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Research Article

Effects of Exercise for Older Women with Osteoporosis: A Systematic Review

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Abstract

Aim: This study aimed to systematically review the available evidence on the effects of physical exercise on muscle strength; balance; risk of falls; and fractures for older women with osteoporosis.

Methods: Bibliographic searches of MEDLINE (PubMed); Cochrane Central Register of Clinical Trials (CENTRAL); Web of Science, PEDro; Lilacs (BIREME) were performed and the methodological qualities measured using the Assessing Risk of Bias (ROB) - Cochrane Collaboration's tool scale.

Results: Eight controlled clinical trials were included.

Conclusion: Multicomponent physical exercise, not only balance, may be considered as an intervention for older women with osteoporosis due to its effects on balance, strength and functional outcomes. We suggest new randomized clinical trials focusing on the parameters to prescribe physical exercise as the progression of resistance and its effects on skeletal muscle function, balance, strength, risk and number of falls and fractures for older women with osteoporosis.

Keywords: Osteoporosis; Elderly; Postural balance; Accidental falls; Exercises

Abbreviations

OP: Osteoporosis; BMD: Bone Mineral Density; WBV: Whole-Body Vibration; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis; RCTs: Controlled and Randomized Clinical Trials; LOS: Limits of Stability; CTSIB: Clinical Test Sensory Interaction Balance; LLFDI: Late Life Function and Disability Instrument; MeSH; Medical Subject Heading; EG: Exercise Group; CG: Control Group; TUG: Timed Up and Go Test; STS: Sit-to-Stand Test; OLST: One-Leg Stance Test; FES-I: Falls Efficacy Scale-International; OKAT-S: Osteoporosis Knowledge Assessment Tool; BT: Balance Training; PA: Physical Activity; RT: Resistance Training; ST; Strength Training; SG: Strengthening Group; STG: Stretching Group; CTSB: Clinical Test Sensory Interaction Balance; LOS: Limits of Stability; LLFDI: Late-Life Function and Disability Instrument; TUGT: Time "Up and Go" Test; BBS: Berg Balance Scale; NW: Nordic Walking; RCT: Randomized Clinical Trial; 1RM: One-Repetition Maximum

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Introduction

Osteoporosis (OP) is characterized by a reduction in skeletal microarchitecture, musculoskeletal fragility, and is associated with vitamin D and calcium deficiencies, loss of independence, physical inactivity, increased risk of falls and fractures, and mortality [1]. OP affects about 200 million people worldwide, with over 9 million osteoporotic fractures reported each year. Femur fractures have a high incidence rate in the elderly population and a large economic impact [2,3]. In comparison to men, women are affected the most and OP is particularly elevated among postmenopausal women with its incidence increasing with age [4].

After an initial fracture the risk for subsequent fractures more than doubles in the next six to twelve months, and persists for up to ten years. Furthermore, around one in three people will die within twelve months of a hip fracture, 40% will be institutionalized or unable to walk independently, and 60% will still require assistance a year later [1].

The management of osteoporosis includes pharmacological treatment with calcium supplementation, with concomitant vitamin D supplementation, for patients at high risk of calcium and vitamin D insufficiency, and for those who are receiving treatment for osteoporosis and nonpharmacologic recommendations such as modifications in risk factors for falls and physical exercise [5-7].

However, pharmaceuticals have no effect on key fracture risk factors, such as muscle strength, muscle power, dynamic balance, coordination and overall functional performance, all of which have been associated with an increased risk for falls and fracture [1].

Training protocols using different types of exercise in the same session, i.e., progressive resistance, weight-bearing impact exercise and balance, called multicomponent exercise training are recommended for older people with osteoporosis [1,8]. Nevertheless, parameters for exercise prescription such as type and dosage (frequency; intensity and duration) and additive effects of vitamin D plus calcium on the musculoskeletal function and risk of falls have not yet been established.

