Postprint of Best Evidence Summary for Exercise Intervention in Postmenopausal Osteoporosis Patients

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Abstract

Background: Exercise is one of the most cost-effective interventions for preventing and treating postmenopausal osteoporosis; however, the current relevant evidence is extensive and fragmented, lacking standardized and comprehensive exercise guidance protocols.

Objective: To retrieve, evaluate, and summarize the best evidence on exercise interventions for patients with postmenopausal osteoporosis.

Methods: A systematic search was conducted in BMJ Best Practice, UpToDate, DynaMed, the National Institute for Health and Care Excellence (NICE) Guidelines website, Guidelines International Network (GIN), Scottish Intercollegiate Guidelines Network (SIGN), U.S. Guidelines, Registered Nurses' Association of Ontario (RNAO), International Osteoporosis Foundation, Royal Osteoporosis Society, National Osteoporosis Foundation, Royal Australian College of General Practitioners, American College of Obstetricians and Gynecologists, Society of Obstetricians and Gynaecologists of Canada, Medlive, Joanna Briggs Institute, Cochrane Library, CINAHL, Web of Science, PubMed, Embase, CNKI, and CBM for clinical practice guidelines, clinical decisions, evidence summaries, expert consensuses, and systematic reviews on exercise interventions for postmenopausal osteoporosis, with the search period from database inception to January 2022.

Results: A total of 18 articles were included, comprising 2 clinical decisions, 7 clinical practice guidelines, 4 expert consensuses, and 5 systematic reviews. Twenty-two pieces of evidence were extracted across five aspects: pre-exercise assessment, exercise type, exercise intensity and duration, health education, and precautions.

Conclusion: Exercise is an effective intervention for maintaining and improving bone mineral density levels and preventing and delaying the progression of post-

menopausal osteoporosis. Healthcare professionals can refer to the best evidence, combine it with clinical practice, consider patient preferences, and provide personalized and reasonable exercise guidance for patients with postmenopausal osteoporosis to reduce the incidence of falls and fractures and improve quality of life.

Full Text

Evidence Summary of Exercise Intervention for Postmenopausal Osteoporosis Patients

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Abstract

Background: Exercise represents one of the most economical and effective interventions for preventing and treating postmenopausal osteoporosis (PMOP). However, current evidence remains extensive yet fragmented, lacking a standardized and comprehensive exercise guidance protocol.

Objective: To systematically search for, evaluate, and summarize the best available evidence regarding exercise interventions for PMOP patients.

Methods: We systematically searched BMJ Best Practice, UpToDate, DynaMed, NICE, GIN, SIGN, NGC, RNAO, IOF, NOGG, NOF, RACGP, ACOG, SOGC, Medlive Guidelines Network, JBI, Cochrane Library, CINAHL, Web of Science, PubMed, Embase, CNKI, and CBM for clinical practice guidelines, clinical decision support tools, evidence summaries, expert consensus statements, and systematic reviews on exercise interventions for PMOP. The search timeframe spanned from database inception to January 2022.

Results: Eighteen articles were included, comprising 2 clinical decision support tools, 7 clinical practice guidelines, 4 expert consensus statements, and 5 systematic reviews. Twenty-two evidence items were extracted across five domains: pre-exercise assessment, exercise types, exercise intensity and duration, health education, and precautions.

Conclusion: Exercise is an effective intervention for maintaining and improving bone mineral density levels while preventing and delaying PMOP progression. Healthcare professionals should reference this best evidence, integrate it with clinical practice, and consider patient preferences to provide personalized, rational exercise guidance for PMOP patients, thereby reducing fall and fracture incidence and improving quality of life.

