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Effects of Mind-Body Exercises for Osteoporosis in Older Adults: A Systematic Review and Meta-analysis of Randomized Controlled Trials

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Abstract

Introduction: Osteoporosis is a major cause of fractures and even life-threatening fractures in the elderly. Mind-body exercise is a beneficial intervention to improve flexibility, control body balance and reduce pain. We aimed to evaluate the effects of physical and mental exercise on osteoporosis in the elderly. **Methods:** Randomized controlled trials (RCTs) focusing on mind-body exercises for osteoporosis were included. Web of Science, PubMed, Science Direct, Medline, Cochrane Library, China National Knowledge Infrastructure (CNKI), and Wanfang were searched from inception to January 2023. Outcomes included bone mineral density (BMD), bone mineral content (BMC), body balance (BB), pain, indicators of bone metabolism (BMI), lower extremity function, fearing level, and quality of life (QOL). The quality of study reporting was rated by 2 reviewers independently, and Review Manager software (version 5.3) was used for meta-analysis. **Results:** Thirty-nine trials with 2325 participants were included. The pooled results showed that mind-body exercises have encouraging effect on elderly people with osteoporosis, especially in aspects of BMD, BMC, QOL, improving the function of lower extremity, reducing pain and fearing level. While, dance and eight-section brocade could not improve the quality of life,or dance and eight-section brocade have no effect on BMD. **Conclusions:** Mind-body exercises may have potential efficacy for osteoporosis in the elderly. However, due to the poor methodological quality of the included trials, more clinical trials with precise methodological design and rigorous reporting are needed.

Keywords
mind-body exercise, osteoporosis, meta-analysis, geriatric medicine, metabolic bone disorders

Introduction

According to the latest World Population Prospects report, the global population aged 65 and over will reach 771 million by 2022 and is expected to grow to 1.6 billion by 2050.[1] The morbidity of some conditions, such as osteoporosis, increases with age. Osteoporosis is a disorder of the skeletal system and the main symptom is a reduction in bone mineral density, which is a major cause of fractures and even a life-threatening cause in older people.[2] Approximately 200 million women are affected by osteoporosis worldwide. In women over 50 years old, 1 third of these fractures will be associated with

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osteoporosis, whereas in men over 50 years old, 1 fifth will experience osteoporosis-related fractures.[3] Osteoporosis is a chronic disease characterized by low bone mass and disruption of bone architecture, resulting in reduced bone strength and increased risk of fracture,[4] leading to reduced quality of life and high costs to individuals and society. Unfortunately, conventional treatment for patients with osteoporosis is not available and only a small proportion of patients are eligible for rehabilitation programs according to osteoporosis guidelines.[5]

Mind-body exercises such as taichi, dance, yoga, eight-section brocade, 5 mimic-animal exercises, yi jinjing and pilates are considered complementary therapies that are beneficial interventions for improving flexibility, controlling body balance and reducing pain. In recent years, several clinical trials and meta-analyses have reported a positive effect of exercise on pain and quality of life in older people with osteoporosis.[6,7]

The high prevalence and cost of osteoporotic fractures, particularly in the ageing population, make prevention and management of this condition important. Mind-body exercise on bone as a non-pharmacological intervention has been focused. A systematic review is required to carry in this area and summarize the evidence for clinical health care, policymakers, and all with an interest in this area. Meta-analysis as a research method can improve the effectiveness of statistical analysis, reveal uncertainties in individual studies, identify general findings and differences between individual studies, suggest new research topics and research directions, and save research costs. Therefore, in this study, a meta-analysis was performed to assess the effect of mind-body exercise on osteoporosis in aging people.

Methods

This meta-analysis was registered in PROSPERO (CRD42020165385). The protocol of this meta-analysis has been published in *Medicine (Baltimore)*.[7]

Search Strategy and Data Sources

Web of Science, PubMed, Science Direct, Medline, Cochrane Library, China National Knowledge Infrastructure (CNKI), and Wanfang database were searched from inception to January 2023. The searching strategies combined Medical Subject Headings and free-text terms including osteoporosis, mind-body exercises, and clinical trials.

Types of Included Studies

All controlled clinical trials including randomized controlled trial (RCT), parallel-group study, and retrospective controlled trial evaluating 1 or more following outcome: bone mineral density (BMD), bone mineral content (BMC), quality of life (QOL), six-minute walking test (SMWT), indicators of bone metabolism (BMI), pain, fearing level, body balance, and sit-to-stand test (SST). Regardless of the published language, blinding, and publication status of the included studies.

Types of Included Participants

The included participants must be diagnosed with osteoporosis in the observation group, regardless of sex, race, nationality, or duration of disease.

Types of Interventions

Interventions in observation groups were mind-body exercises including taichi, dance, yoga, eight-section brocade, 5 mimic-animal exercise, yi jinjing, and pilates. Interventions in comparisons groups were no regular exercise, or other exercises (ie jogging, walking).

Types of Outcome Measures

The primary outcome was the global assessment of osteoporosis (ie BMD), and the secondary outcomes were other indexes related to osteoporosis (ie QOL, BMC, SMWT, SST, VAS, fearing level, indicators of bone metabolism, and body balance).

Data Extraction

Study ID, sample size, age of patients, interventions, outcomes, and duration of exercise were extracted in a table.

Risk of Bias and Reporting Quality of Included Trials

Two authors assessed quality of reporting and methodology independently by using Cochrane Review Handbook. Seven domains including selection bias, performance bias, detection bias, attrition bias, reporting bias and other bias would be judged with low, unclear and high risk. Discussions should be carried out and a third author should make a final decision when there were disagreements.

Statistical Analysis

Review Manager 5.3 software (Cochrane Collaboration, UK) was used for meta-analysis. Mean difference (MD) with 95% confidence interval (CI) was used for analyzing continuous data. I^2 statistics were calculated to the heterogeneity and to choose the effect model. Statistical heterogeneity existed among included trials when $I^2 > 50\%$ and P value <.1, so that a random-effects model would be selected; otherwise a fixed model was chosen. Subgroup analysis would be carried out by different interventions or if the pooled results included clinical heterogeneity.

Results

Study Identification and Selection

Six hundred and eighty-one possibly relevant papers were identified at first and 161 were excluded because of duplicate. The remaining 520 papers were screened by titles or abstracts, and 441 were excluded. The remaining 79 studies were retrieved and full texts were read. Finally, thirty-eight papers remained that met the inclusion criteria (Figure 1).

