the number of articles included in one analysis was limited (i.e., less than 10), publication bias was not assessed.

A sensitivity analysis was conducted by removing each study individually to estimate the results' consistency. When there was heterogeneity, subgroup analyses were performed to identify its potential sources. Subgroup analyses were performed according to different types of TQPs used in the program (Tai Chi, Qigong, Tai Chi plus Qigong) and program duration (in weeks). Additionally, a post hoc subgroup analysis was conducted to explore heterogeneity originating from the heart failure subtype (HFrEF or HFpEF).

3. Results

In total, 1,480 records were retrieved from database searches. After excluding duplicates, 999 potentially relevant abstracts were screened, and 934 were excluded for failing to meet the inclusion criteria. The remaining 65 full texts were read, and 33 RCTs [12–44] (24 in Chinese [12, 14, 18–22, 24–30, 34–42, 44] and 9 in English [13, 15–17, 23, 31–33, 43]) were deemed eligible for this systematic review. The quantitative synthesis was performed with 32 RCTs by pooling the results through a meta-analysis. A flowchart of the study selection process is shown in eFigure 1 in Supplementary Materials.

3.1. Characteristics of Included Studies

3.1.1. Study Characteristics. The characteristics of the included studies are shown in Table 1. The studies were published between 2004 and 2019. States or regions of publication were China ($n = 25$) [12, 14, 17–22, 24–30, 34–42, 44], Taiwan ($n = 2$) [17, 44], the United States ($n = 5$) [13, 23, 31–33], the United Kingdom ($n = 1$) [15], Italy ($n = 1$) [16], and Sweden ($n = 1$) [43].

3.1.2. Participants. The included RCTs involved a total of 2,465 CHF patients (age ranging from 52 to 74 yrs) with NYHA functional class ranging from I to IV. The sample size per RCT ranged from 16 to 180, 84% of whom were Chinese.

3.1.3. Intervention. For the TQP exercise program type, researchers used Tai Chi in 17 RCTs [13, 14, 16, 18, 19, 22–25, 30–33, 35, 38, 41, 43], Qigong in 14 RCTs, and Tai Chi plus Qigong in the remaining two RCTs [15, 40]. Qigong included Baduanjin [17, 21, 26, 27, 36, 37, 39, 42], Liuzijue [12], Baduanjin plus Liuziju [20, 28, 29, 34], and Chan-Chuang [44]. TQP exercise time lasted from 15 to 60 minutes per session, and TQP program duration varied between 4 weeks ($n = 2$) [19, 36], 8 weeks ($n = 1$) [21], 12 weeks ($n = 17$) [12, 16, 17, 23–27, 31–33, 35, 37–40, 44], 16 weeks ($n = 3$) [13, 15, 43], 24 weeks ($n = 5$) [14, 18, 22, 30, 41], and 52 weeks ($n = 5$) [20, 28, 29, 34, 42].

Table 1: Characteristics of included studies.

Source (country)	Populations: NYHA class	Populations: Sample size (drop out) (I/C), #	Populations: Male (I/C), %	Populations: Age, yrs (I/C) mean ± SD	TQPs (time/ frequency]	Period (weeks)	Comparison (A[a]/B[b])	Routine management[c]	Outcomes	Adherence to TQPs
Barrow et al. [15] (UK)	II~III	65 (32/33) (13 (7/6))	81%/ 82%	68.4 ± NA[d]/ 67.9 ± NA[d]	III. Tai Chi and Qigong (55 mins/twice per week)	16	A[a]	TDs[e]	MLHFQ, SCL-90-r (depression and anxiety), SBP DBP, ISWT	78% retention rate; practice for >1 h/week: $n = 14$; <1 h/week: $n = 11$
Caminiti et al. [16] (Italy)	II	60 (30/30) (0)	83%/ 87%	74.1 ± 6.0/ 73.4 ± 2.0	I. Tai Chi (30 min/ twice per week)	12	B[b] (cycling: 30 mins/twice per week)	TDs[e]; walking: (30 min/twice per week)	6MWD, SBP, DBP, NTpro-BNP, strength, heart rate, QoL-VAS, MacNewQL	100% retention rate
Chen et al. [17] (Taiwan)	I~II	80 (39/41) (17 (9/8))	46%/ 59%	70.3 ± 13.5	II. Qigong (*Baduanjin*) (35 min/3 times per week)	12	A[a]	TDs[e]	MLHFQ, fatigue (PFS)	77% retention rate
Feng [18] (China)	II-III	60 (32/28) (0)	50%/ 54%	60.6 ± 6.5/ 61.6 ± 5.1	I. Tai Chi (30 min/3~5 times per week)	24	A[a]	TDs[e]; dietary advice	VO_{2peak}, MLHFQ, VO_{2AT}, O_2 pulse, NT-proBNP, LVEF	100% retention rate
Huang [19] (China)	III	88 (44/44) (0)	48%/ 50%	64.3 ± 6.5/ 64.5 ± 5.9	I. Tai chi (30 min/ daily)	4	A[a]	TDs[e]; walking (30 min/daily)	6MWD, MLHFQ, LVEF, LVEDd, BNP	100% retention rate
Li et al. [20] (China)	II~IV	180 (90/ 90) (0)	57%	70.5 ± 4.5	II. Qigong (*Baduanjin and Liu-Zi-Jue*) (NA[d])	52	A[a]	TDs[e]; supervision; daily life advice	6MWD, BNP	100% retention rate
Li [21] (China)	II~III	60 (30/30) (0)	60%/ 67%	69.2 ± 6.6/ 66.6 ± 5.3	II. Qigong (*Baduanjin*) (4~8 sets/daily)	8	B[b] (walking: 1,000 meters/twice per day)	TDs[e]	6MWD, MLHFQ	100% retention rate
Pan [22] (China)	II-III	61 (31/30) (0)	58%/ 57%	67.7 ± 12.1/ 66.2 ± 11.8	I. Tai Chi (≥30 min/ daily)	24	A[a]	TDs[e]; dietary advice	6MWD, LVEF, LVEDd, BNP, cTNT, SF-36	100% retention rate
Redwine et al. [23] (US)	II	24 (12/12) (4 (4/0))	83%/ 92%	72.6 ± 6.2/ 63.9 ± 12.0	I. Tai Chi (60 min/ twice per week)	12	A[a]	TDs[e]; regular medical visits	BDI (depression), MFSI-S (fatigue)	67% retention rate; 87.5% class attendance rate
Sang [24] (China)	II-III	100 (50/ 50) (0)	56%/ 58%	65.3 ± 8.2/ 76.2 ± 7.5	I. Tai Chi (15 min/ daily)	12	A[a]	TDs[e]	6MWD, MLHFQ, LVEF, AngII, BNP,	100% retention rate
Wang [25] (China)	I~III	56 (28/28) (0)	43%/ 36%	67.0 ± 1.8/ 66.7 ± 2.0	I. Tai Chi (30 min/5 times per week)	12	B[b] (walking, 30 min/5 times per week)	TDs[e]	6MWD, SF-36	100% retention rate
Xiong and Xu [26] (China)	II~III	63 (33/30) (0)	61%/ 60%	70.3 ± 6.4/ 69.7 ± 7.2	II. Qigong (*Baduanjin*) (30 min/daily)	12	A[a]	TDs[e]	6MWD, MLHFQ, LVEF, NT-proBNP	100% retention rate
Xiong [27] (China)	II~III	60 (30/30) (0)	63%/ 60%	70.1 ± 6.3/ 69.4 ± 7.1	II. Qigong (*Baduanjin*) (30 min/daily)	12	A[a]	TDs[e]	MMSE (mental state), ADL	100% retention rate

TABLE 1: Continued.

Source (country)	Populations: NYHA class	Populations: Sample size (drop out) (I/C), #	Populations: Male (I/C), %	Populations: Age, yrs (I/C) mean ± SD	TQPs (time/ frequency]	Period (weeks)	Comparison (A^a/B^b)	Routine management[c]	Outcomes	Adherence to TQPs
Yan [28] (China)	II~IV	72 (36/36) (0)	56%/ 61%	71.4 ± 6.5/ 73.4 ± 6.9	II. Qigong (*Baduanjin and Liu-Zi-Jue*) (NA[d])	52	A^a	TDs[e]; supervision; daily life advice	6MWD, BNP	100% retention rate
Yang [29] (China)	II~IV	60 (30/30) (0)	53%/ 50%	70.5 ± 4.9/ 68.5 ± 4.9	II. Qigong (*Baduanjin and Liu-Zi-Jue*) (15–30 min/5 times per week)	52	A^a	TDs[e]; supervision; daily life advice	6MWD, BNP	100% retention rate
Yao et al. [30] (China)	II	150 (80/ 70) (0)	59%/ 60%	52.4 ± 6.3/ 51.7 ± 7.3	I. Tai Chi (≥30 mins/5 times per week)	24	A^a	TDs[e]; daily life advice	6MWD, MLHFQ, LVEF, LVEDd	100% retention rate
Yeh et al. [31] (US)	I~IV	30 (15/15) (0)	67%/ 60%	66.0 ± 12.0/ 61.0 ± 14.0	I. Tai Chi (60 min/ twice per week)	12	A^a	TDs[e]; dietary counsel; exercise advice	6MWD, VO_{2peak}, MLHFQ, BNP, norepinephrine	100% retention rate, 83% class attendance rate, 93% reported home practice for 86 min/week
Yeh et al. [32] (US)	I~III	100 (50/ 50) (4 (1/ 3))	56%/ 72%	68.1 ± 11.9/ 66.6 ± 12.1	I. Tai Chi (60 min/ twice per week)	12	A^a (education)	TDs[e]; dietary counsel; exercise advice	6MWD, VO_{2peak}, MLHFQ, Norepinephrine, CRP, TNF, Endothelin, TUG, BNP, POMS, SEE	92% retention rate, 75% class attended rate, 93% home practice for 48 min/ week
Yeh et al. [33] (US)	I~III	16 (8/8) (0)	50%/ 50%	68.0 ± 11.0/ 63.0 ± 11.0	I. Tai Chi (60 min/ twice per week)	12	B^b (aerobic exercise: 60 min/ twice per week)	TDs[e]; dietary counsel; exercise advice	6MWD, VO_{2peak}, MLHFQ, TUG, BNP, POMS, SEE, SBP, DBP, LVEF, LAD, LAV, E/A	100% retention rate, 89% class attendance rate
Yu [34] (China)	II~IV	82 (41/41) (0)	46%/ 49%	72.1 ± 8.4/ 71.5 ± 8.4	II. Qigong (*Baduanjin and Liu-Zi-Jue*)(15~30 min/daily)	52	A^a	TDs[e]; daily life advice	6MWD	100% retention rate
Yuan [35] (China)	II~III	60 (30/30) (0)	57%/ 53%	66.3 ± 5.6/ 67.5 ± 3.8	I. Tai Chi (20–40 min/5 times per week)	12	A^a	TDs[e]; education; antidepressants	MLHFQ, HAMD (depression), PSQI (sleep)	100% retention rate
Zheng et al. [12] (China)	II~III	28 (11/9/ 8) (4(2/1/ 1))	67%/ 71%/ 75%	59.5 ± 7.2/ 59.1 ± 9.1_{C1}/ 58.9 ± 8.6_{C2}	II. Qigong (*Liu-Zi-Jjue*) (30 min/daily)	12	$A^a{}_{C1}$; $B^b{}_{C2}$(walking, 30 min/daily)	TDs[e]	6MWD, MLHFQ, LVEF, NT-proBNP	82% retention rate; averaged practice time: 19.7 ± 9.9 mins per day
Shi [36] (China)	II~III	55 (26/29) (5(4/1))	46%/ 59%	58.6 ± 4.2/ 58.2 ± 4.4	II. Qigong (*Baduanjin*) (30 min/daily)	4	A^a	TDs[e]	VO_{2peak}, MLHFQ, VO_{2AT}, VE/VCO_2, NT-proBNP, LVEF	85% retention rate
Yu [37] (China)	I~II	109 (54/ 55) (11 (6/ 5))	42%/ 39%	60.3 ± 8.8/ 60.7 ± 9.7	II. Qigong (*Baduanjin*) (45 min/2–3 times per week)	12	B^b (rehab exercises: 45 min/ twice weekly)	TDs[e]; education; exercise advice	6MWD, VO_{2peak}, MLHFQ, VO_{2AT}, METs, LVEF, LVEDd, NT-proBNP, CRP	89% retention rate

Table 1: Continued.

Source (country)	NYHA class	Populations: Sample size (drop out) (I/C), #	Male (I/C), %	Age, yrs (I/C) mean ± SD	TQPs (time/ frequency]	Period (weeks)	Comparison (A^a/B^b)	Routine management[c]	Outcomes	Adherence to TQPs
Liu [38] (China)	II~III	66 (33/33) (0)	45%/ 48%	55.2 ± 1.3/ 54.8 ± 1.3	I. Tai Chi (30–60 min/ 3-4 times per week)	12	A^a	TDs[e]	6MWD, MLHFQ, LVEF	100% retention rate
Li [39] (China)	II~III	100 (50/ 50) (0)	74%/ 70%	65.3 ± 7.9/ 62.0 ± 9.3	II. Qigong (*Baduanjin*) (20~30 min/≥5 times per week)	12	A^a	TDs[e]	MLHFQ, BNP, CgA	100% retention rate
Yu [14] (China)	I~III	120 (40/ 40/40) (0)	23%/ 24%/ 26%	$58.8 \pm 11.2_{I1}$/ $59.4 \pm 12.1_{I2}$/ 61.8 ± 12.7^{C}	I. Tai Chi (30 min^{I1}, 60 min^{I2}/5 times per week)	24	B^b (walking, 30 min/once daily)	TDs[e]	6MWD, BNP, LVEF	100% retention rate
Yu and Jiang [40] (China)	II~III	98(49/49) (0)	65%/ 61%	65.5 ± 7.0/ 65.8 ± 7.1	III. Tai Chi and Qigong (*Baduanjin*) (30 min/ once $daily^{Tai\ Chi}$; 30 min 5 times $weekly^{BDJ}$)	12	A^a	TDs[e]	6MWD, VO_{2peak}, LVESd, LVEDd, LVEF, E/A, VO_2/HR, SF-36	100% retention rate
Deng et al. [41] (China)	I~III	113 (57/ 56) (2 (2/ 0))	54%/ 52%	64.7 ± 4.2/ 67.2 ± 4.9	I. Tai Chi (40~60 min/ ≥5 times per week)	24	A^a	TDs[e]; daily life advice	6MWD, NT-proBNP, LVEF, HAMA (anxiety), HAMD (depression)	96% retention rate
Lu [42] (China)	III-IV	80 (40/40) (0)	80%/ 23%	69.0 ± 6.8/ 68.6 ± 7.6	II. Qigong (*Baduanjin*) (30 min/twice per day)	52	A^a	TDs[e]	MLHFQ	100% retention rate
Hagglund et al. [43] (Sweden)	NA[d]	45 (25/20) (11 (5/6))	76%/ 80%	76(71–85)/ 76(71–83)	I. Tai Chi (60 min/ twice per week)	16	A^a	TDs[e]	MLHFQ, NT-proBNP, MFI-20 (fatigue), SPPB (balance),	96% retention rate; 72% of participants completed ≥75% of sessions
Redwine et al. [13] (US)	NA[d]	70 (25/23/ 22) (7 (4/ 0/3))	92%/ 86%/ 87%	63.0 ± 9.0/ $67.0 \pm 7.0_{C1}$/ $65.0 \pm 9.0_{C2}$	I. Tai chi (60 min/twice per week)	16	$A^a{}_{C1}$; $B^b{}_{C2}$ (resistant band train: 60 min/ twice per week)	TDs[e]; usual care	6MWD, BDI (depression), LVESd, LVEF	84% retention rate; 87% class attendance rate; a median of 74 min/week practice time
Zheng [44] (Taiwan)	II	91(41/44) (9 (3/6))	72%/ 70%	62.2 ± 15.1/ 66.6 ± 12.7	II. Qigong (*Chan-Chuang*) (≥15 min/2~3 times per day)	12	A^a	TDs[e]	6MWD, HADS (depression), SF-12	93% retention rate

a. A: TQPs versus no TQPs or other exercises; b. B: TQPs versus general exercises; c. Routine managements were given to all participants; d. Data are not available from original papers; e. Therapeutic drugs were prescribed according to heart failure management guidelines. NYHY: New York Heart Association, I: intervention group, C: control group, SD: standard deviation, TQPs: Tai Chi-Qigong Practices, NA: not available, TDs: therapeutic drugs, MLHFQ: Minnesota Living with Heart Failure Questionnaire, SCL-90-R: symptom checklist-90-revised, SBP: systolic blood pressure, DBP: diastolic blood pressure, ISWT: incremental shuttle walk test, 6MWD: 6-minute walking distance, NTpro-BNP: N-terminal B-type natriuretic peptide, QoL-VAS: quality of life assessment by a visual analog scale, MacNewQL: MacNew quality of life after myocardial infarction questionnaire, PFS: piper fatigue scale, VO_{2peak}: peak oxygen consumption, VO_{2AT}, oxygen consumption at anaerobic threshold, O_2: oxygen, LVEF: left ventricular ejection fraction, LVEDd: left ventricular end-diastolic diameter, BNP: B-type natriuretic peptide, cTNT: cardiac troponin-T, BDI: beck depression inventory, MFSI-S: multidimensional fatigue symptom inventory–short form, AngII: angiotensin II, MMSE: minimental state examination, ADL: daily activities, CRP: C-reactive protein, TNF: tumor necrosis factor, TUG: Time Up and Go test, POMS: profile of mood state, SEE: self-efficacy for exercise, LAD: left atrial dimension, LAV: left atrial volume, HAMD: Hamilton depression rating scale, PSQI: Pittsburgh sleep quality index, VE/VCO_2: ventilatory equivalents for carbon dioxide, CgA: chromogranin A, LVESd: left ventricular end-systolic diameter, HAMA: Hamilton anxiety rating scale, MFI-20: multidimensional fatigue inventory-20 items, SPPB: short physical performance battery, HADS: hospital anxiety and depression scale.

3.1.4. Comparators. In terms of the comparison, 26 studies compared TQPs plus RMs against RMs alone [15–20, 22–24, 26–32, 34–36, 38–44]. Five studies compared TQPs plus RMs against general exercises plus RMs [14, 21, 25, 33, 37], one of which applied two TQP groups using Tai Chi with different practice times (30 minutes vs. 60 minutes) [14]. There were two 3-arm studies that included two control groups comparing TQPs plus RMs vs. general exercises plus RMs vs. RMs [12, 13]. Generally, RMs included standard pharmacological treatments in all of the RCTs; in some of the RCTs, it also included education, dietary counseling, and/or general exercise advice.

3.1.5. Outcomes. Results of three primary outcomes (MLHFQ, 6MWD, and VO_{2peak}) and two secondary outcomes (LVEF and BNP) are summarized in Figure 1.

3.2. MLHFQ. (A) *TQPs plus RMs versus RMs.* The addition of TQPs produced a statistically significant lower MLHFQ score (better quality of life), but the heterogeneity was considerable (14 RCT [12, 15, 17–19, 24, 26, 30–32, 35, 36, 38, 42], $n = 10{,}000$; MD: −8.63 scores; 95% CI, −10.60 to −6.67; $I^2 = 94\%$; Figure 2A). The subgroup analysis based on TQP types and program durations did not resolve the heterogeneity (Figure 2A).

(B) *TQPs versus General Exercise.* The pooled results also showed statistically significant lower MLHFQ scores in the TQPs group than in the general exercise group, but again heterogeneity was considerable (4 RCTs [12, 21, 33, 37], $n = 203$; MD: −9.18 scores; 95% CI, −17.95 to −0.41; $I^2 = 86\%$; Figure 2B). Subgroup analyses revealed that TQP durations and HF subtype might explain the heterogeneity (Figure 2B).

3.3. 6MWD

3.3.1. TQPs plus RMs versus RMs. The pooled results from 17 RCTs [12, 13, 19, 20, 22, 24, 26, 28–32, 34, 38, 40, 41, 44] ($n = 1{,}416$) showed that adding TQPs led to a statistically significant 56.52 meter increase in 6MWD (95% CI, 41.27 to 71.78), but the heterogeneity was considerable ($I^2 = 88\%$; Figure 3A). In the subgroup analyses, the heterogeneity declined in the Qigong subgroup and the 12-week subgroup (Figure 3A).

3.3.2. TQPs versus General Exercise. The pooled results, though not statistically significant, showed that TQPs were more effective, but with considerable heterogeneity (7 RCTs [12–14, 16, 21, 33, 37], $n = 428$; MD: 46.66 meters; 95% CI, −18.17 to 111.49; $I^2 = 98\%$) (Figure 3B). Deleting the study with the stronger effect [21] reduced the heterogeneity to $I^2 = 20\%$, without changing the results' significance (Supplementary Materials: eTable 1). TQP durations might also explain the heterogeneity (Figure 3B).

3.4. VO_{2peak}

3.4.1. TQPs plus RMs versus RMs. The pooled results from 4 RCTs [18, 31, 32, 36, 37] ($n = 245$) showed that adding TQPs into RMs can lead to a statistically significant 1.24 mL/kg/min improvement in patients' VO_{2peak} (95% CI, 0.91 to 1.57; $I^2 = 0\%$; Figure 4A).

3.4.2. TQPs versus General Exercise. The pooled MD, although not statistically significant, showed that TQPs were more effective (2 RCTs [33, 37], $n = 125$; MD: 0.14 mL/kg/min, 95% CI, −0.43 to 0.7; $I^2 = 0\%$; Figure 4B). Both of these RCTs included HFpEF patients, and both lasted for 12 weeks.

3.5. Secondary Outcomes. The addition of TQPs showed a small but significant improvement in the LVEF (Figure 5A), as well as in the BNP (Figure 6A). Similarly, when compared to general exercises, the pooled MD showed that TQPs were more effective for the LVEF (Figure 5B), as well as for the BNP (Figure 6B). However, neither was statistically significant. Results of other secondary clinical outcomes reported in more than one study are presented in Table 2.

3.6. Sensitivity Analysis. Sensitivity analysis showed that most of the pooled results were robust when removing each study individually. When comparing TQPs with general exercises, the beneficial effects of TQPs on MLHFQ became statistically insignificant if 2 studies were removed individually (Supplementary Materials: eTable 1). For the pool of 6MWD comparing TQPs with general exercises, deleting one study [21] made the beneficial effects of TQPs significant and reduced the heterogeneity from $I^2 = 97\%$ to $I^2 = 20\%$ (Supplementary Materials: eTable 1). In the BNP sensitivity analysis, deleting Pan's study [22] reduced the heterogeneity from $I^2 = 95\%$ to $I^2 = 39\%$, without changing the results' significance (Supplementary Materials: eTable 1).

3.7. TQP Safety and Patient Adherence. No adverse event related to TQPs was found in the included studies, and patient dropout in the TQP groups was low, with most withdrawals being due to hospitalization or CHF exacerbation. TQP adherence was good. The retention rate in the TQP groups ranged from 67% to approximately 100%. The six studies that included TQP training classes reported attendance between 75% and 89% [13, 23, 31–33, 43] (Table 1).

3.8. Evidence Quality and Certainty. Individual items on the risk-of-bias assessment are shown in Figures 12 and 13 in Supplementary Materials. As TQP is an exercise training, designing an experiment with a credible placebo-control arm is challenging. Thus, all RCTs were open-label. All studies were unclear on outcome assessment blinding except for two RCTs [32, 33] in which the authors claimed that the outcome assessors had been blind to patient treatment allocation. Only half of the RCTs provided adequate random sequence generation [16–19, 22, 25, 29, 35–40, 44], and only

Outcomes (measurements)	Source				Effect size			Level of Certainty	Certainty assessment				
	Countries (year range)	NYHA	LVEF range	No. of patients (RCTs)	Mean difference (95% CI)	I^2	Referred figure		Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias
A. [Taichi-Qigong-Practice plus RM] vs [RM]													
- Qualigy of life (MLHFQ) FU: 4~52 wks	China/Taiwan/ US/UK (2004~2019)	I~IV	22~60% (n = 687) ≤50% (n = 115) unknown (n = 198)	1000 (14)	−8.63 scores (−10.60 to −6.67)	94%	Figure 2A	Moderate	Not serious	Serious[c]	Not serious	Not serious	Not serious
- Exercise capacity (6MWD) FU: 4~52 wks	China/Taiwan/ US (2004~2019)	I~IV	22~52% (n = 865) unknown (n = 551)	1416 (17)	59.63 meters (43.35 to 75.90)	88%	Figure 3A	Moderate	Not serious	Serious[c]	Not serious	Not serious	Not serious
- Exercise function (Peak VO_2) FU: 4~24 wks	China/US (2004~2018)	I~IV	22~42% (n = 190) ≤50% (n = 55)	245 (4)	1.24 mL/kg/min (0.91 to 1.57)	0%	Figure 4A	Moderate	Not serious	Not serious	Not serious	Serious[d]	Undetected
- Echocardiography (LVEF) FU: 4~24 wks	China (2010~2019)	I~III	30~52% ≤ (n = 747) 50% (n = 55) unknown (n = 66)	868 (11)	3.97% (1.22 to 6.72)	96%	Figure 5A	Moderate	Not serious	Serious[c]	Not serious	Not serious	Not serious
- Laboratory test (BNP) FU: 4~52 wks	China/US (2004~2019)	I~IV	22~49% (n = 279) ≥50% (n = 100) unknown (n = 312)	691 (8)	−76.12 pg/mL (−134.61 to −17.62)	95%	Figure 6A	Moderate	Not serious	Serious[c]	Not serious	Not serious	Undetected
B. [Taichi-Qigong-Practice plus RM] vs [General Exercises plus RM]													
- Qualigy of life (MLHFQ) FU: 8~12 wks	China/US (2013~2018)	I~III	52~65% (n = 34) ≥40% (n = 109) unknown (n = 60)	203 (4)	−9.18 scores (−17.95 to −0.41)	86%	Figure 2B	Low	Serious[a]	Serious[c]	Not serious	Serious[d]	Undetected
- Exercise capacity (6MWD) FU: 12~24 wks	China/ Italy/US (2011~2019)	I~III	31~65% (n = 260) ≥40% (n = 108) unknown (n = 60)	428 (7)	46.66 meters (−18.17 to 111.49)	97%	Figure 3B	Low	Serious[b]	Serious[c]	Not serious	Serious[d]	Undetected
- Exercise function (Peak VO2) FU: 12 wks	China/US (2013~2018)	I~III	62~65% (n = 16) ≥40% (n = 109)	125 (2)	0.14 mL/kg/min (−0.43 to 0.70)	0%	Figure 4B	Moderate	Not serious	Not serious	Not serious	Serious[d]	Undetected
- Echocardiography (LVEF) FU: 12~24 wks	China/US (2013~2019)	I~III	31~65% (n = 273) ≥40% (n = 109)	382 (4)	3.17% (−1.25 to 7.59)	0%	Figure 5B	Moderate	Not serious	Not serious	Not serious	Serious[d]	Undetected
- Laboratory test (BNP) FU: 12~24 wks	China/US (2013~2019)	I~III	31~65% (n = 136)	136 (2)	61.29 pg/mL (−52.22 to 174.79)	77%	Figure 6B	Low	Not serious	Serious[c]	Not serious	Serious[d]	Undetected

Figure 1: Summary of findings. a: 30% of the information from 1 high-risk RCT; removing this RCT significantly altered the effect estimates; 25% of the studies had a high risk of the randomization process. b: 20% of the information from 1 high-risk RCT; removing this RCT moderately altered the size of effect estimates; 17% of the studies had a high risk of the randomization process. c: considerable heterogeneity based on I^2. d: imprecision, as OIS criteria were not met, primarily due to the small sample size (<400). 6MWD: 6-minute walking distance, BNP: B-type natriuretic peptide, CI: confidence interval, FU: follow-up, LVEF: left ventricular ejection fraction, MLHFQ: Minnesota Living with Heart Failure Questionnaire, NYHA: New York Heart Association, Peak VO2: peak oxygen consumption, RCT: randomized controlled trial, RM: routine management (according to current guidelines).

five RCTs reported allocation concealment methods [13, 17, 31, 37, 44]. Twenty-nine (88%) studies were at unclear risk of selective reporting because neither protocol nor trial registration info was available.

Publication bias analyzed by funnel plots showed only minor asymmetry (Supplementary Materials: eFigure 14), and there was no evidence of funnel plot asymmetry for 6MWD ($p = 0.10$), MLHFQ ($p = 0.817$), or LVEF ($p = 0.929$). Thus, a publication bias mechanism is not a major cause for concern.

Evidence from RCTs indicated (with a moderate level of certainty) that the addition of TQPs into RMs was associated with a better quality of life, improved exercise capacity, increased LVEF, and reduced BNP level, as compared with the associated with the RMs alone. Low evidence certainty showed that TQPs were associated with a larger improvement in the quality of life and exercise capacity than general exercise (Figure 1).

4. Discussion

This systematic review identified 33 RCTs with a total of 2,465 participants to evaluate the evidence of rehabilitative effects from TQPs for patients with CHF. There are three main findings. (1) When compared to RMs, TQPs plus RMs improved VO_{2peak}, 6MWD, and MLHFQ, and the pooled effects were robust with heterogeneity found in 6MWD and MLHFQ, but not in VO_{2peak}. In addition, TQPs might have beneficial effects on other clinical outcomes such as LVEF and BNP. (2) When compared to general exercise, superior improvements were found in the TQP group; they were significant in MLHFQ, but not in VO_{2peak}, 6MWD, LVEF, or BNP. (3) Evidence was also found that TQP is safe and that there is high adherence to TQP programs.