The effectiveness of the way a training regimen was carried out on the Bone Mineral Density (BMD) of the femoral neck and lumbar spine in adult women was investigated. They revealed that femoral neck and lumbar spine BMD respond differently depending on the type of exercise. While Whole-Body Vibration (WBV) improved lumbar spine BMD compared to aerobic, resistance and combine training, there was a reduction when aerobic exercise was compared to resistance training, combined training and WBV, without changing femoral neck BMD in postmenopausal women [9]. However, another systematic review with adults at the age of 50 or over showed that WBV has no effect on BMD but reduces fall rate and prevents fractures [10]. Another systematic review, including prospective Randomized Controlled Trials (RCTs) comparing at least one exercise group *vs.* a control group revealed that even non-supervised exercise improves femoral neck and lumbar spine BMD in adult women over 30 years old. However, beneficial effects are more pronounced in those with poor bone health compared with healthy counterparts [11].

In studies developed with older women with osteoporosis and a history of vertebral fractures revealed that twelve weeks of a supervised multicomponent resistance and/or balance exercise programme improved muscle strength and balance and reduced fear of falling [12,13]. In addition, with regard to fear of falling, a significantly better result was recorded even after twelve months of follow-up [12]. Moreover, when exercises were performed including dual-tasks, other authors found greater effects compared to single-task gait supporting the role of cognitively demanding exercises for the maintenance of safe ambulation in older women with osteoporosis [14].

A multicomponent program of high-speed training exercises combined with simulated functional tasks can be efficient in improving mobility, balance and self-reported measures of functioning. Moreover, physical exercise carried out at people's homes can be beneficial for people with OP. However, this systematic review and meta-analysis mentioned that due to substantial clinical heterogeneity of the target groups and specific demands of exercise modes, it is unclear which exercise program is optimal [15].

Another systematic review and meta-analysis concluded that multicomponent training with an average of 27.2 weeks, 2.6 sessions per week, and 45 minutes per session showed improvements in strength, flexibility, quality of life, bone mineral density, balance, functional fitness and reduced the risk of falls for elderly women with OP. Nevertheless, studies investigated different intervention protocols and the lack of patterns for the outcomes among the elected studies are limitations in the findings and should be analyzed with caution when prescribing physical exercises for women with osteoporosis.

In the Systematic Review and Meta-Analysis of Randomized Controlled Trials, the effects of resistance training in patients with osteoporosis and risk of fracture were investigated, concluding that resistance exercise can improve femoral neck BMD, health-related quality of life and physical function. However, the authors report that there were limitations in the study due to the fact that most studies use more than one training method in addition to resistance training, characterizing it as multi-modal training and it was not possible to conclude whether resistance training contributes to prevent falls [16].

However, the evidence on the dosage of each type of exercise is limited, particularly with regard to the gradual increase in load, intensity, duration and frequency, and is incompletely described. Also, the dose-response effects of physical exercise and detraining on bone mineral density, falls and fractures risk factors, mainly in individuals with osteoporotic fractures are not known. It is difficult to generate exercise recommendations on bone strengthening and precisely designed randomized controlled exercise trials may be the most appropriate tool to address the characteristics of a single exercise and thus generate exercise recommendations in the area of osteoporosis prevention and therapy [17].

Therefore, the aim of this systematic review was to verify the effects of physical exercise on muscle strength; balance; fear of falling; dizziness; risk of falls and fractures and quality of life in older women with osteoporosis.

Materials and Methods

This systematic review was developed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) [18], and was registered with International Prospective Register of Ongoing Systematic Reviews (PROSPERO) under the registration number CRD 42018096205 (available at http://www.crd.york.ac.uk/prospero/#myprospero).

Eligibility criteria

Type of study: Controlled and Randomized Clinical Trials (RCTs), including simple blind, non-blind and crossover assays, comparing physical exercise with another intervention or control; in English; since 2010. Studies without the intervention of physical exercise, review studies, pharmacological drugs in the title and experimental animal model studies were excluded.

Participants: This study considered eligible for inclusion elderly women (over 65 years of age) with osteoporosis diagnosed according to bone mineral densitometry measured in the last 12 months, reduced by at least 2.5 standard deviations or more below the mean value for healthy young women (a T-score of <-2.5 SD) Individuals with other associated diseases and/or fractures were excluded [19].

Interventions: Studies with physical exercise as an intervention were considered, including the following types of training: strength, stretching and balance.

