DOI 10.26773/jaspe.251004

Journal of Anthropology of Sport and Physical Education

SYSTEMATIC REVIEW

Analysis of different physical activity modalities as therapeutic intervention in women with osteoporosis: A scoping systematic review

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Abstract

Osteoporosis represents a growing public health concern characterized by progressive bone mass reduction and increased fracture risk, particularly among the elderly. Physical activity emerges as one of the most important non-pharmacological preventive measures, achieving multidimensional benefits through simultaneous preservation of bone density, enhancement of muscle strength, and improved balance capabilities. Accordingly, the aim of this systematic literature review is a comprehensive critical analysis of current scientific research examining the therapeutic potential of physical activities in the treatment of osteoporosis in women.This systematic review was conducted according to PRISMA-ScR guidelines, searching four electronic databases from January 2015 to May 2025, where two independent researchers applied PICOS criteria and the PEDro scale for quality assessment. Finally, 18 studies met the criteria and were included in the final analysis.The analysis demonstrates that physical activity achieves significant therapeutic effects in women with osteoporosis through improvement of muscle strength, postural stability, and bone density maintenance, with positive outcomes achieved regardless of specific exercise modality - including aerobic and anaerobic training, Pilates, yoga, and vibration therapies. Implementation of regular physical activity represents a fundamental component of the multidisciplinary approach in osteoporosis treatment among women, enabling individualized application of various modalities according to specific needs and capabilities of patients.

Keywords: *physical activity, osteoporosis, women, importance, impact*

Introduction

Epidemiological studies indicate a growing trend of metabolic disorders, among which obesity and type 2 diabetes stand out, while osteoporosis occupies a special place as a "silent killer," yet often represents a neglected public health issue (Alswat, 2017; Li et al., 2024; Yang et al., 2025). This metabolic disorder is frequently associated with bone fractures, which can result in disability and, in extreme cases, death (Lyu et al., 2025). This bone tissue disorder, whose name derives from the Latin words "osteo" meaning bone, and "porosis" meaning pore, is defined as a condition of reduced bone density accompanied by compromised structural integrity. According to the World Health Organization's definition, osteoporosis represents a condition in which the degradation of bone mass and microstructure leads to increased bone fragility and consequent increased risk of fractures (World Health Organization, 2020). This metabolic condition, which impacts approximately 200 million individuals globally, weakens the body's structural framework that normally provides physical support, facilitates movement, and shields essential organs (Anthamatten & Parish, 2019). Although often perceived as exclusively a problem in postmenopausal women, osteoporosis represents a clinical entity that manifests in both sexes through different temporal patterns and intensities (Lorentzon & Cummings, 2015). Existing literature indicates a fourfold higher prevalence in women, while men are exposed to the risk of more complex complications, making aging the main predisposing factor through complex biopsychosocial mechanisms (Bijelic et al., 2017). At age 60, approximately 10% are affected by osteoporosis, at age 70, around 20%, at age 80, nearly 40%, while

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at age 90, as many as 2/3 of all women are affected (Sarafrazi et al., 2021). It is estimated that the prevalence of osteoporosis will increase by 1/3 in people aged 50-60 years, and by as much as 1/2 in people older than 80 years (Kanis, 2007). By 2050, it is projected that the number of individuals with osteoporosis will increase threefold, including both men and women (Lorentzon et al., 2022).

Bone Mass Loss by Gender

The process of bone mass reduction represents an integral part of physiological aging, whereby gender-specific patterns of loss can be quantified through analysis of annual rates, identification of risk factors, and monitoring of bone metabolism biomarkers (Drake et al., 2015).

A longitudinal study by Jones et al. (1994), which included 769 participants of both sexes over 60 years of age, assessed annual bone mass loss. The results demonstrated that men recorded annual bone mass loss at the femoral neck level of 0.82%, while women showed a statistically significantly greater loss of 0.96% annually. Analysis of age cohorts reveals that the period of accelerated bone mass decline in men manifests between the ages of 74 and 79, in contrast to women, in whom this critical period occurs earlier, between the ages of 65 and 69. These results indicate a universal tendency of bone mass loss in both women and men, but in women, bone mass loss manifests at a younger age and a faster rate compared to men.

The physiology of bone tissue is based on a continuous process of remodeling (formation and resorption), whose homeostasis is disrupted by aging (Gennari et al., 2008). In the female population, resorptive mechanisms progressively surpass formative activity, resulting in a net reduction of bone substance (Noirrit-Esclassan et al., 2021). This complex process is regulated by the coordinated activity of osteoblasts that mediate bone synthesis and osteoclasts responsible for resorption, while their functions are modulated by a wide spectrum of bioactive substances, including estrogen hormones, parathyroid hormone, calcitriol, and multiple additional regulatory factors (Gennari et al., 2008). The initial decades of life are characterized by predominantly formative processes; however, in the third decade of life, a gradual reduction of the trabecular bone component begins (Armada et al., 2018). The critical period of bone mass loss occurs in the sixth decade, as a consequence of menopause, which brings with it lower levels of estrogen hormones (Pedro et al., 2017).

Menopause is a natural reproductive transition that occurs due to primary ovarian insufficiency, characterized by a progressive decline in ovarian function (Ji & Yu, 2015). This physiological phenomenon is characterized by a dramatic reduction in estradiol production and total estrogens (Boschitsch et al., 2017). In menopause, the physiological cycle of bone remodeling is significantly disrupted due to estrogen deficiency. Osteoclastic resorption activity increases, while osteoblastic activity decreases. Consequently, the amount of resorbed bone exceeds that of deposited bone, resulting in bone mass loss.