Characteristics of the Included Trials

Among the 38 articles included, 1 article was a three-group comparison, and the 3 groups were combined into 2 groups, named A and B; a total of 39 randomized controlled trials were included. Among these included trials, the intervention of thirteen trials focused on taichi, 5 were dance, 3 were pilates, and 4 were yoga, 7 were eight-section brocade, 5 were 5 mimic-animal exercise, 1 were yi jinjing. And the exercise duration of the included participants were 3-72 months. Thirty-one trials used BMD as the main outcome to assess the effect of mind-body exercises for osteoporosis, 4 used QOL, 5 measured BB, 6 involved BMC, 6 involved indicators of bone metabolism, 2 took SMWT, 2 took SST, and eleven used VAS. The detailed information on characteristics of the included trials showed in Table 1.

Quality Assessment of the Included Trials

Among the 39 included trials, eighteen trials (50.00%)[20,23,25-28,32-41,44]reported random sequence generation using random number table.But none of those trials reported using allocation concealment methods. Almost all of the included trials failed to blind the participants and personnel, because mind-body exercise is not a pharmacological treatment. While the control group in 2 trials[11,14] took other exercises, and 5 included trials[11,20,28,32,40] were retrospective studies, so unclear risk was assessed in these 7 trials (17.95%). The outcome assessments were blinded in one trial[17] (2.56%). Thirty-nine trials (100%) were assessed as having a low loss risk and

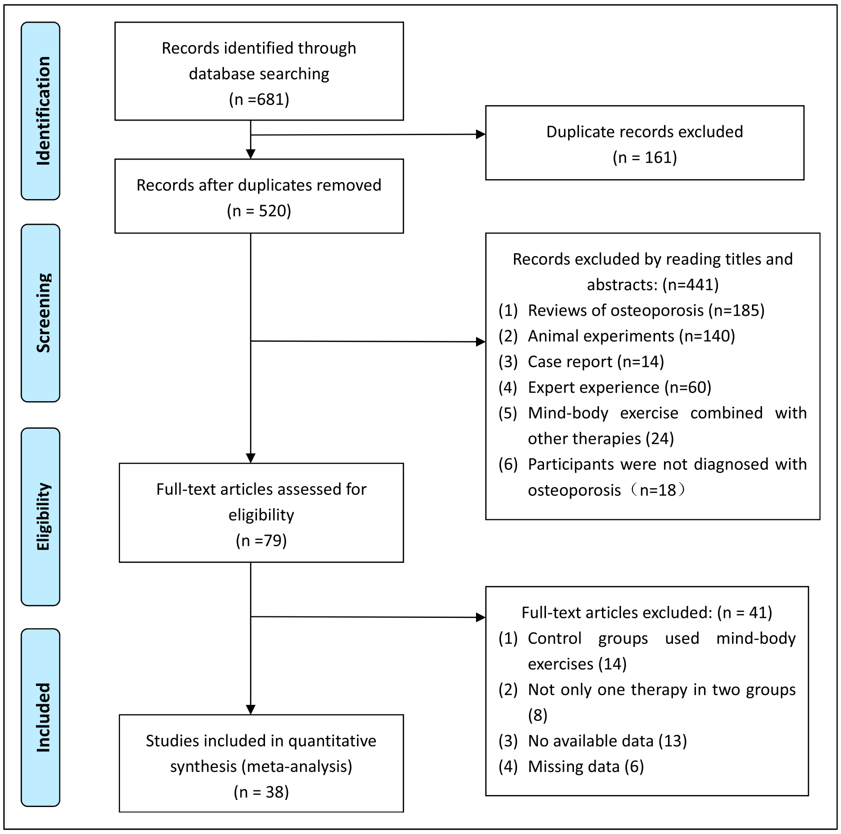

Figure 1. Literature screening process and results.

Table 1. Characteristics of the Included Trials.

