Chronic effects of resistance training in women with low bone mineral density associated with medication use: a systematic review

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Objective. To analyze the chronic effects of resistance training in women with low bone mineral density associated with medication use.
Methods. This systematic review followed the recommendations outlined by PRISMA. The databases searched included PubMed, Scopus, Web of Science, SportDiscus, and Scielo.
Results. Six studies met the eligibility criteria and were included in the analysis, covering a total of 233 participants. Three studies incorporated jump exercises in addition to resistance training. Five studies implemented training models with progressive load increases over the intervention weeks, including reassessments for intensity adjustments.
Conclusions. It was concluded that moderate-to-vigorous intensity resistance training programs, when combined with medication use, can be recommended as an accessible, effective, and safe therapeutic strategy for increasing and maintaining bone mineral density in postmenopausal women with osteopenia or osteoporosis.

Key words: resistance training, osteoporosis, bone mineral density

INTRODUCTION

Osteoporosis is a progressive osteometabolic disease characterized by a reduction in bone mass and impairment of the bone tissue microarchitecture, leading to an increased susceptibility to injuries and fractures [1]. This disorder is defined by a condition in which bone mineral density (BMD) is equal to or lower than 2.5 standard deviations (SD) below the ideal peak bone mass, while values between -1 and -2.4 SD are considered osteopenia [2].

Osteopenia is the initial stage of bone loss, which can occur at various stages of life, being more common in women after menopause. If not properly treated, it can progress to a diagnosis of osteoporosis. This condition may result from hormonal changes during menopause, calcium deficiency, as well as a lack of other minerals in the bones, making them porous and brittle, and more prone to injuries and fractures, even after minor trauma [3]. This disorder can be classified into three types according to its causative factor: the first type, considered primary of idiopathic or unknown origin, affects approximately 80% of women and 60% of young

adult men; the second type, known as type I osteoporosis, is caused by estrogen deficiency and is characterized by rapid bone density loss, being more common in postmenopausal women. This type predominantly affects trabecular bone and is associated with fractures of the vertebrae, femoral neck, and distal radius; and the third type, type II osteoporosis, is degenerative, primarily caused by natural aging, increased parathyroid hormone activity, and decreased bone formation [4].

In the postmenopausal period, women have a higher prevalence of type I osteoporosis, which is often accompanied by fractures, most commonly in the femoral neck, lumbar spine, and distal radius. Additionally, postmenopausal women experience a deficiency or decrease in estrogen levels, which may be related to the pathogenesis of bone disorders, as estrogen plays a protective role in the skeletal system, participating in the regulation of bodily processes through receptors located in the brain, musculoskeletal system, and gastrointestinal tract [5].

Physical exercise is recognized as an important means to develop and maintain optimal bone health throughout life. Resistance training (RT) is a type of physical exercise that can be performed progressively, combined with impact activities and weightlifting, and is recommended as an accepted strategy to prevent bone loss during the postmenopausal process [6]. There is evidence that RT contributes to the prevention and treatment of osteoporosis through the osteogenic effect of mechanical stress and tension on bone tissue, resulting from complex interactions between muscle and joint loads [7,8]. Thus, RT preserves and prevents bone mass loss in postmenopausal women, as this tissue has characteristics of constant renewal and is capable of adapting to mechanical loads [9]. However, the response of bone structure to exercise and the sensitivity of the osteogenic process depend not only on the mechanical load but also on the individuality of the woman, the type, duration, and intensity of the stimulus, as well as the direction and magnitude of the stress imposed [10].

Thus, based on the understanding of the mechanism of the effect of resistance training on bone remodeling and the prevalence of osteopenia and osteoporosis during postmenopausal life, an in-depth analysis of the relationship between RT prescription and bone health is necessary. Therefore, the present study aimed to analyze the chronic effects of resistance training in women with low bone mineral density associated with medication use.

METHODS

Study design

This systematic review was conducted according to the recommendations outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [11]. A search was conducted in the International Prospective Register of Systematic Reviews (PROSPERO), where no studies on the topic were found. Therefore, the study was registered under the number: CRD42024617583.

Eligibility criteria

The study gathers information on the effects of resistance training with different exercise protocols that influence bone mineral density (BMD) in postmenopausal women with osteopenia or osteoporosis. Regarding eligibility, the searched articles followed the criteria of the PICOS strategy [12]: Population: women with low bone mineral density aged 45 or older; Intervention: strength training combined with medication use; Comparison: Control Group (CG); Outcome: bone mineral density; Study design: randomized clinical trials. No language or time filters were applied.