Keywords: Osteoporosis, postmenopausal; Exercise therapy; Evidence summary; Best evidence; Evidence-based medicine

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Postmenopausal osteoporosis (PMOP) is a degenerative skeletal disease characterized by decreased estrogen levels following menopause, leading to reduced bone mass, disrupted bone microarchitecture, and diminished bone strength with increased fracture risk. It represents the primary form of primary osteoporosis, where bone strength encompasses both bone mineral density and bone quality. Epidemiological surveys indicate that PMOP prevalence in China ranges from 9.4% to 37.9%, with over 40% of affected individuals experiencing osteoporotic fractures. PMOP-related fractures can result in pain, depression, loss of functional independence, reduced quality of life, and increased economic burden and mortality. Current PMOP management primarily relies on pharmacotherapy; however, due to safety concerns, high costs, and poor patient compliance, fewer than one-quarter of patients in China receive drug treatment.

Multiple studies demonstrate that exercise, as one of the most economical and effective interventions for PMOP prevention and treatment, not only generates mechanical stimuli that promote bone formation and reduce bone resorption but also improves muscle strength, coordination, and balance while regulating the endocrine system and increasing estrogen levels. These effects collectively maintain and improve bone mineral density, prevent and delay PMOP progression, and reduce fall and fracture risks. Nevertheless, existing PMOP guidelines predominantly focus on diagnosis and pharmacotherapy, with content that is extensive and evidence fragmented, lacking standardized and comprehensive exercise guidance protocols that would enable healthcare professionals to scientifically direct PMOP patients in exercise training. Therefore, this study employed evidence-based methodology to systematically search for, evaluate, and synthesize relevant evidence to provide a foundation for clinical practice regarding exercise interventions for PMOP patients.

1.1 Literature Inclusion and Exclusion Criteria

We constructed the evidence summary question using the PIPOST framework. **Population (P):** Postmenopausal osteoporosis patients or women with PMOP prevention needs. **Intervention (I):** Various exercise measures related to PMOP. **Professionals (P):** Clinical healthcare providers. **Outcomes (O):** Bone mineral density values at different sites, fall and fracture risk. **Setting (S):** Hospital, community, or home environments. **Type of evidence (T):** Clinical decision support tools, clinical practice guidelines, expert consensus statements, and systematic reviews. Exclusion criteria comprised conference abstracts, incomplete literature information, unobtainable full texts, superseded versions, and literature focusing on drug selection, hormone therapy, or other non-exercise PMOP interventions.

1.2 Search Strategy

Following the "6S" model of evidence resources and employing a top-down search approach, we searched: (1) Clinical decision support systems: BMJ Best Practice, UpToDate, DynaMed; (2) Guideline repositories, professional association websites, and evidence summaries: NICE, GIN, SIGN, NGC, RNAO, IOF, NOGG, NOF, RACGP, ACOG, SOGC, Medlive Guidelines Network, and JBI; (3) Systematic review and journal databases: Cochrane Library, CINAHL, Web of Science, PubMed, Embase, CNKI, and CBM. For clinical decision support systems and guideline repositories, Chinese search terms included "menopause/osteoporosis/exercise" and English terms included "postmenopausal/osteoporosis/exercise." For systematic review and journal databases, we combined MeSH terms and free-text terms using "osteoporosis/osteopenia/OP/bone loss/bone mineral density," "postmenopause/postmenopausal/menopause," and "exercise/training/sports/exercise therapy/physical activity/vibration/resistance training" as English search terms, with corresponding Chinese equivalents. The search timeframe extended from database inception to January 2022.

1.3 Literature Quality Assessment Standards

We used the Critical Appraisal for Summaries of Evidence (CASE) instrument developed by Foster et al. (2013) to evaluate clinical decision support tools, comprising 10 items rated as "yes," "partial yes," or "no." Guidelines were assessed using the Appraisal of Guidelines for Research and Evaluation (AGREE II) instrument, which includes six domains: scope and purpose, stakeholder involvement, rigor of development, clarity of presentation, applicability, and editorial independence. Domain scores were calculated as the sum of item scores standardized as a percentage of the maximum possible score. Recommendations were classified as: Grade A (strong recommendation) if >60% in all domains, Grade B (general recommendation) if $ $3 domains scored >30%, and Grade C (not recommended) if $ $3 domains scored <30%. Systematic reviews were evaluated using the JBI Critical Appraisal Checklist for Systematic Reviews, and expert consensus statements were assessed using the JBI Critical Appraisal Checklist for Text and Opinion Papers (2016). Guidelines were appraised by three researchers trained in evidence-based methodology, with other literature evaluated by two researchers; disagreements were resolved through discussion with a third researcher.