The pattern of bone degradation in the female population manifests through two phases (Noirrit-Esclassan et al., 2021):

The initial phase begins in the trabecular component of bones simultaneously with the onset of menopause, resulting from estrogen deficiency that leads to disproportionate elevation of bone resorption relative to bone formation.

The secondary phase occurs 4-8 years after the initial phase and is characterized by slower but constant degradation of both trabecular and cortical bone architecture. This second phase is primarily associated with chronological aging and represents the only pattern of bone degradation present in the male population.

Prevention and Treatment

The foundations of contemporary understanding of estrogen's role in osteoporosis prevention were established in the early 1940s through revolutionary research by Albright and Reifenstein. Such discoveries led to the formal adoption of estrogen therapy in 1960 as a standard approach in preventing bone loss in women (Prior, 2018). Contemporary scientific literature abounds with evidence regarding the efficacy of estrogen therapy in preserving bone mass during menopause and the postmenopausal period (Prior, 2018; Zhao et al., 2017). Parallel to hormonal approaches, significant risk factors that negatively affect healthy bone structure formation have been identified, particularly tobacco consumption and excessive alcohol intake, which necessitate their complete elimination (Chan et al., 2018). Adequate supplementation with calcium and vitamin D represents a fundamental component of bone health preservation, whereby women over 50 years of age are recommended a daily calcium intake of 1200 mg (Alswat, 2017; Qaseem et al., 2017). According to AACE and ACE guidelines, optimal serum vitamin D3 levels are maintained through supplementation of 1000-2000 international units daily. Although the principle "exercise preserves bones" is widely accepted, reality indicates alarmingly low participation of the elderly population in regular physical activities (Anthamatten & Parish, 2019). Physical activity as therapy falls under non-pharmacological measures, which have always been promoted and recommended to women not only during and after menopause but throughout their entire lives. Solid empirical evidence supports the fundamental role of physical activity in increasing bone mass (Howe et al., 2011; Hsu et al., 2014). Considering that falls constitute the predominant mechanism of fractures in the geriatric population, their association with deteriorated balance and muscle tissue atrophy requires focused attention (Souto Braz et al., 2022). High levels of functional strength in the lower extremities and preserved postural control represent an imperative for independent functional status and competent performance of activities of daily living in older age (Chen & Jiang, 2014). Physical activity achieves multidimensional benefits through simultaneous preservation of bone mass, optimization of muscle performance, and improvement of balance abilities (Otero et al., 2017). Clinical studies consistently demonstrate that aerobic training and strength training, implemented as standalone interventions without pharmacological support, generate measurable effects in attenuating bone loss in women with verified osteoporosis (Borba-Pinheiro et al., 2016; Linhares et al., 2022).

The primary objective of this systematic literature review is a comprehensive critical analysis of current scientific research examining the therapeutic potential of physical activities in the treatment of osteoporosis in women. Specifically, the review focuses on evaluating the efficacy of different modalities of physical activity, including outdoor and indoor exercises, in the context of osteoporosis management in the female population. This approach aims to systematically assess evidence regarding physical activity as a significant therapeutic modality, expanding perspectives beyond conventional pharmacological paradigms in the treatment of this bone pathology.

This systematic review seeks to answer the following fundamental research questions:

− What is the efficacy of different types of physical activities in improving bone mineral density in women with osteoporosis?

− Are there significant differences in therapeutic effects between physical activities performed outdoors versus those in indoor environments?

− What are the optimal parameters of physical activities (intensity, frequency, duration) for achieving maximum therapeutic benefits in women with osteoporosis?

− What is the impact of physical activities on functional outcomes such as balance, muscle strength, and fall risk in women with osteoporosis?

− Can physical activities as a standalone intervention provide clinically significant results compared to combined therapeutic approaches?

This systematic review enables:

− Synthesis of existing evidence: Integration of fragmented research into a coherent picture of the role of physical activities in osteoporosis treatment in women, enabling a better understanding of the therapeutic potential of non-pharmacological interventions.

− Identification of best practices: Definition of evidence-based recommendations for implementing physical activities as a therapeutic modality, including optimal exercise protocols and specific populations that benefit most from such interventions.

− Mapping research gaps: Systematic identification of areas where there is insufficient quality research, which can guide future scientific efforts and research priorities.

− Support for clinical decision-making: Providing a solid scientific foundation for healthcare professionals to integrate physical activities into multidisciplinary therapeutic plans for women with osteoporosis.

− Treatment paradigm change: Contributing to the shift in focus from exclusively medicinal to holistic approaches that include physical activity as a central component of osteoporosis therapy.

− Informing public policies: Generating evidence that can inform the creation of public health strategies and programs for prevention and treatment of osteoporosis in women through physical activity promotion.

Methodology

For this research, PRISMA-ScR guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) were employed, which represent a standardized methodological framework for conducting scoping studies. Implementation of these guidelines ensured a systematic and transparent approach in the process of identifying, selecting, and synthesizing relevant scientific publications (Page et al., 2021).

Search Strategy

The relevant literature was identified using a systematic approach across appropriate electronic databases. Standardized MeSH terms (Medical Subject Headings) and relevant keywords directly related to the research questions were applied to formulate the search strategy. The search encompassed the following scientific databases: PubMed, Web of Science, ResearchGate, and Google Scholar. The chronological framework of the research was established for the period from January 2015 to May 2025. The tabular overview presents specific combinations of search terms in detail (Table 1).