Quality of life and exercise capacity are two different domains of interest in rehabilitation research [45]. The positive results of MLHFQ suggest that TQPs can improve CHF patients' quality of life. The present findings are consistent with those of other systematic reviews and meta-analyses of RCTs of Tai Chi for CHF [46–48]. Moreover, the pooled effects are also clinically significant, with the effect estimate being greater than the minimally important clinical difference of 5 points [49] (Figure 2). TQPs are characterized by the interplay between flowing circular physical postures and movements, mindful awareness, and breathing techniques in a harmonious manner [5]. Hence, they exert less

	Subgroups	No. of studies	No. of patients	Statistical method	Mean difference (95% CI)	I^2
A. TQPs vs no exercise						
Total	All	14	1000	RM	−8.63 (−10.60 to −6.67)	94
TQP types	-Tai Chi	8	654	RM	−8.50 (−10.88 to −6.13)	93
	-Qigong	5	294	RM	−8.75 (−12.98 to −4.52)	95
	-TC&QG	1	52	RM	−13.50 (−22.53 to −4.47)	NA
Duration	-4 weeks	2	143	RM	−7.48 (−17.41 to 2.44)	94
	-12 weeks	8	515	RM	−8.66 (−10.69 to −6.62)	92
	-16 weeks	1	52	RM	−13.50 (−22.53 to −4.47)	NA
	-24 weeks	2	210	RM	−11.77 (−14.80 to −8.75)	0
	-52 weeks	1	80	RM	−2.60 (−3.77 to −1.43)	NA
B. TQPs vs general exercise						
Total	All	4	203	RM	−9.18 (−17.95 to −0.41)	86
TQP types	-Tai Chi	1	16	RM	0.10 (−20.47 to 20.67)	NA
	-Qigong	3	187	RM	−10.44 (−20.12 to −0.77)	90
Duration	-8 weeks	1	60	RM	−18.11 (−24.21 to −12.01)	NA
	-12 weeks	3	143	RM	−5.63 (−11.76 to 0.51)	53
EF subtype	-HFrEF	2	78	RM	−14.73 (−21.76 to −7.70)	57
	-HFpEF	2	125	RM	−3.05 (−6.00 to −0.11)	0

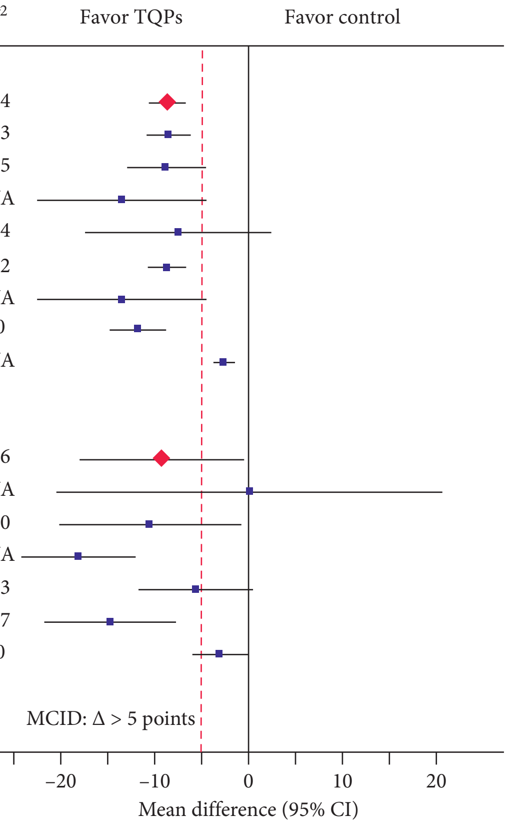

Figure 2: Meta-analysis results for MLHFQ (total score) including overall pooled effects and subgroup effects. The pooled effect from all included studies and each subgroup is shown in red diamond and blue square, respectively. Both are along with their 95% confidence intervals. Meta-analysis results showing individual study data are presented in Supplementary Materials: eFigures 2 and 3 for part A and part B, respectively. MLHFQ: Minnesota Living with Heart Failure Questionnaire, No.: number, CI: confidence interval, TQP: Tai Chi and Qigong Practice, NA: not available, TC&QG: Tai Chi and Qigong, RM: random-effects model, MCID: minimum clinically important difference, EF: ejection fraction, HFrEF: heart failure with reduced ejection fraction, HFpEF: heart failure with perceived ejection fraction.

cardiopulmonary stress and enable the body to relax after practicing. They also address breathing, a crucial aspect of CHF management. Slowing breathing patterns allows more complete inspiration/expiration and gas exchange in patients with CHF [50]. This mitigates their symptoms, thus improving their quality of life.

We found a moderate level of evidence that the addition of TQPs into RMs benefits CHF patients' exercise capacity. Firstly, positive results were found for the 6MWD, both in the overall pooling of 17 studies (60 meters) and in each of the TQP subgroups. Our results are consistent with a previous systematic review of Tai Chi which reported a similar improvement of 50 meters [46]. The pooled improvements were also clinically relevant because they are larger than the minimum clinically important difference (>30 meters) [51].

Secondly, positive results were also found for the VO_{2peak} which is the gold standard for assessing exercise capacity [52]. This reinforces the beneficial gains in exercise capacity by practicing TQPs for CHF patients. Unlike findings from previous reviews which reported that Tai Chi could not change the VO_{2peak} [46–48], there was a positive result for VO_{2peak} in the Tai Chi subgroup in our study. Our meta-analysis involves two more recent RCTs [18, 36] which were not included in those previous meta-analyses. This results in a larger sample size. In addition, we have restricted our attention to those studies without exercise controls. Studies with exercise controls, similar to the active-control in the pharmacological trials, are expected to have negative results and the effects' estimates are usually smaller than those of placebo-control trials, especially for the open-label studies.

Evidence from the RCTs indicated (with a low level of certainty) that TQPs may have rehabilitation effects on quality of life and exercise capacity that are similar to those of general aerobic exercises. Our findings show that TQPs' benefits are superior to those of general exercise at improving quality of life (MD: −9.18). This has not been reported in earlier studies. The effect size is similar to that reported in a Cochrane systematic review [53], in which the reviewers compared all exercise interventions with usual care (−7.11 points, 95% CI −10.49 to −3.73). In addition, the magnitude of the pooled improvements from the TQPs in VO_{2peak} and 6MWD was similar to that of the pooled improvements from conventional exercise modalities in other systematic reviews, respectively [54, 55]. Moreover, although the pooled effect estimate for 6MWD was not statistically

	Subgroups	No. of studies	No. of patients	Statistical method	Mean difference (95% CI)	I^2
A. TQPs vs no exercise						
Total	All	17	1416	RM	59.63 (43.35 to 75.9)	88
TQP types	-Tai Chi	9	754	RM	50.99 (27.01 to 74.97)	92
	-Qigong	7	564	RM	74.11 (59.50 to 88.71)	0
	-TC&QG	1	98	RM	49.47 (33.95 to 64.99)	NA
Duration	-4 weeks	1	88	RM	0.53 (−13.08 to 14.14)	NA
	-12 weeks	8	564	RM	48.95 (34.32 to 63.59)	59
	-16 weeks	1	48	RM	−9.00 (68.69 to 50.69)	NA
	-24 weeks	3	322	RM	88.32 (34.00 to 142.65)	94
	-52 weeks	4	394	RM	81.42 (60.66 to 102.18)	0
B. TQPs vs general exercise						
Total	All	7	428	RM	46.66 (−18.17 to 111.49)	97
TQP types	-Tai Chi	4	243	RM	14.35 (−10.11 to 38.81)	32
	-Qigong	3	185	RM	93.10 (−33.13 to 219.34)	99
Duration	-8 weeks	1	55	RM	181.89 (162.26 to 201.52)	NA
	-12 weeks	4	223	RM	22.65 (12.09 to 33.21)	0
	-16 weeks	1	62	RM	−51.00 (−122.85 to 10.85)	NA
	-24 weeks	1	120	RM	26.35 (−3.67 to 56.37)	NA

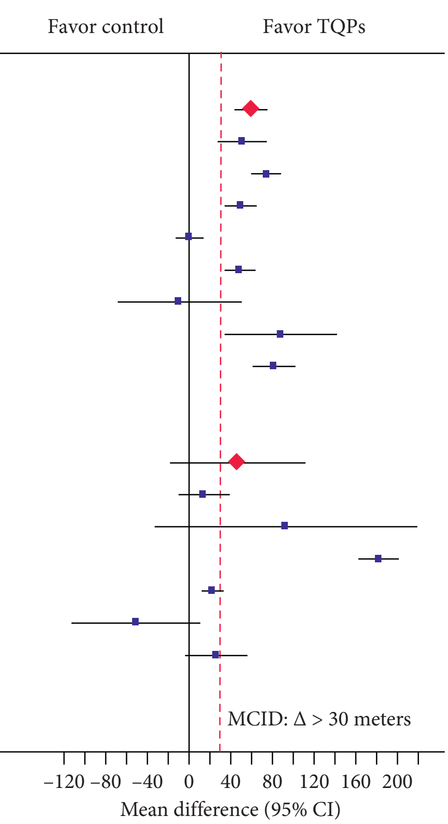

Figure 3: Meta-analysis results for 6MWD (meters) including overall pooled effects and subgroup effects. The pooled effect from all included studies and each subgroup is shown in red diamond and blue square, respectively. Both are along with their 95% confidence intervals. Meta-analysis results showing that individual study data are presented in Supplementary Materials: eFigures 4 and 5 for part A and part B, respectively. 6MWD: 6-minute walking distance, No.: number, CI: confidence interval, TQP: Tai Chi and Qigong Practice, NA: not available, TC&QG: Tai Chi and Qigong, RM: random-effects model, MCID: minimum clinically important difference.

significant when compared to general exercise controls, it is clinically significant as it exceeds the minimum important clinical difference of 30 meters [51].

The improvements in LVEF and BNP provide further objective evidence (with a moderate level of certainty) for TQPs' benefit in patients with CHF. The pooled effect of LVEF and BNP is consistent with previous research [46]. The possible mechanisms for the improvement observed in LVEF and BNP in trials of TQP therapy have yet to be established. TQPs, as a moderate-intensity exercise, could improve the parasympathetic nervous degree, inhibit sympathetic activity, and increase coronary collateral circulation, cardiac stroke volume, and cardiac output. In this way, it could reduce BNP and increase LVEF [56].

It is also worth noting that no adverse events were reported, and patient dropout in the TQP groups was low, with most withdrawals being due to hospitalization or CHF exacerbation. The included RCTs showed that participants had good adherence to TQP programs. These results indicate that TQPs are safe and engender good patient compliance.

5. Limitations

There are several limitations to this review:

Firstly, the interpretation of our results may be challenged by the heterogeneity observed. Sensitivity analyses by TQP styles or durations revealed some sources of heterogeneity but were unable to account for all of the variations. For example, practitioner expertise, heart failure etiopathogenesis, NYHA classification, and patients with different cultural backgrounds were each revealed to be potential sources of heterogeneity. As many individuals or combined factors may have influenced heterogeneity, this study did not succeed in identifying the reasons for this.

Secondly, the descriptions of the 33 RCTs regarding the randomization method, allocation concealment, and blinding evaluation were neither detailed nor comprehensive. Therefore, the included studies might exhibit moderate selection, implementation, and measurement biases. Because of the intervention itself, participants could identify they were in the experimental group. Trials with inadequate blinding are likely to exaggerate treatment effects, especially with regard to subjective results and with participants with knowledge of Chinese traditional culture.

Thirdly, training characteristics regarding training intensity are rarely described adequately enough to

	Subgroups	No. of studies	No. of patients	Statistical method	Mean difference (95% CI)	I^2
A. TQPs vs no exercise						
Total	All	4	245	FM	1.24 (0.91 to 1.57)	0
TQP types	-Tai Chi	3	190	FM	1.14 (068 to 1.61)	0
	-Qigong	1	55	FM	1.35 (0.88 to 1.82)	NA
Duration	-4 weeks	1	55	FM	1.35 (0.88 to 1.82)	NA
	-12 weeks	2	130	FM	0.21 (−1.36 to 1.78)	0
	-24 weeks	1	60	FM	1.23 (0.74 to 1.72)	NA
B. TOPs vs general exercise						
Total	All	2	125	FM	0.14 (−0.43 to 0.70)	0
TQP types	-Tai Chi	1	16	FM	2.20 (−2.80 to 7.20)	NA
	-Qiugong	1	109	FM	0.11 (−0.46 to 0.68)	NA
Duration	-12 weeks	2	125	FM	0.14 (−0.43 to 0.70)	0

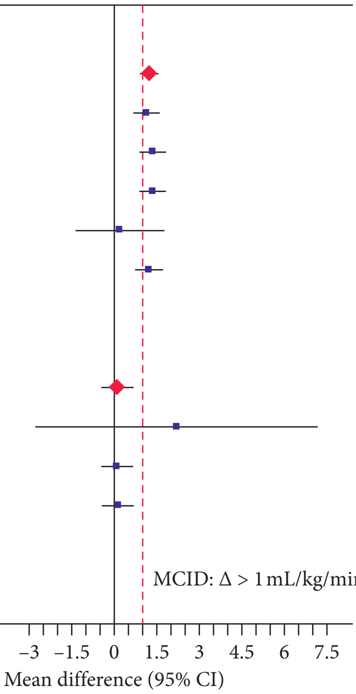

Figure 4: Meta-analysis results for peak VO2 (mL/kg/min) including overall pooled effects and subgroup effects. The pooled effect from all included studies and each subgroup is shown in red diamond and blue square, respectively. Both are along with their 95% confidence intervals. Meta-analysis results showing that individual study data are presented in Supplementary Materials: eFigures 6 and 7 for part A and part B, respectively. VO2: oxygen consumption, No.: number, CI: confidence interval, TQP: Tai Chi and Qigong Practice, NA: not available, RM: random-effects model, FM: fixed-effects model, MCID: minimum clinically important difference.

	Subgroups	No. of studies	No. of patients	Statistical method	Mean difference (95% CI)	I^2
A. TQPs vs no exercise						
Total	All	11	868	RM	3.97 (1.22 to 6.72)	96
TQP types	-Tai Chi	7	636	RM	4.82 (1.05 to 8.60)	97
	-Qigong	3	134	RM	0.94 (−3.78 to 5.65)	83
	-TC&QG	1	98	RM	5.13 (3.04 to 7.22)	NA
Duration	-4 weeks	2	143	RM	0.19 (−2.48 to 2.87)	70
	-12 weeks	2	143	RM	0.19 (−2.48 to 2.87)	98
	-52 weeks	4	382	RM	3.17 (−1.25 to 7.59)	90
B. TQPs vs general exercise						
Total	All	4	382	RM	3.17 (−1.25 to 7.59)	0
TQP types	-Tai Chi	2	136	FM	1.98 (−0.91 to 4.88)	11
	-Qigong	2	126	FM	1.11 (−1.92 to 4.15)	0
Duration	-12 weeks	3	142	FM	0.72 (−2.11 to 3.55)	0
	-24 weeks	1	120	FM	2.60 (−0.51 to 5.71)	NA

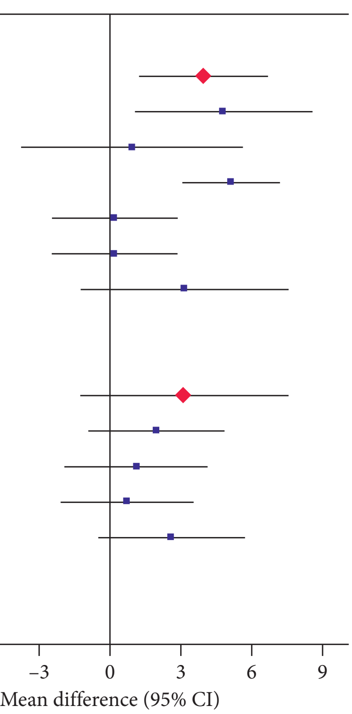

Figure 5: Meta-analysis results for LVEF (%) including overall pooled effects and subgroup effects. The pooled effect from all included studies and each subgroup is shown in red diamond and blue square, respectively. Both are along with their 95% confidence intervals. Meta-analysis results showing that individual study data are presented in Supplementary Materials: eFigures 8 and 9 for part A and part B, respectively. LVEF: left ventricular ejection fraction, No.: number, CI: confidence interval, TQP: Tai Chi and Qigong Practice, NA: not available, TC&QG: Tai Chi and Qigong, RM: random-effects model, FM: fixed-effects model, MCID: minimum clinically important difference.

	Subgroups	No. of studies	No. of patients	Statistical method	Mean difference (95% CI)	I^2
A. TQPs vs no exercise						
Total	All	8	691	RM	−76.12 (−134.61 to −17.62)	95
TQP types	-Tai Chi	4	279	RM	−73.44 (−196.86 to 49.98)	96
	-Qigong	4	412	RM	−52.10 (−75.21 to −28.99)	42
Duration	-4 weeks	1	88	RM	−0.18 (−40.90 to 40.54)	NA
	-12 weeks	3	230	RM	−38.81 (−52.17 to −25.45)	0
	-24 weeks	1	61	RM	−181.00 (−201.29 to −160.71)	NA
	-52 weeks	3	312	RM	−72.87 (−116.33 to −29.41)	18
B. TQPs vs general exercise						
Total	All	2	136	RM	61.29 (−52.22 to 174.79)	77
TQP types	-Tai Chi	2	136	RM	61.29 (−52.22 to 174.79)	77
Duration	-12 weeks	1	16	RM	−9.00 (−114.68 to 96.68)	NA
	-24 weeks	1	120	RM	109.00 (78.41 to 139.59)	NA

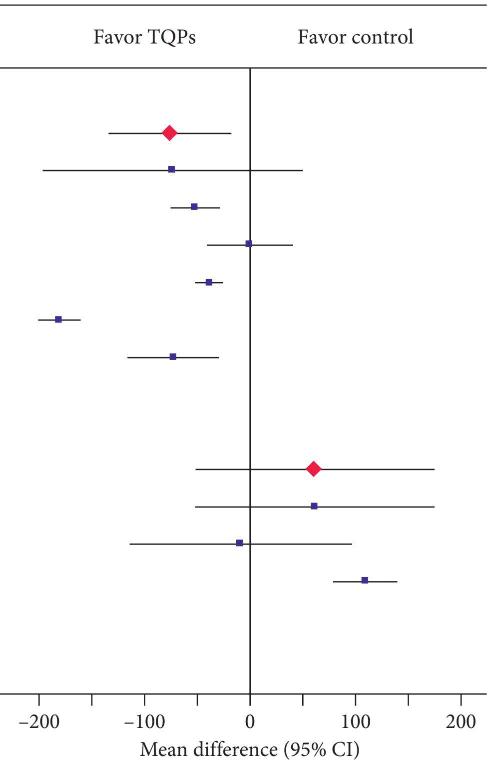

Figure 6: Meta-analysis results for BNP (pg/mL) including overall pooled effects and subgroup effects. The pooled effect from all included studies and each subgroup is shown in red diamond and blue square, respectively. Both are along with their 95% confidence intervals. Meta-analysis results showing that individual study data are presented in Supplementary Materials: eFigures 10 and 11 for part A and part B, respectively. BNP: B-type natriuretic peptide, No.: number, CI: confidence interval, TQP: Tai Chi and Qigong Practice, NA: not available, RM: random-effects model, MCID: minimum clinically important difference.

Table 2: Meta-analysis results of clinical outcomes with more than one study.

Outcomes measurements	No. of RCTs	No. of patients	Statistical method	Effect sizes MD (95% CI)	Effect sizes p value	Heterogeneity (I^2) (%)
A. (Tai Chi and Qigong Practice plus RM) vs. (RM)						
NT-proBNP, pg/mL	6	350	MD, REM	−232.05 (−578.87 to 114.78)	0.19	97
VO_{2AT}, ml/kg/min	2	115	MD, REM	1.43 (0.59 to 2.28)	0.0009	93
LVEDd, mm	4	397	MD, REM	−3.00 (−5.09 to −0.91)	0.005	63
Depression	6	462	SMD, REM	−0.64 (−1.03 to −0.25)	0.001	76
Anxiety	2	163	SMD, FEM	−1.00 (−2.41 to 0.41)	0.17	94
Mood state	2	160	SMD, REM	−0.08 (−1.47 to 1.31)	0.91	94
Fatigue	2	125	SMD, REM	0.01 (−1.07 to 1.09)	0.98	88
Norepinephrine	2	130	MD, FEM	0.51 (−0.71 to 1.72)	0.41	0
SF-36-bodily pain	2	159	MD, REM	5.84 (0.62 to 11.06)	0.03	80
SF-36-mental health	2	159	MD, REM	6.55 (1.78 to 11.32)	0.007	58
SF-36-physical function	2	159	MD, FEM	6.73 (4.05 to 9.42)	<0.00001	20
SF-36-role emotional	2	159	MD, FEM	5.60 (2.78 to 8.43)	<0.0001	48
SF-36-role physical	2	159	MD, REM	9.87 (0.52 to 19.22)	0.04	92
SF-36-social function	2	159	MD, FEM	6.78 (4.09 to 9.47)	<0.00001	0
SF-36-vitality	2	159	MD, REM	8.28 (0.77 to 15.79)	0.03	91
Hospitalizations per capita	3	322	MD, FEM	−0.82 (−0.95 to −0.69)	<0.00001	$I^2 = 0$
Hospitalization cost per capita	3	322	MD, FEM	−1.60 (−1.85 to −1.36)	<0.00001	$I^2 = 0$
B.(Tai Chi and Qigong Practice plus RM) vs. (general exercises plus RM)						
NT-proBNP, pg/mL	3	186	MD, FEM	−12.01 (−23.65 to −0.37)	0.04	0
SBP, mmHg	2	76	MD, FEM	−9.60 (−22.02 to 2.83)	0.13	0
DBP, mmHg	2	76	MD, FEM	0.82 (−5.27 to 6.92)	0.79	0
Depression	2	63	SMD, FEM	−0.28 (−0.77 to 0.22)	0.28	0

RCT: randomized controlled trial, CI: confidence interval, RM: routine management, NT-proBNP: *N*-terminal B-type natriuretic peptide, VO_{2AT}: oxygen consumption at anaerobic threshold, MD: mean difference, SMD: standardized mean difference, REM: random-effects model, FEM: fixed-effects model, LVEDd: left ventricular end-diastolic end-systolic diameters, SBP: systolic blood pressure, DBP: diastolic blood pressure.

evaluate TQP's dose-response effects, i.e., to render the studies replicable, or to interpret the findings' validity and translate the interventions into practice. This might be due to the fact that there is still no standardized method to measure TQPs' intensity. As exercise intensity is reported to be the most critical component for improving cardiorespiratory fitness [57], future research on TQPs should provide descriptions of intensity, in combination with frequency, duration, and adherence.

Lastly, the majority of this review's sample is from China, but people from different cultures may experience variegated responses to TQPs. Moreover, rehabilitation-related trials have been investigating the efficacy of exercises in selective populations, such as women, the elderly, ethnic minorities, HFpEF, and high-risk patients. Future research might also identify subgroups that benefit the most/least from TQPs.

6. Conclusions

The findings of this systematic review and meta-analysis suggest that based on moderate-level evidence, adding TQPs into RMs was associated with statistically significant improvements to the quality of life and exercise capacity in CHF patients. In addition, evidence from RCTs indicated (with a low level of certainty) that TQPs may have similar rehabilitation effects as general aerobic exercises. Considering the lack of special equipment requirements, low costs, and multiple physical benefits, TQPs may represent a promising rehabilitation therapy as an adjunct to routine pharmacotherapies or as an alternative to conventional exercises. Incorporation into cardiac rehabilitation programs for patients with CHF should be considered, especially in home-based settings.

Abbreviations

6MWD: 6-minute walking distance
BNP: B-type natriuretic peptide
CHF: Chronic heart failure
CI: Confidence intervals
EBCR: Exercise-based cardiac rehabilitation
IQR: Interquartile range
LVEF: Left ventricular ejection fraction
MD: Mean difference
MLHFQ: Minnesota Living with Heart Failure Questionnaire
NYHA: New York Heart Association
RCT: Randomized controlled trial
RM: Routine management
SD: Standard deviation
SMD: Standardized mean difference
TQP: Tai Chi and Qigong Practice
VO_{2peak}: Peak oxygen consumption.

Data Availability

Data are available upon request to the corresponding author.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Supplementary Materials

eTable 1: sensitivity analysis of the effect size of Peak VO2, 6MWD, MLHFQ, LVEF, and BNP. eFigure 1: flow chart of study identification and selection. eFigure 2: MLHFQ total scores, TQPs plus RMs versus RMs (supplements to Figure 2(a)). eFigure 3: MLHFQ total scores, TQPs plus RMs versus general exercises plus RMs (supplements to Figure 2(b)). eFigure 4: 6MWD (meters), TQPs plus RMs versus RMs (supplements to Figure 3(a)). eFigure 5: 6MWD (meters), TQPs plus RMs versus general exercises plus RMs (supplements to Figure 3(b)). eFigure 6: Peak VO2 (mL/kg/min), TQPs plus RMs versus RMs (supplements to Figure 4(a)). eFigure 7: Peak VO2 (mL/kg/min), TQPs plus RMs versus general exercises plus RMs (supplements to Figure 4(b)). eFigure 8: LVEF (%), TQPs plus RMs versus RMs (supplements to Figure 5(a)). eFigure 9: LVEF (%), TQPs plus RMs versus general exercises plus RMs (supplements to Figure 5(b)). eFigure 10: BNP (pg/mL), TQPs plus RMs versus RMs (supplements to Figure 6(a)). eFigure 11: BNP (pg/mL), TQPs plus RMs versus general exercises plus RMs (supplements to Figure 6(b)). eFigure 12: risk-of-bias summary: eFigure 13: risk-of-bias graph. eFigure 14: publication bias. (*Supplementary Materials*)

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Research Article

Effects of 16-Form Wheelchair Tai Chi on the Autonomic Nervous System among Patients with Spinal Cord Injury

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Objective. This study aims to investigate the effects of 16-form Wheelchair Tai Chi (WCTC16) on the autonomic nervous system among patients with spinal cord injury (SCI). *Methods*. Twenty patients with chronic complete thoracic SCI were recruited. Equivital life monitoring system was used to record and analyze heart rate variability (HRV) of patients for five minutes before and after five consecutive sets of WCTC16, respectively. The analysis of HRV in the time domain included RR intervals, the standard deviation of all normal RR intervals (SDNN), and the root mean square of the differences between adjacent NN intervals (RMSSD). The analysis of HRV in the frequency domain included total power (TP), which could be divided into very-low-frequency area (VLFP), low-frequency area (LFP), and high-frequency area (HFP). The LF/HF ratio as well as the normalized units of LFP (LFPnu) and HFP (HFPnu) reflected the sympathovagal balance. *Results*. There was no significant difference in RR interval, SDNN, RMSSD, TP, HEP, VLFP, and LFP of SCI patients before and after WCTC16 exercise ($P > 0.05$). LFPnu and HF peak decreased, while HFPnu and LF/HF increased in SCI patients after WCTC16 exercise. The differences were statistically significant ($P < 0.001$). *Conclusion*. WCTC16 can enhance vagal activity and decrease sympathetic activity so that patients with chronic complete thoracic SCI can achieve the balanced sympathovagal tone.

1. Introduction

Spinal cord injury (SCI) refers to damage to the structure and function of the spinal cord due to various reasons, resulting in sensory, motor, and autonomic dysfunction below the injury level [1]. Autonomic dysfunction after SCI is a common complication with an incidence of 43% [2], which can lead to stroke, convulsions, cardiac arrest, and death [3].

Autonomic dysfunction is a potentially life-threatening complication that occurs in patients with SCI [4]. Autonomic disorders are currently the main cause of death in patients with chronic SCI [5]. Some scholars have pointed out that autonomic dysfunction can reach a relatively "internally stable" state through complex adjustments in patients with chronic SCI [6–8]. For example, after the sympathetic innervation of the heart in patients with chronic quadriplegia is interrupted, the brain can also send signals that inhibit the activity of the parasympathetic nerve in order to maintain the homeostasis of the sympathetic-vagus nerve and simultaneously provoke reduction of sympathetic and parasympathetic nerve activity meaning autonomic reflex disorders [7].

Exercise is particularly important for the patients with SCI for that it can promote the recovery of neurological function and functional compensation, improve motor function and activities of daily living, enhance cardiovascular and respiratory functions, and develop balance function [9–13]. However, inappropriate exercise can induce autonomic disorders. It has been reported that about 90% of tetraplegic athletes induce abnormal autonomic reflexes in order to increase performance [14].

Tai Chi is a treasure of Chinese culture and has been widely applied in rehabilitation [15, 16]. A large number of studies have confirmed that traditional Tai Chi exercises can improve the cardiopulmonary function of practitioners [17, 18], but the mechanism of autonomic nervous system regulation that improves cardiovascular function is still unclear, and the results were often controversial [19, 20].