Study ID	Sample size (n)		Age (year)		Interventions		Outcomes	Duration (month)
	T	C	T	C	T	C		
Zhou2004[8]	12	12	55.94 ± 2.83	55.94 ± 2.83	Taichi	NRE	BMD	10
Zhou2005[9]	16	16	57.21 ± 3.41	57.21 ± 3.41	Taichi	NRE	BMD	12
Wang2007[10]	20	20	60 ± 8	61 ± 5	Taichi	NRE	BMD	6
Liu2010[11]	14	14	53.43 ± 1.91	54.57 ± 1.74	Dance	Jogging	BMD	6
Lin2010[12]	31	28	60.84 ± 5.58	62.62 ± 6.71	Taichi	NRE	BMD	12
Xu2010[13]	46	47	59 ± 5	59 ± 5	Dance	NRE	BMD	≥12
Tuzun2010[14]	13	13	60.62 ± 8.54	61.31 ± 8.43	Yoga	Exercise	QOL	3
Zhang2011[15]	32	32	62.47 ± 2.56	57.20 ± 4.14	Taichi	NRE	BMD	6
Fu2011[16]	25	20	68.4 ± 6.1	66.5±6.1	Dance	NRE	BMD	≥12
Nurten2013[17]	35	35	56.3 ± 5.0	56.6 ± 5.5	Pilates	HE	VAS,SMWT,SST,QOL	12
Du2014[18]	15	15	51.69 ± 3.18	52.21 ± 3.01	Taichi	NRE	BMD,BMC,BMI	6
Yao2014[19]	21	20	64.2 ± 3.58	65.4 ± 3.60	Taichi	NRE	BMD	72
Zhao2015[20]	30	30	58.8 ± 3.2	60.1 ± 2.8	Taichi	NRE	BMD	6
Zhou2015[21]	25	20	53.52 ± 5.09	53.40 ± 4.22	Taichi	NRE	BMD,BMC	6
Ender2015[22]	22	19	40-69	40-69	Pilates	NRE	BMD,QOL,SMWT	4
Zhu2016[23]	28	27	64 ± 3	64 ± 4	Taichi	NRE	SST	18
Bao2016[24]	58	49	70.4 ± 6.9	68.4 ± 7.1	Taichi	NRE	BMD	6
Shi2017[25]	63	63	58.2 ± 4.3	57.6 ± 3.5	Yoga	NRE	BMD	6
Sevim2017[26]	20	20	59.45 ± 7.47	61 ± 7.55	Pilates	NRE	TKS,VAS	6
Cai2018[27]	30	30	52.1 ± 4.2	51.4 ± 4.9	Eight-section brocade	NRE	BMD,BMC,BMI	12
Su2018[28]	40	40	58.93 ± 4.01	59.12 ± 3.88	Eight-section brocade	NRE	BMD,BMI,VAS,BBS	6
Huang2018[29]	30	30	73.07 ± 2.5	72.86 ± 2.6	Five mimic-animal exercis	NRE	BMD,VAS	6
Zhang2018[30]	16	9	58.88 ± 4.05	58.36 ± 4.79	Dance	NRE	BMD	12
Yu2019[31]	40	40	61.5 ± 7.5	62.5 ± 6.6	Dance	NRE	BMD	6
Peng2019[32]	33	32	60.88 ± 4.59	62.31 ± 4.96	Eight-section brocade	NRE	BMD,BMC,BMI	6
Li2019[33]	51	51	62.9 ± 5.2	63.4 ± 5.0	Yi jinjing	NRE	BMI	3
Guo2019[34]	35	38	68.31 ± 10.27	69.71 ± 9.51	Five mimic-animal exercis	NRE	VAS	12
Li2019[35]	44	44	65.1 ± 5.1	65.5 ± 5.1	Eight-section brocade	NRE	BMD,BBS	6
Kuang2019[36]	41	41	68.68 ± 3.22	70.33 ± 3.34	Eight-section brocade	NRE	VAS,BBS	3
Abeer M2020[37]	22	21	55.09 ± 4.19	57.29 ± 4.44	Whole-body vibration (WBV) training	NRE	BMD	6
Li202A[38]	28	29	62.6	62.6	Five mimic-animal exercis	NRE	BMD,VAS,BBS	6
Li2020B[38]	29	29	62.6	62.6	Five mimic-animal exercis	NRE	BMD,VAS,BBS	6
Sun2020[39]	30	30	73.96 ± 6.32	72.53 ± 7.04	Eight-section brocade	NRE	BMD,QOL,VAS	12
Mao2020[40]	50	50	59.5 ± 6.3	60.1 ± 6.9	Five mimic-animal exercis	NRE	BMD,BMC	6
Chen2020[41]	40	40	59.8 ± 6.3	60.6 ± 6.5	Eight-section brocade	NRE	BMD,BMC,VAS	6
Grahn Kronhed2020[42]	10	10	71.3 ± 5.3	72.4 ± 6.5	Yoga	NRE	VAS	2.5
Liang2020[43]	17	17	61.3 ± 2.4	61.9 ± 2.5	Taichi	NRE	BMD	12
Solakoglu2022[44]	16	16	60.23 ± 9.69	65.27 ± 8.57	Yoga	NRE	BMD	3
Xue2022[45]	51	49	61.23 ± 10.66	62.25 ± 9.18	Taichi	NRE	BMD,BMI	6

NRE: no regular exercise. QOL: quality of life. BMD: Bone mineral density. BMC: Bone mineral content. BMI: indicators of bone metabolism. TKS: Tampa Kinesiophobia Scale. VAS: Visual Analogue Scale. BBS: Berg Balance Scale. SST: sit-to-stand test. SMWT: six-minute walk test.

reporting bias risk because there was no exit or detailed explanation for exit in these trials. Nineteen trials[8-13,15-21,23,24,30,42-44] (50.00%) did not show the detailed information on ethic, diagnostic criteria of osteoporosis and other relevant information, so unclear risk was assessed with other bias. Overall, fifteen included trials[25-28,32-41] were assessed high methodological quality, and the remaining trials were deemed to low according by Jadad Scale (low risk got 1 point, and unclear and high risk got zero; if the total score was 4-7 points, high quality was judged; if 1-3 points, then low quality was judged) (Figure 2).

Analysis of Outcome

Bone mineral density. Bone mineral density as the main indicators to assess the severity of osteoporosis, so 31 included trials[8-13,15,16,18-22,24,25,27-32,35,37-41,43-45] measured BMD, and we assessed BMD classified by different participants, body parts and interventions in this study.

For different participants, a random-effects model was used because of the high heterogeneity of the pooled results (I^2 = 91%, P < .00001). The pooled result showed that the overall effect on mind-body exercise for different kind of participants was significant when compared with control groups (MD = .05, 95% CI [.03, .08], P .00001, n = 1452). Twelve included trials[8-13,18,19,22,30,31,44] focused on menopause women (MD = .05, 95% CI [.00, .10], P = .04, n = 525); 7 trials[15,20,24,29,38,45] focused on elderly people both men and women (MD = .08, 95% CI [.04, .12], P = .0001, n = 506); only 1[16] focused on elderly men (MD = .01, 95% CI -[.00, .03], P = .06, n = 45); while 5 trials[21,25,27,28,32] focused on elderly women showed no significant difference between mind-body exercises and control groups (MD = .03, 95% CI [.01, .04], P = .003, n = 376) (Supplementary File 1).

For different body parts, a random-effects model was used because of the high heterogeneity of the pooled results (I^2 = 91%, P < .00001). The pooled result showed that the overall effect on mind-body exercise for different body parts was significant when compared with control groups (MD = .07, 95% CI [.05, .08], P < .00001, n = 2637). And there were significant difference in every part: 25 included trials[8-13,18,20,21,24,25,27,28,30,32,33,37-41,43-45] measured BMD of lumbar spine (MD = .07, 95% CI [.04, .09], P < .00001, n = 1541); Three[15,16,19] focused on calcaneal (MD = .04, 95% CI [-.02, .10], P = .18, n = 150); Eleven[10,20,24,31,35,37,39-41,43,44] focused on collum femoris (MD = .07, 95% CI [.03, .10], P < .0001, n = 739); Three[10,20,24] focused on caput femoris (MD = .10, 95% CI [.05, .14], P < .0001, n = 207) (Supplementary File 2).

