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The Role of Strengthening Exercises in Managing Osteoporotic Spine in Postmenopausal Women: A Comprehensive Review

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Abstract

Osteoporosis is a chronic disease that occurs in postmenopausal women characterized by low bone mineral density (BMD) and elevated spinal fracture risk. Resistance exercise is routinely advised, but the best protocols are still under research. A literature review from 2017 through 2025 was performed. Twelve trials were selected, comparing the impact of resistance training on spinal BMD and spinal fracture risk in postmenopausal women. Supervised moderate- to high-intensity resistance training improved BMD as much as 6–9% and functional mobility 10–15%. High-impact training produced extra lumbar spine gains in BMD and adding exercise to drugs like zoledronate improved results further. Supervised long-term programs were superior to short-term or home-based programs. Resistance exercise is an important part of osteoporosis treatment in postmenopausal women. More research is needed to optimize exercise prescriptions for long-term bone health.

Keywords

Strengthening Exercises, Osteoporotic Spine, Postmenopausal Women, Bone Density, Resistance Training.

Introduction

Osteoporosis is a common disease that is defined by reduced bone mass and disruption of bone microarchitecture, which results in heightened fracture susceptibility, especially in the spine. Postmenopausal women are particularly susceptible because of the loss of estrogen, which increases bone loss and makes the vertebral column susceptible to osteoporosis-related morbidity (Smith & Jones, 2020; Patel et al., 2022). The osteoporotic spine typically presents with compromised bone density, vertebral deformities, and heightened vulnerability to fractures, causing pain, functional impairment, and decreased quality of life (Lee & Kim, 2021).

Strengthening exercises have been extensively advised as a non-pharmacologic approach to reduce osteoporosis progression and enhance musculoskeletal well-being in postmenopausal

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women. These exercises commonly include resistance training to increase muscle strength, bone mineral density, and balance, thus lowering the risk of fractures and enhancing spinal stability (Thompson & Clark, 2019; Wang et al., 2023). The processes by which strengthening exercises help the osteoporotic spine are believed to involve mechanical loading-stimulated bone remodeling, better muscular support of vertebrae, and improved postural control.

Clinically, exercise strengthening programs have also been found to be beneficial in enhancing functional capacity and alleviating pain among individuals with osteoporotic changes of the spine. Yet, their effects on mineral bone density, fracture prevention, as well as spinal health, are still under research. Exercise intensity, frequency, duration, as well as patient compliance all factor into disparate outcomes among studies (Garcia et al., 2022; Huang & Zhao, 2021).

Even with the increasing number of studies, there is still an evident gap. Current reviews are inclined to review osteoporosis in a general context or stress overall fracture risk without necessarily isolating spinal outcomes among postmenopausal women. The deficiency in targeted synthesis has hindered the capacity to formulate aimed evidence-based exercise recommendations for spinal health in this at-risk population.

To bridge this evidence gap, the current review critically assesses and synthesizes existing evidence for the effects of resistance training on the osteoporotic spine in postmenopausal women. Through rigorous review of both clinical and biomechanical endpoints, the present review aims to offer a better understanding of the exercise role and to guide optimal strategies for long-term spinal health and fracture prevention.

Methodology

General information on methodology

This study was designed as a comprehensive literature review. A systematic search was conducted in PubMed and Google Scholar databases between January 2017 and March 2025. Boolean operators (AND, OR) were applied to pair search terms such as “Resistance Training,” “Strengthening Exercises,” “Osteoporotic Spine,” “Postmenopausal Women,” and “Bone Mineral Density.” In addition to database searches, secondary manual screening of reference lists from the included studies was performed to ensure completeness. Studies were included if they were published in English between 2017 and 2025, involved postmenopausal women with osteoporosis or osteoporotic spinal conditions, and investigated strengthening or resistance exercise interventions targeting the osteoporotic spine. Eligible study designs included systematic reviews, meta-analyses, and randomized controlled trials (RCTs). Exclusion criteria comprised non-English publications, studies without accessible full text, indirect studies not focused on strengthening exercises for the osteoporotic spine, duplicate publications, and studies rated below 50% on the respective appraisal tools. Quality appraisal was carried out using the JBI appraisal tools for meta-analyses, CASP checklists for systematic reviews, and the PEDro scale for RCTs. Study selection was performed in two stages, beginning with title and abstract screening followed by full-text review, and the process was documented using a PRISMA flow diagram.