Because traditional Tai Chi is performed in a standing posture, many practitioners have difficulty in completing it due to various reasons. Therefore, based on the essence of traditional Tai Chi, wheelchair Tai Chi was proposed. It retains the movements of the upper limbs and torso and reduces or even does not have the movements of the lower limbs. It is suitable for a wider range of people, especially for the patients with SCI [21]. Similarly, it is unclear whether wheelchair Tai Chi can enhance the balance of autonomic nerve activity in chronic SCI.

In terms of autonomic nerve function assessment, heart rate variability (HRV), the 24-hour sinus heart rate having a certain degree of change over time, is getting more and more attention. HRV reflects the activity of the autonomic nervous system and quantitatively evaluates the tension and balance of the cardiac sympathetic nerve and vagus nerve, thereby revealing the regulation or influence of the autonomic nervous system on the cardiovascular system. HRV is a reliable, sensitive, and repeatable noninvasive detection method in SCI [22, 23]. Its time domain and frequency domain analysis method are basically mature in theory, and its clinical application range is wide. The frequency domain method can quantitatively indicate the modulation of the heart by the sympathetic nerve and the vagus nerve.

This study investigated the HRV indicators to explore the effect of 16-form Wheelchair Tai Chi (WCTC16) on the autonomic nervous system of patients with SCI in order to provide theoretical basis for safe and effective scientific fitness.

2. Methods

2.1. Participant Recruitment. The immediate effect of WCTC16 on autonomic nervous modulation in patients with chronic SCI was investigated. Twenty patients with complete thoracic SCI were recruited. These participants were right-handed SCI inpatients recruited during their recovery period from a rehabilitation hospital. The inclusion criteria were people who met the diagnostic criteria for complete SCI according to the American Spinal Injury Association [24]. They were all between 20 and 60 years old, able to communicate and follow instructions, and able to maintain a sitting posture for more than 30 minutes in a wheelchair.

The exclusion criteria were people with an unstable spine, metastatic cancer, spine tumor, serious cardiopulmonary disease, poorly controlled hypertension, poorly controlled trunk and upper limb hypertonia, or serious complications related to SCI, such as pressure ulcers and contracture.

The protocol was approved by the ethics committee of the rehabilitation, hospital and written informed consent was obtained from all participants before study. This study was registered on the Chinese Clinical Trial Registry (ChiCTR-1900023734).

2.2. Test Equipment. The Equivital series of dynamic vital signs monitors (Equivital Life Monitor HIDA3330-13-1P16, UK) monitored the participants' real-time heart rate, respiratory rate, body position, and body temperature; analyzed the HRV RR interval and the standard deviation of normal RR interval (SDNN), total power (TP), low-frequency power (LFP), high-frequency power (HFP), standardized HF, and other indicators of the changes using the built-in software; and then inferred the regulatory mechanism of the autonomic nervous system (sympathetic nerve and vagus nerve). The reliability and validity of the instrument had been confirmed [23].

2.3. Testing Method. Participants should avoid strenuous exercise within 24 hours before the test and smoking or drinking during the 2 hours before the test. They should have proper rest about 30 minutes and no full meals. Loose clothing was suitable for exercise during each test. After the participants arrived at the test site, they sat quietly to restore their physical functions. When they were sitting quietly, they were instructed to breathe calmly and steadily, stay in the surrounding environment away from noise interference, forbid talking with the participants, and keep the posture as relaxed and stable as possible.

Then, they wore a dynamic vital sign monitor, and HRV indicators were collected in a resting state for 5 minutes, as shown in Figure 1. The participants completed the warm-up with music, five consecutive WCTC16 exercises, and finishing exercises. After the recovery period, HRV indicators were collected for 5 minutes. After the test, all the data were imported into the automatic analysis software to explore the regulation mechanism of autonomic nerve function during the resting or pre-WCTC16 period before exercise and during the recovery or post-WCTC16 period after exercise. The rhythm and duration of WCTC16 exercises were controlled by 5-minute Tai Chi music with action prompts.

2.4. Test Parameters

2.4.1. Time Domain Index of HRV

RR interval: the average value of the normal RR interval, in ms

SDNN: the standard deviation of the normal RR interval, in ms

RMSSD: the root mean square of the difference between adjacent RR intervals basically reflecting the average absolute value of the RR interval changes per

Figure 1: Dynamic vital sign monitor during 16-form Wheelchair Tai Chi.

stroke was sensitive to irregular heartbeats and/or heartbeat waveform marking errors, in ms

2.4.2. Frequency Domain Index of HRV

Total power (TP): it is the total variance of HRV, in ms^2

Very-low-frequency power (VLFP): it is the amplitude of the basic heart rate oscillation of the heart rate mode from once every 25 seconds to once every 5 minutes (0.003–0.04 Hz), in ms^2

Low-frequency power (LFP): it is the amplitude of the heart rate oscillation in the range of 3–9 cycles per minute (0.04–0.15 Hz), in ms^2

High-frequency power (HFP): it is the amplitude of the heart rate oscillation in the range of 9–24 cycles per minute (0.15–0.40 Hz, which is the typical adult breathing frequency range), in ms^2

LF/HF ratio: it is a ratio, usually referred to as "sympathetic-vagus" balance

Normalization unit of low-frequency power (LFPnu): it is the ratio of LFP to HRV

Normalization unit of high-frequency power (HFPnu): it is the ratio of HFP to HRV

2.5. Statistical Analyses. Each parameter was represented by the mean ± standard deviation (SD), and the data met the homogeneity of variance test and the normality test, and the paired sample *t*-test before and after itself was used. $\alpha = 0.05$ was set, and $P < 0.05$ indicated that the difference was statistically significant using IBM-SPSS 23.0 software (SPSS Inc., Chicago, IL, USA) for statistical analyses.

3. Results

3.1. Time Domain Analysis. All the analysis results are listed in Table 1. Though WCTC16 exercise increased RR interval, SDNN, and RMSSD of SCI patients, all these changes were not statistically significant ($P > 0.05$).

3.2. Frequency Domain Analysis. As shown in Table 1, WCTC exercise increased TP and HFP, while decreased VLFP and LFP of SCI patients, but all these changes were not statistically significant ($P > 0.05$).

Compared with that before exercise, LFPnu and HFP peak decreased, while HFPnu increased along with LF/HF in SCI patients after WCTC16 exercise, and all these differences were statistically significant ($P < 0.001$).

4. Discussion

The new evidence-based exercise guidelines for SCI adults updated by the International Spinal Cord Association put more emphasis on guidelines for cardiovascular disease in SCI patients [25]. It was recommended to do aerobic exercise of medium-to-high intensity at least 2 times a week for more than 20 minutes each time and 2 times a week for each major functional muscle group, 3 groups each time medium-to-high intensity strength training (strongly recommended), to improve cardiorespiratory fitness and muscle strength. It was recommended to do aerobic exercise of medium-to-high intensity at least 3 times a week for more than 30 minutes each time (recommendation with conditions) to improve cardiovascular metabolism.

The human cardiovascular system is mainly dominated by sympathetic and parasympathetic nerves. Xiong et al. [19] found that Tai Chi could improve the HRV of middle-aged and elderly people and optimize the heart rate status. On the basis of cardiac rehabilitation, combined with Tai Chi, the sensitivity of vagus nerve reflex in patients with coronary atherosclerotic heart disease was improved, but HRV had no significant change [20]. Chen et al. [20] concluded that Tai Chi could enrich the quality of life of patients with coronary heart disease, but it had no effect on HRV.

The rMSSD is an indicator that reflects the tone of the vagus nerve [21]. In this study, the rMSSD increased slightly after WCTC16, but it was not statistically significant. As an indicator reflecting the tension of sympathetic and vagus nerve, SDNN is often used to evaluate the overall degree of autonomic nervous system damage and recovery [21]. SDNN and RR interval increased slightly following WCTC16, and they were still not statistically significant. The results of this study are consistent with the results of many authors [26–28]. The reason might be that the above indicators were not sensitive to short-term Wheelchair Tai Chi [29].

The changes of TP, VLFP, LFP, and HFP after WCTC16 exercise were not statistically significant. However, after WCTC16 exercise, the LF/HF ratio, LFPnu, and peak of HF decreased, and HFPnu increased, all of which were

Table 1: HRV between pre- and post-WCTC16 (mean ± SD).

Parameter (unit)	Pre-WCTC16	Post-WCTC16	t	P
RR interval (ms)	604.89 ± 47.56	607.33 ± 58.12	−0.445	0.662
SDNN (ms)	34.96 ± 11.89	35.29 ± 17.76	−0.183	0.857
RMSSD (ms)	39.87 ± 19.41	41.37 ± 25.07	−0.936	0.363
TP (ms^2)	749.00 ± 536.62	754.56 ± 586.90	−0.369	0.717
VLFP (ms^2)	51.94 ± 21.92	50.72 ± 25.89	0.813	0.427
LFP (ms^2)	340.06 ± 234.79	337.28 ± 258.66	0.392	0.700
HFP (ms^2)	339.50 ± 236.88	372.28 ± 313.18	−1.455	0.164
LFPnu	61.75 ± 11.21	52.89 ± 17.48	12.753	<0.001
HFPnu	38.25 ± 11.21	46.81 ± 17.48	−10.835	<0.001
LF/HF	2.24 ± 0.68	1.49 ± 0.85	7.565	<0.001
HF peak (Hz)	0.29 ± 0.08	0.23 ± 0.08	7.526	<0.001

HRV, heart rate variability; WCTC16, 16-form Wheelchair Tai Chi; TP, total power; VLFP, power in very-low-frequency area; LFP, power in low-frequency area; HFP, power in high-frequency area; LFPnu, normalization unit of low-frequency power; HFPnu, normalization unit of high-frequency power; LF/HF, low-frequency area divided by high-frequency area; HF peak, peak of high-frequency area.

statistically significant. These results were consistent with the results of Buker [30].

As an objective HRV indicator, LF/HF ratio is usually used to reflect the overall sympathetic and vagal balance state [21]. In this study, the LF/HF ratio dropped from 2.24 in the rest or pre-WCTC16 period to 1.49 in the recovery or post-WCTC16 period, which was closer to the ratio of healthy adults [31]. It suggested that WCTC16 helped to restore the sympathetic-vagal balance to the level of healthy adults. Giagkoudaki et al. [32] also found that the excitability of the vagus nerve in patients with Down syndrome increased after aerobic training, the LF/HF ratio decreased (2.45~1.72), and the balance of sympathetic-vagus nerve tension revived. Some authors showed that decreased cardiac vagus nerve activity might lead to increased mortality in patients with myocardial infarction [33]. In this study, WCTC16 increased the parasympathetic nerve activity of SCI patients. It was speculated that WCTC16 could improve autonomic nerve control and reduce mortality in SCI patients.

HFP reflects the vagus nerve regulation function [34]. In this study, HFPnu increased after WCTC16 exercise. It showed that the activity of the vagus nerve increased. LFP reflects the comprehensive regulation results of parasympathetic and sympathetic efferent nerve activity and is affected by baroreflex activity [35]. In this study, significantly reduced LFPnu suggested common regulation of vagus-sympathetic nerves and the balance function between them.

Tai Chi exercise emphasizes the training of "Qi" (bioenergy) by breathing and the mind in body. The peak of HF can reflect the influence of exercise on breathing rate [36]. The Wheelchair Tai Chi exercise also requires deep and slow breathing. In this study, the peak of HF of subjects after WCTC16 decreased from 0.29 before exercise to 0.23 during the recovery period, implying that the activity of the vagus nerve relatively increased [28, 37].

The decrease in the ratio of LFPnu and LF/HF was the result of the combined effect of decreased sympathetic nerve activity and increased parasympathetic nerve activity. It was related to the intrinsic vagus nerve reactivity, baroreceptor sensitivity, and the adaptive state accompanying spinal cord injury in patients with SCI, or a combination of the above. In addition to the abovementioned regulation of the autonomic nervous system, other factors have to be considered [38]. For example, motor stimulation interrupts the central command from the motor cortex of the brain; the stimulation of mechanoreceptors, baroreceptors, and thermoreceptors is reduced; hormone levels are disordered [39]. These are consistent with the results of related research on the effect of standing Tai Chi on heart disease in the healthy elderly [40].

WCTC16 is a moderate-to low intensity exercise for patients with complete thoracic SCI. During exercise, SCI patients have increased heart rate, blood pressure, and faster breathing, which are manifested as a relative increase in dominant sympathetic nerve activity with decreasing vagus nerve activity. After WCTC16 exercise, the parasympathetic nerve activity significantly increased, the sympathetic nerve activity decreased, and the sympathetic-vagus nerve balance improved. It showed that the body's autonomic nervous "automatic regulation" was on and a process of establishing a new balance. It is important for SCI patients with autonomic dysfunction, especially for patients whose sympathetic and parasympathetic nerve activity was reduced at the same time, to restore the dynamic balance of autonomic nervous function.

During WCTC16 exercise, it is necessary to coordinate breathing and exercise under the guidance of mind. This is consistent with the principles of cardiopulmonary rehabilitation for SCI patients. Although the primary center of the visceral reflex activity was damaged, exercise could stimulate the lower brainstem, hypothalamus, and cerebral cortex, and the combined effects developed the function of autonomic nerves and the role of system regulation. Therefore, WCTC16 had a positive role on improving the cardiopulmonary function, preventing, and treating SCI complications.

However, this study has several limitations. Firstly, the relationship between LF power of HRV and cardiac autonomic function has still been unclear. LF power seems to provide an index not of cardiac sympathetic tone but of baroreflex function [41]. This would limit the interpretation of LF and LF/HF ratio to some extent [42]. Secondly, blood pressure has some effect on HRV, but blood pressure has not been investigated in this study. Thus, it is difficult to explore the relationship between the autonomic control and blood pressure regulation [43]. So, it is incomplete to make a thorough inquiry about the mechanism of WCTC16 affecting HRV. In future, we shall design and perform correlational research studies to solve these problems.

5. Conclusion

The WCTC16 might enhance vagal activity and decrease sympathetic activity with balanced sympathovagal tone in patients with complete thoracic SCI. By recovering the autonomic dysfunction and hyper-reflexia causing life-threatening complication during exercise or postural changes, SCI patients could achieve a relatively “internally stable” state through complex regulation. In addition to the increase in the sympathetic nerve activity of patients during WCTC16, the parasympathetic nerve activity was significantly increased and dominant through the recovery period. In a word, WCTC16 exercise might enable the body to activate the automatic regulation of the autonomic nervous system and present a new dynamic balance.

Abbreviations

SCI: Spinal cord injury
WCTC16: 16-form Wheelchair Tai Chi
HRV: Heart rate variability
SDNN: The standard deviation of the normal RR interval
rMSSD: The root mean square of the difference between adjacent RR intervals
TP: Total power
VLFP: Very-low-frequency power
LFP: Low-frequency power
HFP: High-frequency power
LFPnu: Normalization unit of low-frequency power
HFPnu: Normalization unit of high-frequency power.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Ethical Approval

The study protocol was in accordance with the Declaration of Helsinki and was approved by the Yang Zhi Rehabilitation Hospital Affiliated to Tongji University Ethics Committee (no. YZ2016001), and the authors registered the study on the Chinese Clinical Trial Registry (no. ChiCTR-1900023734).

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

Authors’ Contributions

Yan Qi and Haixia Xie contributed equally to this work.

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Research Article

Effect of Taijiquan Exercise on Rehabilitation of Male Amphetamine-Type Addicts

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Taijiquan is a traditional Chinese sport that is classified as a moderate exercise. Recent studies have evaluated the effectiveness of Taijiquan in substance abuse rehabilitation. *Objective*. To test the rehabilitation effect of Taijiquan exercise in patients with amphetamine (ATS) drug dependence. *Methods*. The effect of Taijiquan intervention was tested by parallel control experiment: Taijiquan group ($n = 38$) and control group ($n = 38$). The factors between the experimental groups were the group (Taijiquan group and the control group), and the factors within the group were the test time (before and after intervention). Repeated measurement analysis of variance was used to compare the two groups, and the factors that may affect the results were included in the covariance. *Results*. Taijiquan exercise promoted the balance control ability of ATS dependent patients ($p = 0.014$, $\eta^2 = 0.064$), increased the overall sense of health ($p = 0.029$, $\eta^2 = 0.100$), vitality ($p = 0.030$, $\eta^2 = 0.056$), and mental health ($p = 0.016$, $\eta^2 = 0.061$), improved trait anxiety ($p = 0.028$, $\eta^2 = 0.053$), and reduced drug craving ($p = 0.048$, $\eta^2 = 0.048$). *Conclusion*. Taijiquan exercise is beneficial to the physical and mental recovery of dependent patients, and the physical and mental benefits of exercise may have an effect on drug craving, which is of the most important significance for addicts to quit drugs and prevent relapse. The study is registered on the Chinese Clinical Trial Registry (No. ChiCTR1800015777).

1. Introduction

Amphetamine-type stimulants, referred to as ATS, are one of the most important new synthetic drugs abused by the United Nations Convention on psychotropic substances, and they are the second most used illegal drug in the world, second only to marijuana [1]. At present, methamphetamine is the most popular and most widely abused in ATS [2]. According to the report on China's drug situation in 2018 released by the Office of the China Drug Control Commission in June 2019, there are 2.404 million drug addicts nationwide, down 5.8 percent from the same period last year, but the scale is still large. Methamphetamine has replaced heroin as the "number one drug" for abuse. 1.35 million people abused methamphetamine, accounting for 56.1 percent. ATS abuse not only brings serious damage to individual physical and mental health of abusers, but also causes serious social problems. There is extensive documentation that the use of synthetic drugs is detrimental to human health. These drugs cause chronic illnesses that lead to dopaminergic neurotoxicity and cardiovascular toxicity by releasing excess stored catecholamines [3]. The release of these excess catecholamines results in serious physical and mental disorders, such as hypertension, myocardial infarction, stroke, and cardiomyopathy, as well as vascular or cerebrovascular dysfunction [4–7]. Aside from their addiction to methamphetamines, chronic abusers may also exhibit symptoms such as significant abnormal motor movement, anxiety, confusion, anhedonia, irritability, fatigue, insomnia, mood disturbances, impaired social functioning, and violent behavior [8–10]. To date, there is no effective therapy for counteracting the toxic effects of these synthetic drugs [11].

Physical exercise has long been considered important in preventing and treating several medical conditions [12]. Sports are often recommended internationally as an effective means for the treatment of physical and mental health of drug addicts [13], or as a new intervention for the treatment of drug abuse [14]. Studies have shown that exercise as an auxiliary method has a certain effect in promoting the rehabilitation of methamphetamine addicts [3]. A systematic review of 17 studies on physical exercise and drug use among adolescents showed that physical exercise reduced drug use [15]. Studies have shown that exercise is an important behavioral factor to reduce the cerebrovascular toxicity of methamphetamine [7]. Taijiquan is a traditional Chinese sport that can be classified as moderate exercise. Taijiquan has physiological and psychosocial benefits and can improve balance control, flexibility, and cardiovascular fitness of older adults with chronic conditions [16, 17]. Several studies have evaluated the effect of Taijiquan on psychological responses, such as depression, distress, well-being, life satisfaction, and perception of health [18]. Taijiquan is beneficial for both men and women over a wide age range. The American College of Sport Association recommended Taijiquan as a functional fitness exercise for improving motor skills, such as balance, coordination, gait, agility, and proprioceptive training [19]. There is evidence that Taijiquan exercise may be an effective means to help people with chronic diseases reduce stress, improve mood, or sleep [20]. The outline of the healthy China 2030 plan points out that we should support and promote traditional national and folk sports such as fitness Qigong and Taijiquan and strengthen nonmedical and health intervention and the integration of sports and medicine. The purpose of this study was to explore the rehabilitation effect of Taijiquan exercise on patients with ATS dependence, assuming that the subjects had a good improvement in physical, emotional, and drug dependence.

2. Methods

2.1. Patients. Brigade of a compulsory isolation detoxification center in Shanghai (5) cluster sampling (men): a total of 76 men were included, 38 in Shanghai and 38 outside Shanghai; the youngest was 21 years old, the oldest was 60 years old, the average was 40 years old, the minimum of BMI was 19.60, the maximum was 36.20, the average was 24.46, and the number of compulsory detoxification ranged from 1 to 7, with an average of 1.62. Inclusion criteria were (1) ATS dependence; (2) meeting the "guidelines for diagnosis and treatment of amphetamine dependence" issued by the Ministry of Health of the pPeople's Republic of China in 2009 and the evaluation criteria of addiction syndrome in "Chinese Classification and Diagnostic Criteria of Mental Disorders" (CCMD-3); (3) completing physical detoxification and entering the psychological rehabilitation stage—the isolation period is less than 12 months; (4) volunteering to participate in this researcher and having no history of Taijiquan. Rule out the following situations: having a history of mental illness, health status, or exercise taboos can not effectively complete the experiment. The data of the subjects were imported into SPSS 20.0 statistical software. They were randomly divided into Taijiquan group (experimental group, $n = 38$) and control group (routine rehabilitation group, $n = 38$). After 6 months of intervention, 38 dependent patients in the Taijiquan group and 34 dependent patients in the control group completed the established tasks. The flow chart of the Taijiquan intervention process is shown in Figure 1.

2.2. Taijiquan Intervention. The Taijiquan group participated in the Taijiquan exercise intervention. The Taijiquan group practiced Taijiquan once a day from Monday to Friday, including a 50-minute tutoring teaching arranged on Thursday afternoon. The tutoring teaching was completed by graduate students majoring in national traditional sports, with the technical level of six sections of Taijiquan; four 20-minute independent exercises were arranged in the evening, and the independent exercises were organized by the management police with experience in physiological rehabilitation education. The first month is teaching introduction, the last 5 months is practice, thus a total of 6 months of intervention. According to the attendance statistics of each Taijiquan exercise, the attendance rate of the Taijiquan group is more than 90%. The control group only received routine rehabilitation exercises, including the ninth set of broadcast gymnastics, sign language exercises, and queue exercises. Taijiquan group and the control group received the same routine rehabilitation exercises with the same content and time. Taijiquan group added Taijiquan exercises. According to the principles of easy to learn, easy to practice, and clear effect, the content of Taijiquan focuses on the main technical arrangement of 24-style Taijiquan.

2.3. Measuring Tool. Exercise intensity testing instrument: using Polar wearable team heart rate meter (model: team2; company: Boneng; origin: Finland). The monitoring results of exercise intensity showed that the average heart rate before exercise was 90.78 beats/min, 50.74% HRmax (maximum heart rate); after 5 minutes of exercise, the average heart rate increased to 99.33 beats/min, 55.52% HRmax; the peak average heart rate appeared 6 minutes after exercise, and the average peak heart rate was 113.22 beats/min, 63.28% HRmax; 5 minutes after exercise, 87.5 beats/min, 48.90%HRmax.

The physical fitness test was conducted with the National Physical Fitness Test tool, and the questionnaire was conducted with the self-made questionnaire for amphetamine addicts and international commonly used related scales, including Baker self-rating depression scale [21], state-trait anxiety scale [22], Health Status Survey (SF-36) [23], and amphetamine craving scale [24].

2.4. Data Collection. The blind subjects are subjects and testers, which are kept secret before the end of the intervention and until all data measurements are completed. The data of baseline (4 weeks), 3 months, and 6 months before the experiment were collected. The test site is in the physiological rehabilitation center of the compulsory isolation drug rehabilitation center. The questionnaire survey is arranged before other tests, and the questionnaire is

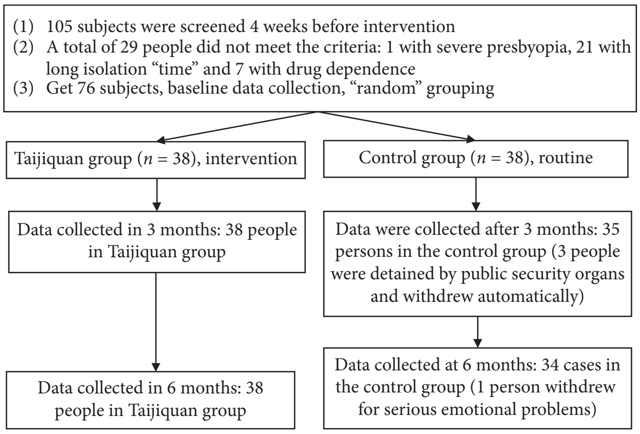

Figure 1: Flowchart of intervention process.

distributed and collected by the investigator on the spot, with a recovery rate of 100%.

2.5. Statistical Analysis. The data were imported into SPSS 20.0 statistical software, and descriptive statistics were used for the basic situation of the subjects. Chi-square test (counting data) and independent sample *t*-test (measurement data) were used for comparison between groups. The intervention experiment was compared with the repeated measurement analysis of variance of 2 (group: Taijiquan group and control group) × 3 (test time: baseline before exercise, 3rd month, and 6th month). The frequency of admission and the number of years of dependence may have an impact on the rehabilitation effect of dependent patients, and the two factors were included in the covariance. The interactions within the group (baseline, 3 months, and 6 months), the Taijiquan group, and the control group were compared, and the physical fitness, psychological craving, depression, anxiety, and quality of life were evaluated according to the results. The spherical test was carried out before the repeated measurement analysis of variance, and the Greenhouse–Geisser method was used to correct it when it was not satisfied with the shape of the football. In the statistical analysis, if the interaction is significant, Bonferroni correction is used for posttest, simple effect analysis is carried out, and the differences between groups in different test time are compared. The index η^2 (partial eta square), which reports the effect of analysis of variance, reflects the effect of the experiment.

3. Results

3.1. The Basic Situation of Taijiquan Group and Control Group. The basic characteristics of 76 amphetamine addicts included in the analysis mainly include demography, drug dependence, and so on, as shown in Table 1. The difference of admission times between the experimental group and the control group is 0.041, considering that the standard deviation of the experimental group is large, and the differences of other indicators are not significant, so the influence here can be ignored; it is considered that the baseline of the Taijiquan group and the control group is balanced.

3.2. Effect of Taijiquan Exercise Intervention on Physical Fitness. Physical fitness is the basic physical health condition where we should have to complete all kinds of physical activities to meet the needs of life. According to the physical fitness index measured, the national physique monitoring index used in the long-term rehabilitation evaluation of compulsory isolation detoxification center mainly includes body composition, blood pressure, and quiet pulse; the four physiques are vital capacity, grip strength, balance, and flexibility. It covers three aspects: body composition, cardiovascular system, and physique.

3.2.1. Effect on Body Composition. The BMI, body fat rate, visceral fat index, and muscle percentage of ATS dependent patients were analyzed by 2 × 3 repeated measurement analysis of variance (ANOVA). The calculation results are shown in Table 2. The main effect of BMI test time was highly significant ($p < 0.001$, $\eta^2 = 0.129$), but the main effect of group was not significant ($p < 0.064$, $\eta^2 = 0.041$), and the interaction between time and group was not significant ($p = 0.461$, $\eta^2 = 0.008$). The main effect of body fat rate test time was highly significant ($p < 0.001$, $\eta^2 = 0.349$), but the main effect of group was not significant ($p < 0.499$, $\eta^2 = 0.007$), and the interaction between time and group was not significant ($p < 0.069$, $\eta^2 = 0.038$). The main effect of visceral fat index test time was highly significant ($p < 0.007$, $\eta^2 = 0.071$), but the main effect of group was not significant ($p = 0.690$, $\eta^2 = 0.002$), and the interaction between time and group was not significant ($p = 0.060$, $\eta^2 = 0.041$). The main effect of muscle percentage test time was highly significant ($p < 0.001$, $\eta^2 = 0.278$), but the main effect of group was not significant ($p = 0.874$, $\eta^2 < 0.001$), and the interaction between time and group was not significant ($p = 0.311$, $\eta^2 = 0.017$).

3.2.2. Effects on Cardiovascular System. The blood pressure and heart rate of patients with amphetamine dependence were analyzed by 2 × 3 repeated measurement analysis of variance (ANOVA). The results are shown in Table 3. The main effect of systolic blood pressure test time was highly significant ($p < 0.001$, $\eta^2 = 0.149$), but the main effect of group was not significant ($p = 0.466$, $\eta^2 = 0.008$), and the interaction between time and group was not significant ($p = 0.882$, $\eta^2 = 0.001$). The main effect of diastolic blood pressure test time was highly significant ($p < 0.001$, $\eta^2 = 0.269$), but the main effect of group was not significant ($p = 0.370$, $\eta^2 = 0.012$), and the interaction between time 5 and group was not significant ($p = 0.878$, $\eta^2 = 0.002$). The main effect of resting heart rate test time was highly significant ($p < 0.001$, $\eta^2 = 0.154$), but the main effect of group was not significant ($p = 0.645$, $\eta^2 = 0.003$), and the interaction between time and group was not significant ($p = 0.499$, $\eta^2 = 0.010$).

Table 1: Comparison of the basic conditions between the Taijiquan group and the control group ($n = 76$, $M \pm SD$).