Search strategy

The search for articles was conducted in January 2025 in the databases PubMed, SCOPUS, SPORTDiscus, SciElo, and Web of Science. The descriptors used were standardized by the Medical Subject Headings (MeSH) and Health Sciences (DeCS). The search was conducted using the descriptors (("Women" OR "Woman" OR "Postmenopause" OR "Postmenopausal") AND ("Resistance Training" OR "Resistance Training" OR "Training, Resistance" OR "Strength Training" OR "Training, Strength")) AND ("BoneDensity" OR "BoneDensity" OR "Bone Mineral Density"). After the search, all the references found were imported into the Rayyan software, where three independent reviewers had access. Two reviewers were responsible for removing duplicate articles, reviewing titles and abstracts, followed by analyzing the full texts. The third reviewer was available to resolve any issues of divergence in decision-making throughout the process.

Methodological quality

For the assessment of methodological quality, the Tool for the Assessment of Study Quality and Reporting in Exercise (TESTEX) was used, an instrument developed to evaluate the methodological quality of studies in the context of physical exercise. TESTEX comprises a 15-point scale designed for experimental studies, containing criteria that assess internal validity and the reporting of statistical analyses. Each criterion on the scale is assigned one point, while the absence of these parameters results in zero points. The maximum score that can be achieved is 15 points. The scale includes the following criteria: 1) specification of inclusion

criteria; 2) random allocation; 3) allocation conceal-
ment; 4) similarity of groups at the start of the study; 5)
blinding of the evaluator; 6) measurement of a primary
outcome in 85% of allocated outcomes (up to three
points); 7) intention-to-treat analysis; 8) comparison
between groups for at least one primary outcome (up
to two points); 9) declaration of variability measures
for all reported outcome measures; 10) monitoring of
activities in the control groups; 11) consistency of rela-
tive exercise intensity; 12) exercise characteristics and
energy expenditure [13].

RISK OF BIAS

For the assessment of risk of bias, the Risk of Bias (RoB
2.0) tool was used. This tool was developed to assist
in the critical evaluation process of articles in system-
atic reviews, allowing reviewers to investigate the risk
of bias in individual studies included in the review. This
instrument addresses various bias domains, each fo-
cusing on a specific area. The domains evaluated by
RoB 2.0 include: 1) Selection bias: how participants are
selected for the groups; 2) Performance bias: assesses
the presence of bias due to systematic differences be-
tween groups in the administration of the intervention;
3) Detection bias: addresses the presence of bias due
to systematic differences between groups in the meas-
urement of outcomes; 4) Attribution bias: refers to how
results are communicated to participants; 5) Reporting
bias: evaluates whether the results are presented with
complete and accurate data [14].

DATA EXTRACTION

The data extraction procedure was performed by two
independent researchers, along with a third researcher
to resolve any identified discrepancies. The information
extracted from the studies included in the analysis: au-
thors, year of publication, age, total body mass, height,
sample size, T-score values, details about the interven-
tion such as exercise volume and intensity, medication
use, duration of the intervention, and the outcomes
found.

RESULTS

Based on established criteria, 1,397 articles were re-
trieved (PubMed = 356, Scopus = 197, Web of Science
= 426, SportDiscus = 415, Scielo = 3). Of these, 417
were duplicates and 913 were excluded after reading
the title and abstract. After further analysis, 4 articles
were excluded during the full-text reading, resulting in 6
articles that met the inclusion criteria (Fig. 1).
The characteristics of the sample are presented in Ta-
ble I. Of the six selected articles, the total number of