Table 1. Search strategy

Database	Search strategy
PubMed	("osteoporosis" OR "bone loss") AND ("physical activity" OR "outdoor physical activity" OR "exercise") AND ("significance" OR "impact" OR "effect") AND ("women" OR "older women")
Web of Science	("osteoporosis" OR "bone loss") AND ("physical activity" OR "outdoor physical activity" OR "exercise" OR "walking" OR "aerobic exercise" OR "resistance exercise") AND ("significance" OR "impact" OR "effect") AND ("women" OR "older women")
ResearchGate	("osteoporosis" OR "bone loss") AND ("physical activity" OR "outdoor physical activity" OR "exercise") AND ("significance" OR "impact" OR "effect") AND ("women" OR "older women")
Google Scholar	("osteoporosis" OR "bone loss") AND ("physical activity" OR "outdoor physical activity" OR "exercise" OR "walking" OR "aerobic exercise" OR "resistance exercise" OR "balance exercise") AND ("significance" OR "impact" OR "effect") AND ("women" OR "older women")

Table 2. Picos methodological framework

PICOS Element	Inclusion criteria	Exclusion criteria
Population (P)	Women, older (+35 years); No serious contraindications for physical activity; Diagnosis of osteoporosis confirmed by DXA scan; Women with primary or secondary osteoporosis; Women who have the ability to move independently.	Studies that do not specify the group of respondents; Men; Women under 35; People with contraindications to physical exercise; Persons who do not have the ability to move independently.
Intervention/ Exposure (I)	Structured outdoor or indoor physical activities including walking, brisk walking, running, cycling, swimming, yoga, Nordic walking, gym, aerobic activities, combined physical activities, supervised activities, individually tailored activities; Different levels of intensity, frequency and duration.	Works involving physical activity; Only pharmacological treatments included; Surgical interventions; Supplementation as the only treatment; Interventions without defined physical activities.
Comparison (C)	No specific comparison required (may include comparisons between women and men; comparisons between control and experimental groups; comparisons of different physical activity programs in terms of modality, frequency, intensity, duration)	Comparisons with inappropriate interventions not relevant to our research question.
Outcomes (O)	Primary outcomes: Bone mineral density. Secondary outcomes: Mental health, Motor skills (primarily strength and balance); Risk of falls; Quality of life.	Studies not measuring relevant osteoporosis outcomes; Studies that focus on subjective measures without objective measures; Studies with invalid measuring instruments.
Study design (S)	Randomized controlled studies, Prospective cohort studies, Longitudinal interventional studies, Original research, professional papers published between January 2015 and May 2025 in English with full text available, Ethically approved studies.	Studies published before January 2015, papers in other languages, letters to the editor, commentaries, conference abstracts, studies without full text available, review papers.

The selection of adequate studies was realized through an independent assessment approach by two researchers (SD and MD), who utilized pre-established inclusion and exclusion criteria, formulated based on the PICOS methodological framework (population, intervention, comparators, outcomes, and study design). The evaluation was conducted with strict adherence to methodological standards, thereby ensuring high precision and transparency of the selection procedure. Specific parameters used for the selection of scientific papers are comprehensively presented in Table 2, which enables complete reproduction of the research approach.

Study Selection and Selection Process

The selection of relevant studies was realized through a two-stage procedure. Initially, two independent researchers (SD and MD) conducted an evaluation of the titles and abstracts of identified publications by applying previously established inclusion and exclusion criteria (Table 2). In the second phase, a comprehensive analysis of complete texts of previously selected studies was performed.

In the initial search, a total of 1170 records were identified (1147 from Google Scholar, 17 from PubMed, 4 from Web of Science, 2 from ResearchGate). During this phase, 1142 articles were eliminated following title and abstract screening due to failure to satisfy the inclusion requirements. Identification and removal of duplicates (n=4) were performed through manual review and comparison of bibliographic information, including paper title, authors, year of publication, and journal. This process was independently conducted by two researchers (SD and MD).

Following the initial selection, evaluation of articles at the full-text level was performed. Artilces for which no full-text was available (n=2), studies without clearly defined types of physical activity (n=2), as well as research with imprecisely described participant characteristics (gender, health status, mobility capacity; n=2) were excluded from further analysis. Eighteen studies that satisfied all predefined criteria were included in the final scoping review (Figure 1).

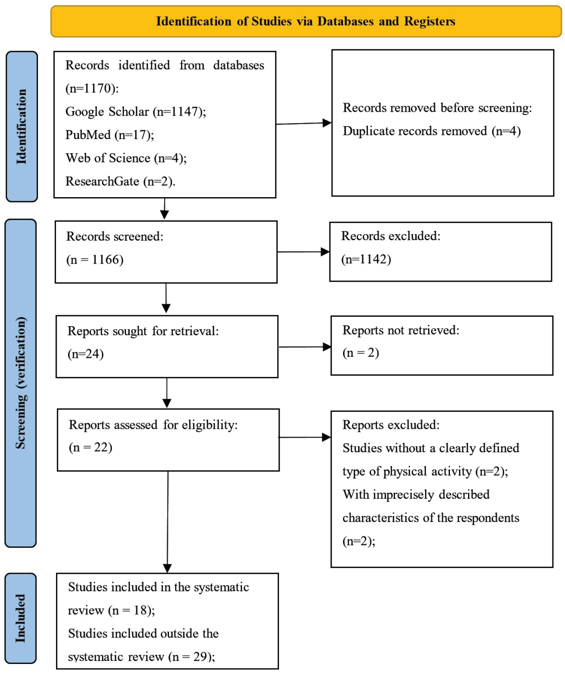

FIGURE 1. Flow diagram of study selection

Methodological Quality

The methodological quality of included studies was independently assessed using the PEDro scale (Physiotherapy Evidence Database), which contains 11 criteria. The evaluation was performed using a binary scoring system (+/- or 1/0) for each criterion (Table 3). Studies with a score ≥6 were classified as high-quality, those with a score of 4-5 as moderate quality, while studies with a score <4 were considered low-quality.