Participants	Taijiquan group ($n = 38$)	Control group ($n = 38$)	t/χ^2	p
Age	41.08 ± 9.94	39.11 ± 8.90	0.912	0.365
Height (m)	1.72 ± 0.47	1.73 ± 0.54	−0.906	0.368
Weight (kg)	72.10 ± 7.80	73.60 ± 9.11	−0.770	0.444
Monthly frequency	12.71 ± 16.35	10.68 ± 10.24	0.647	0.519
Dependence (age)	7.76 ± 5.90	7.13 ± 5.39	0.487	0.627
Hypertension			0	1
Yes	9(23.7%)	9(23.7%)		
No	29(76.3%)	29(76.3%)		
Use of drugs			0.060	0.807
One person	13 (34.2 %)	12 (32.9 %)		
2 or more	25(65.8%)	26(67.1%)		
The number of times of compulsory detoxification	1.89 ± 1.39	1.34 ± 0.85	2.092	0.041*
Monthly cost of medication	2505.26 ± 2671.67	3044.74 ± 3489.73	−0.757	0.452

Note. * $p < 0.05$.

Table 2: Comparison of the changes of body composition between the two groups of dependent subjects before and after the experiment ($M \pm SD$).

	Taijiquan group ($n = 38$)			Control group ($n = 34$)			Time F value	Group F value	Time × group F value
	Baseline	3 months	6 months	Baseline	3 months	6 months			
BMI (kg/m^2)	24.34 ± 2.22	24.20 ± 2.49	24.85 ± 2.36	24.66 ± 2.81	24.41 ± 2.67	25.43 ± 2.63	10.095**	0.549	2.924
Body fat percentage (%)	21.43 ± 3.30	20.89 ± 3.52	23.95 ± 3.00	21.70 ± 3.17	20.77 ± 3.37	24.61 ± 3.30	36.481**	0.463	2.720
Visceral fat index	9.52 ± 2.80	9.49 ± 3.10	10.26 ± 2.97	9.62 ± 3.40	9.31 ± 3.22	10.74 ± 3.26	5.202**	0.161	2.875
Muscle percentage (%)	32.66 ± 1.61	33.08 ± 1.80	31.60 ± 1.53	32.75 ± 1.63	33.15 ± 1.67	31.48 ± 1.74	26.158**	0.025	1.149

Note. ** $p < 0.01$.

3.2.3. Influence on Physique. The vital capacity, grip strength, standing on one foot (eyes closed), and body flexion of ATS dependent patients were analyzed by 2 × 3 repeated measurement analysis of variance. The results are shown in Table 4. The main effect of vital capacity test time was significant (p = 0.026, $\eta^2 = 0.052$), but the main effect of group was not significant (p = 0.218, $\eta^2 = 0.022$), and the interaction between time and group was not significant (p = 0.899, $\eta^2 = 0.002$). The main effect of grip strength test time was highly significant (p = 0.008, $\eta^2 = 0.069$), but the main effect of group was not significant (p = 0.300, $\eta^2 = 0.016$), and the interaction between time and group was not significant (p = 0.647, $\eta^2 = 0.006$). The main effect of standing time on one foot was highly significant ($p < 0.001$, $\eta^2 = 0.119$), but the main effect of group was not significant (p = 0.175, $\eta^2 = 0.027$), and the interaction between time and group was significant ($p < 0.014$, $\eta^2 = 0.064$). Further simple effect analysis showed that there was no significant difference between the two groups at 3 months ($p > 0.05$), but there was significant difference at 6 months between the two groups ($p < 0.05$), and the standing time of Taijiquan group was longer than that of Taijiquan group. The standing time of one foot in the Taijiquan group increased all the time, while that in the control group increased at first and then decreased slightly. The main effect of sitting body flexion test time was highly significant (p = 0.002, $\eta^2 = 0.087$), but the main effect of group was not significant (p = 0.145, $\eta^2 = 0.031$), and the interaction between time and group was not significant (p = 0.427, $\eta^2 = 0.012$).

3.3. The Influence of Taijiquan Exercise Intervention on Emotion. The results of 2 × 3 repeated test variance analysis of depression in amphetamine dependent patients showed that the main effect of depression test time was significant (p0.001, $\eta^2 = 0.093$), but the main effect of group was not significant (p = 0.948, $\eta^2 < 0.001$). The interaction between time and group was not significant (p = 0.427, $\eta^2 = 0.012$). The state anxiety and trait anxiety of amphetamine addicts were analyzed by 2 × 3 repeated measurement analysis of variance (ANOVA). The main effect of time in state anxiety test was not significant (p = 0.470, $\eta^2 = 0.011$), the main effect of group was not significant (p = 0.576, $\eta^2 = 0.005$), and the interaction between time and group was not significant (p = 0.284, $\eta^2 = 0.018$). The main effect of time in trait anxiety test was not significant (p = 0.365, $\eta^2 = 0.014$), the main effect of group was not significant (p = 0.129, $\eta^2 = 0.034$), and the interaction between time and group was significant (p = 0.028, $\eta^2 = 0.053$). The further simple effect analysis of the interaction between trait anxiety time and group showed that there was no significant difference at 3 months (p = 0.098), but there was significant difference at 6 months (p = 0.035), and the trait anxiety decreased more in Taijiquan group. The results are shown in Table 5.

Table 3: Comparison of the changes of blood pressure and resting heart rate between the two groups of dependent subjects before and after the experiment ($M \pm SD$).

	Taijiquan group ($n = 38$)			Control group ($n = 34$)			Time F value	Group F value	Time × group F value
	Baseline	3 months	6 months	Baseline	3 months	6 months			
Systolic blood pressure (mmHg)	124.67 ± 14.10	119.58 ± 15.93	131.28 ± 18.49	128.19 ± 13.26	122.10 ± 14.66	134.35 ± 17.38	11.943**	0.538	0.089
Diastolic blood pressure (mmHg)	75.53 ± 9.85	74.50 ± 10.76	84.41 ± 8.01	78.41 ± 9.51	76.37 ± 10.93	86.91 ± 11.28	25.070**	0.815	0.130
Heart rate (/min)	71.71 ± 10.04	64.66 ± 10.33	70.53 ± 8.60	71.31 ± 8.49	65.72 ± 6.52	73.51 ± 11.12	12.422**	0.214	0.699

Note. ** $p < 0.01$.

Table 4: Comparison of the changes of physique indexes between the two groups of dependent patients before and after the experiment ($M \pm SD$).

	Taijiquan group ($n = 38$)			Control group ($n = 34$)			Time F value	Group F value	Time × group F value
	Baseline	3 months	6 months	Baseline	3 months	6 months			
Vital capacity (ml)	2565.89 ± 704.31	2616.76 ± 663.68	2792.74 ± 698.13	2704.41 ± 675.92	2819.53 ± 644.58	2994.35 ± 464.05	3.735*	1.545	0.118
Grip strength (kg)	51.03 ± 7.39	51.91 ± 7.03	47.98 ± 7.03	52.30 ± 8.77	52.64 ± 5.66	49.86 ± 6.90	5.015**	1.090	0.437
Standing on one foot (s)	10.82 ± 7.45	18.29 ± 12.67	24.61 ± 20.13	12.03 ± 8.60	17.02 ± 12.55	16.54 ± 9.29	9.183**	1.875	4.682**
Body flexion (cm)	2.02 ± 7.78	5.29 ± 7.57	7.69 ± 6.64	5.31 ± 7.85	8.36 ± 8.49	9.05 ± 9.03	6.448**	2.178	0.855

Note. * $p < 0.05$, ** $p < 0.01$.

Table 5: Comparison of the changes of emotion between the two groups of dependent patients before and after the experiment ($M \pm$ SD).

	Taijiquan group ($n = 38$)			Control group ($n = 34$)			Time F value	Group F value	Time × group F value
	Baseline	3 months	6 months	Baseline	3 months	6 months			
BDI	9.11 ± 5.24	8.13 ± 5.86	5.71 ± 4.75	9.00 ± 5.15	8.06 ± 5.06	6.85 ± 6.45	6.992**	0.004	0.857
S-AI	44.61 ± 10.04	41.47 ± 10.77	39.26 ± 10.91	44.71 ± 9.31	43.97 ± 10.15	43.00 ± 10.53	0.760	0.315	1.272
T-AI	45.47 ± 8.25	41.66 ± 9.63	38.71 ± 11.56	46.09 ± 8.93	46.18 ± 9.31	45.76 ± 9.61	0.999	2.358	3.821*

Note. $^{*}p < 0.05$, $^{**}p < 0.01$, BDI: Baker self-rating depression scale, S-AI: state anxiety, and T-AI: trait anxiety.

3.4. Effect of Taijiquan Exercise Intervention on Quality of Life. The total score and each dimension of quality of life (SF-36) of patients with amphetamine dependence were analyzed by 2 × 3 repeated measurement analysis of variance (ANOV-A).The results are shown in Table 6. The main effect of SF-36 total score test time was not significant ($p = 0.783$, $\eta^2 = 0.004$), the group main effect was not significant ($p = 0.302$, $\eta^2 = 0.016$), and the interaction between time and group was not significant ($p = 0.957$, $\eta^2 = 0.001$). The main effect of physiological function (PF) test time was not significant ($p = 0.355$, $\eta^2 = 0.015$), the main effect of group was not significant ($p = 0.731$, $\eta^2 = 0.002$), and the interaction between time and group was not significant ($p = 0.394$, $\eta^2 = 0.014$). The main effect of physiological function (RP) test time was not significant ($p = 0.834$, $\eta^2 = 0.003$), the main effect of group was not significant ($p = 0.593$, $\eta^2 = 0.004$), and the interaction between time and group was not significant ($p = 0.574$, $\eta^2 = 0.008$). The main effect of somatic pain (BP) test time was not significant ($p = 0.505$, $\eta^2 = 0.010$), the main effect of group was not significant ($p = 0.943$, $\eta^2 < 0.001$), and the interaction between time and group was not significant ($p = 0.271$, $\eta^2 = 0.019$). The main effect of (GH) test time of general sense of health was not significant ($p = 0.276$, $\eta^2 = 0.038$), the main effect of group was not significant ($p = 0.267$, $\eta^2 = 0.018$), and the interaction between time and group was significant ($p = 0.029$, $\eta^2 = 0.100$). Further simple effect analysis showed that there was no significant difference at 3 months ($p = 0.260$), but there was significant difference at 6 months ($p < 0.01$). The overall sense of health in Taijiquan group was significantly higher than that in the control group. The main effect of life vitality (VT) test time was not significant ($p = 0.789$, $\eta^2 = 0.003$), the main effect of group was not significant ($p = 0.115$, $\eta^2 = 0.036$), and the interaction between time and group was significant ($p = 0.030$, $\eta^2 = 0.056$). Further simple effect analysis showed that there was significant difference between 3 months and 6 months ($p < 0.05$). The vitality (VT) of Taijiquan group was significantly higher than that of the control group. The main effect of social function (SF) test time was highly significant ($p = 0.002$, $\eta^2 = 0.085$), but the main effect of group was not significant ($p = 0.735$, $\eta^2 = 0.002$), and the interaction between time and group was not significant ($p = 0.192$, $\eta^2 = 0.024$). The main effect of affective function (RE) test time was not significant ($p = 0.659$, $\eta^2 = 0.006$), the main effect of group was not significant ($p = 0.251$, $\eta^2 = 0.019$), and the interaction between time and group was not significant ($p = 0.178$, $\eta^2 = 0.025$). The main effect of mental health (MH) test time was not significant ($p = 0.205$, $\eta^2 = 0.023$), the main effect of group was not significant ($p = 0.151$, $\eta^2 = 0.030$), and the interaction between time and group was significant ($p = 0.016$, $\eta^2 = 0.061$). Further simple effect analysis showed that there was no significant difference at 3 months ($p < 0.05$), but there was significant difference at 6 months ($p < 0.05$). The mental health (MH) of Taijiquan group was significantly higher than that of the control group.

3.5. Effect of Taijiquan Exercise Intervention on Drug Craving. A 2 × 3 repeated measurement analysis of variance for ATS dependent patients' psychological craving for (DSQ) was carried out, and the results are shown in Table 7. The main effect of psychological craving (DSQ) test time was not significant ($p = 0.544$, $\eta^2 = 0.008$), the main effect of group was not significant ($p = 0.052$, $\eta^2 = 0.055$), and the interaction between time and group was significant ($p = 0.048$, $\eta^2 = 0.048$). Simple effect analysis showed that the difference was significant at 3 months ($p = 0.016$) and highly significant at 6 months ($p = 0.008$). The psychological craving of Taijiquan group was much lower than that of the control group.

4. Discussion

The standing time of one foot in the Taijiquan group has been increasing, while that in the control group increased at first and then decreased slightly. The balance ability of the Taijiquan group was improved, which is of great significance to the work and life of the dependent subjects. A foreign meta-analysis summarized 7 randomized controlled trials of Taijiquan, including 1088 participants (544 subjects and 544 control subjects). The results show that Taijiquan exercise can improve flexibility and standing time on one leg, which helps to improve balance control, which may prevent falls [25]. Compared with other intervention or nontreatment, Taijiquan is more effective in preventing falls in frail and high-risk adults [26]. It is worth noting that the values of BMI in both groups were obese at each time point (BMI > 24), which showed an increasing trend as a whole, while the visceral fat index increased more significantly. Taijiquan exercise has a positive effect on BMI, body fat rate, visceral fat index, and muscle percentage, but the difference is not significant. The test time was 3 months in summer July, and the average daytime temperature in Shanghai was 30°C or above, up to 40°C. Dependent people generally reflect poor appetite, which may be an important factor in the decrease of BMI and other indicators, but also in line with the normal law of people's life. There is no difference in

Table 6: Comparison of the changes of quality of life between the two groups of dependent patients before and after the experiment ($M \pm SD$).

	Taijiquan group ($n = 38$)			Control group ($n = 34$)			Time F value	Group F value	Time × group F value
	Baseline	3 months	6 months	Baseline	3 months	6 months			
SF-36	580.58 ± 107.01	586.61 ± 128.54	609.79 ± 119.71	604.65 ± 127.00	600.79 ± 110.76	620.97 ± 96.73	0.245	1.081	0.044
PF	90.66 ± 7.64	83.16 ± 16.42	87.50 ± 13.99	88.38 ± 14.81	85.00 ± 16.05	89.41 ± 14.71	1.045	0.119	0.938
RP	87.50 ± 28.32	83.68 ± 27.23	88.82 ± 27.07	84.56 ± 31.39	85.29 ± 26.91	92.65 ± 20.90	0.182	0.288	0.557
BP	85.37 ± 18.62	83.00 ± 23.77	83.71 ± 21.81	84.53 ± 21.34	81.38 ± 19.82	87.94 ± 15.42	0.686	0.005	1.318
GH	67.32 ± 19.78	71.34 ± 24.71	77.58 ± 23.02	68.44 ± 23.00	64.18 ± 20.15	65.59 ± 19.01	0.886	1.253	4.015*
VT	64.16 ± 18.08	68.66 ± 19.35	70.84 ± 18.00	65.06 ± 20.97	59.32 ± 17.03	59.62 ± 15.31	0.173	2.544	4.008*
SF	54.89 ± 23.96	59.21 ± 16.61	58.18 ± 20.00	54.09 ± 15.04	61.76 ± 17.93	50.78 ± 14.76	6.326**	0.116	1.672
RE	84.21 ± 31.71	79.82 ± 32.46	84.21 ± 34.43	82.35 ± 36.00	88.24 ± 28.29	92.16 ± 24.70	0.418	1.338	1.747
MH	60.58 ± 19.40	66.58 ± 20.78	72.37 ± 18.59	61.24 ± 16.80	57.68 ± 14.62	60.82 ± 14.79	1.614	2.113	4.433*

Note. $^{*}p < 0.05$, $^{**}p < 0.01$; SF-36: total score of quality of life; PF: physiological function; RP: physiological function; BP: body pain; GH: general sense of health; VT: vitality; SF: social function; RE: emotional function; MH: mental health.

Table 7: Comparison of the changes of psychological craving (DSQ) between the two groups of dependent patients before and after the experiment ($M \pm SD$).

	Taijiquan group ($n = 38$)			Control group ($n = 34$)			Time F value	Group F value	Time × group F value
	Baseline	3 months	6 months	Baseline	3 months	6 months			
DSQ	93.79 ± 41.98	73.42 ± 28.95	69.03 ± 24.00	91.74 ± 19.70	88.50 ± 29.66	83.06 ± 18.93	0.531	3.926	3.419*

注: * $p < 0.05$; DSQ: psychological craving.

vital capacity between the Taijiquan group and the control group, which may be related to the small amount of exercise and exercise intensity.

Taijiquan exercise intervention reduced the subjects' anxiety; many experiments reported similar views. It has been reported that moderate intensity aerobic exercise can significantly reduce the anxiety and depression of methamphetamine addicts [27]. Taijiquan exercise is beneficial to the rehabilitation of cardiovascular diseases; at the same time, it can reduce anxiety and improve mood. Taijiquan therapy is considered to be one of the important choices of rehabilitation treatment [28]. The benefit of Taijiquan on mood improvement has gradually attracted people's attention. More and more scientific evidence shows that Taijiquan exercise is beneficial to improve mental and emotional health and reduce stress [18]. Taijiquan provides a possible way to reduce anxiety [29]. Long-term exercise in the form of collective organization can better relieve anxiety, especially trait anxiety [30]. Taijiquan may provide an opportunity to reconnect your body and mind. Taijiquan pays attention to the inner mental activities and pays attention to "intention without exertion." The mental interpretation of the thirteen potentials says, "the mind is the order, and the qi is the flag; first in the mind, then in the body." Chen Xin said, "the heart of boxing is the master; it is used in the heart; this is the true formula; the operation is all in one mind." Dependent people can achieve physical and mental balance through Taijiquan exercise and achieve a better level of social function. Karen Horney, a German-American psychologist and psychiatrist, believes that drug abuse can be understood as an individual's escape strategy to certain social situations, and the psychological defense process of personal anxiety is a kind of "transfer." Indulging in drug use can get rid of or avoid anxiety [23]. Drug use can improve negative emotions such as anxiety, depression, and despair, so some people tend to abuse drugs. Most drug abusers have obvious mental disorders and psychological problems, lack trust in others and society, have empty life, and escape through drug abuse. Although the reasons for this phenomenon are very complicated, drug abuse is obviously a comprehensive physiological and behavioral response of addicts to seek advantages and avoid disadvantages [18]. The communication between human mind and body is very complex, and when such abuse is carried out for a long time, it becomes a dependent behavior of euphoria when it replaces the original brain natural reward or shows as a new reward. Taijiquan intervention makes the trait anxiety of dependent patients in Taijiquan group decrease more, which has important rehabilitation significance, but although the depression level of dependent patients decreases greatly, the effect of Taijiquan group and control group is not obvious. Exercise tried in the process of clinical rehabilitation shows that high-intensity training seems to be particularly beneficial to depressive symptoms [31], which seems to be an experimental direction.

Taijiquan exercise has an obvious effect on improving the quality of life, and the overall sense of health, vitality, and mental health in the Taijiquan group are significantly higher than those in the control group. Some studies have conducted a randomized controlled trial of Taijiquan, which shows that Taijiquan is effective in managing mental health related to cancer, especially in reducing physical and mental fatigue and discomfort and increasing vitality [32]. Taijiquan practice requires the elimination of distractions, concentration, and calmness of mind. This process is actually a process of psychological adjustment and exercise. In addition, the psychological promotion benefit of Taijiquan should have a synergistic effect with traditional music. Taijiquan exercise is usually accompanied by quaint and leisurely music. In addition, Taijiquan exercises are mostly group activities and group communication activities, which can promote people's socialization and interpersonal relationship development and improve interpersonal communication, emotional communication, and self-closure in sports, so as to regulate and dredge negative emotions and enhance the sense of health. Quality of life is the subjective feeling and satisfaction of individuals in physical, psychological, and social aspects. Compared with epidemiological indicators such as morbidity, quality of life can sometimes more accurately reveal the interaction between health and disease, life events, and environment. Studies have shown that the quality of life is related to the cure of many diseases, and improving the quality of life of patients has become a problem that can not be ignored in the process of treatment [33]. Drug addicts are more addicted to the illusory world and the feelings brought by drugs, self-closure, closed circles, and reduced communication and communication with the outside world; normal living habits and social activities disappear, not to mention the social barriers. Taijiquan exercise provides a way to socialize communication.

The psychological craving in the Taijiquan group is much lower than that in the control group, which may be due to the fact that Taijiquan promotes the decline of craving by acting on other intermediary factors. Animal experiments show that physical activity reduces the self-administration of cocaine in animals, and physical activity may be an effective intervention in drug abuse prevention planning [34]. Physical activity, to some extent, is related to well-being, which is similar to drug-induced addictive behavior. Animal experiments have shown that running and cocaine have a common induction mechanism in the brain's reward pathway [35, 36]. Exercise can be used as an alternative nondrug reward to compete with drugs and reduce the possibility of their use [37]. At present, there are many theories about how exercise produces beneficial effects; although it is not entirely clear, but it can be determined that physical activity can be used as a preventive intervention for drug abuse by improving stress response and emotional regulation [38]. When abstaining from drug abuse, physical exercise can be a good medicine to enhance the function of the brain [39]. By participating in physical exercise, dependent people can improve cognitive control functions such as brain memory lost by drug abuse. According to the degree of muscle participation in exercise, Taijiquan is a sports skill with complex spatial navigation. During this exercise, practitioners need to integrate all kinds of self-ontological spatial information and participate in spatial navigation and spatial information at the same time. Taijiquan exercise seems to be more effective in improving the cognitive ability of people who depend on ATS. Therefore, Taijiquan exercise can improve the cognitive control system of ATS dependent patients, inhibit their decision to use illegal drugs, and play a good role in protecting long-term abstinence. The reduction of the psychological craving of the dependent is of great significance to the return to society. There is a certain relationship between psychological craving and dependence years, emotion, and physical and mental health [40], so it is of practical significance to abstain from treatment as soon as possible, scientifically increase physical exercise, and improve mental health. The mechanism of Taijiquan reducing psychological craving of ATS dependent patients needs to be further confirmed.

The exercise program studied pays too much attention to the control of exercise risk, limits the increase of exercise intensity and amount of exercise, and may affect the performance of exercise efficiency. If the dependent patients are followed up after leaving the institute, it is a good topic to observe the long-term effects of exercise habits. There are a large number of dependent people for community detoxification; they are closer to the natural state of society. Taijiquan intervention in the community may be more promising.

5. Conclusions

The balance ability, trait anxiety, overall health, vitality, and mental health of the ATS dependent Taijiquan group were significantly better than those of the control group. These factors may indirectly affect their psychological craving for drugs, and the psychological craving of the Taijiquan group is much lower than that of the control group. The decrease of psychological craving for drugs is of great significance for them to return to society.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Ethical Approval

The study was approved by the Scientific Research Ethics Committee of Shanghai Institute of Physical Education.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Wuqinxi Exercise Improves Hand Dexterity in Patients with Parkinson's Disease

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Objective. This study was designed to evaluate the effect of Wuqinxi after one session and 12-week intervention on hand dexterity in patients with Parkinson's disease (PD). *Methods*. Forty-six elderly participants with mild-to-moderate PD were randomly assigned to the groups trained with Wuqinxi ($n = 23$) or stretching ($n = 23$). All participants practiced 60 min session of either of these exercises, 2 sessions a week for 12 weeks in standing position. The score of Purdue Pegboard Test (PPT) and time for Soda Pop Test (SPT) were performed to assess hand dexterity and motor function along assessing the 39 items of Parkinson's Disease Questionnaire before and after 12-week interventions. In addition, the PPT scores were compared before vs. after one session of either of these two exercise modes. *Results*. Single session with either Wuqinxi or stretching exercise tended to improve PPT scores in PD patients. Furthermore, the improved SPT time was significant ($P < 0.01$) following 12-week training interventions with Wuqinxi (-1.32 ± 0.38 sec) or stretching (-0.89 ± 0.16 sec), which showed no group difference ($P = 0.734$). However, only the participants in Wuqinxi group significantly improved the PPT scores of the dominant hand ($+0.61 \pm 1.34$), both hand ($+1.83 \pm 3.13$) and assemble ($+2.04 \pm 3.44$) performance after 12-week training intervention. In parallel with improved hand dexterity and motor function, 12-week Wuqinxi training also significantly improved the patient's emotional wellbeing. *Conclusion*. The Wuqinxi intervention could be safely and effectively applied to improve hand dexterity following single-session exercise or 12-week training, which were accompanied by improved quality of life in patients with mild-to-moderate PD.

1. Introduction

Hand dexterity is as essential as walking ability or posture stabilization for maintaining independence and quality of daily living activities (DLA) [1, 2]. Patients with Parkinson's disease (PD) often have impaired hand dexterity [3–5] even in the early stages of the disease. Manual tremor, rigidity, or bradykinesia impair not only normal DLA, such as dressing, feeding, grooming, typing, and/or writing, but also the manual function and performance for utilizing assistive devices, such as crutches and wheelchairs in PD patients [6]. Although dopaminergic treatment can improve some main symptoms of PD, such as tremor, rigidity, or bradykinesia, impaired manual dexterity may be less responsive to pharmacological intervention [7]. Physical therapy has been proved to be able to enhance PD patients' manual dexterity and hand function [8–10]. However, the question remains whether exercise training can be safely and effectively applied to improve hand dexterity in patients with PD.

Qigong exercise is a traditional Chinese physical activity that integrates body movements, breathing techniques, and meditation to manipulate the patient's energy ("qi") to improve physical skill or achievement ("gong"), as well as mental and spiritual wellbeing [11]. Qigong is characterized by slow movement incorporated with moderated breathing, both of which help keep the mind in a state of calm relaxation [12]. It is believed that Tai Chi exercise [13] and Baduanjin Qigong [14] are safe and easy to practice by patients with mild-to-moderate PD. However, the impact of Wuqinxi exercise on hand dexterity of patients with PD has not been examined. Wuqinxi, also known as gymnastics of 5 animals (tiger, bear, deer, monkey, and bird), is a well-known traditional form of Qigong physical exercise [15, 16]. For a long time, Wuqinxi exercise has been established as a type of medical sport to provide physical wellbeing and to prevent and treat diseases in China. Documented reports indicate that Wuqinxi exercise has been applied to improve function of the lumbosacral multifidus [17], lumbar spine bone mineral density [18], immune function [15], and exercise capacity in patients with COPD [19] and to reduce the risk factors of cardiovascular disease and metabolic syndrome [20]. The focus of the present study was to test the hypothesis that Wuqinxi can be safely and effectively applied to improve hand dexterity in elderly adults with mild-to-moderate PD.

2. Materials and Methods

2.1. Study Participants. PD patients were recruited through Shanghai University of Sport or Xinhua Hospital, by referrals from neurologists and/or physical therapists, and distribution of the study information to local support groups for persons with PD. All participants provided an informed consent and signed the consent form which described the study procedure and was approved by the local ethical committee. The inclusion criteria for the study participants included a clinical diagnosis of PD, with a disease severity from mild to moderate level (rating from 1 to 3 out 5) according to the Hoehn and Yahr scale [21]; at least one limb with tremor, rigidity, bradykinesia, and/or postural instability based on the Unified Parkinson's Disease Rating Scale-Motor Examination (UPDRS-Part III) [22]; regularly taking prescribed medications for PD; ability to stand unaided and walk with or without an assistive device; willingness to be assigned to either of the two exercise groups; and an age of 55 to 80 years with medical clearance for participation in the study from his/her primary care physician. The exclusion criteria included currently involved in any behavioral or pharmacological intervention study or in instructor-led exercise training program, cognitive impairment based on medical history and/or clinical assessment, debilitating conditions or vision impairment that prevented from full participation in the study, and inability to attend to the exercise training program during the study period. Exercise training interventions started in September and completed in December 2018. A total of 58 patients gave an informed consent and passed physical examination. However, only 46 participants with mild-to-moderate PD enrolled were able to complete the study protocols. They were randomly assigned to the group trained with traditional Wuqinxi exercise ($N = 23$) or the group trained with the stretching exercise as control ($N = 23$) (see Table 1).

2.2. Exercise Interventions

2.2.1. Wuqinxi Exercise. Wuqinxi exercise (Figure 1) consisted of ten movements (two movements for each of the five animals): (1) tiger exercise (including raising the tiger's paws and tiger seizing the prey); (2) deer exercise (including colliding with the antlers and running like a deer); (3) bear exercise (including wobbling body like a bear and rubbing abdomen like a bear); (4) monkey exercise (including being on the alert like a monkey and plunking fruit like a monkey); and (5) bird exercise (including stretching arms upward like a bird and flying like a bird). These established traditional movements targeted to exercise muscles/joints including the facial muscles, eyes, mouth/teeth, hand/wrist, shoulder, cervical vertebra, and spine. Exercises of the fingers and toes are particularly emphasized for improving the blood circulation to the extremities but also for stimulating the acupuncture points that can be found there. Natural breathing was emphasized during the exercise.

2.2.2. Stretching Exercise. Stretching exercise was intended to provide a variety of upper body and lower body movements with slow and gentle joint extension and flexion and trunk rotation. Natural breathing was also emphasized during the stretching exercise.

2.2.3. Exercise Training. Both traditional Wuqinxi and stretching training programs were carried out 60 minutes per session, 2 sessions a week for 12 weeks. Both Wuqinxi and stretching exercises were performed in standing position. Background Health Qigong music was provided for all Wuqinxi and stretching training sessions. The participants' heart rates were monitored by Polar Team^2 monitor (Polar Electro, Finland) during exercise training. During the initial 2 to 3 weeks of the training, each session mainly emphasized learning and practicing two or three maneuvers or movement forms through repetitions, along with practicing previously learned movements. All training sessions were led and supervised by a Qigong instructor during these initial weeks. All participants were able to learn and familiarize the complete set of the established Wuqinxi exercise or stretching movements within 3 weeks of the training program. The participants were requested to continue their prescribed medications and to maintain the daily routine, normal lifestyle, and diet during the entire period of the study.