For different interventions, a random-effects model was used because of the high heterogeneity of the pooled results (I^2 = 90%, P < .00001). The pooled result showed that the overall effect on mind-body exercise for different interventions was significant when compared with control groups (MD = .05, 95% CI [.03, .06], P < .00001, n = 2068). Twelve included trials[8-10,12,15,18-21,24,43,45] assessed the effect of taichi, and the result showed that there was significant difference (MD = .07, 95% CI [.03, .11], P = .0006, n = 636). The effect of pilates, yoga, chinese exercises, 5 mimic-animal exercise and yi jinjing also showed significant difference: 1 trial[22] assessed pilates (MD = .06, 95% CI [.01, .11], P = .01, n = 41); 2 trial[25,44] assessed yoga (MD = .11, 95% CI [.04, .18], P = .004, n = 158); 5 trial[27,28,32,38] assessed Chinese Exercises (MD = .02, 95% CI [.02, .03], P .00001, n = 320); 4 trial[29,38,40] assessed 5 mimic-animal exercise (MD = .03, 95% CI [.00, .06], P = .03, n = 175) and 1 trial[33] assessed yi jinjing exercise (MD = .14, 95% CI [.04, .24], (P = .006,n = 102). However, from the results of the 2 included trials, there seemed to be no difference between dance and control interventions and between eight-section brocade and control interventions. Four trial[11,13,16,30] assessed dance exercise (MD = .03, 95% CI [-.06, .12], P = .53, n = 191) and 5 trial[27,28,32,39,41] assessed eight-section brocade(MD = .02, 95% CI [-.00, .04], P = .12,n = 345) (Supplementary File 3).

Bone mineral content. Six included trials[18,21,27,32,40,41] measured the effect of mind-body exercise for BMC. For different mineral content, a random-effects model was used because of the high heterogeneity of the pooled results (I^2 = 90%, P < .00001). The pooled results showed significant difference (MD = .07, 95% CI [.06, .09], P < .00001, n = 747). One trial[18] focused on BMC - Mg(MD = -.08, 95% CI [-.13,- .03], P.004, n = 30); 6 trials[18,21,27,32,40,41] focused on BMC - Ca(MD = .12, 95% CI [.10, .14], P .00001, n = 382); While 5 trials[18,27,32,40,41] focused on BMC - P showed no significant difference between mind-body exercises and control groups (MD = .02, 95% CI [-.01, .05], P.22, n = 335) (Figure 3. A).

Indicators of bone metabolism. Five included trials[18,27,28,32,45] measured the effect of mind-body exercise for indicators of bone metabolism. For different bone metabolism indexes, a random-effects model was used because of the high heterogeneity of the pooled results (I^2 = 100%, P < .00001). The pooled results showed significant difference (MD = .88, 95% CI [.82, .95], P < .00001, n = 545). Three trials[18,27,32] focused on ALP (MD = -1.01, 95% CI [-3.15,1.12], P.35, n = 155); 3 trials[28,32,45] focused on BGP(MD = 1.90, 95% CI [1.82, 1.98], P .00001, n = 245); 2 trials[28,32] focused on DPD(MD = -.77, 95% CI [-.87, -.67], P .00001, n = 145) (Figure 3. B).

Function of lower extremity. Participants were asked to walk as fast as they could on a well-illuminated, flat 25 meters long corridor for 6 minutes for evaluating lower limbs muscle strength in 2 included trials.[17,22] A fixed-effects

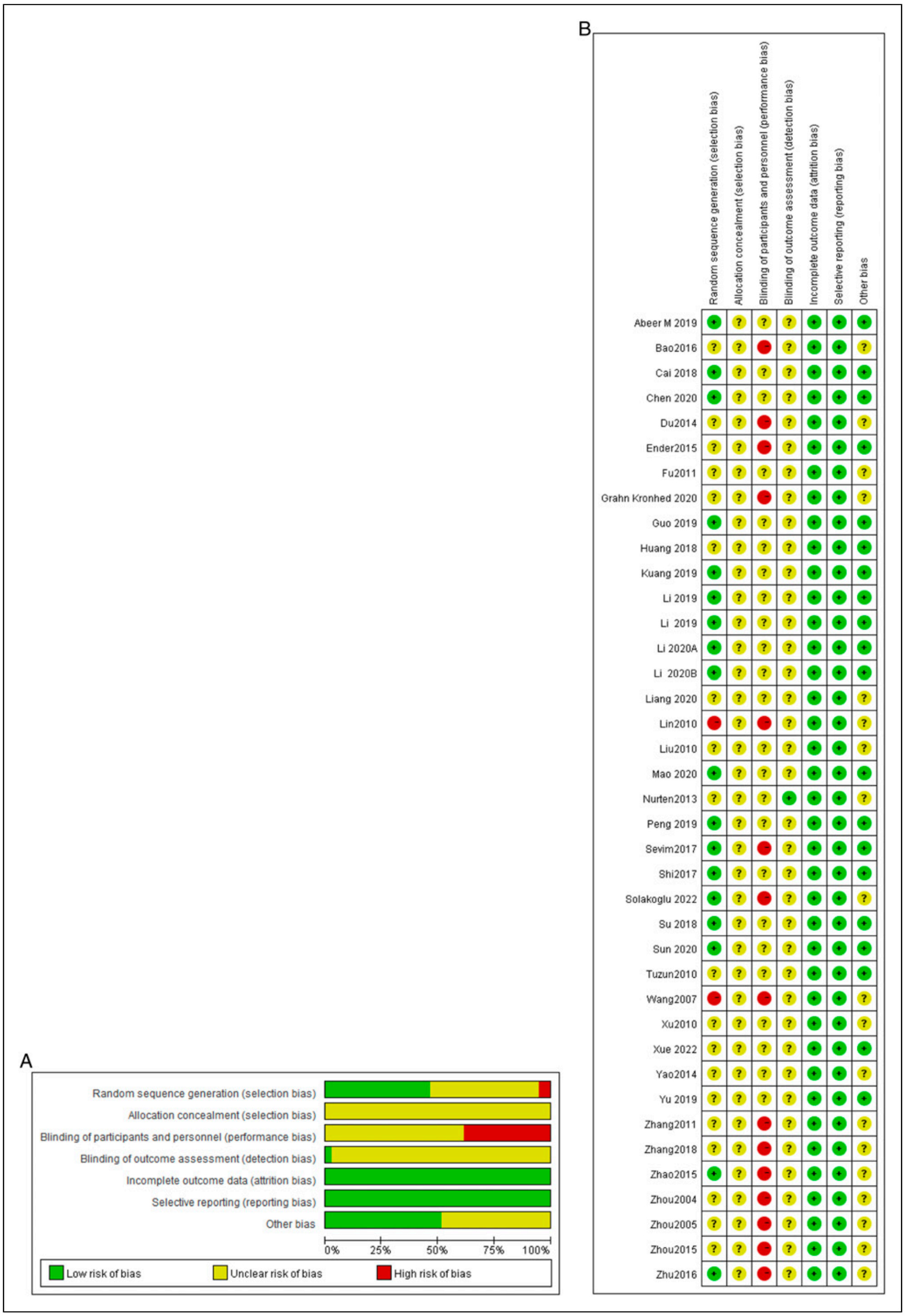

Figure 2. Risk of bias assessment in the studies; (A) risk of bias graph; (B) risk of bias summary.

model was used because of no heterogeneity of the pooled results (I^2 = 0%, P = .39). The pooled results showed that there was a significant difference between the mind-body exercise and control groups (MD = 32.87, 95% CI [.50, 65.23], P = .05, n = 101) (Figure 3. C).