Table 3. Physiotherapy Evidence Database (PEDro) score of the included studies

No.	Author(s)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	Angin et al. (2015)	+	+	+	+	-	-	-	+	+	+	+	8/11
2	Kemmler et al. (2016)	-	+	+	+	-	-	+	+	+	+	+	8/11
3	Motorwala et al. (2016)	-	-	-	+	+	+	+	+	-	-	+	6/11
4	Otero et al. (2017)	-	-	+	+	-	-	+	+	+	+	+	7/11
5	Wen et al. (2017)	-	-	-	+	+	-	+	+	+	-	+	6/11
6	Arazi et al. (2018)	+	+	-	+	-	-	-	+	-	+	+	6/11
7	Dizdar et al. (2018)	+	+	-	+	-	-	-	-	+	+	+	6/11
8	Miko et al. (2018)	-	+	+	+	-	-	+	+	+	+	+	8/11
9	Watson et al. (2018)	-	+	+	+	-	-	+	+	+	+	+	8/11

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Table 3. Physiotherapy Evidence Database (PEDro) score of the included studies

No.	Author(s)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
10	Razzak et al. (2019)	-	-	+	+	-	-	+	+	-	+	+	6/11
11	Khan et al. (2019)	-	+	+	+	-	-	+	+	+	+	+	8/11
12	Conradsson & Halvarsson (2019)	+	+	-	+	-	-	-	+	-	+	+	6/11
13	de Oliveira et al. (2019)	+	+	-	+	-	-	+	-	-	+	+	6/11
14	Yu et al. (2019)	+	-	+	+	-	-	-	+	+	+	+	7/11
15	Filipović et al. (2020)	+	+	-	+	-	-	-	-	+	+	+	6/11
16	ElDeeb et al. (2020)	+	+	-	+	-	-	+	-	+	+	+	7/11
17	Solakoglu et al. (2022)	+	+	+	+	-	-	+	+	+	+	+	8/11
18	Bittar et al. (2023)	+	+	-	+	-	-	-	+	+	+	+	7/11

Legend: + indicates one point, – indicates no point. (1) Eligibility criteria; (2) Randomization; (3) Concealment of allocation; (4) Between-group homogeneity; (5) Blinded subjects; (6) Blinded trainers; (7) Blinded testers; (8) Dropout rate < 15%; (9) Intention-to-treat; (10) Statistical between-group comparisons; (11) Point and variability estimates; (12) Total scores.

Results

Results of Included Studies

The systematic review encompassed a total of 18 studies focused on physical interventions in women with osteoporosis.

This review encompassed 18 research studies involving 1087 participants in total. The majority of research (88.9%) represents randomized controlled trials, indicating a high level of evidence. Experimental pre-post studies and retrospective cohort studies each comprised 5.6%. The average sample size was 60.4 participants per study, with a range from 30 to 100 participants. A detailed analysis is provided in Figure 2.

Aerobic exercise and combined training protocols were the most commonly examined interventions, each representing 22.2% of the studies. Strength and resistance training, along with balance-focused exercises, accounted for 16.7% each. Pilates and yoga interventions were each featured in 11.1% of the research. Figure 3 presents a comprehensive breakdown of these findings.