2.3. Outcome Assessments

2.3.1. Purdue Pegboard Test. The Purdue pegboard test (PPT) was used to test the timed speed and flexibility of hand movement, which has been commonly applied to evaluate hand dexterity in patients with PD [14, 23–25]. The test consisted of 4 subtests and the scores were determined by the number of pins placed in the pegboard within 30 seconds using the dominant hand (D), nondominant hand (ND), or both hands (B), and the number of pieces (containing pin, washer, and collar) assembled completely with two hands [25]. All tests were administered by a trained research assistant who followed the standard procedure and provided instructions according to the PPT manual. The test was

Table 1: Characteristics of the study participants.

	Wuqinxi	Stretching
Number of participants	23 (10 women)	23 (13 women)
Age (yr)	67.0 ± 5.6	67.1 ± 6.1
Body mass index (kg/m2)	23.6 ± 2.6	23.2 ± 3.0
PD severity level		
1–1.5	9	9
2–2.5	12	12
3	2	2
Duration of disease (yr)	5.0 ± 3.1	5.3 ± 3.8

There is no statistical difference in any characteristic category between two groups.

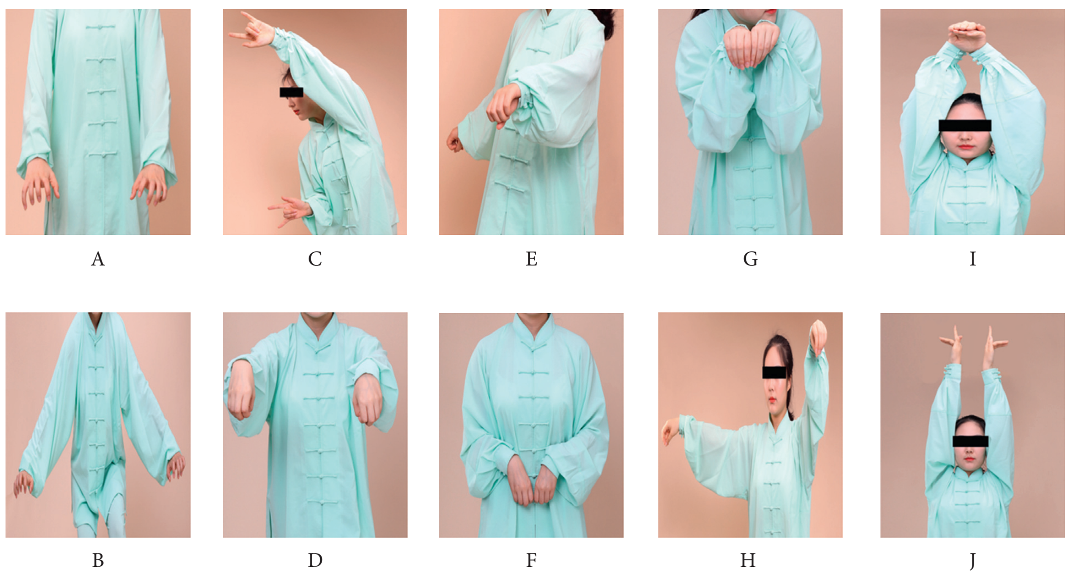

Figure 1: Illustrations of Wuqinxi exercise maneuvers. (a, b) Tiger exercise; (c, d) deer exercise; (e, f) bear exercise; (g, h) monkey exercise; (i, j) bird exercise.

administered individually for all participants. They all completed four PPT trials per test session. The PPT assessments were carried out before (i.e., baseline) and after 12-week training program (≥24 hours after the last exercise training session). In addition, all participants were tested before and after the first training session in the 4th week of the training program to assess the effect of one single-session exercise on the hand dexterity. They all were able smoothly to practice the complete set of the stretching exercise or the Wuqinxi exercise without reminder during the 4th week of the training.

2.3.2. Soda Pop Test. The Soda Pop Test (SPT) was used to test the hand movements and hand-eye coordination [13]. The test performed on a cardboard platform (32″ in length and 5″ in wide) with six circles (3.25″ in diameter) drawn centered on the cardboard 1.5″ apart. Three full soda pop cans were used for the test and placed in every other circle starting from the side of the hand being tested. On the signal of "Go," the stopwatch was started and the participant began to turn each can upside down into the adjacent empty circle within the drawn line, and then returned to the first can turned, replaced it in the original position, and continued with the other two cans. After two practice trials, the SPT process was repeated twice and the fastest time (in seconds) was documented as the test score. The dominant hand was used by all participants. The SPT measures were assessed and compared before (baseline) and after 12 weeks of Wuqinxi exercise or the stretching exercise training.

2.3.3. Parkinson's Disease Questionnaire. All participants completed the 39 items of Parkinson's Disease Questionnaire (PDQ-39) [26, 27] before (baseline) and after 12-week exercise training. The PDG-39 set was categorized into 8 thematic domains: mobility (questions 1–10), activities of daily living (questions 11–16), emotional problems (questions 17–22), stigma (questions 23–26), social support (questions 27–29), cognition (questions 30–33), communication (questions 34–36), and bodily discomfort (questions 37–39). Every item of the PDQ-39 had a range from 0 to 4 up to a maximum of 156 points. The scores in each of these 8 domains and a total score of the 39 items were summarized and compared before and after 12 weeks of the exercise training interventions. A lower score indicated a better condition.

2.4. Statistics Analysis. Normal distribution of the data was examined using Shapiro–Wilk's test. Data before and after exercise interventions within the group were analyzed using paired *t*-test. Outcomes following exercise interventions between the two groups were analyzed by two-factor analysis of variance (ANOVA) to assess the significance of the group factor (i.e., the Wuqinxi exercise vs. the stretching groups) and the time factor (i.e., before vs. after exercise interventions). The change (Δ) in the measured variables, i.e., the outcome difference following the interventions between the two groups, was compared using *t*-test for two independent groups or Rank Sum test if the data failed to pass a normal distribution test. The statistical analysis was performed using SPSS 22.0 software. All data were reported as group mean ± standard deviation (SD) of the mean. P value < 0.05 was considered statistically significant.

3. Results

All patients safely tolerated the workload of practicing the traditional Wuqinxi or stretching exercise. There was not any unexpected or adverse event that occurred during the study. Figure 2 shows the PPT performance following a single session of traditional Wuqinxi and stretching exercise. Both of these single-session interventions tended to improve the PPT scores significantly. There was no statistical significance for the group factor in the PPT score of the dominant hand ($P = 0.414$), nondominant hand ($P = 0.061$), or assemble ($P = 0.167$), except the performance by both hands ($P = 0.001$). The improved PPT score (Δ) from the two hand performance was greater or better ($P < 0.001$) following one session of stretching exercise (+1.65 ± 0.62) than Wuqinxi exercise (+0.52 ± 0.49).

After 12-week training with Wuqinxi exercise, the PPT performance of the dominant hand ($P = 0.040$), nondominant hand ($P = 0.056$), both hands ($P = 0.010$), and assemble ($P = 0.009$) was improved (Figure 3). However, 12-week training with stretching exercise did not have the significant effect on hand dexterity tested in terms of the change in PPT performance. The improved scores from the dominant hand and both hand performances were significantly greater or better ($P = 0.003$) after 12-week Wuqinxi training than stretching training (Figure 3).

The performance of the SPT was significantly ($P < 0.01$) improved following 12-week interventions with Wuqinxi exercise or stretching training (Figure 4). Nonetheless, the changes in the SPT scores were not significantly different between two interventions ($P = 0.657$).

After 12-week training, both Wuqinxi ($P < 0.01$) and stretching exercise ($P < 0.01$) interventions significantly decreased (i.e., improved) the overall PDQ-39 scale scores according to ANOVA for the time factor ($P = 0.003$). However, the improved scale scores were not different ($P = 0.92$) between these two exercise interventions. Furthermore, both Wuqinxi exercise and stretching interventions similarly improved ($P < 0.01$) the scale scores in Domain II–Activities of daily living, Domain III–Emotional wellbeing, and Domain VII–Communication with no group difference in all these improved scores. The scale scores in Domain IV–Stigma and Domain VIII–Bodily discomfort showed the significance with the time factor following 12-week training intervention (Figure 5).

4. Discussion

The present study was the first to confirm that Wuqinxi exercises were safe to be applied on patients with PD and effective to help reduce the hand dyskinesia and non–gait freezing. The improved hand dexterity in terms of changed PPT scores was significant following one-session Wuqinxi or stretching exercise. After 12 weeks of exercise training, the improved hand function was more significant in the patients trained with traditional Wuqinxi than the participants in the stretching group. In alignment with the improved hand dexterity and movement which could potentially improve daily function and quality of life, the participants' emotional wellbeing and self-confidence seemed to be significantly improved following 12-week interventions with traditional Wuqinxi.

4.1. The Effect of Single-Session Exercise. Previously, Pelosin et al. [28] demonstrated that a single 45 min finger exercise could significantly improve finger motor performance. Mateos-Toset et al. [9] reported that hand dexterity and strength could be enhanced by one-session hand exercise in PD patients. In agreement with these previous studies, our data confirmed that following one 60 min single session of either traditional Wuqinxi or stretching exercise, hand dexterity could be significantly improved in the patients with mild-to-moderate PD (Figure 2). Both the dominant and nondominant hands had significantly improved PPT scores after single session of Wuqinxi exercise. Parkinson's disease is a progressive neurodegenerative disorder associated with the loss and/or dysfunction of dopaminergic neurons in the substantia nigra [29]. Thus, the acute effect of one-session exercise on the hand dexterity in PD patients was more likely a result of improved function of the skeletomuscular system, including muscles/joints of the fingers and palms/hands. Movements in Wuqinxi exercise target actions on the fingers, palm, and wrist, in addition to the movements of the facial muscles, eyes, teeth/mouth, fontanel, arm, shoulder, cervical vertebra, etc., according to 2003 Health Qigong Management Center of State General Administration of Sports in China. However, the acute effects of the 60 min single-session stretching exercise intervention also significantly improved performances by the nondominant hand and two hands in patients with mild-to-moderate PD. This seems to suggest that any finger and palm stretching can acutely and positively affect hand dexterity.

4.2. The Effect of 12-Week Training. Parkinson's disease is characterized by tremor, rigidity, bradykinesia, and/or postural instability, which impairs daily motor functioning and quality of life and, thus, affects both physical and mental status. Physical activity and/or exercise have been shown to retard the PD-related deterioration of motor functions and to prolong functional independence [30, 31]. The present

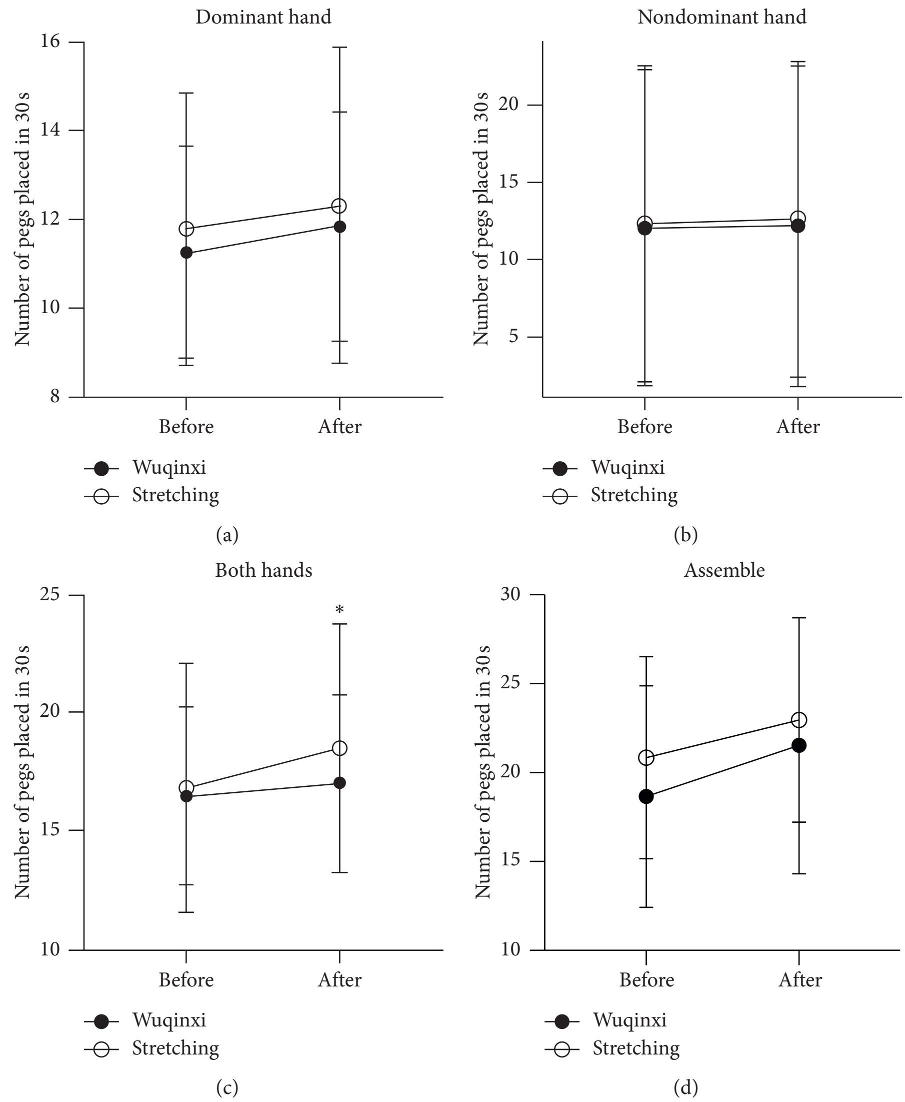

Figure 2: Placement of pegs after a single session of exercise. The number of pegs placed in 30 seconds after a single session of Wuqinxi (filled circles) and stretching (open circles). Asterisk denotes a significant difference between the groups. (a) Dominant hand. (b) Nondominant hand. (c) Both hands. (d) Assemble.

study confirmed that a 12-week training program with Wuqinxi significantly improved hand dexterity, i.e., with reduced hand rigidity and bradykinesia in patients with mild-to-moderate PD, evidenced by improved PPT scores (see Figure 3) and reduced SPT time (Figure 4). However, 12-week training intervention with stretching exercise only significantly improved the SPT performance, not the PPT scores. It was not clear about this discrepancy or the difference in the PPT performance between 12-week training with Wuqinxi and stretching exercise or between a significant improved SPT performance and no change in PPT scores after 12-week training with the stretching exercise intervention. It might be due to an influence of seasonal circadian and/or ambient temperature which could negatively impact muscle metabolism [32] and physical functionality, especially in the elderly adults [33], since the baseline of the present study started in September and the 12-week training intervention ended in December 2018. It has been reported that 4 out of 5 animal imitation movements (except the tiger imitation) in Wuqinxi exercise, a well-known established traditional Qigong, could have a positive thermogenesis effect according to the increases in skin temperature [16]. However, exercise intervention induced thermogenesis in stretching exercise is unknown, which might be less significant than Wuqinxi exercise. Nonetheless, both 12-week training programs with Wuqinxi and stretching exercise seemed to be safe and to have beneficial influence in improving overall motor function (Figure 5) along with the improved hand dexterity evident by improved SPT scores.

4.3. Improvement of Emotional Wellbeing. It has been well recognized that patients with PD are often inflicted by depression or psychological commodities [34–36] because tremor, rigidity, bradykinesia, and/or postural instability

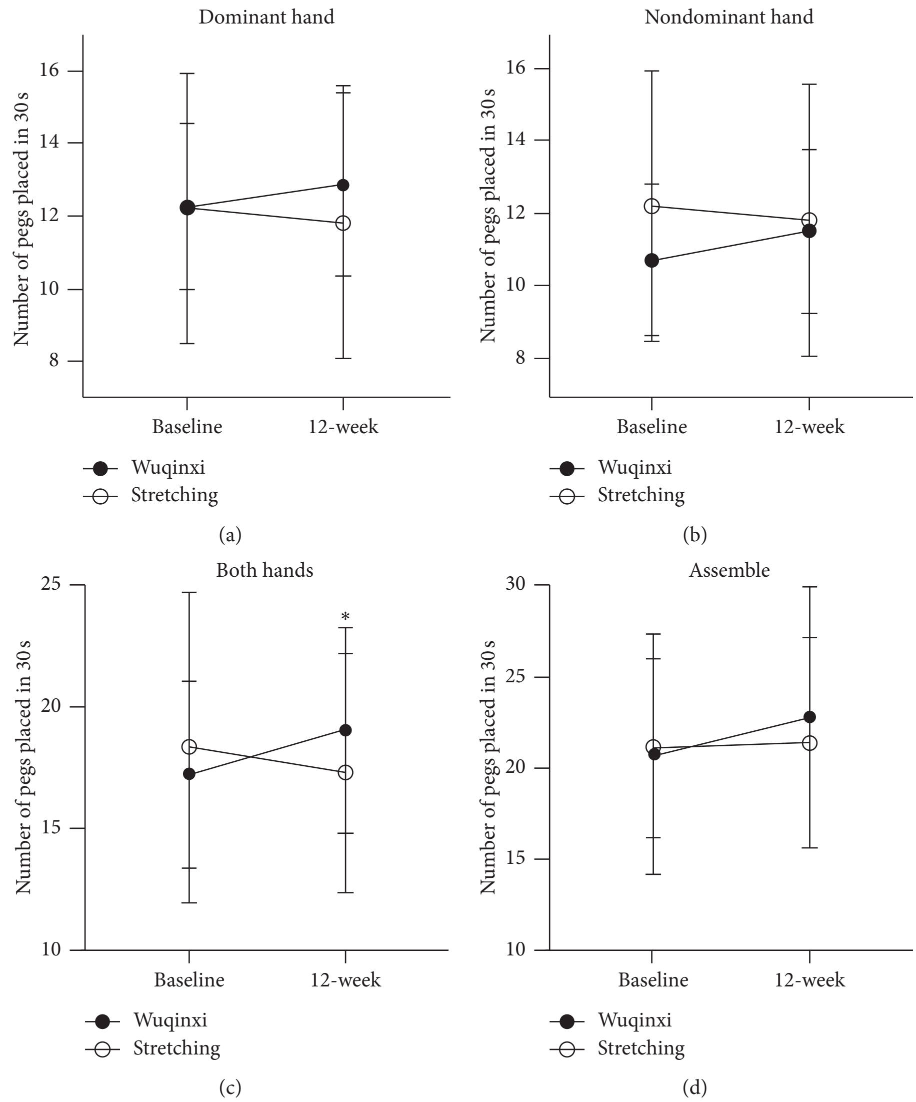

Figure 3: Placement of pegs after a 12-week training program. The number of pegs placed in 30 seconds in the Wuqinxi (filled circles) and stretching (open circles) groups after 12-week intervention. The PPT performance of the dominant hand ($P = 0.040$), nondominant hand ($P = 0.056$), both hands ($P = 0.010$), and assemble ($P = 0.009$) seem to be improved after 12-week training with Wuqinxi exercise. Asterisk denotes a significant difference between the groups. However, 12-week training with stretching exercise have no effect on hand dexterity tested in terms of the change in PPT performance. (a) Dominant hand. (b) Nondominant hand. (c) Both hands. (d) Assemble.

impair daily activities as well as emotional state [37, 38]. Deficits in hand dexterity may limit or restrict the individual's capacity to complete basic life tasks, such as writing [39], personal hygiene [40], eating with chopsticks, and dressing. In alignment with the improvement of motor function and activities of daily living, our data demonstrated that both 12-week interventions with Wuqinxi and stretching exercise seemed to significantly improve emotional wellbeing and self-confidence in the elderly participants with mild-to-moderate PD, as evident by the improved scale scores in PDQ-39 Domain III–Emotional wellbeing and Domain VII–Communication (Figure 5). The present study was the first to demonstrate that improved hand dexterity and motor function was accompanied by significantly improved psychological or mental status in PD patients following Wuqinxi and stretching exercise interventions.

However, both interventions with Wuqinxi exercise or stretching exercise had no effect on PDQ-39 Domain VI–Cognitions (see Figure 5), which could be related to the fact that the participants in the present study had a normal cognitive function which provided no margin for further improvement.

4.4. Study Limitations and Perspectives. The main limitation of the present study was no sham-training or control group in the study. Future study should consider using crossover design, which allows to have a control group meanwhile all participants are able to partake the benefits of the exercise intervention. In addition, there was no follow-up assessment in the study to determine how long the intervention-induced benefits sustain after the termination of the training

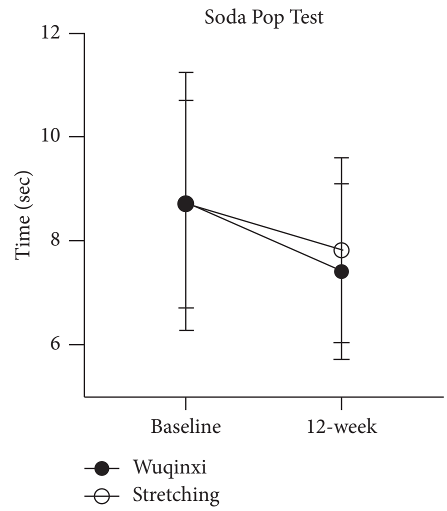

Figure 4: Soda Pop Test after a 12-week training program. The time spent on the Soda Pop Test is significantly improved in the Wuqinxi (filled circles) and stretching (open circles) groups after 12-week intervention. There is no difference between the groups.

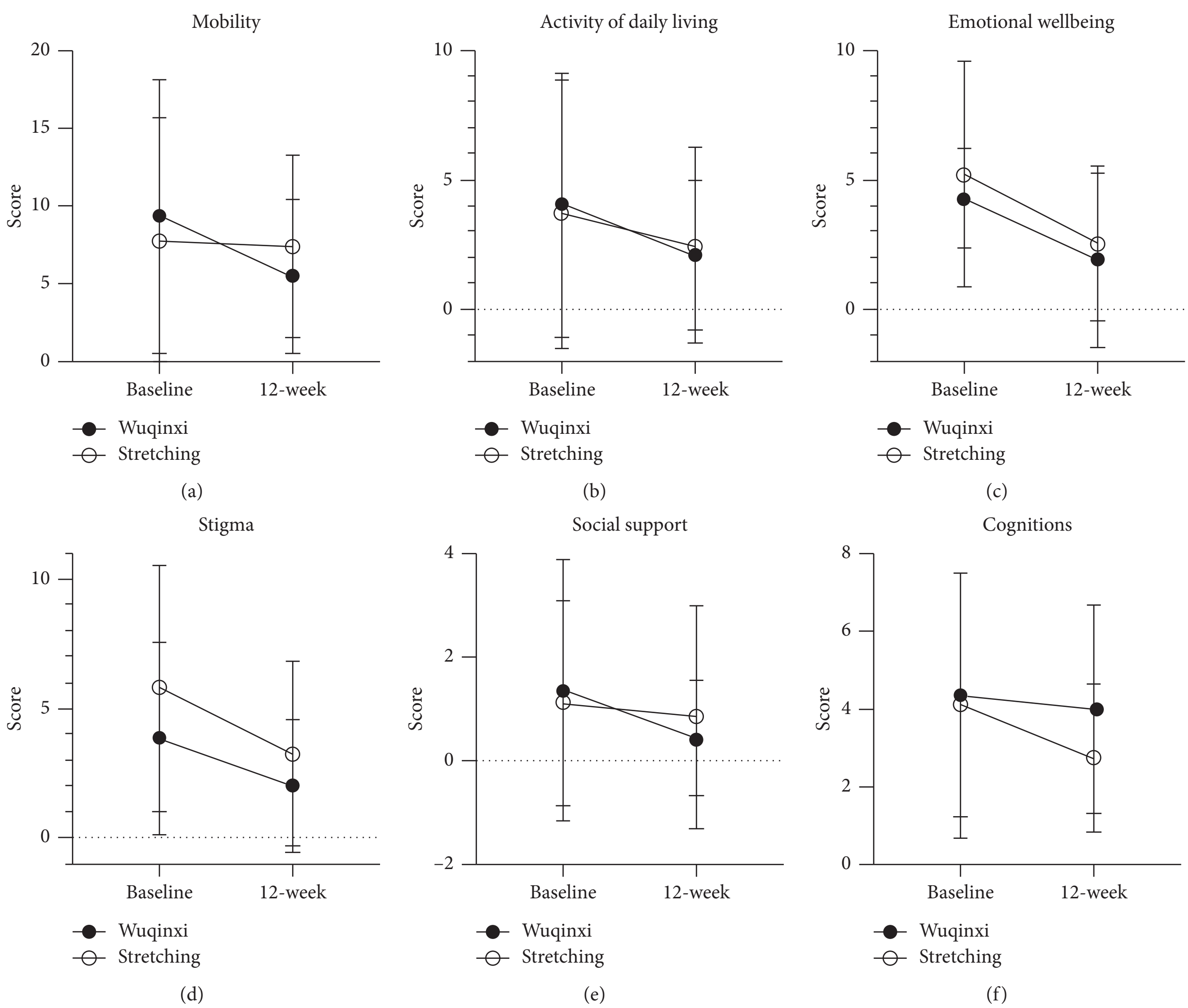

Figure 5: Continued.

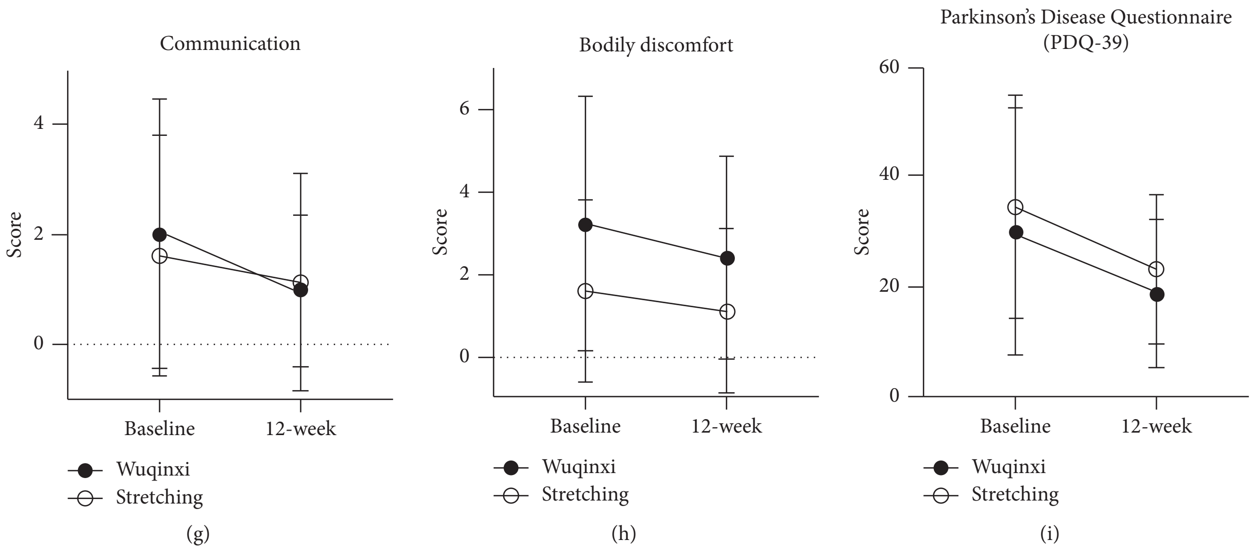

Figure 5: Scores of the 39 items of Parkinson's Disease Questionnaire before and after 12-week training. Scores of 8 dimensions and total points of the 39 items of Parkinson's Disease Questionnaire (PDQ-39) in the Wuqinxi (filled circles) and stretching (open circles) groups before vs. after 12-week exercise. Both interventions seem to improve the overall scores. The group difference is not significant. (a) Mobility. (b)Activity of daily living. (c) Emotional wellbeing. (d) Stigma. (e) Social support. (f) Cognitions. (g) Communication. (h) Bodily discomfort. (i) Parkinson's Disease Questionnaire (PDQ-39).

program. Assessing the effect of Wuqinxi on balance function should be the main focus of future study.

5. Conclusions

In conclusion, this study suggests that Wuqinxi exercise is safe, quick, and effective in improving hand dexterity in patients with mild-to-moderate PD. In association with improved physical motor function, the participants' emotional wellbeing and self-confidence seem to be enhanced following these exercise training interventions.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Research Article

Characteristic of Clinical Studies on Baduanjin during 2000–2019: A Comprehensive Review

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To date, a growing number of clinical studies have demonstrated the safety and health benefits from Baduanjin intervention. Based on this, our objective is to systematically retrieve and summarize the clinical studies on Baduanjin, with a view to providing more evidence-based evidence in support of the application of Baduanjin for healthcare, and to identify the shortcomings of existing research and provide feasibility suggest for further clinical research. Both four English language and four Chinese language electronic databases were used to search articles related to Baduanjin during 2000–2019. SPSS 22.0 software was used to analyze the data, and the risk of bias tool in the RevMan 5.3.5 software was used to evaluate the methodological quality of randomized controlled trials. A total of 810 publications were identified, including 43 (5.3%) systematic reviews, 614 (75.8%) randomized controlled trials, 66 (8.1%) nonrandomized controlled clinical studies, 84 (10.4%) case series, and 3 (0.4%) case reports. The top 10 diseases/conditions included diabetes, chronic obstructive pulmonary disease, hypertension, low back pain, neck pain, stroke, coronary heart disease, cognitive impairment, insomnia, and osteoporosis or osteopenia. The style of State General Administration of Sport of China in 2003 was the most commonly used version of Baduanjin, and Baduanjin was practiced with an average of 35 minutes, 1 or 2 times a day, 3–5 days per week, and a 18-week average duration. It is also worth noting that there were no serious adverse events related to Baduanjin intervention. Most studies were small sample size research, and the methodological quality of randomized controlled trials is generally low. The clinical studies of Baduanjin have a substantial quantity and evidence base. However, there are significant differences among different studies in the specific intervention measures such as style, intensity, duration, learning, and practice methods, which need to be further standardized and unified. Further high-quality designed and reporting studies are recommended to further validate the clinical benefits of Baduanjin.