Participants were asked to stand up and then sit down quality in 1 minute for testing the lower extremity endurance in 2 included trials.[17,23] A random-effects model was used because of the high heterogeneity of the pooled results (I^2 = 80%, P = .03). The pooled results showed that there was a significant difference between the mind-body exercise and control groups (MD = 7.19, 95% CI [2.04, 12.34], P = .006, n = 125) (Figure 3. D).

Body balance. The Berg Balance Scale(BBS) was used to evaluate body balance by reflecting overall balance function. Five included trials[28,35,36,38] assessed balance and a random-effects model was used because of the high heterogeneity of the pooled results (I^2 = 91%, P .00001). The pooled results showed that there was a significant difference between the mind-body exercise and control groups (MD = 4.25, 95% CI [2.42, 6.08], P .00001, n = 365) (Figure 3. E).

Fearing level. In 1 included trial[26] assessed the participants' fearing level and avoidance associated with movement by using Tampa Kinesiophobia Scale (TKS). The result showed that there was a significant difference when compared the mind-body exercise and control groups (MD = 2.85, 95% CI [1.68, 4.02], P < .00001, n = 40) (Figure 3. F).

Pain. Pain was assessed in eleven included trials[17,26,28,29,34,36,38,39,41,42] by using Visual Analogue Scale (VAS). A random-effects model was used because of the high heterogeneity of the pooled results (I^2 = 91%, P < .00001). The pooled results showed that there was a significant difference between the mind-body exercise and

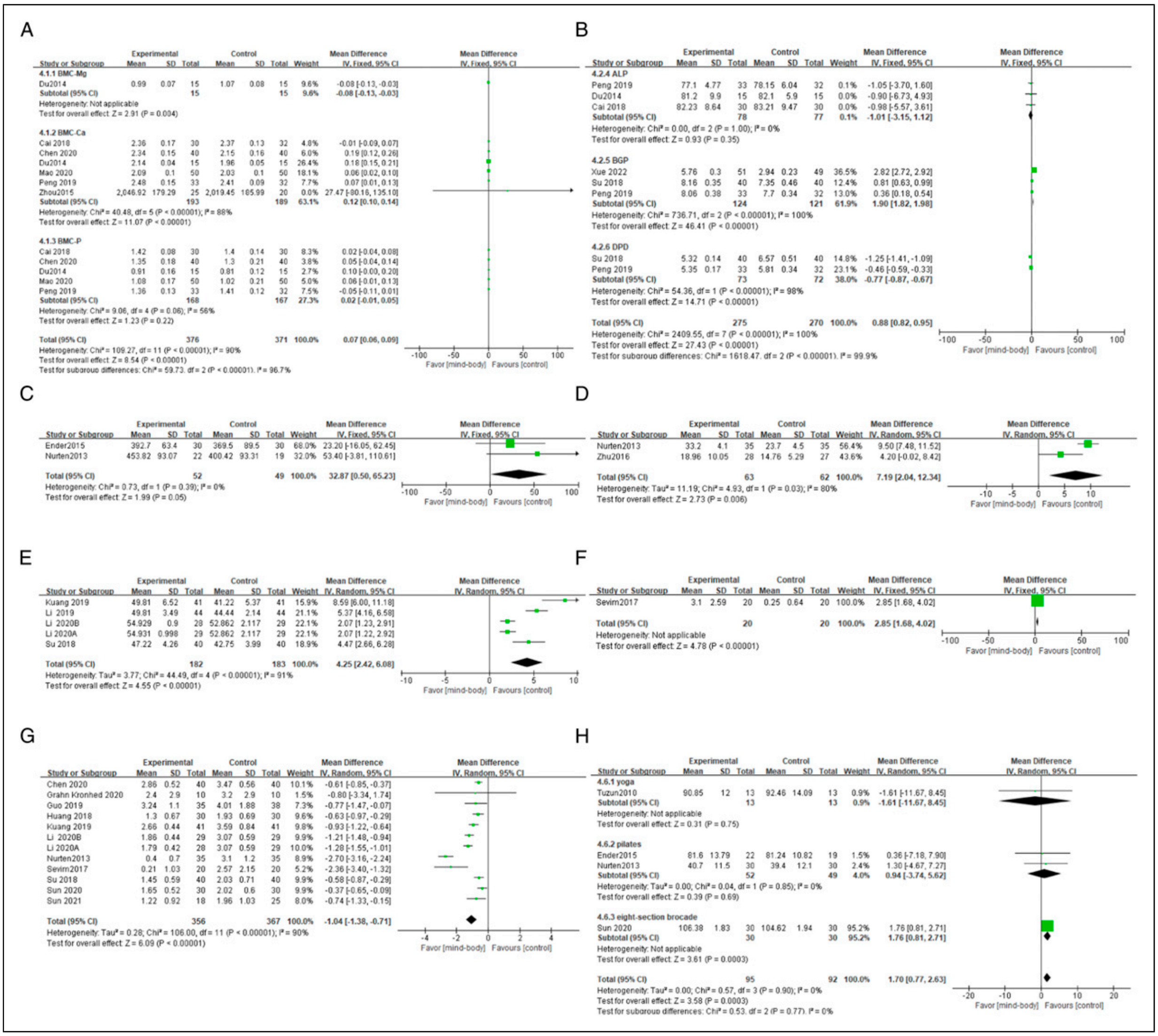

Figure 3. Pooled results of meta-analysis; (A) Bone mineral content (BMC); (B) indicators of bone metabolism (BMI); (C) six-minute walk test (SMWT); (D) sit-to-stand test (SST); (E) Body balance (BBS); (F) Fearing level; (G) Visual Analogue Scale (VAS); (H) quality of life (QOL).

control groups (MD = -1.07, 95% CI [-1.43, -.72], $P < .00001$, n = 680) (Figure 3. G).