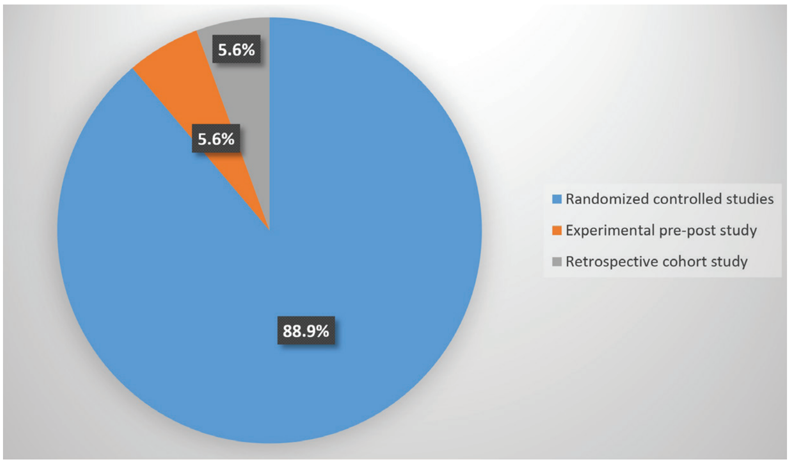

FIGURE 2. Overview of study types

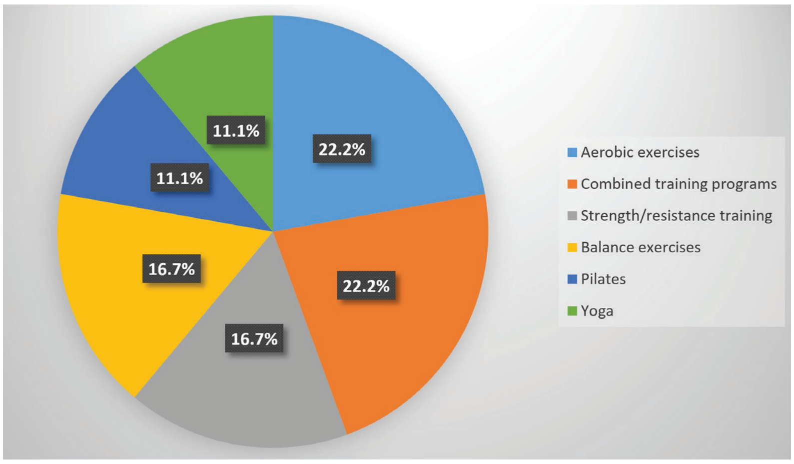

FIGURE 3. Overview of represented interventions

The largest number of studies (38.9%) conducted 12-week programs, while 24-week programs were represented in 16.7% of cases. A detailed analysis is provided in Figure 4.

Positive effects on bone mass were recorded in 61.1% of studies, while 22.2% of studies showed maintenance of bone density. The osteoanabolic exercise program particularly stood out, yielding the best results regarding increased bone mass density. A detailed analysis is provided in Figure 5.

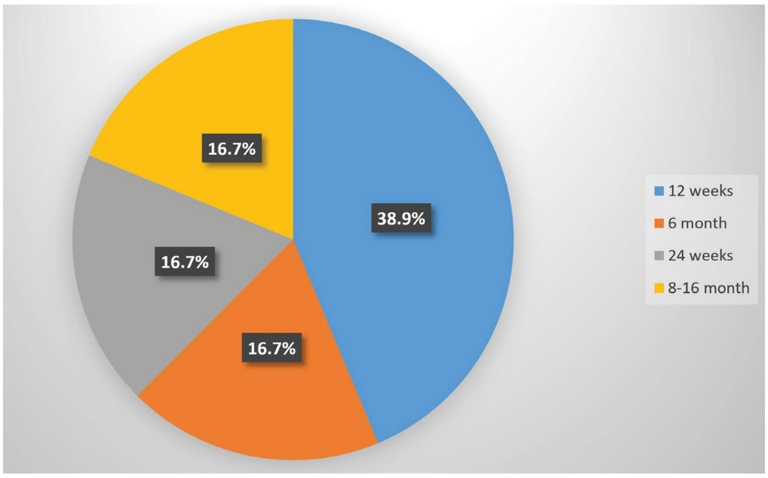

FIGURE 4. Overview of intervention duration

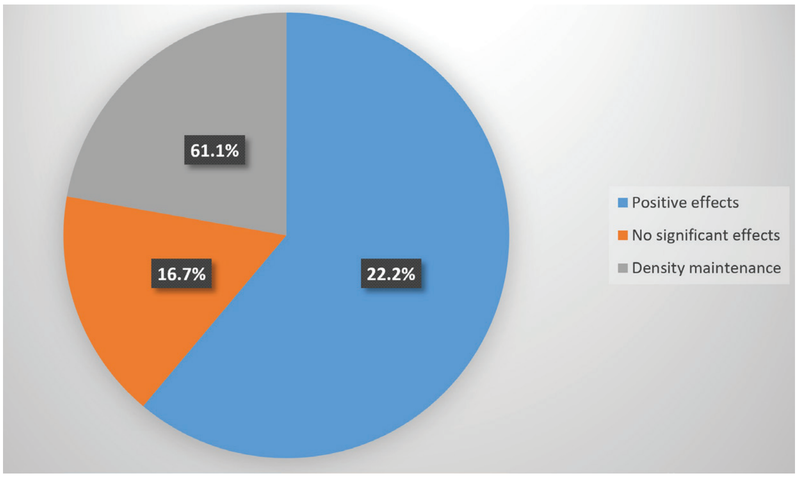

FIGURE 5. Overview of effects

A complete methodological review of the research is presented in Table 4, which provides a comprehensive taxonomic overview of individual research characteristics. The table integrates key metadata, including: authors and year of publication, research design typology, demographic structure of participants, specificities of applied physical interventions, and predominant research outcomes. This detailed overview enables systematic evaluation and critical analysis of methodological approaches and results.

Table 4. Characteristics of studies included in the review

No.	Author(s)	Study type	Number of respondents	Activities	Conclusion
1	Angin et al. (2015)	A randomized control trial	41	Clinical Pilates program for the experimental group.	Pilates increases bone mass, relieves pain, improves physical performance and quality of life.
2	Kemmler et al. (2016)	A randomized control trial	55	16 years of practice, at least 2 sessions per week.	At least 2 sessions of weekly exercise maintain bone density.
3	Motorwala et al. (2016)	Experimental pre-post study	30	Yoga, 6 month.	Helps maintain bone mass density.
4	Otero et al. (2017)	A randomized control trial	65	Low intensity strength and balance exercises.	This program improved strength and balance, reduced the number of falls.
5	Wen et al. (2017)	A randomized control trial	48	The experimental group attended a 10-week step aerobics program, 90 min 3 sessions per week.	It had no positive effects on bone mass, but it improved the muscles of the lower extremities.