1. Introduction

Baduanjin, also known as eight-section brocades, dates back to the Chinese Song Dynasty (10th–13th century A. D) and is a traditional Chinese sports method that uses the combination of human physical activity, breathing, and psychological regulation as elements [1]. As one is practicing the exercise, both the breathing and the body movement are slow, and the breathing is rhythmic and in harmony with the body movements. For hundreds of years, millions of Chinese have practiced Baduanjin to cultivate and maintain health. In recent years, due to its effectiveness for keeping fit, ease in learning, and economy of exercising time, Baduanjin has become popular worldwide as a promising low-intensity, physical and mental exercise.

To date, a growing number of clinical studies have demonstrated the safety and health benefits from Baduanjin intervention [2, 3]. Several systematic reviews have examined the evidence provided by Baduanjin in randomized controlled trials or nonrandomized clinical trials for various specific diseases and health conditions, such as diabetes mellitus [4–6], chronic obstructive pulmonary disease (COPD) [7], and cardiovascular disease [8, 9]. It is particularly worth noting the coronavirus disease 2019 (COVID-19) that broke out in Wuhan, China; some of the discharged patients in 2019 novel coronavirus (2019-nCoV) still have clinical manifestations such as fatigue, anorexia, and emotional abnormalities, with varying degrees of impaired lung function, changes in interstitial pneumonia, and the possibility of pulmonary fibrosis. National Health Commission and National Administration of Traditional Chinese Medicine of the People's Republic of China jointly issued the "Guidelines for Rehabilitation of Traditional Chinese Medicine in the Recovery Period of New Coronary Virus Pneumonia (Trial)" (referred to as "Rehabilitation Recommendations for Recovery Period"), suggesting that 2019-nCoV patients with light or ordinary type can adopt traditional exercises such as Baduanjin, Tai Chi Chuan, and Liuzijue after leaving hospital [10]. However, there is currently no direct evidence that Baduanjin, Tai Chi Chuan, and Liuzijue can promote the recovery of 2019-nCoV patients. In addition, with the rapid development of the peer-reviewed literature of Baduanjin, there is no comprehensive systematic review on its application in the fields of disease prevention, treatment, and rehabilitation.

Therefore, we systematically retrieved and summarized the clinical studies on Baduanjin, with a view to providing more evidence-based evidence in support of the application of Baduanjin for healthcare and to identify the shortcomings of existing research and provide feasibility suggest for further clinical research.

2. Methods

2.1. Data Sources and Searches. A comprehensive literature search was conducted by two review authors (JZ and YYY) through 3 January to 12 January 2020. Baduanjin-related articles published between 2000 and 2019 were retrieved from four well-respected English language electronic databases (PubMed, Cochrane Library, Web of Science, and Embase). The following keywords were used by the review authors: "Baduanjin," "Baduanjin exercise," and "eight-section Brocade." No language restriction was applied. Taking a specific strategy as an example, the search terms in the PubMed database were as follows: (((Baduanjin[title/abstract]) or (Baduanjin exercise[title/abstract])) or (eight section brocades[title/abstract])) and (("2000/01/01"[date-publication]: "2019/12/31"[date-publication])). In addition, the four highly respected Chinese academic databases, which included China National Knowledge Infrastructure (CNKI), SinoMed, Wanfang database, and Chinese Scientific Journal database (VIP), were also adopted to search Chinese literature by using the keyword "八段锦" (Baduanjin). Publication language is limited to Chinese or English.

2.2. Inclusion/Exclusion Criteria. We included all types of clinical studies with Baduanjin intervention, including systematic review (SR), randomized clinical trial (RCT), nonrandomized controlled clinical studies (CCS) (quasirandomized clinical trial or observational studies such as cohort or case-control study), case series (CS), and case report (CR), which included Baduanjin as the intervention for any disease/condition or healthy participants. Any type of Baduanjin, regardless of its style or training method, was included.

Anecdotes, newsletters, cross-sectional studies, study protocols, and duplicate publications were excluded. Reports published as abstracts and lack of research on basic information on Baduanjin interventions were excluded. Neither the reviews irrelevant to Baduanjin intervention nor the studies of complex interventions using Baduanjin as one of the intervention components, which did not provide a detailed description of Baduanjin intervention, were also excluded.

2.3. Literature Screening and Data Extraction. Two authors (YYY and JJ) independently screened the article titles and abstracts based on the inclusion and exclusion criteria, downloaded the full text for further screening, and also classified all eligible clinical studies according to their study designs. The screening and extraction results of the two research members were compared, and if there was any uncertainties or discrepancies, a third author (YZ) was consulted.

A structured data extraction form was designed by two authors (YYY and JJ) to extract data from the included articles independently. The form consisted of the following sections:

(1) *Basic Information*. Including article title, author, country/region, year of publication, study design, publication type, and funding information if available
(2) *Disease/Condition*. According to the International Classification of Diseases, 11th Revision (ICD-11), the names of directly extracted diseases/conditions were divided into different categories [11]. In addition, the sample size of subjects included in each clinical study was also recorded.
(3) *Baduanjin Intervention*. We extracted the style of Baduanjin, single intervention/combined intervention, qualification of the instructor, practice methods, frequency, and treatment duration. If Baduanjin was used in combination with other therapies, other therapies were extracted. Besides,

the interventions of the control group were specifically recorded.

(4) *Outcomes and Conclusions*. We extracted all the outcomes directly and classified them into different categories. If shedding and adverse reactions were reported, the results were extracted if available. We also summarized the conclusions (positive, negative, or unclear) of the overall authors. "Positive" was defined if the study achieved its objective and statistically favored Baduanjin; "negative" was defined if the study failed to reach its objective or did not favor Baduanjin; "unclear" was defined if the study objective was unclear or the conclusions were inconclusive.

2.4. Methodological Quality Assessment. Using the risk of bias (ROB) tool in the Review Manager (RevMan) software (Version 5.3.5, Nordic Cochrane Center, Cochrane Collaboration, Copenhagen, Denmark) and referring to the ROB assessment criteria in the Cochrane Handbook [12], the included randomized controlled trials were evaluated "low risk of bias," "unclear risk of bias," and "high risk of bias" from these aspects that included random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other bias.

2.5. Data Analysis. The extracted data were analyzed using the SPSS software (Version 22.0, SPSS, Inc., Chicago, IL, USA) and were presented by counts, percentage, and frequency.

3. Results

3.1. Selection of Studies. Flow of the study search and selection process is shown in Figure 1. 5660 articles were initially identified through electronic retrieval. After removing duplicates, 3513 articles were obtained, and the titles and abstracts of these literatures were screened to exclude 2039 articles that did not meet the inclusion criteria. According to the inclusion and exclusion criteria, the remaining 1474 articles were selected for full-text download, and 664 articles were excluded again, and then, 810 studies were left for further analysis. The characteristics of included clinical studies on Baduanjin are shown in Table S1.

3.2. General Characteristics of Included Studies. In the last 20 years, the publication of clinical studies on Baduanjin generally increased with years (Figure 2). Among the 810 studies, 737 (91.0%) were published in Chinese and 73 (9.0%) in English. Depending on the type of article published, it included 655 (80.9%) journal articles, 17 (2.1%) conference papers, and 138 (17.0%) master's and doctoral dissertations. Furthermore, 332 (41.0%) studies reported the support from a foundation, most of which were funded by government.

The included studies covered almost all types of clinical research, including 43 (5.3%) systematic reviews, 614 (75.8%) randomized controlled trials, 66 (8.1%) nonrandomized controlled clinical studies, 84 (10.4%) case series, and 3 (0.4%) case reports. The 810 studies were implemented in 9 countries/regions, and the majority of studies (789/810, 97.4%) were implemented in Chinese Mainland, followed by Hong Kong (10/810, 1.2%) and Taiwan (5/810, 0.6%) (Table 1).

3.3. Disease/Condition Categories. Of the 810 articles included, 152 (18.8%) studies explored the health-promoting effects of Baduanjin on healthy participants; 19 (2.3%) studies explored the health-recovery effects of Baduanjin on subhealthy participants; the remaining 639 (78.9%) studies observed the efficacy and safety of Baduanjin in 81 clinical diseases/conditions. According to ICD-11 categorization, Baduanjin was most commonly used in diseases of the musculoskeletal system or connective tissue, endocrine, nutritional or metabolic diseases, and diseases of the circulatory system (Table 2). The top 10 diseases/conditions included diabetes, chronic obstructive pulmonary disease (COPD), hypertension, low back pain, neck pain, stroke, coronary heart disease, cognitive impairment, insomnia, and osteoporosis or osteopenia (Table 3).

3.4. Sample Size. Excluding systematic reviews and case reports, the study sample size of 764 articles including randomized controlled trials, nonrandomized controlled clinical studies, and case series was analyzed. The average sample size of all studies was 82 cases, which belonged to small sample size studies, and the sample size fluctuated greatly. The sample size varies significantly between different types of studies, and the sample size fluctuations between the same types of studies are also large (Table 4).

3.5. Baduanjin Intervention. We removed systematic reviews to avoid duplication of information and performed statistical analysis on the Baduanjin intervention in 767 articles including randomized controlled trials, nonrandomized controlled clinical studies, case series, and case reports. Table 5 shows the Baduanjin styles applied in the 767 clinical studies, of which 332 (43.3%) studies identified the style of Baduanjin, and the style of State General Administration of Sport of China in 2003 was the most commonly used.

324 (42.2%) studies used Baduanjin alone as intervention, while Baduanjin was applied in combination with other therapies in the remaining 443 (57.8%) studies, which include conventional medications, acupuncture, herbal medications, health education, diet and lifestyle guidance, psychological, and other physical therapies. 440 (57.4%) studies reported that participants learned Baduanjin under the guidance of instructors, but rarely described the qualification of instructors. There were 339 (44.2%) studies that mentioned the practice methods of Baduanjin, in which participants practiced Baduanjin under the guidance and

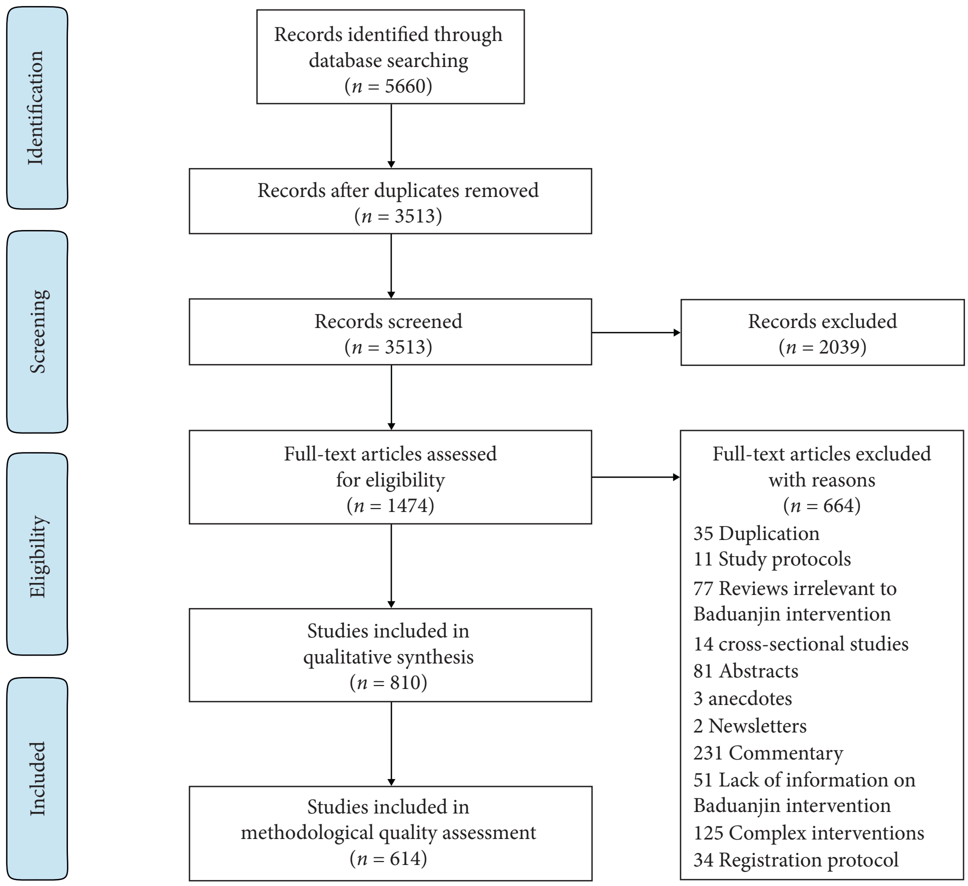

Figure 1: Flow diagram. Presentation of the procedure of study searching and selection with numbers of articles at each stage.

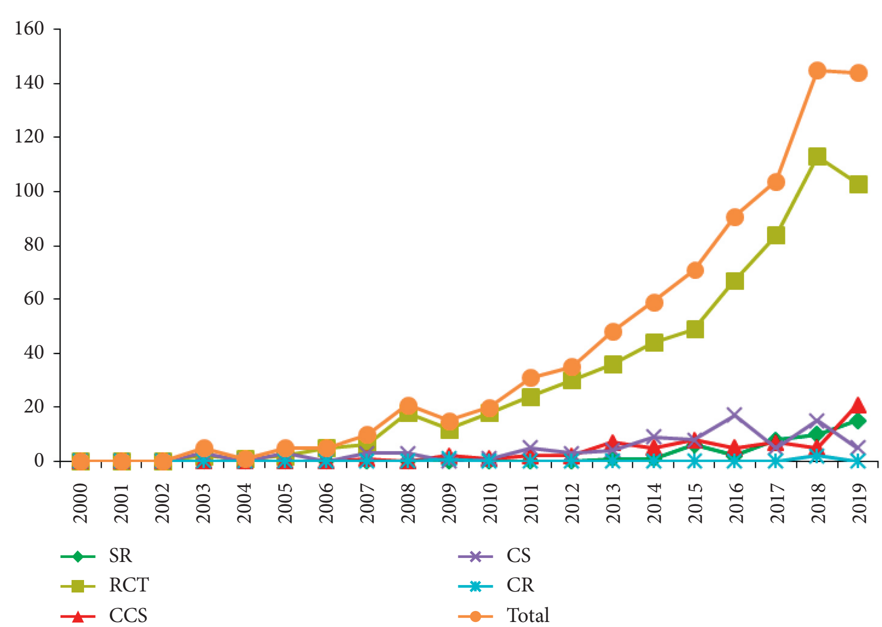

Figure 2: Study designs over time in the numbers of published clinical studies on Baduanjin. Abbreviations: SR, systematic review; RCT, randomized clinical trial; CCS, nonrandomized controlled clinical studies (quasirandomized clinical trial or observational studies such as cohort or case-control studies); CS, case series; CR, case report.

Table 1: Number of clinical studies on Baduanjin conducted in different countries/regions ($n = 810$).

Country/region	Study design (number of studies)					Total (%)
	SR	RCT	CCS	CS	CR	
Chinese Mainland	35	603	66	82	3	789 (97.4)
Hong Kong	4	6	0	0	0	10 (1.2)
Taiwan	0	4	0	1	0	5 (0.6)
USA	1	0	0	0	0	1 (0.1)
Australia	1	0	0	0	0	1 (0.1)
Brazil	1	0	0	0	0	1 (0.1)
Chile	1	0	0	0	0	1 (0.1)
Spain	0	1	0	0	0	1 (0.1)
Macao	0	0	0	1	0	1 (0.1)

SR, systematic review; RCT, randomized clinical trial; CCS, nonrandomized controlled clinical studies (quasirandomized clinical trial or observational studies such as cohort or case-control studies); CS, case series; CR, case report; USA, United States of America.

Table 2: Clinical trials of Baduanjin organized by prevalence of disease categories based on ICD-11 classifications.

Chapter	Blocks	Disease/conditions (ICD-11 codes)	No. of study*
15	FA00–FC0Z	Diseases of the musculoskeletal system or connective tissue	124
05	5A00–5D46	Endocrine, nutritional, or metabolic diseases	124
11	BA00–BE2Z	Diseases of the circulatory system	114
08	8A00–8E7Z	Diseases of the nervous system	65
12	CA00–CB7Z	Diseases of the respiratory system	63
06	6A00–6E8Z	Mental, behavioral, or neurodevelopmental disorders	46
02	2A00–2F9Z	Neoplasms	32
16	GA00–GC8Z	Diseases of the genitourinary system	24
07	7A00–7B2Z	Sleep-wake disorders	17
13	DA00–DE2Z	Diseases of the digestive system	10
14	EA00–EM0Z	Diseases of the skin	6
04	4A00–4B4Z	Diseases of the immune system	5
01	1A00–1H0Z	Certain infectious or parasitic diseases	4
09	9A00–9E1Z	Diseases of the visual system	2

ICD-11, International Classification of Diseases, 11th Revision. *Some systematic reviews involved more than one type of diseases or conditions.

Table 3: Top 10 diseases/conditions included in clinical studies on Baduanjin.

Disease/Condition	Study design (number of studies)					Total (%)
	SR*	RCT	CCS	CS	CR	
Diabetes	6	79	6	6	0	97 (12.0)
COPD	4	54	3	0	0	61 (7.5)
Hypertension	6	35	5	2	0	48 (5.9)
Low back pain	2	38	2	0	0	42 (5.2)
Neck pain	1	34	1	1	0	37 (4.6)
Stroke	3	28	1	1	0	33 (4.1)
Coronary heart disease	3	18	2	1	0	24 (3.0)
Cognitive impairment	3	17	0	0	0	20 (2.5)
Insomnia	1	14	0	2	0	17 (2.1)
Osteoporosis or osteopenia	1	14	0	0	0	15 (1.9)

SR, systematic review; RCT, randomized clinical trial; CCS, nonrandomized controlled clinical studies (quasirandomized clinical trial or observational studies such as cohort or case-control studies); CS, case series; CR, case report; COPD, chronic obstructive pulmonary disease. *Some systematic reviews involved more than one type of diseases or conditions.

supervision of instructors (132/767, 17.2%), or by themselves at home with the support of videos (71/767, 9.3%), or both of the two methods (136/767, 17.7%).

Baduanjin practice in 747 (97.4%) studies varied from 5 minutes [13] to 120 minutes [14] each session, with an average of 35 minutes. Most studies practice 1 or 2 times a day, 3–5 days per week, and five 30 minutes sessions per week (73/767, 9.5%) were most popular. The duration of Baduanjin intervention varied from 5 days [15] to 3 years [16], with an average of 18 weeks, and the most common duration was 12 weeks (261/767, 34.0%), followed by 24 weeks (159/767, 20.7%).

3.6. Control Intervention. The control interventions of 680 randomized clinical trials and nonrandomized controlled clinical studies were statistically analyzed, and the most common intervention was the routine treatment plan

Table 4: Sample size in the clinical study on Baduanjin ($n = 764$).

Study design	No. of study	Sample size		
		Minimum	Maximum	Mean ± standard deviation
RCT	614	16	1973	81.16 ± 86.32
CCS	66	12	1721	109.98 ± 208.67
CS	84	12	500	69.45 ± 68.84

RCT, randomized clinical trial; CCS, nonrandomized controlled clinical studies (quasirandomized clinical trial or observational studies such as cohort or case-control studies); CS, case series.

Table 5: Baduanjin styles applied in 767 clinical studies including RCT, CCS, CS, and CR.

Baduanjin style	No. of study	Frequency (%)
Unspecified style	445	58.0
The style of State General Administration of Sport of China in 2003	264	34.4
Homemade style	18	2.3
Others	12	1.6
The style of Chinese Health Qigong Association	11	1.4
Deng Tietao style	9	1.2
The style of Chinese Traditional Sport Health Preservation	5	0.7
The style of Beijing Sport University	3	0.4

RCT, randomized clinical trial; CCS, nonrandomized controlled clinical studies (quasirandomized clinical trial or observational studies such as cohort or case-control studies); CS, case series; CR, case report.

(234/680, 34.4%), followed by blank control (181/680, 26.6%), exercise (134/680, 19.7%), health education (65/680, 9.6%), medications (58/680, 8.5%), and other traditional Chinese medicine methods (including Tuina, acupuncture, and herbal medications). Among the 134 studies using exercise as a control intervention, the most commonly used mode was walking (49/680, 7.2%), followed by traditional Chinese exercise such as Tai Chi Chuan, Wuqinxi, Yijinjing, and Liuzijue (31/680, 4.6%), jogging (12/680, 1.8%), broadcast calisthenics (7/680, 1.0%), and other aerobic and resistance exercises.

3.7. Outcomes. In addition to systematic reviews, statistical analysis was conducted on the primary outcomes of 767 clinical studies. The most common outcomes were related to laboratory tests, such as blood glucose and blood lipids. Second, the related symptom scales were evaluated, such as the visual analogue scale (VAS), JOA score, Oswestry disability index (ODI), COPD assessment test (CAT), Seattle Angina Questionnaire (SAQ), Pittsburgh Sleep Quality Index (PSQI), and Kupperman score. The third was the quality of the life scale, such as the Diabetes-Specific Quality of Life Scale (DSQL), SF-36, and World Health Organization Quality of Life Brief Scale (WHOQOL-BREF). There were also assessments of physiological functions including body mass index (BMI) and balance ability. As well as psychological assessment, such as the self-rating anxiety scale (SAS), self-rating depression scale (SDS), Hamilton depression scale (HAMD), Profile of Mood States (POMS), and Symptom Checklist 90 (SCL-90).

Except for 43 systematic reviews, only 70 (9.1%) of the remaining 767 studies mentioned records of adverse reactions, of which 7 (0.9%) studies reported that there were adverse events in detail, such as muscle and joint pain caused by exercise, fatigue, dizziness, chest tightness, palpitation, shortness of breath, and so on. There were no serious adverse events related to Baduanjin intervention.

After removing 3 case reports again, only 218 (28.5%) of the remaining 764 studies mentioned that the reasons for shedding included patients who were lost to follow-up, failed to complete the test, excluded from the study protocol, and combined other diseases or deaths that were not significantly related to Baduanjin intervention.

3.8. Methodological Quality Assessment. The methodological quality of 614 randomized controlled trials was evaluated using the ROB tool in RevMan 5.3.5, which suggests moderate quality (Figure 3). Only less than half of the studies have identified low-risk random sequence generation methods (273/614, 44.5%), and there were still a few studies that used high-risk random methods such as grouping by odd and even numbers of hospital records (41/614, 6.7%). The method of allocation concealment was clearly identified in only 57 (9.3%) studies; so, the selectivity bias was significant in the included studies. Because Baduanjin intervention could not blind participants, bias was high risk in all studies. Only 37 (6.0%) studies explicitly blinded the outcome evaluators, 192 (31.3%) studies completely reported the approach to case dropout and missing data, and very few studies mentioned protocol registration and published the

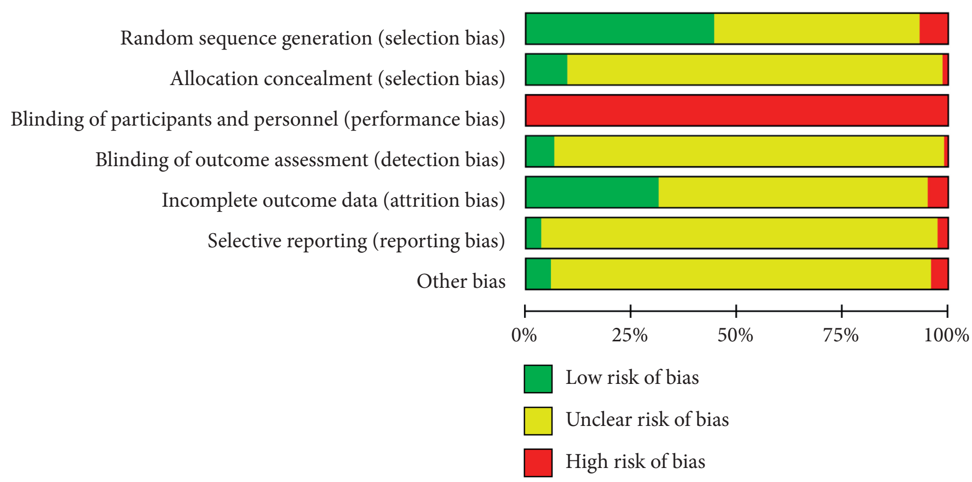

Figure 3: Risk of bias graph: review authors' judgments about each risk of the bias item presented as percentages across all included studies.

results in full (19/614, 3.1%), so the overall quality of the study included in the detection bias, attrition bias, and reporting bias was not high. Only a few studies have fully reported protocol registration, clinical ethics review, and clinical trial procedures, which were sufficient to exclude other risks of bias (32/614, 5.2%).

4. Discussion

This systematic review is a comprehensive qualitative analysis from 2000 to 2019 of the clinical evidence on Baduanjin for healthcare, treatment, and rehabilitation, including systematic reviews, randomized controlled trials, nonrandomized controlled clinical trials, case series, and case reports. Our findings indicate that after 2000, the number of clinical studies on Baduanjin has shown an increasing trend, especially higher level evidence such as RCTs. This may be related to the fact that the Health Qigong Management Center of State General Administration of Sport of China organized and edited Health Qigong including Baduanjin in 2003 and promoted it vigorously throughout the country. Of note, nearly half of studies are supported by the fund, which also reminds the national government and medical institutions to attach importance to the clinical benefits of Baduanjin.

The clinical research of Baduanjin not only involves the physical and mental state of healthy/subhealthy people but also includes a wide range of diseases/conditions such as diabetes, chronic obstructive pulmonary disease (COPD), hypertension, lower back pain, neck pain, stroke, coronary heart disease, cognitive impairment, insomnia, osteoporosis or osteopenia, and so on. Most diseases are diseases of the musculoskeletal system or connective tissue, endocrine, nutritional or metabolic diseases, diseases of the circulatory system, diseases of the nervous system, and diseases of the respiratory system, which may be related to the physiological and biomechanical processes Baduanjin training influences. Baduanjin is a low-intensity aerobic exercise, which is characterized by a slow coordinated posture combined with musculoskeletal stretching movements, meditation minds, and breathing techniques. Several recent research studies have shown that practicing Baduanjin can relieve musculoskeletal pain [17–19], adjust blood pressure, glucose, and lipid [4, 8, 20], enhance cardiopulmonary function [7, 21], and improve sleep quality by relaxing the mental state and regulating breathing [22, 23].

It is of great significance to fully describe the details of interventions in clinical trials not only to provide solid evidence for clinical application but also to provide a detailed reference for further repeated trial operations [24]. This review shows that most of the included clinical trials did not adequately describe the style and form, session, frequency, duration, learning methods, and qualification of instructors of Baduanjin intervention. In this review, the included clinical trials of Baduanjin have a wide range of exercise intensity, with an average time of 35 minutes per session. Most studies practice 1 or 2 times a day, 3–5 days per week, and five 30 minutes sessions per week were most popular. The requirement of moderate-intensity exercise may be the reason why most studies have obtained positive results. On this basis, we recommend standardizing the design, conduct, and reporting of Baduanjin intervention to ensure that it is better implemented and evaluated in clinical trials.

Most of the control interventions in the clinical study of Baduanjin are without exercise or other exercise. Clinically, the evidence of health benefits of exercise is accurate [25], and Baduanjin also shows obvious advantages compared with no exercise. However, when compared with other exercises such as walking and jogging, the results of the study are significantly different. This may be because the study design of different clinical studies is different, and we cannot combine them for further quantitative analysis.

The vast majority of clinical trials included in this study obtained positive results, showing that Baduanjin has certain benefits in prevention, treatment, or rehabilitation. However, most of the included studies are small-sample studies, and the methodological quality of randomized controlled trials is low. Therefore, according to the current clinical evidence, the clinical benefits of Baduanjin still need to be further verified by random controlled trials with a large sample size and strict design. Besides, patient participation and compliance also have a certain impact on the research results. In this study, 218 (28.5%) clinical trials reported that the reason for shedding was mainly related to the low compliance of patients. Thus, how to improve patient compliance in subsequent clinical trials is worthy of serious consideration and design.

There is currently no review to systematically assess the frequency and quality of adverse event reports related to the clinical trial of Baduanjin. Only a few studies mentioned mild symptoms such as muscle and joint pain caused by exercise, and most of them relieved or disappeared quickly after stopping exercise and resting. Similarly, due to poor and inconsistent reports of adverse events, this review also failed to clearly draw conclusions about the safety of Baduanjin, but none of the existing studies reported serious adverse events related to Baduanjin.