Outcome measures

Outcomes: Isometric muscle strength (measured with a dynamometer); postural control and balance measured through: Limits of Stability (LOS); Clinical Test Sensory Interaction Balance (CTSIB); one-leg and the modified figure of eight test; Berg balance scale; Timed up and go; Romberg; preferred gait speed with and without a cognitive dual-task (measured by means of gait speed); fast gait speed (measured by means of gait speed); fear of falling (measured with the question: Are you afraid of falling? and through the Falls Efficacy Scale-International); physical activity level (Frandin-Grim by activity scale) and physical function measured with Late Life Function and Disability Instrument (LLFDI).

Search strategy: The research was carried out in September 2023 and studies published in scientific journals in English between 2010 and 2023 were included. The search sources used were: MEDLINE (PubMed); The Cochrane Central Register of Controlled Trials (CENTRAL); Web of Science; PEDro, Lilacs (BIREME). In order to identify other relevant test data, the authors of published trials whose data were incomplete were contacted, but there was no response.

The search strategy included a combination of the Medical Subject Heading (MeSH) terms described as follow: ("elderly") AND ("osteoporosis") AND ("fall"), ("elderly") AND ("osteoporosis") AND ("exercise"), ("elderly") AND ("osteoporosis") AND ("balance").

Selection of studies: Two independent reviewers (CFS and MR) assessed study eligibility independently. The reviewers screened the titles and abstracts of the articles for subject relevance. Studies that could not be definitely excluded based on abstract information were also selected for full text screening. During the second phase, the same reviewers independently assessed the full articles in duplicate to select those that met the eligibility criteria. Differences between the reviewers were resolved by consensus.

Data extraction

The following data were extracted and recorded in tables of evidence: author and year of publication; study population (number of individuals, age and gender); study design; rating scale; study duration and results of the intervention period. If there was any inconsistency, the original documents were analyzed by both reviewers to resolve the disagreement.

The risk of bias assessment

The risk of bias was evaluated in duplicate by the same independent reviewers using the Cochrane Handbook for Systematic Reviews of Risk of Bias tool (Assessing Risk of Bias (RoB) - Cochrane Collaboration's tool) that considers: Whether randomization was adequate; if there was concealment of the allocation in the groups; if there was blinding of patients and investigators; if there was blinding of the assessors; if there was a description of losses and exclusions; if there were descriptions of the results in all outcomes and, if there were other biases not described in the instrument itself.

Results

Study selection

A total of 8,607 studies were found using the electronic search. Of these, 583 were excluded because they were duplicates and 8,024 were selected for title analysis, with 7,543 being excluded. Thus, 481 abstracts were assessed, excluding 397 studies that did not meet the eligibility criteria, pilot study, study protocol, case studies, experimental study, and 84 articles were read in full. After reviewing the full texts, 76 were excluded for not meeting the eligibility criteria and 08 (eight) articles were included. Figure 1 shows the stages of the study selection process and exclusions.

Study characteristics

The eight (100%) studies included in this systematic review were randomized clinical trials, with female patients (100%), and published between 2010 and 2023 [20-27]. The studies were conducted in several countries: Serbia, Filipović et al. [20]; Sweden, Conradsson and Halvarsson [21]; Hungary, Miko et al. [22]; Sweden, Halvarsson et al. [23,24]; in Brazil, Burke [25,26]; Madureira et al. [27].

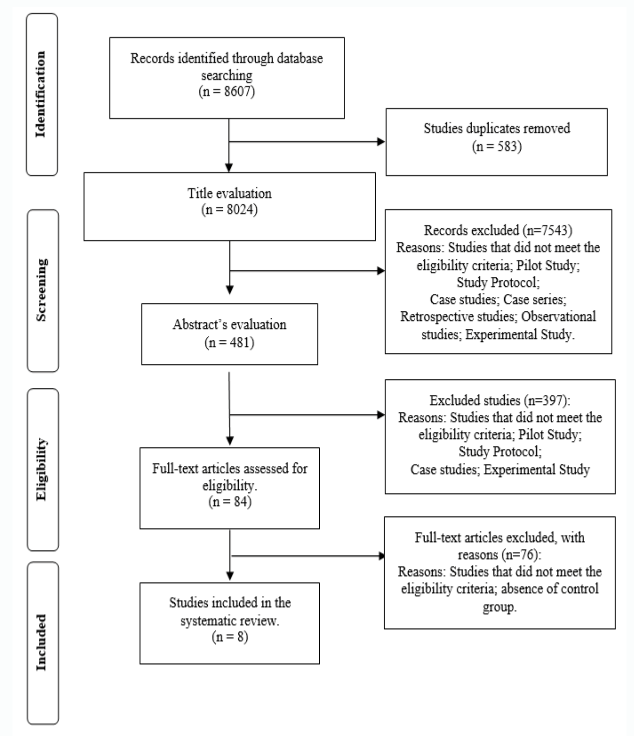

Figure 1: Shows the stages of the study selection process and exclusions.