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Table 4. Characteristics of studies included in the review

No.	Author(s)	Study type	Number of respondents	Activities	Conclusion
6	Arazi et al. (2018)	A randomized control trial	40	Combined training (aerobic and resistance training) 3 sessions of 90-110 min during 10 weeks, with milk consumption 500 ml per day.	Significant changes in bone mass increase; improvement of biochemical markers in the experimental group.
7	Dizdar et al. (2018)	A randomized control trial		The participants were randomly divided into three groups: balance and coordination, muscle strengthening, and aerobic exercises. The exercise programs were performed for 12 weeks, 60 min a day, 3 times a week.	Aerobic exercises were effective for physical performance, strengthening exercises were effective in reducing pain, and balance and coordination in reducing falls.
8	Miko et al. (2018)	A randomized control trial	100	12 months of balance exercise program 3 times a week for at least 30 min.	It increased stability, reduced falls and improved aerobic capacity.
9	Watson et al. (2018)	A randomized control trial		High intensity resistance and impact training for 8 months.	This program has been shown to be very effective in delaying bone loss.
10	Razzak et al. (2019)	A randomized control trial	94	Two groups. The first group had aerobic exercises, and the second group had resistance exercises, for 12 weeks.	Aerobic exercise has a greater effect on estradiol and lean mass.
11	Khan et al. (2019)	A randomized control trial	93	Three groups, one had aerobic exercises, the second anaerobic exercises and the third osteoanabolic exercises. The duration of the experiment is 12 weeks.	Bone mass density improved in all three groups, but the most in the group with osteoanabolic exercises.
12	Conradsson, & Halvarsson (2019)	A randomized control trial	95	Balance and gait training for the experimental group lasting 12 weeks, 3 sessions per week.	Improved balance in the experimental group and reduced falls.
13	de Oliveira et al. (2019)	A randomized control trial	51	Group 1: Whole-body vibration (WBV) training; Group 2: Pilates exercises. Duration: 6 months, 3 sessions per week.	Both groups showed improvement in bone mass.
14	Yu et al. (2019)	Retrospective cohort study	80	24-week aerobic dance.	It results in a reduction of fractures and improves balance.
15	Filipović et al. (2020)	A randomized control trial	96	12-week supervised exercise program (resistance, balance and aerobic training)	There was an improvement in the functional condition of women.
16	ElDeeb et al. (2020)	Randomized controlled study	43	Whole-body vibration (WBV) training 2 times a week for 24 weeks, vitamin D and calcium	In the experimental group, the work of the hip and leg muscles improved, and falls were reduced.
17	Solakoglu et al. (2022)	A randomized control trial	32	Two groups, one conservative exercise (30 min a day, 12 weeks), and the other yoga (32 min, exactly 12 weeks).	There was an improvement in functioning in both groups, while balance improved more in the yoga group.
18	Bittar et al. (2023)	A randomized control trial	30	Group 1 (n=10): Walking on a treadmill for 20 minutes at 60% VO2max; Group 2 (n=10): Treadmill walking for 20 minutes at 40% VO2max with blood flow restriction; Group 3 (n=10): Only blood flow restriction without exercise (20 minutes). The experiment lasted 24 weeks.	There were no differences between groups ($p = 0.87$), but a significant increase in all groups after 24 weeks ($p = 0.002$).

Methodological Quality Assessment of Included Studies

Evaluation of methodological quality using the standardized PEDro (Physiotherapy Evidence Database) instrument established that all 18 included studies are high-quality research, which indicates a satisfactory methodological standard of the analyzed included studies (Table 3).

Discussion

Multidimensional benefits of physical activity in osteoporosis

The findings of this scoping systematic review confirm the multidimensional benefits of physical activity in the therapeutic approach to women with osteoporosis. The results indicate a complex spectrum of positive effects that manifest through improvement in neuromuscular control, functional capabilities, and quality of life. The most significant recorded effects include increased muscle strength and improved postural stability, which directly contribute to reducing the risk of falls, one of the key factors influencing fracture frequency in this population. Additionally, regular physical activity demonstrates a positive impact on maintaining existing bone mass density, which represents a fundamental therapeutic goal in osteoporosis management.

Heterogeneity of physical activity modalities and their applicability

The heterogeneity of applied physical activity modalities in the analyzed studies - including Pilates, aerobic and anaerobic exercises, osteoanabolic exercises, resistance training, balance training, vibration therapy, yoga exercises, and coordination activities - indicates the broad applicability of different approaches in osteoporosis therapy. It is important to emphasize that positive effects manifested independently of specific intervention characteristics, including duration (6-16 months), frequency, intensity, and training volume. Such findings suggest that the key factor for therapeutic success is the implementation of regular physical activity itself, while the choice of specific modality can be adapted to individual preferences, physical capabilities, and available resources of patients.

The pathophysiological basis of osteoporosis and the need for an integrated approach

Considering that osteoporosis predominantly affects women in perimenopause and postmenopause due to progressive reduction in estrogenic activity, early implementation of an integrated therapeutic approach represents an imperative (Li et al., 2024; Yang et al., 2025). Physiological changes that characterize the menopausal period, primarily the drastic decline in serum estrogen levels, lead to accelerated bone tissue resorption and disruption of the balance between bone formation and degradation processes (Noirrit-Esclassan et al., 2021). This pathophysiological basis of osteoporosis requires a comprehensive approach that combines pharmacological and non-pharmacological therapy, representing the gold standard in contemporary treatment of this condition (Anthamatten & Parish, 2019; Prior, 2018).