Quality of life. Quality of life was evaluated by the quality of life questionnaire of the European foundation for osteoporosis (QUALEFFO). A fixed model was used, because of low heterogeneity of the pooled results ($I^2 = 0\%$, $P = .90$). The pooled result showed that the overall effect on mind-body exercise for QOL was a significant difference compared with control groups (MD = 1.70, 95% CI [.77, 2.63], $P = .0003$, n = 187). The subgroup analysis showed no difference: 1 trial[14] focused on yoga (MD = -1.61, 95% CI [-11.67, 8.45], $P = .75$, n = 26); 2 trials[17,22] focused on pilates (MD = .94, 95% CI [-3.74, 5.62], $P = .69$, n = 101). Eight-section brocade[39] has an impact on the quality of life. Because eight-section brocade can promote the recovery of spinal mechanical balance, regulate bone growth, improve bone cell activity, improve blood circulation in the waist and back, and effectively improve the quality of life. (MD = 1.76, 95% CI [.81, 2.71], $P = .0003$, n = 60) (Figure 3. H).

Discussion

Osteoporosis is a systemic disease that affects bone metabolism and its major complications include pain, fractures and spinal deformities. These complications can cause significant damage and pose a threat to the health and quality of life of older people.[4] There are 3 basic principles for preventing osteoporosis: calcium supplementation, dietary management and exercise.[3] Of these 3 principles, exercise therapy is increasingly being used in clinical practice due to its effectiveness, affordability, safety, ease of use, lack of side effects and ease of adherence.[46] Research suggests that mind-body exercises have a positive effect on preventing osteoporosis and improving bone density.[6,7] In addition, mind-body exercises can also improve balance problems, reduce the risk of falling, reduce body fat, and improve diabetes and high blood lipids. Therefore, mind-body exercises can not only improve the physical condition of older people, but also help to prevent and treat the symptoms of osteoporosis.[6,7,30,32]

Mind-body exercises are a low cost, easy to perform, low impact, moderate intensity aerobic exercise that emphasizes skeletal muscle stretching and relaxation, body coordination training and breathing and movement control along with concentration and is a multi-modal exercise.[47-49] Research has found that physical and mental exercise is an effective intervention which not only improves strength, balance, flexibility and self-efficacy.[6,7] It is also effective in improving sleep levels and quality of life. It is also effective in improving sleep levels and quality of life.[50] It mainly includes taichi, dance, yoga, eight-section brocade, 5 mimic-animal exercises, yi jinjing, chinese exercises and pilates.[6,7]

The indicators used in this experiment are BMD, BMC, BB, QOL, BMI, VAS, SST, SMWT and fearing level. BMD, known in full as bone mineral density, is an important indicator of bone strength, an important marker of bone quality, a reflection of the degree of osteoporosis and an important predictor of fracture risk.[27,32,44] Increasing improvements in measurement methods and the development of advanced software have allowed the method to be used at different sites with significantly improved measurement accuracy.[33,40,41] In addition to diagnosing osteoporosis, it can also be used for clinical pharmacological observations and epidemiological investigations, and is significantly superior in predicting osteoporotic fractures.[11,19,31]

BMC, or bone mineral content, varies with age in the human skeleton in the physiological state, and can be altered by certain drugs in the pathological state.[27,32] The quantitative determination of bone mineral content in humans has therefore become an important topic in modern medicine.[40,41] It is important for determining and studying the physiology and pathology of the skeleton, the degree of ageing and the diagnosis of various diseases of the body.[21]

BB is the abbreviation for body balance. Balance refers to the process of self-regulation of balance by the musculoskeletal system under the control of the human nervous system within a certain period of time, and is an important physiological function of the human body, which is the ability to maintain human posture. Balance ability usually reflects the health condition of the human body.[28,38] As an important indicator in national physical fitness monitoring, balance ability has been researched in the fields of medical rehabilitation and sports training, and has become 1 of the hot spots of current research.[34,35,37]

Quality of life (QQL), the subjective perception of an individual's life in many aspects, is a comprehensive indicator of one's health status and is influenced by many factors, such as: physical, psychological and social.[14,17,26] The SF-36 scale was developed from the Boston Health Study and is now widely used to assess quality of life.[22]

BMI is an abbreviation for Biochemical Indicators of Bone Metabolism, which includes indicators of calcium and phosphorus metabolism regulation, bone formation markers, bone resorption markers, hormones and cytokines.[27,32] BMI is derived from bone, cartilage, soft tissue, skin, liver, kidney, small intestine, blood and endocrine glands, etc. They are enzymes and hormones secreted by osteoblasts or osteoclasts, and collagen or non-collagen metabolites of the bone matrix.[33] Bone metabolism biochemical indicators can reflect the state of bone transformation in a timely manner, with high sensitivity and specificity, and are used for diagnostic typing of osteoporosis, prediction of fracture risk, evaluation of the efficacy of anti-osteoporosis treatment, and diagnosis and differential diagnosis of metabolic bone diseases.[45]

The Visual Analogue Scale (VAS) is used for the assessment of pain. The basic method is to use a 10-cm long moving scale with 10 scales on 1 side and a "0" and "10" scale at each end, with a score of 0 indicating no pain and a score of 10 indicating the most severe pain that is unbearable. A score of 0 indicates no pain and a score of 10 indicates the most intense pain that is unbearable.[34]

The six-minute walk test (SMWT) is patients were asked to walk as fast as they could for 6 minutes along a well-lit, flat, 25-metre corridor. The total distance covered was measured in metres (m).[17]

The sit-to-stand test (SST) is where the patient is asked to stand up from a chair and then sit down as quickly as possible within 1 minute.[17] The number of repetitions is also recorded as a measure of the lower limbs, and the Tampa Kinesiophobia Scale (TKS) was used to measure each patient's level of fear and avoidance associated with movement.[26]

Summary of Findings

This was a meta-analysis to evaluate all the main types of mind-body exercises for older people with osteoporosis. This systematic review included a meta-analysis of 39 RCTs with 2325 participants. Bone mineral density, bone mineral content, body balance, function of lower extremity,indicators of bone metabolism, pain, fearing level and quality of life were assessed in elderly participants with and without osteoporosis. A number of conclusions have been drawn from this study. The pooled results showed that mind-body exercises could improve the BMD compared to the control groups. As the high heterogeneity of the pooled results, subgroups based on participants, body parts and interventions were carried out. The results showed that mind-body exercises could improve BMD compared with control groups, regardless of participant or body part(except for calcaneus). When it came to different interventions, taichi, yoga, Chinese Exercises, 5 mimic-animal exercise, yi jinjing and pilates were superior to control groups, while dance and eight-section brocade had no advantage.Compared with the control group, physical exercise and psychological exercise had effects on BMC-Mg, BMC-Ca, body balance, bone mineral content, bone metabolic index, lower limb function, exercise-related pain and fear levels (except for BMC-P). According to the results of this study, mind-body exercises, especially the eight-section brocade, can improve the quality of life of patients with osteoporosis.