participants was 233, who were divided into a control
group (n = 112) and an experimental group (n = 121).
The average age of the control group was 61.3 years,
and the experimental group was 59.5 years. All the
studies included women with osteopenia or osteopo-
rosis who were using some form of medication for their
respective treatment.
Table II presents the data extracted from the training
interventions in the selected studies, including informa-
tion on frequency, intensity, type of training/exercises,
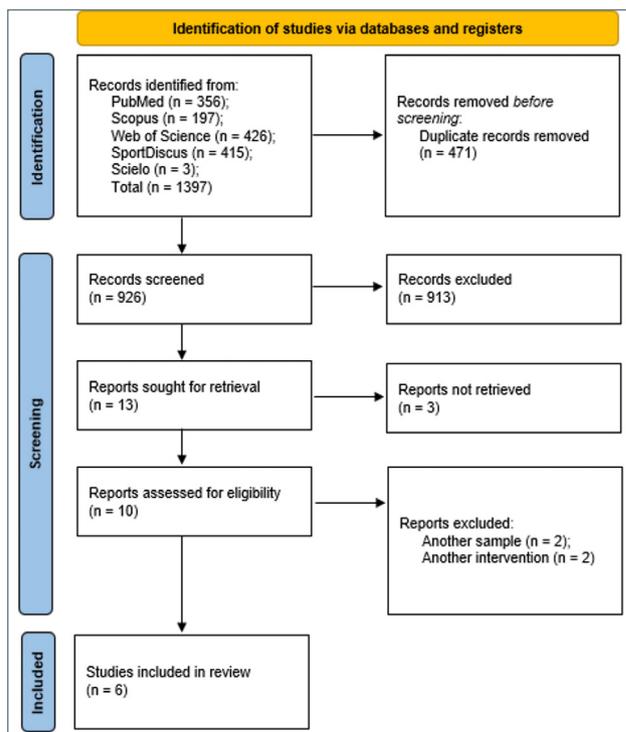stimulus interval, rest time, and type of supplementation

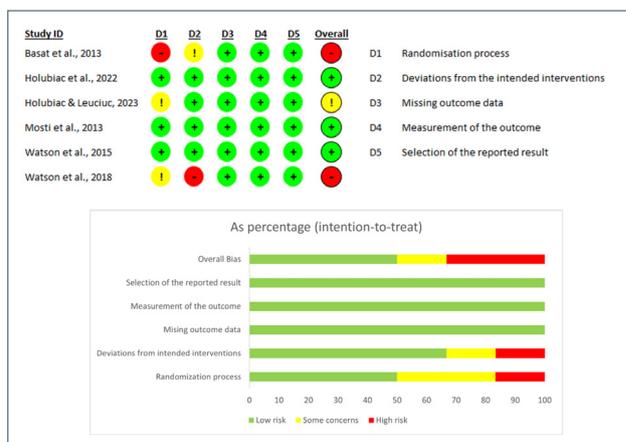**Figure 1.** PRISMA flow diagram of the article selection process.

Figure 2. Risk of bias of the studies.

Table I. Characterization of the sample of the included studies.

Author	N	Body mass (kg)/ height (cm)	Age & BMD (T-score LS, FN or H)	Intervention duration
Holubiac et al., 2023 [15]	39	EG 65.7 ± 6.6/ 160.7 ± 6.1 CG 64.2 ± 7.4/ 159.3 ± 4.6	EG 56 ± 2.9 years CG 56.4 ± 2.1 years (-1,5 a -3 T-score)	12 months
Holubiac et al., 2022 [16]	29	EG 65.8 ± 7.4/ 161 ± 6.3 CG 63.2 ± 7.5/ 157.6 ± 4.7	EG 56.2 ± 3.2 years CG 56.8 ± 2.3 years -1.1 a -2.5 (T-score)	6 months
Watson et al., 2018 [17]	86	EG 63.9 ± 11.3/ 161.6 ± 5.4 CG 62.2 ± 9.5/ 161.9 ± 6.4	EG 65 ± 5 years CG 65 ± 5 years (< -1 T-score)	8 months
Watson et al., 2015 [18]	28	EG 61.8 ± 8.9/ 163.4 ± 6.2 CG 63.4 ± 11.4/ 163.0 ± 5.5	EG 65.3 ± 3.9 years CG 66.7 ± 5.4 years (<-1 T-score)	8 months
Basat et al., 2013 [19]	35	EG 54.0 ± 4.7/ NI PG 56.0 ± 3.5/ NI CG 56.5 ± 3.7/ NI	EG 55.9 ± 4.9 years PG 56.6 ± 2.9 years CG 56.2 ± 4.0 years (-1 a -2.5 T-score)	6 months
Most et al., 2013 [20]	16	EG 72.3 ± 7.7/ 169.3 ± 6.5 CG 66.2 ± 8.8/ 162.9 ± 6.3	EG 61.9 ± 5.0 years CG 66.7 ± 7.4 years -1.5 a -4.0 (T-score)	4 months

kg: kilograms; Cm: centimeters; CG: control group; EG: experimental group; PG: plyometric group; LS: lumbar spine; FN: femoral; H= hips; BMD: bone mineral density; NI: not informed.