Table 1 describes the characteristics of the studies included in this review in terms of the following items: author; year of publication; study participants (number; age; gender); methodology; interventions; variables analyzed and results obtained.

Risk of bias assessment

Among the studies included in this systematic review, one did not perform randomization; three did not report concealment of patient's allocation in the groups and blinding patients and investigators; two did not describe whether there was blinding of assessors; three if there was description of losses and exclusions, and finally just two reported other bias not described in the ROB instrument (Table 2).

Effects of physical exercises

There was an improvement in the isometric strength of the knee flexors and extensors and ankle flexors and in postural control after balance and strength training, compared to the control group [26]. Another study investigated the effects of different exercise training regimen: balance and strengthening; balance and stretching; compared to no activities. The results suggested that both modes of intervention are effective in improving postural control when compared to the control group, but the strengthening group was superior to the stretching group in knee extension strength and in directional control [25].

Other results were found, such as improvements in fall-related self-efficacy; balance performance; walking speed with a dual-task; fast walking speed and lower extremity physical function [23,24]; enhancement of balance and significant decrease in the number of falls in postmenopausal women who have already had at least one fracture in the past [22]; significant improvement in quality of life,

Table 1: Description of the characteristics of the studies included in this review.

Author, year	Design	Subjects (n)	Intervention Groups and Time	Control Group (CG)	Variables Assessed	Results
Filipović et al. [20]	RCT	96 (Women)	Exercise group (EG, n=47): resistance training, balance exercise and aerobic exercise. 4 and 12 weeks	CG, (n=49), had not participated in any exercise program	Functional outcomes: Timed up and Go test (TUG); Sit-to-stand test (STS); One-Leg Stance Test" (OLST) Falls Efficacy Scale-International (FES-I); Osteoporosis Knowledge Assessment Tool (OKAT-S)	Significant improvement in all observed measurements in EG after 4 and 12 weeks. OLST significantly changed only in EG, not in CG, in both experimental periods. Comparison between groups showed improvement in EG compared to CG in all functional outcomes in observed periods ($p<0.001$ for all). OLST significantly changed only in EG, not in CG, in both experimental periods. After 4 weeks, in CG there were no statistically significant changes in any of the monitored parameters, while after 12 weeks improvements were detected with TUG, STS, FES-I and OKAT-S.
Conradsson and Halvarsson [21]	RCT	43 (Women)	BT: balance training group (n= 43) 12-weeks	CG (n= 25), care as usual.	Gait with GAITRite® Level of physical activity during free-living conditions (waking hours of the day) with accelerometers (Actigraph, GT3X+)	GAITRite: The training group walked faster for single- and dual-task gait following training ($P \leq .044$) by increasing their cadence ($P \leq .012$) and reducing step and swing time ($P \leq .045$) compared with the control group. Significant between-group differences in favor of the training group were found for gait variability during dual-task gait ($P \leq .041$). The improvement in speed was greater for dual- than single-task gait (0.10 *vs.* 0.05 m/s) and the effect sizes revealed small to medium effects for dual-task gait, and either non-existent or small for single-task gait. Level of community ambulation has not shown significant improvement.
Miko et al. [22]	RCT	100 (Women)	BT (n=50) 12-months	CG (n=50), only received osteoporosis treatment and had no intervention.	Balance static and dynamic (BBS; TUGT); Static postural balance ('Romberg1' 'Romber 2').	The Berg Balance Scale and the Timed Up and Go Test showed some statistically significant improvement of balance in the intervention group ($p = 0.001$ and $p = 0.005$, respectively). Balance tests using the stabilometer also showed a statistically significant improvement in static and dynamic postural balance for osteoporotic women after the completion of the Balance Training Programme. As a consequence, the one-year exercise programme significantly decreased the number of falls in the exercise group compared with the control group.
Halvarsson et al. [23]	RCT	3 months= 69; 9 months= 60; 15 months=55 (Women)	BT (n= 22) BT+PA (n= 14). 12-weeks Follow ups: 9 months and 15 months	CG (n=19), offered participation in the balance training programme at the end of the study and was encouraged to live their regular lives during the study period.	Balance (one-leg stance; the modified figure of eight test); Fear of Falling (are you afraid of falling?); Falling (the Falls Efficacy Scale -International-FES-); physical activity level (Frändin-Grimby Activity Scale (1-6)); referred and fast gait speed with and without dual-task (GAITRite); physical function (LLFDI).	Participants in the training group maintained positive effects throughout the study period for concerns about falling (baseline vs. 15 months, median 27.5 *vs.* 23 points, $p < 0.001$) and walking performance (baseline vs. 15 months, $p \leq 0.05$ with an improvement of 0.9–1.4 m/s). The Training+physical activity group declined to baseline values at the nine-month follow-up, and were even lower at the 15-month follow-up for concerns about falling (median 26 *vs.* 26 points), walking performance (changes of −0.02 to 0.04 m/s), and physical function (mean 44.0 *vs.* 42.9 points). The control group remained unchanged throughout the study period.
Halvarsson et al. [24]	RCT	69 (Women)	BT (n= 25) BT+PA (n= 18); 12-weeks	CG (n=26) were encouraged to live their regular lives and were offered the same balance training at the end of the study.	Balance (one-leg stance; the modified figure-of-eight test); Fear of Falling (are you afraid of falling?); Fall-related self-efficacy (the Falls Efficacy Scale -International-FES-I); physical activity level (Frändin-Grimby Activity Scale (1-6)); preferred and fast gait speed with and without cognitive dual-task (GAITRite); physical function (LLFDI).	All groups improved their fall-related self-efficacy; Intervention groups decreased fear of falling, increased their preferred and fast walking speed, and increased balance; BA+PA increased preferred walking speed with a cognitive dual-task, increased balance (modified figure-of-eight test) and improved physical activity