Inevitably, there are some limitations in this review. First, subjected to the condition that our search language is limited to Chinese and English, and the search results also show that most of the Baduanjin studies were published in Chinese by Chinese researchers, but it cannot be ruled out that there may be a small number of clinical studies published in other languages, such as Japanese and Korean. Second, although most studies have obtained positive results, its methodological quality is low; so publication bias cannot be ruled out, and it also limits the level of evidence for bibliometric evaluation. Third, we focus on using qualitative analysis methods to describe the clinical research trends and characteristics of Baduanjin in the past 20 years; however, there is no quantitative analysis of a specific disease, and it is impossible to provide specific evidence-based evidence for the application of Baduanjin to a certain disease.

We make the following suggestions for further clinical studies on Baduanjin. First of all, we should improve and standardize the reporting of Baduanjin interventions in clinical trials. According to CONSORT 2010 statement [26], we recommend that the style and form, session, frequency, duration, learning methods, practicing methods, instructor qualification, participant compliance, and follow-up of Baduanjin intervention can be clarified in the research protocol. In addition, except for the fact that Baduanjin intervention cannot be blinded, which leads to performance bias, other aspects of the randomized controlled trials should be designed strictly. What is more, we can try to explore the relationship between the intensity and/or duration of Baduanjin and its effect on specific diseases and optimize the dose-response to further provide evidence for the clinical application of Baduanjin. Finally, in this review, we found that the majority of included clinical trials were not registered for prospective trials. Therefore, we recommend that trials should be registered in public clinical trial registries to prevent reporting bias.

5. Conclusions

This review, based on various diseases/conditions literature available in the past 20 years, suggests that the clinical studies of Baduanjin have a substantial quantity and evidence base. Although most studies report positive effects of Baduanjin on prevention, treatment, and rehabilitation, there are significant differences among different studies in the specific intervention measures such as style, intensity, duration, learning, and practice methods, which need to be further standardized and unified. Furthermore, because the methodological quality of the current research is low, it is recommended that high-quality designed and reporting studies should be conducted in the future to further validate the clinical benefits of Baduanjin.

Data Availability

All data generated or analyzed during this study are included within this article. Raw data are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Jing Zhou and Yunyang Yu are the co-first authors, applied the search strategy, and wrote the manuscript. Jing Zhou, Yunyang Yu, and Yan Zhao contributed to the conception and design of the review. All authors performed the experiments. Yunyang Yu and Jian Jia analyzed the data and completed methodological quality assessment. Yan Zhao reviewed and revised the draft of the manuscript and is responsible for the overall project. All authors read and approved the final manuscript.

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Supplementary Materials

Table S1: characteristics of included clinical studies on Baduanjin. (*Supplementary Materials*)

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Review Article

The Beneficial Effect of Traditional Chinese Exercises on the Management of Obesity

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This paper systematically reviewed the clinical update of traditional Chinese exercises in the treatment of simple obesity in recent years and discussed their specific advantages in this aspect. This review focused on several typical traditional Chinese exercises, namely, Tai Chi, Ba Duan Jin, Yi Jin Jing, Wu Qin Xi, Shaolin Neigong, and Liu Zi Jue, which all showed clinical beneficial effect on the treatment of simple obesity with their own characteristics. To optimize the clinical therapeutic effect of these traditional Chinese exercises, we need to seek the most appropriate exercise or the combo exercise based on the characteristics of different obese population, to improve the efficiency of weight loss, reduce sports injury, and consolidate the therapeutic effect. In the future, we need to further evaluate the efficacy of sitting exercise, lying exercise, and static training in the treatment of simple obesity, subdivide the treatment population, and explore the working mechanism of these traditional Chinese exercises.

1. Introduction

Obesity is a clinical syndrome in which the body fat content is too high and/or the distribution is abnormal under the action of genetic and environmental factors, so that the actual body weight exceeds 20% of the ideal body weight and can be complicated with cardiovascular disease and a variety of endocrine and metabolic disorders [1].

Data from the Blue Book on Obesity Prevention and Control in China in 2019 show that the proportion of overweight and obesity in China is more than 40%, and 10 to 20% of children are obese or overweight [2]. Obesity not only affects the external image but also causes psychological problems such as depression [3]. Obesity in adolescents can cause chronic brain hypoxia and affect learning. Obesity is also a risk factor for chronic diseases such as cardiovascular disease, diabetes, and some tumors [4].

According to the management guidelines of the American Obesity Society, the treatments for obesity include dietary intervention, lifestyle intervention, drug treatment, and surgery [5]. Due to some nonideal situation including poor patient compliance, many adverse reactions, and easy rebound, there is an urgent need for a healthier, simpler, and more sustainable treatment.

Exercise is a common way to lose weight, and scholars at home and abroad are exploring and establishing scientific and effective exercise way [6].

Traditional Chinese exercises are an ancient way of exercise and fitness, which have been reported to have unique advantages in the treatment of obesity. In this paper, we summarize the related research on the traditional Chinese exercises in the treatment of obesity in recent years to provide reference for clinical application and experimental research.

2. Tai Chi

Tai Chi is a form of sport that includes oriental culture, with the characteristics of both internal and external practice, firmness and softness, and slow and light spirit, which is the first batch of national intangible cultural heritage in our country [7]. Tai Chi is a medium- and low-intensity aerobic project [8]. A large number of studies have shown that Tai Chi has a significant effect in the treatment of the onset and progression of obesity.

Studies have found that Tai Chi exercise can gradually restore the normal activity of abnormally expressed AMPK genes in obese patients [9] and significantly reduce plasma neuropeptide Y [10], especially in patients with high triglycerides. Tai Chi can also improve the level of serum ghrelin in high-risk groups of metabolic syndrome [11], regulate the feeding center, reduce body weight, reduce waist circumference, improve blood lipid indexes, and eliminate the risk factors of metabolic syndrome.

The rapid proliferation of adipocytes caused by the proliferation and differentiation of preadipocytes is one of the possible mechanisms of obesity [12]. It has been found that the growth of hormone GH and catecholamine can inhibit the differentiation of preadipocytes in different degrees [13, 14]. Long-term Tai Chi exercise can significantly increase the GH content of growth hormone [15], reduce the concentration of catecholamine, and increase the level of catechol statin [16]. In the study of lipid metabolism and related hormones in Tai Chi, it was found that after Tai Chi exercise, the indexes of total cholesterol (TC), triglyceride (TG), and low-density lipoprotein cholesterol (LDL C) decreased, while high-density lipoprotein cholesterol (HDL C) increased [17]. Tai Chi can significantly reduce the levels of serum insulin and leptin [18] and increase the level of adiponectin, a special active peptide secreted by adipocytes [19]. It can enhance insulin sensitivity and promote the oxidation of fatty acid in the body. It can inhibit inflammation to a certain extent [20]. Tai Chi exercise can reduce fasting blood glucose, 2-hour postprandial blood glucose, and glycosylated hemoglobin, stabilize human blood glucose level [21], and has a good balance effect on human energy metabolism.

A study found that after 6 months of Tai Chi exercise [22], the number of intestinal *acidophilus*, *Lactobacillus*, and *Bifidobacterium* increased significantly in obese elderly people and positively correlated with the training time. Through the effect on intestinal flora, the transformation and utilization of cholesterol was strengthened, and the level of blood lipids in the human body was ameliorated. In addition, Tai Chi exercise can also reduce lipid peroxidation, significantly reduce hs-CRP, IL-6, TNF-α, and other inflammatory indicators, and ameliorate the micro-inflammatory status caused by obesity [23].

3. Ba Duan Jin

Ba Duan Jin has the advantages of softening the tendons and strengthening the bones, nourishing the qi and enhancing strength, promoting qi and invigorating blood circulation, and coordinating the functions of all the organs. After the reorganization by the State General Administration of Sports, the current version has a total of eight movements, each with a different focus, which can be practiced according to a certain viscera or disease syndrome [24].

Studies have shown that Ba Duan Jin exercise has a good effect on weight loss and good posture by losing weight and reducing waist and hip circumference [25]. Ba Duan Jin exercise could effectively reduce fasting blood glucose, serum insulin concentration, and insulin resistance index [26] and reduce the concentration of total cholesterol, triglycerides, and free fatty acid, and the level of leptin decreased with the decrease of blood lipid level and obesity index (body weight, BMI, and percentage of body fat), while adiponectin level was negatively correlated [27]. There is evidence showing that after practicing Ba Duan Jin, the number of *Bifidobacterium*, *Bacteroides*, and *Lactobacillus* increased significantly, while *Enterobacter*, *Clostridium*, and *Enterococcus* decreased significantly [28]. By regulating the structure of intestinal flora in the elderly, fasting-induced fat factor (fasting-induced adipocyte factor, FIAF) [29] can be affected and triglyceride deposition and storage can be reduced. The inflammatory markers (CRP, IL-6, and TNF-α) have been found decreased significantly in Ba Duan Jin participants [30]. However, its inhibitory effect on obesity still needs to be verified by further experiments.

4. Yi Jin Jing

Yi Jin Jing is a fitness exercise characterized by improving the function of muscles and bones, stimulating the circulation of the blood, and causing the muscles and joints to relax. After the reorganization by the State General Administration of Sports, the current version has a total of 12 postures, with the combination of movement and stillness. The movement requires stretching tendons and bones, fully flexion and extension, abduction, adduction, torsion of the body, etc., in order to pull the muscles and fascia of various parts of the human body, as well as the tendons, ligaments, joint capsules, and other connective tissues, which can play a positive role in body shape and physiological function. Persistent exercise can strengthen the muscles and bones and benefit the internal viscera [31].

Practicing Yi Jin Jing can also regulate glucose and lipid metabolism. The study found that 6 months of Yi Jin Jing exercise can significantly reduce the levels of serum TC, TG, and LDL C and increase the level of HDL C [32]. Long-term persistence can reduce the levels of fasting blood glucose and insulin and reduce insulin resistance accompanied by the decrease of inflammatory reactions [33]. The percentage of CD4+ T cells, CD8+ T cells, and NK cells and the levels of IL-2, IL-6, and IFN-γ in the immune indexes of the elderly were significantly increased after 24 weeks of practicing Yi Jin Jing [34], so as to improve the immunity of the elderly.

5. Wu Qin Xi (Five Fowl Opera)

Wu Qin Xi is a set of traditional aerobics exercise created by Hua Tuo, a famous physician of the Eastern Han Dynasty, who combined the posture and movements of the tiger, deer, bear, bird, and ape, with the theory of the five elements of traditional Chinese medicine. It is the earliest guiding technique recorded so far and is the world-class intangible cultural heritage [35].

Wu Qin Xi exercise could reduce the serum levels of TC, TG, and LDL C and increase the level of HDL C in elderly women and significantly improve the level of blood lipids after 6 months of practice [36]. After 24 weeks of practice of Wu Qin Xi, blood sugar and glycosylated hemoglobin levels decreased by 7.14% and 13.23%, respectively, which effectively controlled blood sugar levels [37]. At the same time, Wu Qin Xi practice can also reduce the levels of leptin and insulin and increase the level of adiponectin [38, 39]. After practicing Wu Qin Xi for 2 months [40], the amount of *Bifidobacterium*, *Lactobacillus*, *Bacteroides*, *Clostridium*, SCFAs, GLP-1, and GLP-2 in the intestine of the practitioners increased, and this effect increased with time. Wu Qin Xi reconditioned human microecology, improved the structure of gut microbiota, reduced intestinal permeability, and regulated human metabolism. Wu Qin Xi practice improved the immune function of the middle aged and elderly [41, 42]. It was found that the activity of NK cells and the ratio of CD+4/CD+8 increased significantly after exercise, which played a positive role in regulating immune balance.

6. Shaolin Neigong

Shaolin Neigong is an important part of internal Qigong massage therapy, that is, Shanghai intangible cultural heritage. This exercise pays attention to strength and endurance with the lower limb standing crotch posture as the basic exercise combining with the upper limb movement. It is characterized by skeletal muscle static contraction exercise [43], emphasizing the "static resistance" of the lower limbs and the "internal strength" of the upper limbs [44].

The effective rate of Shaolin Neigong in the treatment of simple obesity among college students is 85.7%, which can significantly reduce the weight, BMI, and waistline and hip circumference of practitioners [45]. Shaolin Neigong can reduce the insulin resistance index and improve the sensitivity of the body to insulin [46]. The exercise frequency test of Shaolin Neigong showed that when the exercise frequency was 1–4 times a day, the subjects' levels of FPG, 2hPBG, and HbA1c were improved [47].

It was found that the inverted suspension of rats could simulate the static characteristics of Shaolin Neigong [48]. It was found that static training could increase the transcription level of the hypothalamic *POMC* gene and the content of β-endorphin in the hypothalamus [49], thus reducing the appetite for food. A study reported that static training combined with massage therapy could increase the protein content of skeletal muscle, reduce the excretion of creatinine (CRE) and 3-methylhistidine (3-MH), and regulate protein metabolism [50]. Qigong training can partially eliminate the RNA interference of the PGC-1α signal pathway [51], suggesting that this kind of static training can facilitate the activation of the PGC-1α signal pathway, induce the expression of PGC-1α, and consequently regulate central appetite.

7. Liu Zi Jue

Liu Zi Jue refers to a breathing practice of exhale and inhale in six different ways, namely, si, xu, xi, he, hu, and chui, in order to mobilize the function of various organs to activate qi and blood circulation. It is an ancient health-preserving method, which can make the breath natural, relax the body, and calm the mind.

Comparing the effects of different traditional exercises on fasting blood glucose, it showed that after 3 months of exercise, Wu Qin Xi, Ba Duan Jin, and Liu Zi Jue all could effectively reduce fasting blood glucose (FPG), and among them Liu Zi Jue showed the strongest effect [52]. After practicing Liu Zi Jue [53], both body weight and BMI showed a trend of decrease, and the grip strength, bouncing strength, fast walking, flexibility, and other exercise abilities of elderly were all improved in varying degrees.

8. Others

Comparing the effects of Tai Chi, Baduanjin, Yi Jin Jing, and Wuqinxi on the immune function of the elderly showed that they all can significantly increase the immune indexes, including CD3+, CD4+, CD8+, and NK cells. Among them, Tai Chi was the best in improving CD4+ and NK cells, and Ba Duan Jin was the best in improving CD3+ and CD8+ cells [54]. Both "Mawangdui Dao Yin" and fitness Qigong "Da Wu" can reduce TG, TC, and LDL C and increase HDL C to some extent [55, 56]. Some scholars combined Mawangdui Dao Yin, Tai Chi, Shi Er Duan Jin, Dao Yin health-preserving gong, and Da Wu to sort out a new set of Qigong exercise [57] and found that this exercise also can regulate lipid metabolism. In the study of the Pigu weight loss experiment, it showed a significant effect on weight loss [58].

Other traditional Chinese exercises that have not been verified by experiments, such as "weight loss and antiaging Qi gong" [59], Huichun Gong [60], Tiaoxi Zhuji Gong [61], Xiaoyao walking, Guanyin Gong, stepping abdomen beating Gong, abdominal retraction Gong, palm closing Gong [62], simple weight loss Gong, relaxation weight loss Gong, Xiao Zhou Tian loss Gong, Yannian Jiuzhuan Gong, Jade toad Xi Zhen Gong, Guanyin lotus seat, Jade toad wave turning Gong, standing pile, Longmen bodybuilding, and longevity Gong [63], are clearly stated that they have a certain degree of effect on weight loss. It is worth further exploring.

9. Summary

At present, there are many studies on the traditional Chinese exercises in the treatment of obesity, which reveal good results from different angles. Among these exercises, it seems that Tai Chi is the most widely studied one. In terms of the research direction, they are mostly focused on the effect of Qigong exercises on the level of glucose and lipid metabolism, but less on central feeding regulation, insulin, leptin, and adiponectin. In recent years, gut microbiota and immune functional regulation have attracted more attention. Compared with modern medicine, traditional Chinese medicine pays attention to personalized therapy based on the difference of patients and their different syndromes. In terms of obesity, it has the characteristics of wide age span, different degrees of obesity, and always has one or more complications. The traditional Chinese exercises mentioned in this paper not only have the commonness of weight loss and fat reduction, but also have their own characteristics, which can be selectively used for different types of obese patients.

Slow movement with breathing is what the above traditional methods have in common. When practicing Tai Chi, Ba Duan Jin, and Wu Qin Xi, the big movements of the upper and lower limbs cooperate with breathing. Tai Chi is beneficial to the overall balance, and Ba Duan Jin can increase lower limb strength and muscle content [64] and reduce fat content [65]. Wu Qin Xi can improve flexibility. The improvement of the heart rate of Tai Chi is better than that of Wu Qin Xi [66], while the exercise intensity is lower than that of Ba Duan Jin and Wu Qin Xi. For example, Tai Chi is suitable for patients with mild to moderate obesity, especially for the middle aged and elderly because Tai Chi belongs to low-intensity exercise and has advantages in controlling blood pressure, increasing bone mineral density, and reducing blood sugar, but it is not suitable for patients with severe obesity or knee osteoarthritis. Ba Duan Jin is more suitable for obese patients with endocrine and digestive system diseases such as cervical spondylosis and perimenopausal syndrome. Wu Qin Xi has certain advantages in improving the hyperlipidemia of adult obese patients.

The standing pile and movement of Yi Jin Jing Sutra pay attention to the stretching of muscles, standing pile after completing the action, and stretching when inhaling and relaxing when exhaling, which belong to intermittent-, medium-, and low-intensity training that can increase the muscle strength of the lower limbs of the elderly [67]. The standing pile and action of Shaolin Neigong emphasize the static contraction of muscles. Both the standing pile and the big movement should include contracting the muscles hard, breathing naturally, completing the action after standing pile, relaxing the whole body, and then continuing to the next standing pile or action after a short rest, which belongs to intermittent-, medium-, and high-intensity training. Shaolin Neigong reduces appetite and increases skeletal muscle content. Yi Jin Jing can slow down the physical decline and improve the symptoms of constipation. Shaolin Neigong has the characteristics of intermittent-, medium-, and high-intensity exercise, which is especially suitable for obese patients who are not easy to exercise because of excessive weight and also fit for the obese patients with poor cardiopulmonary function.

Liu Zi Jue can improve human body function through breathing exercises, slow down heart rate, increase vital capacity, stimulate vegetative nervous system, promote venous reflux, change hemodynamics, reduce hemorheological indexes, and improve the motility of visceral organs [68]. Liu Zi Jue is most suitable for obese patients with chronic obstructive pulmonary disease.

In addition, the sitting and lying exercises in the traditional method have also their own features, which are especially suitable for patients who cannot practice standing up; however, it still needs further study.

The traditional Chinese exercises have a long history, which contain the Chinese traditional fitness culture and also a concrete practice of the concept of "preventive treatment of disease" in traditional Chinese medicine. These exercises not only reduce fat and weight and adjust posture but also cultivate physical and mental health, which is beneficial. It is a simple and effective way to lose weight with low cost and is environment friendly.

Data Availability

This article is a review article and does not contain relevant data.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Authors' Contributions

Yuan Qin, Weiyi Xia and Wei Huang contributed equally to this work.

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Research Article

Effects of Wuqinxi in the Patients with Chronic Low Back Pain: A Randomized Controlled Trial

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Low back pain (LBP) is one of the major concerns of the current health care. The guidelines for chronic LBP recommend traditional Chinese exercise as an effective treatment. As one of the representatives of traditional Chinese exercise, Wuqinxi has been famous in China for its effects on improving health and treating chronic diseases for thousands of years. The objectives of the study were to assess the effects of Wuqinxi in the patients with chronic LBP on pain intensity, trunk muscle strength, and quality of life. The primary outcome measure was assessed by the Short-Form McGill Pain Questionnaire (SF-MPQ), including the Visual Analog Scale (VAS) and Present Pain Intensity (PPI) as the subtables. The effects of Wuqinxi on the quality of life were also assessed by the Short-Form Health Survey (SF-36) and the Pittsburgh Sleep Quality Index (PSQI) from physical component summary (PCS), mental component summary (MCS), and sleep quality. Besides, the electrical activities of the rectus abdominis (RA), obliquus externus abdominis (OEA), lumbar erector spinae (ES), and multifidus (MF) were assessed by integrated electromyogram (iEMG) after the end of the intervention. Both the groups showed statistically significant improvement in SF-MPQ, SF-36, PSQI, and iEMG at 12 weeks and 24 weeks when compared with baseline ($P < 0.05$). However, Wuqinxi demonstrated better effects in SF-MPQ and MCS after 24 weeks of intervention compared with the general exercise ($P < 0.05$). The patients in the Wuqinxi group (WQXG) also showed a significantly higher iEMG on OEA than the general exercise group (GEG) in 30°/s and 90°/s ($P < 0.05$). Our results showed that Wuqinxi had better effects on chronic LBP for a long time compared with general exercise, including pain intensity and quality of life. Thus, Wuqinxi should be recognized as a possible standalone therapy and self-management skill in chronic LBP, which is suitable for long-term practice.

1. Introduction

Low back pain (LBP) is one of the most common, costly, and disabling health conditions and now seems to be extending worldwide [1–3]. However, the symptoms are not attributed to particular etiologic or neurologic causes in 85% of the LBP patients, and most patients will not benefit from a single surgery [4]. So, patients with chronic LBP are eager to seek care and health services to relieve their pain [5]. A study showed that health care utilization due to chronic LBP was increasing every year, but the number of patients with disability increased by 54% from 1990 to 2015 [6].

The causes of chronic LBP are quite complicated, which may be attributed to long-term excessive physical exertion or trauma, resulting in strain or degradation of the vertebrae, intervertebral discs, or spinal muscles [7]. Therefore, patients with chronic LBP should also be treated for a period of time to achieve long-term results. However, the financial burden will increase with the frequent use of spinal injections, analgesic drugs, or visits to therapists [8].

Current guidelines for chronic LBP recommend exercise as an effective treatment option [9, 10]. Past studies have shown that exercise therapy appears to be effective in relieving pain and improving physical function, which encompasses various interventions, ranging from aerobic exercises to muscle strengthening and stretching [11–13]. On the one hand, exercise therapy can strengthen and train the core muscles, so as to enhance the stability of the body [14]; on the other hand, breathing control during exercise is also important for the rehabilitation of chronic LBP because it plays a role in exercising the core muscles, such as the diaphragm and abdominal internal and external oblique muscles [15]. However, many forms of physical activity are either very intense or monotonous, making it difficult to practice and keep for a long time. Traditional Chinese exercise has long been used to raise the physical and moral integrity level and prevent chronic disease progression [16]. Tai-chi exercise is one of the traditional Chinese exercises, which is recommended as a therapeutic exercise in the guidelines of the American College of Physicians because of its good effect on chronic LBP [10].

Wuqinxi (five-animal exercise) is another famous traditional Chinese exercise, which was created by a well-known Chinese physician Huatuo in Donghan Dynasty. It mimics the movements of five animals in terms of tiger, deer, bear, monkey, and crane, which emphasizes the integration of body movement, breathing, and mental together harmoniously during practice. Therefore, compared with Tai-chi exercise, Wuqinxi pays more attention to the relationship between human and nature. With the enhancement of people's awareness of self-care, more and more studies have shown the benefits of Wuqinxi in improving health and treating chronic diseases [17–19]. A prospective study demonstrated that Wuqinxi can improve the function of the lumbosacral multifidus and reduce LBP, but no further efficacy evaluation was carried out [20]. Therefore, the objectives of the study were to assess the effects of Wuqinxi in patients with chronic LBP at the end of a 24-week treatment program on pain intensity, trunk muscle strength, and quality of life.

2. Methods

2.1. Study Design. This study was a parallel-group, assessor- and analyst-blinded randomized controlled trial (RCT) conducted in the Department of Physiotherapy, Shanghai Hongkou District Quyang Community Health Service Center, and the Yueyang Hospital of Integrated Traditional Chinese and Western Medicine for 24 weeks. Eligible participants were randomly assigned to the Wuqinxi group (WQXG) and the general exercise group (GEG) in a 1 : 1 ratio. The study protocol was in accordance with the Declaration of Helsinki and was approved by the Chinese Ethics Committee (No. ChiECRCT-20160048). Also, we registered the study on the Chinese Clinical Trial Registry (No. ChiCTR-INR-16009038). The sample size calculation of the trial was based on our previous study, with the power of 0.9 (1-β) and a significant P value less than 0.05. Taking a possible 15% drop rate into consideration, a total of 72 participants were enrolled.

2.2. Participant Recruitment. The patients with chronic LBP consistent with the disease definition in the ICD-11 were recruited. The 72 participants were recruited from the Shanghai Hongkou District Quyang Community Health Service Center and the Yueyang Hospital of Integrated Traditional Chinese and Western Medicine. We also sought a few patients through posters, Internet advertisements, and the official microblog and WeChat platforms. According to guidelines in [21], chronic LBP is defined as pain and discomfort persisting for at least 12 weeks, localized below the costal margin and above the inferior gluteal folds, with or without referred leg pain.

2.2.1. Inclusion Criteria. The inclusion criteria were as follows:

(1) History of LBP as the main symptom persisting for at least 3 months
(2) Pain lasting for more than 20 min per time and at least once per month
(3) Aged between 18 and 70 years, male or female
(4) Promise not to receive other related therapy (e.g., analgesic drugs) during the period of treatment
(5) Volunteer to take part in the study and sign the informed consent form

2.2.2. Exclusion Criteria. The exclusion criteria were as follows:

(1) Caused by specific diseases (fractures, carcinoma, anomalies, disc prolapse, spinal stenosis, tumor, spinal infection, ankylosing spondylosis, spondylolisthesis, kyphosis or structural scoliosis, and nerve root affection with neurological signs)
(2) Severe primary diseases such as cardiovascular, lung, kidney, and hematopoietic disease and mental disorder
(3) Surgery to the low back within the past 6 months
(4) Received formal physical therapy or other therapies in the last 1 month
(5) Pregnant or lactating women

2.2.3. Dropout and Suspension Criteria. According to the Patient Management Protection Rules, patients have the right to withdraw for any reason during the study period. The following conditions were considered as withdraw criteria:

(1) Patients cannot finish the protocol treatment on schedule
(2) Participation in other treatments during the trial
(3) Intolerable adverse events
(4) Lost to follow-up

In addition, if severe poor efficacy or adverse reactions had occurred during the trial, the trial was forcibly suspended immediately.

2.3. Randomization and Allocation. Eligible participants were randomly assigned to the WQXG and GEG, with 36 patients in each group. The randomization sequence was computer generated and concealed in sealed, opaque envelopes by a member of the research team not involved in recruitment. The therapist was responsible for sequentially opening randomly assignment envelopes and allocating the participants accordingly.

2.4. Blinding. Owing to the limitation of the study, participants and therapists were not possible to be blinded to treatment. For the sake of reducing the risk of bias, we told the patients that the purpose of the study was to compare the two exercise therapies, and the patients were unlikely to know which group they were in. In addition, the evaluators, data managers, and statisticians were blinded to the group allocation in the outcome evaluation procedure and data analysis.

2.5. Interventions. Patients from both groups participated in a supervised exercise therapy program four times a week with 1 hour of each session for 24 weeks. Heart rate changes and rating of perceived exertion (RPE) were recorded to keep the same volume of exercise [22]. All the participants were called to the Quyang Community Health Service Center to take part in exercise training and a short forum of back pain before starting the intervention. The therapist must have 10 years of experience of the traditional Chinese exercises and be skillful in health care education. The standard movements of the therapist were recorded as videos and distributed to patients to guide their future treatment. Dedicated logbooks were sent to patients to record the weekly exercise and supervised by our researchers on WeChat. Besides, guidance was given outdoors every month, which also helped us evaluate the recovery of everyone.

2.5.1. Intervention Methods in the WQXG. The patients participated in a supervised Wuqinxi program for 24 weeks. The sessions were conducted four times a week with 1 hour of each session. Each session consisted of 10 minutes of warm-up, 40 minutes of Wuqinxi, and 10 minutes of cool down. Wuqinxi imitates the specific movements of five animals in terms of tiger, deer, bear, monkey, and crane, which combines breathing control, body movement, and meditation. The core movements of Wuqinxi are illustrated in Table 1. At the beginning of each month, patients in this group were called to exercise and receive guidance from the therapist.

2.5.2. Intervention Methods in the GEG. The patients participated in a supervised exercise program with the same volume of training as Wuqinxi for 24 weeks. The exercise included the movements addressing muscle activity of the abdominals, erector spinae, gluteal, quadriceps, and hamstrings muscle groups. The exercise program started with nonweight bearing positions and progressed by increasing load. Weights and resistance were individualized according to the physical capacity of the patient and progressively increased according to the guidelines of the American College of Sports Medicine [23]. This exercise was chosen as the control intervention because it is credible for the treatment of LBP [24]. At the end of each month, patients in this group were called to exercise and receive guidance from the therapist.

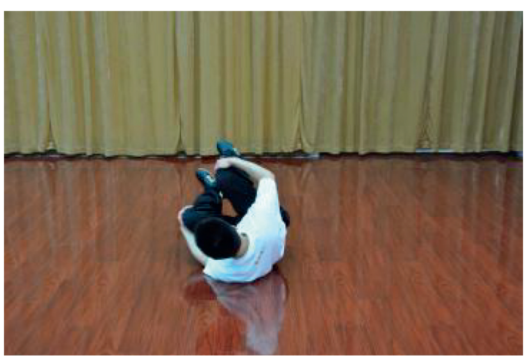
2.6. Outcome Measurements. The outcomes were measured at 12 weeks and 24 weeks, which can reflect the changes in pain intensity, quality of life, and trunk muscle strength of the patients with chronic LBP.