Synergistic effect of combined pharmacological and non-pharmacological therapy

The synergistic effect of an adequately designed physical activity program, which involves carefully titrated training intensity and frequency, in combination with targeted pharmacotherapy - including hormone replacement therapy, vitamin D, and calcium supplementation - represents the most effective approach in preventing bone loss and slowing disease progression (Alswat, 2017; Qaseem et al., 2017; Borba-Pinheiro et al., 2016; Souto Braz et al., 2022).

The efficacy of the integrated therapeutic strategy was confirmed in a randomized controlled trial conducted by Arazi et al. (2020), where the impact of a combined intervention on 40 participants with osteoporosis was evaluated. A ten-week program that encompassed combined aerobic training and resistance training with a frequency of three sessions per week (minimum 90 minutes per session), along with simultaneous calcium supplementation through daily intake of at least 500 ml of milk, resulted in significant improvement in bone mass density and normalization of key biochemical parameters of bone metabolism. Such findings represent direct confirmation of the hypothesis that synchronous application of pharmacological measures through structured training and adequate nutritional status can achieve a synergistic effect on bone tissue, which surpasses the benefits achieved by isolated application of any of the mentioned modalities.

Modality-specific efficacy and individualization of treatment

However, it is important to note that the therapeutic benefits of physical activity are not universally applicable to all exercise modalities. Kemmler et al. (2016) demonstrated in their longitudinal study that through long-term exercise with a minimal frequency of two sessions per week, progression of bone mass loss can be successfully inhibited. Nevertheless, this generalization requires a more cautious approach when considering specific types of physical activity. The research by Wen et al. (2017) is illustrative, which evaluated the impact of step aerobics on 48 women with osteoporosis through a ten-week protocol of 90 minutes per session, with a frequency of three times per week. Results showed that this modality, despite adequate duration and intensity, did not achieve significant changes in bone mass density, but primarily contributed to improvement in lower extremity muscle strength. These findings suggest that the efficacy of physical activity in osteoporosis treatment depends on the specificity of biomechanical characteristics of the applied modality, indicating the need for an individualized approach in therapeutic protocol selection.

Secondary therapeutic benefits: fall prevention and functional status

Parallel to the analysis of direct effects on bone tissue, growing attention is directed toward secondary therapeutic benefits of physical activity, particularly in the context of fall prevention and functional status improvement. Otero et al. (2017) demonstrated through the implementation of a strength and balance exercise program in 65 women with osteoporosis that improvement in neuromuscular control and postural stability results in a significant reduction in fall incidence, which directly contributes to improved quality of life in participants. Such results were confirmed in a more extensive study conducted by Miko et al. (2018), where a twelve-month balance training program with a frequency of three sessions per week (minimum 30 minutes per session) in a larger sample of women resulted not only in increased postural stability and fall reduction, but also in unexpected improvement in aerobic capacity. Synergistic effects of combined modalities were further elaborated in research by Conradsson and Halvarsson (2019), where a twelve-week program that integrated balance training with a progressive walking protocol achieved significant improvement in body stability and fall reduction in women with osteoporosis.

Comparative analysis of different types of physical activity

The complexity of the therapeutic effects of combined interventions is particularly evident in the study by Filipović et al. (2020), where a multidimensional approach that encompassed balance training, resistance exercises, and aerobic activities resulted in comprehensive improvement of participants' functional status, surpassing the narrowly focused benefits of individual modalities. An additional dimension in understanding the differential efficacy of physical activity is provided by the comparative findings of Razzak et al. (2019), who, through a randomized study on 94 women with osteoporosis over twelve weeks, compared the impact of aerobic exercises with resistance exercises. Results indicated the superiority of aerobic activities in terms of estradiol stimulation and maintenance of lean body mass, which represent key determinants in bone tissue homeostasis and suggest hormonally mediated mechanisms of therapeutic action.

Systematic analysis of differential efficacy of various physical activity modalities was further elaborated through research by Dizdar et al. (2018), who comparatively evaluated three distinct approaches: coordination and balance exercises, muscle strength training, and aerobic activities. Findings demonstrated modality-specific adaptations, where aerobic exercises primarily influenced improvement in physical performance, muscle strengthening exercises resulted in significant pain reduction, while coordination and balance exercises optimized postural control with consequent reduction in fall risk. This differential nature of therapeutic responses was further confirmed in the study by Khan et al. (2019), where comparative analysis of aerobic training, anaerobic training, and osteoanabolic protocols over twelve weeks showed that all three modalities induced improvement in bone mass density, with osteoanabolic treatments achieving the most pronounced benefits on bone tissue.

Temporal dimension of therapeutic effects and long-term approach

The temporal dimension of therapeutic effects represents an additional critical factor in the optimization of intervention protocols, which was explicitly demonstrated in the longitudinal study by Bittar et al. (2023). Their comparative analysis of three different intervention programs over twenty-four weeks revealed that significant positive effects on bone mass manifest only after an extended implementation period, whereby after twelve weeks the effects proved marginal, while after twenty-four weeks uniform improvement was evidenced in all experimental groups. Such findings suggest that intervention duration is a crucial determinant of therapeutic success, indicating the need for a long-term approach in implementing physical activity as a therapeutic modality in osteoporosis.