Table II. Data extracted from the selected studies.

Study	Aims	Intervention	Results
Holubiac et al., 2023 [15]	Observe the impact of a resistance training program on femoral BMD	F: 2 days/week I: 2 sets of 12 reps (6 reps at 70% 1RM + 6 reps at 50% 1RM) D: 60 minutes T: 1st protocol: hip abduction and adduction; standing hip extension; seated hip flexion; seated back extension 2nd protocol: bicep curl; leg press; squat; seated row; leg extension machine R: 90 seconds CG: did not perform exercises S: 0.5g of alfacalcidol per day	↑ Femoral neck BMD in the GTR (Δ% = 2.05, p = 0.001) Significant difference between groups (p = 0.01) ↑ Trochanteric BMD in the GTR (Δ% = 3.8, p < 0.001) ↑ Bone mass in the intertrochanteric region (Δ% = 0.9, p = 0.01) in the GTR ↓ BMD in the CG (Δ% = -0.2, p = 0.49) ↑ Total femur BMD in the GTR (Δ% = 1.9, p < 0.001)
Holubiac et al., 2022 [16]	Evaluate the influence of resistance training on spinal BMD (L1-L5)	F: 2 days/week I: 2 sets of 12 reps (6 reps at 70% 1RM, followed by 6 reps at 50% 1RM) R: 1 min 30 s D: 60 minutes T: Seated hip abduction and adduction; hip flexion and extension; horizontal leg press; knee extension; seated dip machine; seated back extension; prone hamstring curls; bicep curls and bodyweight squats CG: did not perform any exercises S: 0.5g alfacalcidol per day (vitamin D)	↑ Total lumbar spine BMD in the GTR (Δ% = 1.82, p = 0.01) No differences between groups (p > 0.05)

Watson et al., 2018 [17]	1. Determine the effectiveness of HiRIT in improving femoral neck and lumbar spine BMD 2. Determine whether HiRIT improves bone geometry 3. Monitor adverse events of HiRIT	F: 2 days/week I: Warm-up - 2 sets of 5 reps - 50 to 70% 1RM in deadlift Main - 5 sets of 5 reps - 80 to 85% 1RM D: 30 minutes T: Deadlift, bench press, free squat, and plyometric exercises CG: 10 to 15 reps at 60% 1RM - Lunges, calf raises, shoulder front raises, and stretching; dumbbell: 3 kg S: 10 participants in each group used osteoporosis medications (Bisphosphonates, Denosumab)	↑ Lumbar spine BMD in HiRIT (Δ% = 2.8, $p < 0.001$) ↑ Femoral neck BMD (Δ% = 2.6, $p = 0.02$) compared to CG ↑ BMC (Δ% = 21.3, $p = 0.028$) and cortical thickness (Δ% = 16.6, $p = 0.027$) of the femoral neck in HiRIT, compared to CG
Watson et al., 2015 [18]	Determine the safety and effectiveness of high-intensity progressive resistance training (HiPRT)	F: 2 days/week I: Warm-up - 2 sets of 5 reps - 50 to 70% 1RM in deadlift Main - 5 sets of 5 reps - 80 to 85% 1RM D: 30 minutes T: Deadlift, free squat, bench press, platform jump CG - 2 sessions/week: Calf raises, lunges, shoulder front raises, and stretching; Max. 3kg Use of osteoporosis medications: Dosage not indicated	↑ Femoral neck BMD (Δ% = 0.5, $p = 0.01$) ↑ Lumbar spine BMD (Δ% = 0.9, $p = 0.005$)
Basat et al. 2013 [19]	Investigate the effects of high-impact and strengthening training on BMD and bone remodeling markers	F: 3 days/week I: Not Indicated D: 60 minutes T: (GTFI) - 1 isometric set - abdominal; hip flexors, extensors, abductors, and adductors; knee flexors and extensors (GS) - Jump rope (10 jumps/day + 5 jumps/week, maximum of 50 jumps/day) S: Calcium (1200mg) and Vitamin D (800 IU) CG: did not perform exercises	↑ Lumbar spine BMD L1-L4 in GTRI (Δ% = 1.3, $p = 0.01$) ↑ Femoral neck BMD in GS (Δ% = 1.2) There was a difference between GS and CG ($p < 0.05$). ↓ Lumbar spine BMD in CG (Δ% = -2.5) ↑ Osteocalcin in GTRI (Δ% = 31.1) and GS (Δ% = 30.32), with ($p=0.03$) for both ↔ CG ↑ NTx in CG (Δ% = 8.9) and ↑ GTR and GS (Δ% = -25.7)
Most et al., 2013 [20]	Examine the effect of strength training using the Hack Machine squat (Impulse Fitness IT 7006, Shandong, China)	F: 3 days/week I: Warm-up – 2 sets of 8 to 12 reps at 50% 1RM T: Hack Machine Squat – 4 sets of 3 to 5 reps at 80-95% 1RM R: 2-3 minutes S: Calcium and Vitamin D (dosage not indicated).	↑ Lumbar spine BMC ($p=0.012$) (Δ% = 2.8) ↑ Femoral neck BMC ($p=0.043$) (Δ% = 5.6) ↑ AO ($p = 0.012$) in the lumbar spine (Δ% = 2.0) and ($p = 0.036$) in the femoral neck (Δ% = 5.1) ↔ BMD