2.6.1. Primary Outcome Measurement. The primary outcome measure was assessed by the Short-Form McGill Pain Questionnaire (SF-MPQ), which has scores ranging from 0 to 45 [25]. The higher SF-MPQ values indicated greater pain levels. The Visual Analog Scale (VAS) as the subtable of SF-MPQ was used to grade the pain severity of patients by a 10-point scale, where 0 means no pain and 10 means severe or unbearable pain [26]. Another subtable of SF-MPQ was Present Pain Intensity (PPI), which has a 6-point scale ranging from 0 (no pain) to 5 (unbearable pain). PPI was used for the measurement of the intensity of pain at the time of the evaluation [23].

2.6.2. Secondary Outcome Measurement. Secondary outcome measures included the Short-Form Health Survey (SF-36) and the Pittsburgh Sleep Quality Index (PSQI). The SF-36 had been applied and validated several times for intervention studies with back pain [27, 28]. The questions were divided into eight domains, which combined physical and psychological questions. Domain scores may be aggregated and normalized using a standard algorithm into two summary component scores, physical component summary (PCS) and mental component summary (MCS), where a value of 50 represents the population norm and higher scores indicate better health status. PSQI was developed by Buysse et al. [29] in 1989 and has been used to assess sleep quality and sleep mode of individuals in the latest months. The qualities assessed included subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disorders, hypnotic agents, and daytime dysfunction (ranging from 0 to 21, with higher scores indicating worse sleep quality). The Chinese version of PSQI and the SF-36 scale was used in this study, and its reliability and validity have been verified in the Chinese population [30].

2.6.3. The Measurement of Trunk Muscle Strength. In addition, trunk muscle strength was assessed by integrated electromyogram (iEMG) after the end of the intervention. A surface electromyography system (Telemyo 2400T-G2 Telemetry EMG system; Noraxon, USA) with disposable bipolar electromyography electrodes was used to measure the electrical activities of the rectus abdominis (RA), obliquus externus abdominis (OEA), lumbar erector spinae (ES), and

Table 1: The core movements of Wuqinxi.

Tiger movement		
Deer movement		
Bear movement		
Monkey movement		
Crane movement		

multifidus (MF) with 1000 Hz sampling frequency [31]. The angular velocity of isokinetic concentric (flexion) and eccentric (extension) movement was set as 30°/s and 90°/s, and each complete movement was regarded as a cycle to repeat 10 times.

2.7. Statistical Analyses. SPSS 21.0 software was used for the analysis. The normality and homogeneity of variance tests were performed on the data. The data were presented as the mean ± standard deviation (SD) if they were normally distributed; otherwise, they were presented as the median (*P*25 and *P*75). The changes in mean were calculated from the difference between the current value and the baseline data. Parametric statistics (independent samples *t*-test and paired samples *t*-test) or nonparametric statistics (Wilcoxon rank-sum test) were used for the within- and between-group analyses in accordance with the results of the homogeneity and normality analyses. When initial homogeneity and normality of data distribution are found, repeated measures analysis of variance (ANOVA) and ANOVA with adjustment of the Bonferroni correction were used to analyze within and between groups. The Friedman test and the Kruskal–Wallis test will be used when initial homogeneity but not the normality of data distribution is found. If the initial homogeneity is not found, a linear mixed model will be adjusted for the baseline value. The statistical significance was defined as $P < 0.05$, and the 95% confidence interval (CI) was reported.

3. Results

3.1. Recruitment and Baseline Data. Flow diagram of the study is presented in Figure 1. A total of 177 patients were recruited, but 71 patients did not meet the inclusion criteria. 106 patients were qualified for the baseline evaluation, among which 34 were unable to complete the entire study for various reasons. The remaining 72 patients met the eligibility criteria and signed the informed consent form. Of the 72 eligible participants, 67 completed the assessment at 12 weeks, and 2 in the WQXG and 3 in GEG dropped out as contact was lost after several weeks of exercise. At 24 weeks, 63 participants finally completed the assessment because 2 participants in each group withdrew from the study after 12 weeks of intervention. Participants in the WQXG and GEG completed 89% and 86% of the total planned exercise session, respectively.

The baseline demographic and clinical characteristics of all participants in both groups are shown in Table 2. The recruited population had a mean age of 53.4 years with a female predominance. The mean body mass index (BMI) was in the normal range, and the participants had LBP for 12.8 years. No significant differences were found between groups ($P > 0.05$) on demographics, medical history, quality of life, and pain intensity at baseline.

3.2. Effects of Wuqinxi on Pain Intensity. The changes from baseline to 12 and 24 weeks in the two groups for pain intensity are shown in Table 3 and Figure 2 in general. At 12 weeks, WQXG and GEG, respectively, showed a significant decrease in the SF-MPQ total score, VAS, and PPI when compared with baseline ($P < 0.05$), but there was no significant difference between the groups ($P > 0.05$). At 24 weeks, the WQXG had a greater decrease in the SF-MPQ total score, VAS, and PPI than the GEG, and the difference was statistically significant ($P < 0.05$). The differences in the means of SF-MPQ, VAS, and PPI between the groups were −1.7 points (95% CI −3.2 to −0.2), −0.9 points (95% CI −1.8 to −0.1), and −0.6 points (95% CI −1.0 to −0.1) at 24 weeks, which indicated that Wuqinxi was more beneficial in relieving pain than the general exercise for patients with chronic LBP.

3.3. Effects of Wuqinxi on Quality of Life. The quality of life was assessed by the SF-36 and PSQI from physical function, mental health, and sleep quality. The changes in the SF-36 and PSQI scores from baseline to 12 and 24 weeks between groups are shown in Table 4 in general. WQXG and GEG, respectively, showed a significant improvement in physical and mental component scores at 12 weeks compared with baseline ($P < 0.05$), but there was no statistically significant difference between groups ($P > 0.05$). At 24 weeks, compared with the GEG, the WQXG had a greater improvement in the scores of the SF-36 physical component and the mental component, but only the difference in MSC was statistically significant ($P < 0.05$). The difference in the mean MSC between groups was 6.7 points (95% CI, 0.8 to 12.5), which indicated a better mental health in the WQXG. In addition, PSQI scores of the two groups at week 12 and week 24 were significantly lower than that at baseline ($P < 0.05$), but the difference between the WQXG and GEG at the same time point was not statistically significant.

3.4. Effects of Wuqinxi on Trunk Muscle Strength. The electrical activities of RA, OEA, ES, and MF were measured to assess trunk muscle strength by iEMG after the end of the intervention. The effects of the 2 different exercise interventions on the lumbar and absolute muscles are shown in Table 5. In our results, both five-animal exercise and general exercise were beneficial to ES, but there were no statistically significant differences ($P > 0.05$). The two exercise interventions improved RA, MF in 30°/s, and MF in 90°/s, and the differences were statistically significant ($P < 0.05$). However, there was no significant difference between the two groups in the improvement of RA and MF. Besides, it was found that general exercise may have no effect on OEA because the electrical activity change of OEA in 30°/s was −2.2 (−3.6 to −0.9) compared with baseline. In contrast, the effect of Wuqinxi on OEA was better than that of general exercise whether at 30°/s or 90°/s, and the difference was statistically significant ($P < 0.05$).

4. Discussion

4.1. Analysis of the Research Results. The traditional Chinese exercise can induce a relaxed state of mind, which is different from the general exercise. Some techniques of traditional

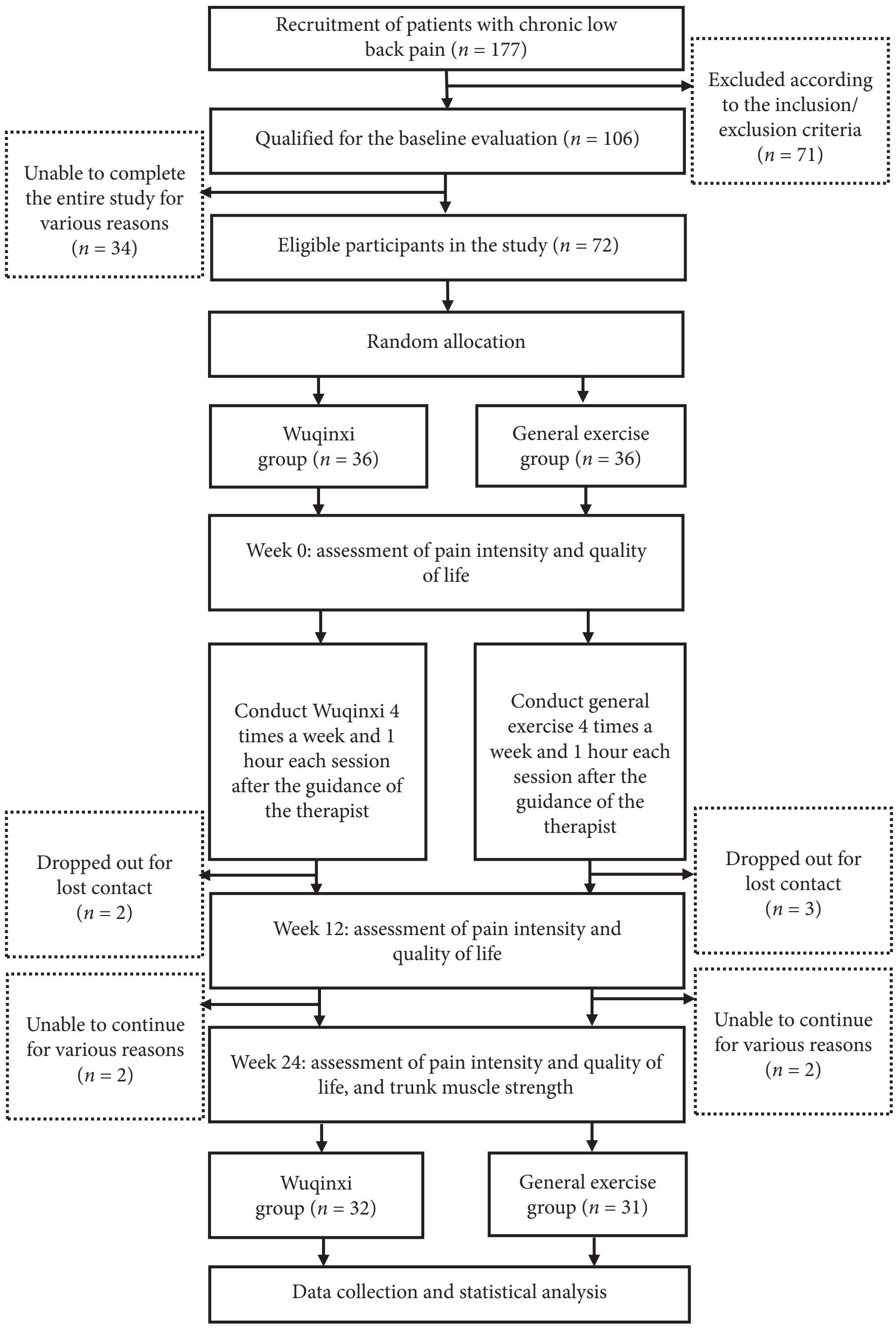


Figure 1: Flow diagram of the study.

Chinese exercise guide and transfer attention from pain via meditating and imagining, which can help alleviate back pain, improve psychosocial well-being, and increase confidence. As a representative, the Tai-chi exercise has attracted attention worldwide in the field of sports medicine for its good effect on chronic diseases [32–34]. However, Wuqinxi has become an alternative choice in China in recent years due to its unique movements and effects [35]. Wuqinxi is a mind-body exercise integrated with training for body strength, flexibility, breathing, and meditating, which emphasizes the unification of mental regulation, breathing exercises, and movement control [35]. Patients need to imagine that they are imitating the might of tiger, vigor of deer, steadiness of bear, flexibility of monkey, and stretching movement of crane. A meta-analysis demonstrated that Wuqinxi significantly improved pain symptom and lumbar spine bone mineral density compared with antiosteoporosis medications, indicating the effect of Wuqinxi on pain [19].

SF-MPQ score is a validated measure for the assessment of acute pain, chronic pain, and postoperative pain, including VAS and PPI as subtables [36]. The findings of our study suggested that both Wuqinxi and general exercise

Table 2: The baseline demographic and clinical characteristics of participants (mean ± SD).

Demographic characteristic	WQXG ($n = 36$)	GEG ($n = 36$)
Age (year)	53 (16)	54 (14)
Gender	30 (83)	28 (78)
Male	6 (17%)	8 (22%)
Female	30 (83%)	28 (78%)
Height (cm)	161 (6.3)	163 (5.8)
Weight (kg)	61 (7.9)	63 (10.6)
Received education years (year)	14 (3.2)	14 (2.8)
Duration of LBP (year)	13.2 (9.2)	12.4 (10.8)
BMI	23.4 (3.1)	23.6 (3.5)
Outcome measures		
SF-MPQ	14.5(6)	14.4 (6.5)
VAS	5.2 (1.3)	5 (1.9)
PPI	2.7 (0.9)	2.8 (1.1)
PSQI	8.8 (4.4)	9.7 (5.2)
PCS	34.6 (8.9)	34.4 (8.8)
MCS	34.1 (11.9)	37.5 (12.8)

There were no significant differences between groups on demographics, medical history, quality of life, and pain intensity at baseline ($P > 0.05$). SD, standard deviation; WQXG, Wuqinxi group; GEG: general exercise group; LBP, low back pain; BMI: body mass index; SF-MPQ: Short-Form McGill Pain Questionnaire; VAS: Visual Analog Scale; PPI: Present Pain Intensity; PSQI: Pittsburgh Sleep Quality Index; PCS: mental component summary; MCS: physical component summary.

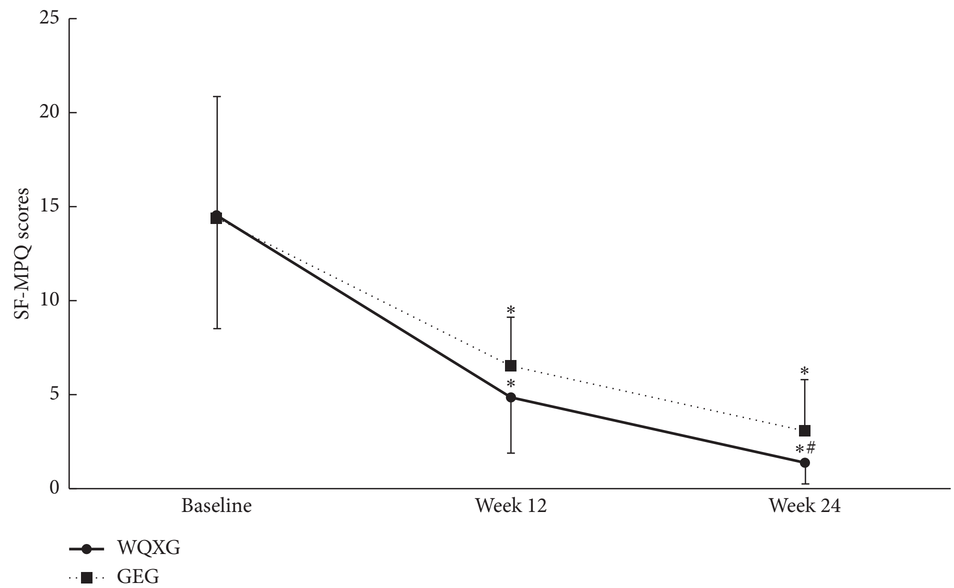
Table 3: The changes in pain intensity from baseline to 12 and 24 weeks.

Outcomes	Difference in mean change (95% CI)		Between-group difference (95% CI)	
	WQXG	GEG	GEG vs. WQXG	P
SF-MPQ (0–45)				
Week 12	−9.8 (−11.9 to −7.6)*	−7.9 (−10.4 to −5.3)*	−1.7 (−3.5 to 0.01)	0.051
Week 24	−13.3 (−15.4 to −11.2)*	−11.4 (−13.9 to −8.9)*	−1.7 (−3.2 to −0.2)#	0.032
VAS (0–10)				
Week 12	−2.5 (−3.2 to −3.8)*	−1.9 (−2.8 to −1.0*	−0.3 (−1.0 to 0.4)	0.357
Week 24	−4.0 (−4.7 to −3.4)*	−2.8 (−3.8 to −1.9)*	−0.9 (−1.8 to −0.1)#	0.035
PPI (0–5)				
Week 12	−1.4 (−1.8 to −1.0)*	−1.2 (−1.7 to −0.7)*	−0.3 (−0.7 to 0.1)	0.166
Week 24	−2.1 (−2.5 to −1.7)*	−1.6 (−2.1 to −1.1)*	−0.6 (−1.0 to −0.1)#	0.014

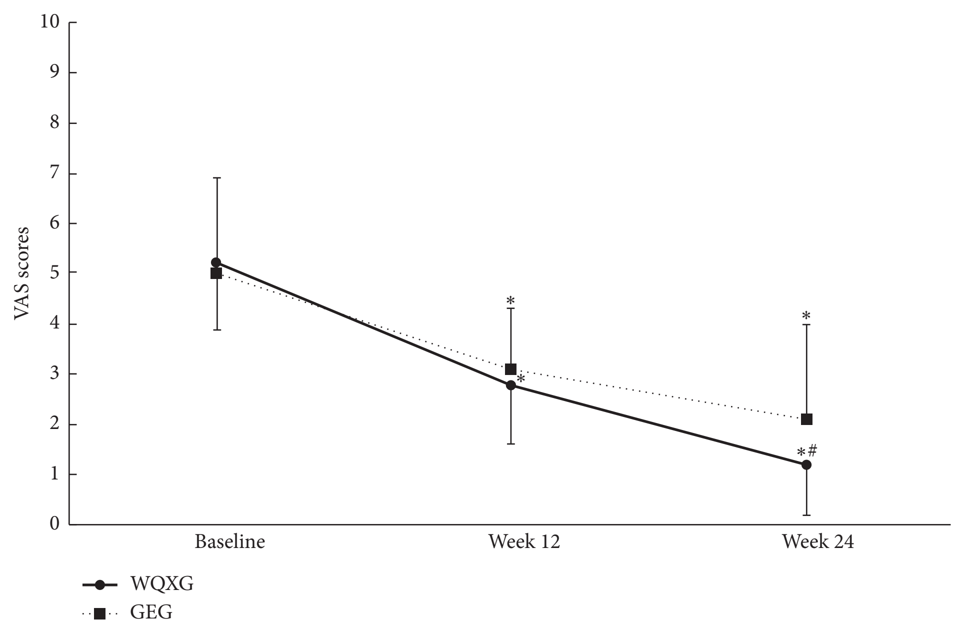
The pain intensity was assessed by SF-MPQ, and VAS and PPI as subtables were used for further evaluation. The changes in mean were calculated from the difference between the current value and the baseline data. Compared with baseline, $^{*}P < 0.05$; compared with the GEG at the same time point, $^{\#}P < 0.05$. CI, confidence interval; WQXG, Wuqinxi group; GEG: general exercise group; SF-MPQ: Short-Form McGill Pain Questionnaire; VAS: Visual Analog Scale; PPI: Present Pain Intensity.

resulted in good effects on chronic pain, which were consistent with the results of published clinical studies [37, 38]. Compared with the GEG, the patients in the WQXG showed a better effect in reducing pain at 24 weeks, and the difference was statistically significant ($P < 0.05$). It might be related to the greater advantage of Wuqinxi in improving related muscle groups. iEMG was used to reflect the total discharge of the motor units participating in the movement at a certain time and was expressed as the integral of the area surrounded by the myoelectricity changing curve and the horizontal axis of time [39]. Nahhas Rodacki et al. [40] suggested that abdominal exercise was associated with the improvement in LBP since the pressure on the intervertebral disks was decreased as a consequence of the increased intra-abdominal pressure during abdominal contraction. However, the strength of OEA was decreased after general exercise in our results, which may be related to insignificant efficacy and development of the disease. Wuqinxi emphasizes on the coordination of breathing and movements, especially training on the breathing pattern, which may stretch OEA and other abdominal at deep inspiration training. The above may be the reason for the better effect of Wuqinxi than the general exercise on pain.

We also observed the effects of Wuqinxi on the quality of life, which were assessed by the SF-36 and PSQI from physical function, mental health, and sleep quality. Our study showed that the PCS and MCS in SF-36 of the participants were significantly improved in the WQXG and GEG at 24 weeks compared with the baseline. However, compared with the general exercise, Wuqinxi has a better effect on mental health, and the difference is statistically significant ($P < 0.05$). A large number of studies confirmed that qigong was more beneficial to psychology than general exercise, which was also consistent with our research results [41–43]. Besides, the patients with chronic LBP in the WQXG or GEG had a significant improvement on the sleep quality of at 24 weeks compared with baseline, according to the changes in PSQI scores. However, there was no statistical

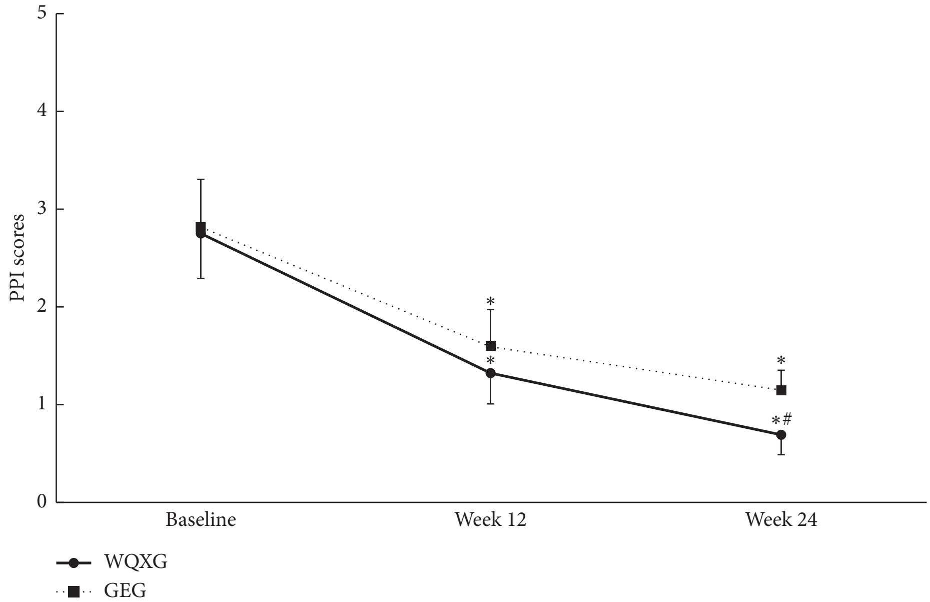


(a)



(b)

Figure 2: Continued.



(c)

Figure 2: The changes in pain intensity from baseline to 12 and 24 weeks. The pain intensity was assessed by SF-MPQ, and VAS and PPI as subtables were used for further evaluation. (a) The changes in the SF-MPQ scores from baseline to 12 and 24 weeks. (b) The changes in the VAS scores from baseline to 12 and 24 weeks. (c) The changes in the PPI scores from baseline to 12 and 24 weeks. Compared with baseline, $^{*}P < 0.05$; compared with the GEG at the same time point, $^{\#}P < 0.05$. WQXG, Wuqinxi group; GEG: general exercise group; SF-MPQ: Short-Form McGill Pain Questionnaire; VAS: Visual Analog Scale; PPI: Present Pain Intensity.

Table 4: The changes in the quality of life from baseline to 12 and 24 weeks.

Outcomes	Difference in mean change (95% CI)		Between-group difference (95% CI)	
	WQXG	GEG	GEG vs. WQXG	*P*
SF-36 PCS				
Week 12	13.6 (7.7 to 19.4)*	12.6 (3.3 to 21.9)*	0.7 (-5.2 to 3.8)	0.051
Week 24	34.0 (28.2 to 39.9)*	24.0 (14.7 to 33.3)*	3.1 (-1.8 to 8.0)	0.032
SF-36 MCS				
Week 12	12.1 (5.7 to 18.6)*	8.5 (−0.9 to 17.9)*	1.5 (−5.4 to 8.4)	0.665
Week 24	29.8 (23.3 to 36.3)*	16.7 (7.3 to 26.1)*	6.7 (0.8 to 12.5)#	0.028
PSQI				
Week 12	−2.8 (−4.7 to −0.9)*	−2.7 (−4.6 to −0.9)*	−0.6 (−2.2 to 1.0)	0.451
Week 24	−3.1 (−5.2 to −1.0)*	−3.9 (−5.9 to −1.9)*	0.3 (−1.3 to −2.0)	0.681

The quality of life was assessed by the SF-36 and PSQI from physical function, mental health, and sleep quality. The changes in mean were calculated from the difference between the current value and the baseline data. Compared with baseline, $^{*}P < 0.05$; compared with the GEG at the same time point, $^{\#}P < 0.05$. CI, confidence interval; WQXG, Wuqinxi group; GEG: general exercise group; SF-36, Short-Form Health Survey; PCS, physical component summary; MCS, mental component summary; PSQI, Pittsburgh Sleep Quality Index.

difference between the two groups, which may need to be further confirmed through a large-sample study.

4.2. Limitations of the Study. First of all, as a prospective experiment, the sample size of the study needs to be improved. In the future, multicenter and large-sample studies should be carried out to determine the therapeutic effect of Wuqinxi on chronic LBP. Secondly, the study lasted a long time and depended on the self-management of patients. Although we communicated with the patients every week and gave them instruction every month, we still cannot guarantee their completion of the experiment. Also, although it can be learned from the network system of the hospital whether the patients received other related treatments in the past 24 weeks, we still cannot neglect the possibility of purchasing drugs from drugstores. But, as a reward, we promised to give free physical therapy for the patients who seriously complete the whole experiment if they have other problems in the future. Therefore, the completion of the study was largely dependent on the active cooperation of patients.

Table 5: The changes in electrical activities of trunk muscle strength from baseline to 24 weeks.

Muscle	Difference in mean change (95% CI)		Between-group difference (95% CI)	
	WQXG	GEG	GEG vs. WQXG	P
RA				
30°/s	10.3(1.7 to 18)*	11.7(1.9 to 21.5)*	−1.4(−13 to 10.2)	0.78
90°/s	2.1(−14.1 to 18.2)	7.4(−2.3 to 17.1)	−5.3(−14.1 to 9.3)	0.64
OEA				
30°/s	8.2(4.3 to 12.1)*	−2.2(−3.6 to −0.9)*	10.4(4.3 to 24.4)#	0.048
90°/s	3.0(−9.8 to 15.9)	−7.5(−22.3 to 7.3)	10.5(1.9 to 19.1)#	0.045
ES				
30°/s	−1.6(−16.6 to 13.4)	3.2(−6.7 to 33.2)	−4.8(−24.7 to 10.1)	0.24
90°/s	3.3(−7.7 to 14.3)	7.8(−8.7 to 22.8)	−4.5(−19.6 to 10.7)	0.69
MF				
30°/s	8.4(2.9 to 13.9)*	15.4(1.9 to 38.9)*	−7(−17.8 to 4.3)	0.34
90°/s	21.3(4.4 to 38.2)*	9.1(3.3 to 14.9)*	12.2(−10.7 to 35.1)	0.42

The electrical activities of RA, OEA, ES, and MF were measured in the angular velocity of 30°/s and 90°/s, respectively, to assess trunk muscle strength after the end of the intervention. The changes in mean were calculated from the difference between the current value and the baseline data. Compared with baseline, * $P < 0.05$; compared with the GEG at the same time point, # $P < 0.05$. CI, confidence interval; WQXG, Wuqinxi group; GEG: general exercise group; RA, rectus abdominis; OEA, obliquus externus abdominis; ES, erector spinae; MF, multifidus.

5. Conclusion

The above results showed that Wuqinxi had better effects on chronic LBP for a long time compared with the general exercise, including pain intensity and quality of life. Thus, Wuqinxi should be recognized as a possible standalone therapy and self-management skill in chronic LBP, which is suitable for long-term practice. Further multicenter large-sample studies should be designed to compare Wuqinxi with other exercises to discover the advantages of traditional Chinese exercise in the treatment of chronic LBP. Besides, strategies are needed to increase motivation for the regular practice of Wuqinxi and explore the possibility of self-management skills in chronic diseases.

Abbreviations

LBP: Low back pain
WQXG: Wuqinxi group
GEG: General exercise group
SF-MPQ: Short-Form McGill Pain Questionnaire
VAS: Visual Analog Scale
PPI: Present Pain Intensity
SF-36: Short-Form Health Survey
PSQI: Pittsburgh Sleep Quality Index
iEMG: Integrated electromyogram
PCS: Physical component summary
MCS: Mental component summary
RA: Rectus abdominis
OEA: Obliquus externus abdominis
ES: Erector spinae
MF: Multifidus
ANOVA: Analysis of variance
CI: Confidence interval.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request. He can be reached at fanglei586@126.com.

Ethical Approval

The study protocol was in accordance with the Declaration of Helsinki and was approved by the Chinese Ethics Committee (No. ChiECRCT-20160048), and the authors registered the study on the Chinese Clinical Trial Registry (No. ChiCTR-INR-16009038).

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Chongjie Yao and Zhenrui Li contributed equally to this work.

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