Limitations

Firstly, 2 studies (6-minute walk test, quality of life) have high heterogeneity. Our analysis suggests that this may be because both studies are subjective evaluations, and each doctor's evaluation criteria for them are inconsistent, which may lead to the above problems. Secondly, the quantity of participants is small in each included trial, which makes the results without abundant. Thirdly, none of the included trials reported adverse events, so the safety of mind-body exercises for osteoporosis could be estimated. Thus, strict trials with precise methodological design and rigorous reporting of clinical efficacy and adverse events assessing mind-body exercises for osteoporosis should be promising in future. And it is important for future research in this area to have standardized recommendations for delivering mind-body exercise interventions and reporting exercise outcomes.

Conclusion

It is limited but evidenced that mind-body exercises have encouraging effects on older people with osteoporosis, especially in aspects of BMD, BMC-Mg, BMC-Ca, improving the function of the lower extremity, reducing pain, body balance, fearing level and quality of life. While yoga and pilates did not improve QOL, dance and eight-section brocade had no effect on BMD. However, the finding should be interpreted with caution because of the limited of methodological quality of the included trials.

Authors' Contribution

JHB and LHL contributed equally to this study, so they are joint first authors of this study.JHB and LHL are guarantors of the integrity of the entire study and wrote this manuscript.ZYH and YSF conducted the study design and literature research with CGX and GZH. WJY and ZJ were used for data collection and analysis, and JHB and LH were used for statistical analysis. The manuscript was edited and reviewed by all authors.

Declaration of Conflicting Interests

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Ethics Approval

Ethical approval was not required, as this was a study-level meta-analysis of published data.

Informed Consent

All authors have read and agreed to publish the manuscript.

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Supplemental Material

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References

1. United Nations. *World Population Prospects 2022: Summary of Results*. https://www.un.org/development/desa/publications/world-population-prospects-the-2022-revision.html Accessed November 15, 2022.
2. Gregson CL, Armstrong DJ, Bowden J, et al. UK clinical guideline for the prevention and treatment of osteoporosis. *Arch Osteoporos*. 2022;17(1):58.
3. Anam AK, Insogna K. Update on osteoporosis screening and management. *Med Clin North Am*. 2021;105(6):1117-1134.
4. Johnston CB, Dagar M. Osteoporosis in older adults. *Med Clin North Am*. 2020;104(5):873-884.
5. Kaijser AC, Uzunel E, Grahn KA, Alinaghizadeh H, Salminen H. Effect of treatment on back pain and back extensor strength with a spinal orthosis in older women with osteoporosis: A randomized controlled trial. *Arch Osteoporos*. 2019;14(1):5.
6. Huang Q, Lu X, He T, Du J, Zhang P. Psychological effects of traditional Chinese mind-body exercises for low back pain: A protocol for meta-analysis. *Medicine (Baltim)*. 2021;100(22):e25605.
7. Zhang Y, Wang Z, Lu M, Wang Q, Wang H. Effects of mind-body exercises for osteoporosis in older adults: Protocol for systematic review and Bayesian network meta-analysis of randomized controlled trials. *Medicine (Baltim)*. 2020;99(11):e19426.
8. Zhou Y. The effect of traditional sports on bone density of menopause women. *Journal of Beijing Sport University*, 2004, 27: 354-355.
9. Zhou Y, Jing L, Chen Y, et al. The effect of taichi and calcium supplement for bone density in menopause women. *Chinese Journal of Sports Medicine*. 2005;24:106-108.
10. Wang J. Influence of taiji softball to postmenopausal women's bone mineral density and bone metabolism index. *Journal of Beijing Sport University*. 2007;30:1226-1228.
11. Liu Z, Xu J. Comparative study on the impact of jogging and dancing on bone metabolism and bone mineral density in postmenopausal women. *Chin J Rehabil Med*, 2010, 25:558-560.
12. Lin F. *The Effect of Long Time Taijiquan on Bone Density and Balance Function of Menopause Women*. Shanghai University of Sport; 2010.
13. Xu Y, Zhao G. Traditional Chinese wainst drum dance by the movement on bone mineral density in elderly women impact study. *Journal of Jilin Institute of Physical Education*. 2010;26:70-71.
14. Tüzün S, Aktas I, Akarirmak U, Sipahi S, Tüzün F. Yoga might be an alternative training for the quality of life and balance in postmenopausal osteoporosis. *Eur J Phys Rehabil Med*. 2010;46(1):69-72.
15. Zhang J. *Influence of Taijiquan Exercise on Aged and Elderly People Bone Quantity and Hormone Related with Bone Metabolism*. Shanghai University of Sport; 2011.
16. Fu S. *Effect of Sport Dance on Lower Limb Strength and BMD in the Male Elderly*. Shanghai University of Sport; 2011.
17. Küçükçakır N, Altan L, Korkmaz N. Effects of Pilates exercises on pain, functional status and quality of life in women with postmenopausal osteoporosis. *J Bodyw Mov Ther*. 2013;17(2):204-211.
18. Du X, Zhang M, Gou B, et al. Influence of taiji softball on estrogen and bone metabolism index of permenopausal period women. *Journal of Xi'an Physical Education University*. 2014;31:459-463.
19. Yao Y, Jiang Y, Sun Y. Effect of taichi softball on calcaneal bone mineral density in elderly women. In: *Collected Papers of the Third National Fitnessscience Conference*; 2014:312-313.
20. Zhao M, Ning L, Fan C, et al. About the influence of taichi push exercise combined with nutrition intervention to recover of patients with primary osteoporosis. *Liaoning Sport Science and Technology*. 2015;37:44-46.
21. Zhou X. *Influence of Sofeball Exercise on the Morphology and Bone Mineral Density on Elderly Female Body*. Xi'an Physical Education University; 2015.
22. Ender. The effects of clinical pilates exercises on bone mineral density, physical performance and quality of life of women with postmenopausal osteoporosis. *J Back Musculoskelet Rehabil*. 2015;28(4):849-858.
23. Zhu Y. *Taichi and Whole-Body Vibration Therapy on Elderly: A Clinical Randomized Controlled Trial*. PLA General Hospital of PLA Medical College; 2016.
24. Bao Q, Gong C, Shen X, et al. The preventive effect of taiji on osteoporosis in elderly patients. *Chinese Journal of Gerontology*. 2016;36:3246-3248.
25. Shi C, Dai H. Effect of long term yoga exercise on estrogen and bone in osteoporotic women. *Journal of Hainan Medicine*. 2017;27:1263-1265.
26. Oksuz S, Unal E. The effect of the clinical pilates exercises on kinesiophobia and other symptoms related to