F: frequency; I: intensity; D: duration; T: type; R: rest; JG: jump group; ISTG: isometric resistance training group; CG: control group; RTG: resistance training group; S: supplementation; RM: repetition maximum; BMD: bone mineral density; NTx: N-telopeptides of type I collagen; ↑: improvement; ↓: reduction; BMC: boné mineral content; BA: bone area; BM: bone mass; HiPRT: high-intensity progressive resistance training; HiRIT: high-intensity resistance and impact training; LiRT: low-intensity resistance training; NI: not informed; s: seconds; min: minutes; reps: repetitions.

Table III. Methodological quality analysis using the TESTEX Tool.

Studies	1	2	3	4	5	Partial (0 a 5)	6a	6b	6c	7	8a	8b	9	10	11	12	Partial (0 a 10)	Total (0 a 15)
Holubiac et al., 2023[15]	1	1	0	1	0	3	1	0	1	0	1	1	1	0	1	1	7	10
Holubiac et al., 2022[16]	1	0	0	1	0	2	1	0	1	0	1	1	1	0	1	1	7	9
Watson et al., 2018[17]	1	1	0	1	0	3	0	1	1	1	1	1	1	0	1	1	8	11
Watson et al., 2015[18]	1	1	0	1	0	3	0	1	1	0	1	1	1	0	1	1	7	10
Basat et al., 2013[19]	1	1	0	1	0	3	1	0	1	0	1	1	1	0	0	1	6	9
Most et al., 2013[20]	1	1	0	1	0	3	0	0	1	0	1	1	1	0	1	1	6	9

*: studies that did not report the dropout number, but all finished with the same number of participants who started the intervention; NC: no control group. Study quality: 1 = specific eligibility criteria; 2 = type of randomization specified; 3 = allocation concealed; 4 = groups similar at baseline; 5 = assessors were blinded (at least for one primary outcome); 6 = outcomes assessed in 85% of participants (6a = 1 point if more than 85% completed; 6b = 1 point if adverse events were reported; 6c = if exercise adherence was reported); 7 = intention-to-treat statistical analysis; 8 = statistical comparison between groups reported (8a = 1 point if comparisons between groups for the primary outcome are reported); 8b = 1 point if statistical comparisons for at least one secondary outcome are reported); 9 = point estimates and measures of variability for all reported outcome measures; 10 = monitoring of activity in the control group; 11 = relative exercise intensity remained constant; 12 = exercise volume and energy expenditure were reported.

used. One study [19] did not adequately report the intensity of the program, and another study did not report the dosage of the medications used [17]. Three studies [17-19] included jump exercises in addition to resistance training. Five studies [15-18,20] implemented training models with load progression throughout the intervention weeks and reassessments for intensity adjustments.

In Figure 2, the risk of bias of the studies included in this systematic review was observed. Three articles [16,18,20] showed low risk of bias, one [15] showed moderate risk of bias, and two [17,20] showed high risk of bias across all the analyzed parameters.