Burke et al. [25]	RCT	50 (Women)	SG (n = 17) STG (n = 17) 8-weeks	CG (n=16) Did not receive any treatment.	Postural control (CTSIB; LOS); Strength (Dynamometer and the shortening).	Relative to controls, participants in the strengthening group displayed significantly increased dorsiflexion strength and knee flexion strength, as well as centre of pressure velocity, directional control, and oscillation velocity (CTSIBm test). The stretching group had significant improvements in hamstring length, knee flexion strength, centre of pressure velocity, and amplitude of movements. Relative to the stretching group, the strengthening group yielded better knee extension strength and directional control.
Burke et al. [26]	RCT	33 (Women)	BT+ST (n =17) 8-weeks	CG (n=16) they did not practice exercises.	Isometric Muscular Strength (dynamometer); Postural Control (LOS; CTSIBm).	Adherence to the program was 82%. When compared with the control group, individuals in the intervention group significantly improved the center of pressure velocity ($P = 0.02$) in the modified clinical test of sensory interaction for balance test, center of pressure velocity ($P < 0.01$), and directional control ($P < 0.01$) in limits of stability test, isometric force during ankle dorsiflexion ($P = 0.01$), knee extension ($P <0.01$), and knee flexion ($P < 0.01$).
Madureira et al. [27]	RCT	60 (Women)	BT (n= 30) 12-months	CG (n=30) no intervention.	Quality of life (*Osteoporosis Assessment Questionnaire*-OPAQ); Functional balance (*Berg Balance Scale*-BBS); Static Balance (CTSIB).	The comparison of OPAQ variations (INITIAL–FINAL) revealed a significant improvement in quality of life in all parameters for BT compared to CG: well-being (1.61±1.44 *vs.* −1.46±1.32, p < 0001), physical function (1.30±1.33 vs. −0.36±0.82, p < 0.001), psychological status (1.58±1.36 vs. −1.02±0.83, p < 0.001), symptoms (2.76±1.96 *vs.* −0.63±0.87, p < 0.001), social interaction (1.01±1.51 *vs.* 0.35±1.08, p < 0.001). Of note, this overall benefit was paralleled by an improvement of BBS (−5.5±5.67 *vs.* +0.5)

BT: Balance Training; PA: Physical Activity; RT: Resistance Training; ST: Strength Training; SG: Strengthening Group; STG: Stretching Group; CTSB: Clinical Test Sensory Interaction Balance; LOS: Limits of Stability; LLFDI: Late-Life Function and Disability Instrument; TUGT: Time "Up and Go"Test; BBS: Berg Balance Scale; NW: Nordic Walking; RCT: Randomized Clinical Trial

Table 2: Risks of Errors in the Included Studies and JADAD Score.