osteoporosis: randomised controlled trial. *Complement Ther Clin Pract*. 2017;26:68-72.
27. Cai Y, Li X, Zhao J, Mo Y, Zheng L. Clinical observation of 30 cases of postmenopausal osteoporosis prevented by Baduanjin combined with Calcqi D. *Chinese National Folk Medicine*. 2018;27(23):130-132.
28. Su J, Deng Q. Clinical study of Baduanjin combined with anti-osteoporosis drugs in the treatment of postmenopausal osteoporosis. *J Tradit Chin Med*. 2018;46(03):84-88.
29. Huang D, Liu W. Clinical study on early recovery of patients with osteoporotic vertebral body fracture treated with five-animal exerciese luxiChinese and Foreign. *Medical Research*. 2018;16(21):7-9.
30. Zhang Y. *The Effect of Outdoor Aerobics on Vitamin D, Bone Mineral Desity and Lower Limb Muscle Strength of Postmenopausal Women*. Shanghai University of Sport; 2018.
31. Yu PA, Hsu WH, Hsu WB, et al. The effects of high impact exercise intervention on bone mineral density, physical fitness, and quality of life in postmenopausal women with osteopenia: a retrospective cohort study. *Medicine (Baltim)*. 2019;98(11):e14898.
32. Peng R, Deng Q, Li Z, et al. Effect of Baduanjin on glucose and bone metabolism indexes in postmenopausal patients with type 2 diabetes mellitus complicated with osteoporosis. *Chinese Medicine Bulletin*. 2019;25(23):53-56.
33. Li S, Zhang G, Zhang H, Li X. Application of Yijjinjing exercise assisted warm acupuncture in elderly patients with primary osteoporosis and its effect on serum osteocalcin level. *Foreign Medicine (Medical Geography)*. 2019;40(1): 27-29.
34. Guo Y, Rui L, Wang L. Clinical analysis of percutaneous vertebroplasty combined with wuqinxi exercise therapy forOsteoporotic thoracolumbar vertebral compression fracture. *Medical Information*. 2019;32(01):119-121.
35. Li Z, Deng Q, Zhang Y, et al. Clinical observation on eight-section brocadein improving balance ability and fall risk of senile osteoporosis. *Western Chinese Medicine*. 2019;32(9): 62-65.
36. Kuang X. Simplified observation of the effect of Libaduanjin on prevention and improvement of primary osteoporosis in the elderly. *Chinese community physicians*. 2019;35(28): 186-188.
37. ElDeeb AM, Abdel-Aziem AA. Effect of whole-body vibration exercise on power profile and bone mineral density in postmenopausal women with osteoporosis: A randomized controlled trial. *J Manip Physiol Ther*. 2020;43(4):384-393.
38. Qi L, Yang D, Yu D, et al. Effect of modified wuqinxi prescription on postmenopausal osteoporosis with deficiency of liver and kidney. *Journal of Liaoning University of Traditional Chinese Medicine*. 2020;22(03):154-157.
39. Sun Z, Gu X, Ou Y, et al. Effects of baduanjin based on virtual reality on fall risk and quality of lifeof elderly osteoporosis patients in nursing institution for the aged. *Chinese Medical Bulletin*. 2020;17(01):90-93.
40. Mao G, Chen S, Sun Y, et al. Clinical study on five animal exercises combined with calcium in the treatment of primary osteoporosis. *Shanghai J Tradit Chin Med*. 2020;54(1): 60-63.
41. Chen S, Sun Y, Jiang D, et al. Clinical observation on Chinese materia medica foot bath combined with baduanjin in theTreatment of yang deficiency osteoporosis. *Journal of Hunan University of Chinese Medicine*. 2020;40(11): 1396-1400.
42. Grahn KA, Enthoven P, Spångeus A, Willerton C. Mindfulness and modified medical yoga as intervention in older women with osteoporotic vertebral fracture. *J Altern Complement Med*. 2020;26(7):610-619.
43. Cheng L, Ba H. Effect of Tai Chi exercise with the same frequency and different exercise duration on the bone mineral density of older women. *J Sports Med Phys Fitness*. 2020;60(10):1396-1400.
44. Solakoglu O, Dogruoz KB, Yumusakhuylu Y, Mesci E, Icagasioglu A. The effect of yoga asana "vrksasana (tree pose)" on balance in patients with postmenopausal osteoporosis: A randomized controlled trial. *Am J Phys Med Rehabil*. 2022;101(3):255-261.
45. Xue D, Yao F, Yu J. The effect of Taiji softball exercise on glycolipid and bone metabolism in patients with type 2 diabetes mellitus complicated with osteoporosis. *Especially healthy*. 2022;3:292-294.
46. Zhang S, Huang X, Zhao X, et al. Effect of exercise on bone mineral density among patients with osteoporosis and osteopenia: A systematic review and network meta-analysis. *J Clin Nurs*. 2022;31(15-16):2100-2111.
47. Zou L, Loprinzi PD, Yeung AS, et al. The beneficial effects of mind-body exercises for people with mild cognitive impairment: A systematic review with meta-analysis. *Arch Phys Med Rehabil*. 2019;100(8):1556-1573.
48. Jin X, Wang L, Liu S, et al. The impact of mind-body exercises on motor function, depressive symptoms, and quality of life in Parkinson's disease: A systematic review and meta-analy- sis. *Int J Environ Res Public Health*. 2019;17(1):31.
49. Zou L, Yeung A, Li C, et al. Effects of meditative movements on major depressive disorder: A systematic review and meta-analysis of randomized controlled trials. *J Clin Med*. 2018;7(8):195.
50. Xu XM, Liu Y, Jia SY, et al. Complementary and alterna-tive therapies for restless legs syndrome: An evidence-based systematic review. *Sleep Med Rev*. 2018;38:158-167.