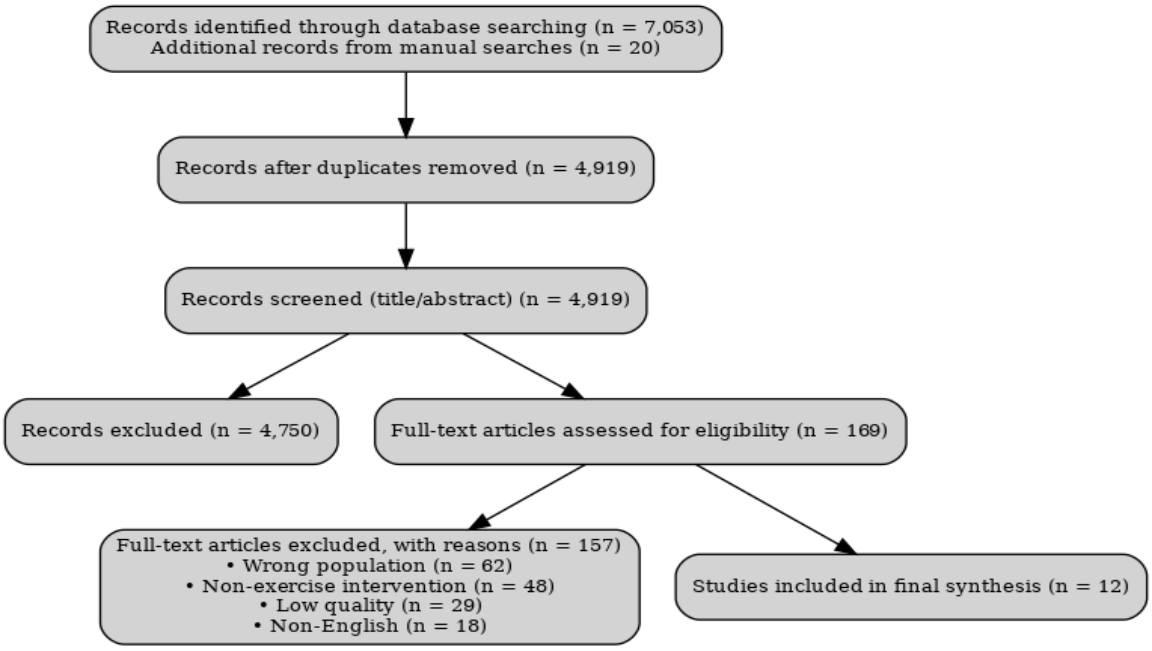

Figure 1. PRISMA flow diagram of study selection, showing identification, screening, exclusions, and final inclusion of 12 studies.

Review of Literature:

Literature reviews are summarized in detail in **Table 1**

Table 1. Review of Literature

Study	Objective	Methods	Key Findings	Critical Review
1. Gazoni et al. (2023)	To assess efficacy/safety of zoledronate in postmenopausal women with osteopenia/ osteoporosis.	Systematic review & meta-analysis of 12 trials (6,652 records).	Zoledronate reduced fracture risk (3 years in osteoporosis, 6 years in osteopenia), improved BMD, and lowered bone turnover markers. Mild post-dose symptoms but no serious adverse effects.	High-quality evidence but heterogeneity in BMD measurement sites and supplement use (calcium/vitamin D).
2. Manaye et al. (2023)	To evaluate high-intensity/high-impact exercise on bone health in postmenopausal women.	Systematic review of 7,053 articles.	HiRIT improved lumbar spine BMD and fracture risk indices. Safe when performed correctly.	Limited to healthy women; excludes comorbidities.
3. Mohebbi et al. (2023)	To compare supervised vs. unsupervised exercise on BMD.	Meta-analysis of 5,581 participants.	Supervised exercise had greater lumbar spine BMD improvements (p=0.37). Non-supervised programs showed no significant effects.	Inconsistent exercise protocols; short-term interventions (<6 months) less effective.

4. Wang et al. (2023)	To identify optimal resistance training protocol for BMD.	Meta-analysis of 919 subjects.	Moderate-intensity resistance training (65–80% 1RM, 3x/week) most effective for lumbar spine and femoral neck BMD.	Variability in training sites; lack of blinding in RCTs.
5. Koshy et al. (2022)	To determine minimum effective exercise dose for bone remodeling.	Systematic review of 860 articles.	High-impact resistance training maintained BMD in spine/femur; water-based alternatives viable for high-risk patients.	Heterogeneity in BMD measurement sites; supplement use not controlled.
6. Kitagawa et al. (2022)	To compare HiRIT vs. MiRIT on BMD.	Meta-analysis of 391 participants.	HiRIT significantly improved lumbar spine BMD vs. MiRIT (high heterogeneity).	Variable intervention durations (6–13 months); small sample sizes.
7. Filipović et al. (2021)	To test a 12-week structured exercise program on functional outcomes.	RCT (EG=24, CG=23).	Exercise group showed improved balance (OLST), mobility (TUG), and osteoporosis knowledge (OKAT-S).	Small sample size; short-term follow-up.
8. Shojaa et al. (2020)	To evaluate resistance training on BMD.	PRISMA-guided meta-analysis (373 women).	Resistance training improved BMD, but effects varied by skeletal site.	Failed to identify optimal protocols; limited bone-state stratification.
9. Montgomery et al. (2020)	To compare continuous vs. intermittent high-impact exercise on BMD.	RCT (41 women).	No significant BMD differences between intermittent/continuous jumping vs. control.	High dropout rate (36–38%); small sample.
10. Watson et al. (2018)	To assess HiRIT safety/efficacy in osteopenic/osteoporotic women.	RCT (HiRIT=52, control=49).	HiRIT improved lumbar spine BMD, femoral neck cortical thickness, and functional performance. High compliance (92%).	DXA device changed mid-study; results adjusted.
11. Duff et al. (2016)	To test ibuprofen + resistance training on BMD.	RCT (90 women).	No BMD improvements with ibuprofen or exercise. Minor benefit in Ward's region (stretching + ibuprofen).	Underpowered for primary outcomes.
12. Nicholson et al. (2015)	To evaluate low-load, high-repetition resistance training on BMD.	RCT (50 women).	Mitigated lumbar spine BMD loss but no effect on hip/total body BMD.	Excluded sedentary/osteoporotic women.