The methodological quality of the selected studies is presented in Table III. Three articles [16,19,20] scored 9 points, two studies [15,18] scored 10 points, and only one study [17] achieved 11 points.

DISCUSSION

This systematic review aimed to analyze the chronic effects of RT on BMD in postmenopausal women diagnosed with osteopenia or osteoporosis, associated with the use of medications. A low number of RCTs, following all eligibility criteria, were found in the conducted searches. However, six articles provided relevant information on the impact of RT interventions in 233 women with osteopenia or osteoporosis.

Bone quality, including bone density and bone remodeling, is a continuous process in which 20% of bone tissue is renewed annually[1]. Osteogenic effects in increasing bone mass occur with the production of mechanical loads above those experienced during activities of daily living. Among the various physical training programs, resistance exercise (RE) is known to be highly beneficial for preserving bone and muscle mass and improving overall and bone health [21]. Thus, RT stimulates bone remodeling with increases in osteoblast and osteoclast activity in response to the tensile, compressive, and shear forces caused by overload exercises [17].

Of the six articles analyzed, five [15-19] showed improvements in lumbar spine and femoral neck BMD, changes in bone geometry and content, suggesting that protocols involving strength exercises and high-intensity progressive resistance training were effective for the bone health of the 217 participants in these studies.

Only the study by Mosti et al. [20] did not report a significant increase in BMD in any body region. This may have occurred due to the authors not using a broader variety of physical exercises that targeted other muscle groups and joints involved in the movements, as throughout the experiment, they only analyzed the effect of the

squat on the Hack Machine on BMD. The duration of the study, compared to the other five, was also shorter, only 4 months, which could also be another explanation for these results. Cussler et al. [22] reported that a program with eight strength exercises over 12 months, 3 times a week, with sessions lasting between 60 and 75 minutes, targeting large muscle groups, resulted in an increase in femoral trochanter BMD in postmenopausal women.

Basat et al. [19] conducted a training program over six months, comparing the effects on BMD in 35 women divided into isometric resistance training (GTRI), jumping (GS), and control (GC) groups. All participants in the study were supplemented with vitamin D (800 IU) and calcium (1200 mg). The training program was carried out three times a week with a duration of 60 minutes, including 15 minutes of warm-up, which consisted of static stretching and stationary walking exercises. The GTRI group performed a 45-minute session with one isometric set for each of the seven selected exercises. The results from Basat et al. [19] indicated that the GTRI protocol was sufficient to promote an increase in lumbar spine BMD compared to the GC, but no differences were found in the femoral region. Meanwhile, participants in the GS group performed jump rope with a maximum of 50 jumps per day, which was able to promote an increase in femoral BMD, reflecting the positive effect of jumping. The fact that this type of exercise does not require sophisticated equipment facilitates its logistical and economic practice, which could provide a favorable application context. From this ease, the practitioner can take advantage of the effectiveness of the exercise, which generates a high mechanical load on the femoral neck due to the impact produced by the specificity of the plyometric training.

The previous results align with the findings of Vainionpaa et al. [23], who reported that a three-times-weekly exercise program for 12 months, including bench jumps, was effective in improving femoral neck BMD (p = 0.006) and intertrochanteric region BMD (p = 0.02) when compared to the regions of the group that did not engage in any type of exercise during the intervention period. Regarding serum osteocalcin levels, an increase was observed in both the GTRI and GS groups compared to the GC. While there is no existing consensus in the literature on bone formation/resorption markers, Azinge & Bolarin [24] suggest that osteocalcin is a marker of bone turnover, which could indicate an increase in bone mineral content.

Basat et al. [19] did not report detailed information about the intensity of the exercises or the participants' perception of effort, it was evident that this training program, involving resistance and plyometric exercises, was beneficial for the bone health of these women with low BMD. Furthermore, their combination could be an interesting prescription strategy for postmenopausal women.

Different intensities of effort can be applied in resistance training (RT). The effect of high-intensity RT was investigated by Mosti et al. [20], who examined its efficacy on BMD using squats on the Hack Machine. The authors pointed out that this type of intervention can be safely applied to the selected sample, as no adverse events were found. The program, conducted three times a week for 4 months with intensity around 85-90% of one-repetition maximum (1RM) in 4 sets of 3-5 repetitions, was able to maintain bone geometry and increase the levels of bone mineral content in the lumbar spine and femoral neck, but it did not show significant changes in BMD. It is worth noting that of the studies analyzed, Mosti et al. [20] investigation was conducted over the shortest period, a total of 12 weeks, and the dosage of medications was not reported. These factors may have contributed to the absence of significant results in BMD increase. Possibly, a longer intervention period, as well as adjustments in medication doses, could have favored bone mineralization to the point where it could be detected by dual-energy X-ray absorptiometry (DXA).