Study	Randomized?	Double Blind?	Described the Losses?	Appropriate Randomization?	Appropriate Masking?	JADAD Classification
Filipović et al. [20]	Yes	No	Yes	Yes	Yes	High quality
Conradsson and Halvarsson [21]	Yes	No	Yes	Yes	No	High quality
Miko et al. [22]	Yes	No	Yes	Yes	No	High quality
Halvarsson et al. [23]	Yes	No	Yes	Yes	No	High quality
Halvarsson et al. [24]	Yes	No	Yes	Yes	No	High quality
Burke et al. [25]	Yes	No	Yes	Yes	No	High quality
Burke et al. [26]	Yes	No	Yes	Yes	No	High quality
Madureira et al. [27]	Yes	No	Yes	Yes	No	High quality

functional balance and a reduction of falls [27]. Reported greater training effects were found in a variety of domains of dual-task gait compared to single-task gait [21]. Significant improvement in muscle strength and balance decreased fear of falling and increased their knowledge about osteoporosis [20].

Discussion

The present study showed that physical exercise reduced fear of falling, improved osteoporosis knowledge; level of physical activity, physical function; gait speed, balance [20-24]. Moreover, improved static, dynamic and functional balance; quality of life and decreased number of [22,27]. Also, enhanced isometric knee flexors and extensors, ankle flexors strength, postural control [25,26] and the lower limb strength and power [20].

It has been reported that physical exercise is recommended to prevent falls in older people with osteoporosis, because it can improve modifiable factors as strength, bone mineral density and balance. However, the physical exercise should be performed as a multicomponent (multi-modal) training, including two or more activity modes, such as weight-bearing, resistance exercises and/or balance training. The multi-modal training should be performed progressing resistance, beginning between 30% to 70% of 1RM (One-Repetition Maximum) increasing to 75% to 85% of 1RM (Borg 5-7/8 of 10); at least twice a week; starting with slow and controlled movements and emphasizing correct lifting technique; progressing to higher speed, functional and multidirectional movements, targeting muscles attached or crossing hip and spine; eight different exercises at each training session with two sets of each exercise, between 8-12 repetitions. The exercises should include weight-bearing impact loading activities as jumps, 3-5 sets of 10-20 repetitions. The balance exercises are recommended for 2h - 3h per week, 10s to 30s each exercise, improving movement speed, challenge, progressing from static to dynamic exercises and adding motor and cognitive dual-task [1].

A multi-modal exercise program, including resistance exercises, weight-bearing impact loading and balance improved functional performance and bone mineral density and reduced risk of falls in community-dwelling older people [8]. Some studies included in the present systematic review investigated the effects of a multi-modal exercise program [20,23-25] and according to Linhares et al. [8], multi-modal training can be a training option for elderly women with OP. Furthermore, according to [14], multicomponent exercises, when diversified with high-speed training and simulated functional tasks, can be efficient to improve functional status in people with osteoporosis.

The study included in the present review, investigated the effects of an intervention program constituted by balance and strengthening training; twice a week; lasting eight weeks compared to the control group, not practicing exercises. They found that balance and strength exercises are effective to improve postural control and lower-limb strength in older women with osteoporosis [26].

Another clinical trial was carried out with the aim of comparing the effectiveness of balance training associated with muscle strengthening or stretching, in relation to no intervention, on the postural control of elderly women with osteoporosis divided into three groups: the strengthening group, which carried out balance training with muscle strengthening; the stretching group, which carried out balance training with stretching; and the control group, with no activities, with interventions for eight weeks, twice a week, 60 minutes a day. Compared to the controls, the participants in the strengthening group showed a significant increase in dorsiflexion strength and knee flexion strength, as well as center of pressure velocity, directional control and sway velocity. The stretching group had significant improvements in hamstring length, knee flexion strength, center of pressure velocity and range of motion. Compared to the stretching group, the strengthening group had better knee extension strength and directional control. The study concluded that both interventions are effective in improving postural control when compared to the control group, with the strengthening group being superior to the stretching group in knee extension strength and directional control [25].