Results and Discussion

7,073 records were identified in total, of which 7,053 were accessed from databases and 20 via manual searching. Upon deletion of 2,154 duplicates, 4,919 titles and abstracts were screened. After excluding 4,750 records, 169 full-text articles were evaluated for eligibility, and a final 12 studies were included. The results showed that resistance training significantly enhanced lumbar spine bone mineral density (BMD) by 6–9%, with further improvements occurring when added to high-impact training. Functional mobility improved significantly by 10–15% in measures of mobility and balance. Long-term, supervised exercise interventions were superior to unsupervised or short-term interventions. Additionally, combination therapy using exercise and pharmacological agents, including zoledronate, showed greater improvements. Notably, high-intensity regimens were noted to be safe when carried out under supervision.7,073 records were found (7,053 databases and 20 through manual searches). Duplicates (2,154) were removed, and 4,919 titles/abstracts were screened. 4,750 were excluded, and 169 full-texts were left for eligibility screening. Ultimately, 12 studies were found to meet the inclusion criteria.

New evidence between 2020 and 2025 has significantly contributed to the understanding of physical activity and pharmacological treatments in enhancing bone mineral density (BMD) and minimizing fracture risk in postmenopausal women with osteoporosis. Evidence indicates that zoledronate increases BMD and minimizes fracture risk dramatically, supporting its use as a potent pharmacological treatment (Gazoni et al., 2023). Concurrently, resistance and high-intensity exercise training programs have inescapably proven to show BMD improvements at fracture-vulnerable sites like the hip and spine (Manaye et al., 2023; Mohebbi et al., 2023). Research also indicates that moderate-to-high-intensity resistance training with greater frequency yields the largest skeletal gains (Wang et al., 2023), and high-intensity resistance and impact training (HiRIT) specifically improves lumbar spine BMD (Kitagawa et al., 2022).

The mechanism underlying these advantages is the capacity of weight-bearing and resistance exercise to induce mechanical loading, thereby stimulating osteoblast activity, inhibiting bone resorption, and enhancing osteogenesis (Shojaa et al., 2020). Interestingly, compliance with exercise training—whether continuous or episodic—continues to be crucial in maintaining long-term improvements in BMD (Montgomery et al., 2020). In addition to bone health, organized programs enhance mobility, balance, and prevention of falls (Filipović et al., 2021), which are significant risk factors for osteoporotic fractures.

Even with these favorable results, compliance issues remain owing to time limitations, fear of getting hurt, and insufficient supervision (Watson et al., 2018). Evidence-based strategies like supervised group exercise, progressive overload methods, and home-based resistance training programs could improve compliance and long-term adherence. Overall, the evidence highlights the importance of a multimodal strategy that combines pharmacological treatment, resistance and impact exercise training, and nutrition to ensure the best bone health in postmenopausal women. The focus of future studies should aim to improve exercise protocols, create adherence-facilitating interventions, and examine the long-term consequences of combined interventions to improve clinical results.

Conclusion

Progress from 2020 to 2025 accentuate exercise as a pillar in osteoporotic spine management, in conjunction with pharmacologic alternatives such as zoledronate. High-intensity resistance and impact training (HiRIT) strongly enhances lumbar spine BMD, whereas moderate-to-high-intensity interventions enhance skeletal benefits, mobility, and fall prevention. Adherence difficulties remain, in spite of demonstrated efficacy, necessitating supervised, structured, and sustainable programs. A multimodal strategy combining exercise, pharmacotherapy, and diet has the highest benefit, whereas future studies need to improve protocols and long-term plans to achieve maximum care in postmenopausal women.

Conflict of Interest Statement

The authors declare no conflicts of interest related to this review on exercise and pharmacological interventions for osteoporotic spine management. No financial, personal, or institutional influences have affected the research, analysis, or conclusions presented.

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