Holubiac et al. [16] and Holubiac & Leuciuc [15] analyzed similar training protocols of moderate to vigorous intensity, with the main difference being the intervention time and the objectives assessed. All participants were supplemented with 0.5g of alfacalcidiol per day (vitamin D), and the exercises were performed twice a week for 60 minutes, consisting of two sets of 12 repetitions (6 repetitions at 70% 1RM followed by 6 repetitions at 50% 1RM within the same set). The exercises selected for the program were chosen in a way that mechanical stress could be applied to the origin and insertion areas of muscles that would stimulate the femur and hip bone regions, while also complementing other muscle groups. Although the authors of both studies chose not to use extremely high loads, maintaining 70% and 50%, with the justification of not overloading the joints involved in the movements and reducing the risk of developing osteoarthritis in the knees and hips, the intervention was able to promote an increase in total BMD of the lumbar spine, femoral neck, bone mass in the intertrochanteric region, and the trochanter.

Although there is limited recommendation in the literature regarding high-intensity resistance and impact training (HiRIT) for postmenopausal women with osteopenia/osteoporosis due to the high fracture risk, proposed two studies, both with eight months of intervention, conducted over a two-year period, with a difference of 58 participants between each study. The authors chose to apply the same training protocol in both studies, with a duration of 30 minutes, performed

twice a week at an intensity of 80-85% 1RM, incorporating the following exercises: deadlift, bench press, free squat, and jump exercises.

In the first trial, Watson et al. [18] observed that some women in the sample were using medications for osteoporosis, but the specific medications and dosages were not detailed. In the second study by Watson et al. [17], ten participants were using medications to reduce bone resorption and stimulate osteoblastic activity. At the end of the study, an increase ($p < 0.05$) in BMD of the femur, lumbar spine, as well as bone mineral content and cortical thickness of the femoral neck, was observed compared to the results from the group that underwent low-intensity training. No differences were found between participants using osteoporosis medications, and no fractures or adverse events were noted. This suggests that HiRIT may be safe for postmenopausal women with osteopenia or osteoporosis, provided the exercises are supervised, emphasizing proper movement technique and respecting the individual's physical capacity and biological limits.

The studies in this review adopted resistance training combined with medication use, aiming to improve bone mass production in postmenopausal women. The use of calcium and vitamin D supplementation alongside strength training proved to be an effective strategy for increasing BMD. However, the study conducted by Eslamipour et al. [25] demonstrated an increase in bone mineral content and BMD in the lumbar spine for the HiRIT group without the use of associated medications. These situations may highlight that strength training, when properly evaluated and dosed, and whether associated with supplements and/or medications or not, can bring benefits to women with osteoporosis during this phase of life. However, a limitation of this systematic review study is that one study [18] did not report the dosage of medications used to maintain calcium levels, and another study [19] did not adequately describe the intensity of the exercises. Another limitation to consider was the small number of studies included in this review. Therefore, the findings should be analyzed with caution when prescribing resistance training programs for postmenopausal women.

CONCLUSIONS

The studies analyzed in this systematic review highlighted that resistance training programs combined with medication use positively contributed to an increase in BMD in the lumbar spine and femoral neck regions, as well as promoted changes in bone mineral content and geometry in postmenopausal women diagnosed with osteopenia or osteoporosis. These findings enhance the understanding of the effects of physical exercise on the bone health of these women and provide guidance for the development of strength training programs. Therefore, resistance training can be considered an accessible, efficient, and safe therapeutic strategy for preserving bone structure.

It is recommended that future studies investigate whether the inclusion of multiple exercises using only body weight can impact BMD, as well as assess the differences in adherence between multiple activities and single exercises, and their respective effects on bone health in postmenopausal women. Furthermore, it is important to explore whether resistance training can contribute to reducing the dosages of medication therapies required to promote bone formation.

Conflict of interest statement
The authors declare no conflict of interest.

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Author contributions
All the authors contributed in the development of this manuscript.

Ethical consideration
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