Alternative approaches: holistic modalities

Exploration of alternative approaches to physical activity has provided significant insights into the therapeutic potential of holistically oriented modalities. Angin et al. (2015) evaluated the efficacy of clinical Pilates through a randomized controlled trial on 41 participants, demonstrating that this integrative approach simultaneously induces increased bone mass density, pain reduction, improved physical performance, and quality of life optimization. A comparative perspective is provided by research from de Oliveira et al. (2019), where a six-month comparative analysis of Pilates exercises and Whole-body vibration (WBV) training with a frequency of three sessions per week showed that both modalities achieve benefits on bone mass, with Pilates demonstrating superiority in pain relief and physical performance improvement. An integrated approach combining technological innovations with pharmacological interventions was elaborated in the study by El-Deeb et al. (2020), where a twenty-four-week implementation of WBV training (twice weekly) with vitamin D and calcium supplementation resulted in improved hip and lower extremity muscle function, balance optimization, and proportionally reduced number of falls, confirming the synergistic potential of pharmacological and non-pharmacological therapeutic approaches.

An additional dimension in the spectrum of alternative modalities is represented by yoga as a traditional approach that integrates physical, mental, and spiritual components. Motorwala et al. (2016) demonstrated through a six-month intervention on 30 participants that yoga successfully maintains bone mass density, while a comparative study by Solakoglu et al. (2022) between the yoga approach and conservative training over twelve weeks showed that both modalities improve functional status, with yoga achieving superior results in postural balance optimization. These findings suggest that the complexity of yoga techniques that integrate isometric contractions, proprioception, and breathing control may provide additional benefits compared to conventional training.

High-impact activities and biomechanical characteristics

Specific biomechanical characteristics of high-impact activities were further investigated through the study by Watson et al. (2018), where an eight-month program of resistance training and high-impact activities demonstrated exceptional efficacy in slowing bone mass loss in women. A complementary approach through rhythmic activity was evaluated in research by Yu et al. (2019) on 80 participants, where a twenty-four-week aerobic dance intervention resulted in a significant reduction in fracture incidence and improved postural stability.

Clinical significance and implications for practice

Comprehensive analysis of available literature unequivocally confirms the central role of physical activity in the therapeutic approach to women with osteoporosis, demonstrating that regular implementation of structured exercise programs represents a fundamental component of contemporary multidisciplinary treatment of this condition. The key insight emerging from the analyzed studies relates to the convergence of positive effects of different physical activity modalities, whereby benefits manifest through a spectrum of physiological adaptations that encompass optimization of bone homeostasis, improvement of neuromuscular function, and reduction of fracture risk.

Particularly significant is the observation that therapeutic success is not limited to specific types of activities, but is achieved through a broad range of approaches - from conventional aerobic and anaerobic modalities to holistically oriented methods such as Pilates and yoga. This flexibility in therapeutic protocol selection enables individualized treatment application that can be adapted to the specific needs, preferences, and functional capabilities of each patient, which represents a key advantage in clinical practice.

The temporal dimension of therapeutic effects indicates the necessity of a long-term approach to physical activity implementation, whereby optimal results are achieved through continuous application over extended periods. The synergistic potential of combined interventions that integrate pharmacological and non-pharmacological modalities represents the gold standard in osteoporosis treatment, enabling maximization of therapeutic benefits through complementary mechanisms of action.

Study Limitations

This systematic analysis has several limitations that should be considered when interpreting the results. The first major limitations relate to the heterogeneity of methodologies among the analyzed studies - different intervention durations, exercise frequency, and intensity complicate direct comparison of efficacy between different physical activity programs.

The limited number of participants in individual studies reduces the statistical power of findings, while short-term follow-up in most studies does not allow assessment of the long-term sustainability of therapeutic effects. Methodological differences in outcome measurement, including different techniques for assessing bone density and functional parameters, limit the possibility of precise quantification of effect sizes.

Strict inclusion criteria, limiting the sample to mobile women over 40 years old without contraindications to exercise, create a homogeneous sample that does not accurately represent the heterogeneous real-world population of women with osteoporosis in clinical practice. This limitation restricts the generalizability of the findings to more complex cases with comorbidities and functional limitations.

Conclusion

The systematic review's findings indicate that organized physical activity interventions constitute an important treatment approach for osteoporotic women. Literature analysis indicates consistent benefits of different types of physical activity on bone health, functional capacity, and fall prevention. Crucially, positive effects are achieved through diverse approaches - from strength training and aerobic exercises to alternative methods such as yoga, enabling treatment adaptation to individual patient characteristics. The findings emphasize the importance of long-term adherence to exercise programs and their integration with conventional therapeutic modalities to achieve optimal clinical outcomes.

Future research should focus on standardizing exercise protocols through the development of consensus recommendations for different stages of osteoporosis. Longitudinal designs with 2-3 year follow-up are necessary to assess long-term efficacy.

Priority should be given to investigating dose-response relationships between exercise modalities and therapeutic outcomes and developing personalized algorithms that integrate genetic and hormonal biomarkers.

Important areas include comparative cost-effectiveness studies of different programs and the implementation of digital technologies for adherence monitoring. Molecular research into the mechanisms of physical activity's action on bone tissue may identify new therapeutic targets and deepen understanding of the pathophysiological basis of osteoporosis.

Conflicts of interest
The authors declare that there are no conflicts of interest.

Received: 17 July 2025 | **Accepted:** 13 August 2025 | **Published:** 15 October 2025

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