Thus, both studies showed that balance and strengthening trainings improve directional control, oscillation speed and strength corroborating to the principle of specificity of training [28]. Moreover, when balance was performed with stretching improvements in hamstring length, knee flexion strength, center of pressure speed, and amplitude of movements were found but the strengthening group was superior to the stretching group in knee extension strength and in directional control. Thus, to maximize efficacy it should be recommended to older women with osteoporosis a combination of balance and strengthening training to improve balance and strength, to increase muscle and bone mass, to prevent bone loss, at least twice weekly, progressing intensity, volume and level of difficulty [28].

In the present review there are two studies developed by the same group of authors, investigating the effects of dual and multi-task, both three times/week over 12 weeks. The one published in 2014 found that a balance training program improved fall-related self-efficacy, gait speed, balance performance, and physical function in older adults with osteoporosis. The study published in 2015 reported not only the effects of a 12-week balance training but also investigated a group with or without supplementary physical activity. Moreover, they included follow ups after 9 and 15 months. They detected that positive effects of walking performance and concerns about falling were maintained even after 15 months. While the group with supplementary physical activity declined at the 9-month follow-up and were even lower at the 15-month follow-up for concerns about falling; walking performance and physical function [23,24].

The effects of balance training were investigated in 30-minute sessions, twice a week, with eight weeks of intervention. There was an improvement in the functional balance of older women with osteoporosis, even after ending eight weeks of intervention [29], although other studies reported that after a training period of one, two or three months the gains were not maintained [30,31]. It is therefore important for the elderly to adhere to and attend exercises using video games, also known as exergames, which are considered to be a dual motor-cognitive task, since motor actions and cognitive aspects must be processed simultaneously. It has been used as a motivating tool to perform exercises and as a way to improve balance, functionality, and strength, as well as cognitive and psychological factors in older adults [32].

In this regard, another study included in this systematic review found greater training effects after 12 weeks in a variety of dual-task gait domains compared to single-task gait, supporting the role of cognitively demanding exercises in maintaining safe ambulation in older women with osteoporosis [21]. The most part of the studies included in the present systematic review reported improvements in balance after a training period of at least four weeks of balance or multicomponent (balance and/or resistance and/or aerobic) exercises [20,21]. However, it is important to assess not only balance but the risk and number of falls. In this regard, only two studies showed that 12-month balance training reduced the number of falls in osteoporotic women who have already had at least one fracture [22,27]. Regarding period of physical training, the present systematic review found significative gains after four weeks [20]; eight weeks [25,26]; 12 weeks [20,23,24], and two longer studies with 12 months [22,27].

Some limitations were found in the present systematic review. The lack of adequate descriptions in the studies included in this review-particularly descriptions of the methods, exercise prescriptions and also methods used to assess the outcomes, made it impossible to conduct a meta-analysis of the included studies. Also, the lack of descriptions of adverse effects in the included studies, which compromises the safety of reported interventions. Although the results of this review indicate that physical exercise improves balance and strength, further studies are needed to investigate if longer periods of intervention are able to modify different aspects of postural control and factors related to falls. A follow-up of these patients is also desirable to investigate if these gains remain after the end of intervention and influence to reduce the number of falls and fractures in this population. We therefore suggest that new randomized controlled trials be conducted with more participants and greater standardization of the evaluation and intervention methods.

Multi-modal physical training, including strength and balance exercises, may be recommended for clinical practice, for intervention periods of four weeks or more, to increase muscle strength; improve knowledge about osteoporosis; quality of life; lower limb physical function; gait and balance; self-efficacy related to falls; reduce worries about falls and the number and risk of falls. Moreover, motor and/or cognitive dual task should be added to physical trainings to improve physical function in older women with osteoporosis and multi-modal physical training, including strength and balance exercises for four weeks.

In conclusion, balance and/or strength training ameliorates fear of falling and improves physical activity levels, gait speed, static and dynamic balance, knee and ankle extensor and flexor strength, postural control and reduces the number of falls. The beneficial effects are more pronounced when multi-modal training was performed, i.e., when resistance; balance and/or stretching were included at the same physical training session, for a period of 12 weeks, in older women with osteoporosis.

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