1.4 Evidence Synthesis and Grading

Evidence derived from clinical decision support tools, guidelines, systematic reviews, and expert consensus statements was synthesized. For consistent evidence from different sources, we translated and integrated items without altering their original meaning. For conflicting evidence, we traced back to original studies and prioritized high-quality, recently published evidence. All evidence

was graded using the JBI Evidence Pre-grading System (2014 edition), which classifies evidence levels from 1a to 5c based on the study design hierarchy.

2.1 Literature Screening Results

The search yielded 1,477 articles. After removing duplicates, 1,055 articles remained. Title and abstract screening left 58 articles, and full-text review ultimately included 18 articles: 7 guidelines, 2 clinical decision support tools, 4 expert consensus statements, and 5 systematic reviews. The literature screening process is illustrated in [Figure 1: see original paper], and general characteristics of included studies are presented in .

2.2 Literature Quality Assessment Results

All seven guidelines demonstrated high quality and were retained. Three researchers independently assessed each guideline using AGREE II, with intraclass correlation coefficients (ICC) exceeding 0.75 for all seven guidelines, indicating high inter-rater reliability. Specific domain scores and overall quality ratings are presented in .

The two clinical decision support tools were rated high quality and retained, though all scored "no" on item 4 ("transparent and comprehensive search"), and Rosen [23] scored "partial yes" on item 3 ("clear and transparent review") and "unclear" on item 9 ("conflicts of interest").

All four expert consensus statements were rated high quality and retained. Giangregorio et al. [24] scored "yes" on all items, while the other three scored "no" only on item 6 ("consistency with previous literature").

Among the five systematic reviews, four scored "unclear"on item 6 ("independent quality assessment by $ $2 reviewers"), while Xu et al. [25] and Ponzano et al. [32] scored "no" on item 9 ("assessment of publication bias"). Kistler-Fischbacher et al. [29] and Marín-Cascales et al. [30] scored "unclear" on item 9. All other items were rated "yes." The reviews were detailed and of high quality, and were retained.

2.3 Evidence Summary

We synthesized evidence across five domains: pre-exercise assessment, exercise types, exercise intensity and duration, health education, and precautions, extracting 22 evidence items for PMOP exercise interventions ().

Pre-exercise assessment: 1. Evaluate comorbidities, medication history, and fracture/fall risk factors before exercise [24,26]. 2. Assess barriers and facilitators to physical activity, including current activity level, self-efficacy, pain severity, economic status, personal goals, and patient preferences to promote long-term adherence [23,24,26].

Exercise types: 3. Recommend diversified exercise programs emphasizing resistance training combined with weight-bearing, impact, aerobic, and balance exercises [1,15,16,17,20,21]. 4. Progressive resistance exercises (e.g., high leg lifts, barbell presses, squats, resistance band pulls, knee extensions, hip abduction/flexion, prone back extensions) are recommended to attenuate femoral neck bone loss [16,25,32]. 5. Combined resistance and impact exercises (e.g., jumping, stepping, rope skipping with weighted vests) represent optimal choices for maintaining and improving femoral neck and lumbar spine bone mineral density [16,17,28]. 6. Static weight-bearing (e.g., single-leg standing) can attenuate hip bone loss, while dynamic weight-bearing such as whole-body vibration (WBV) training may improve lumbar spine bone mineral density, mobility, and functional parameters [16,18-19,30]. 7. Weight-bearing aerobic exercises (e.g., walking, Tai Chi, jogging, tennis, volleyball, stair climbing, dancing) benefit bone mineral density and muscle strength, whereas non-weight-bearing activities like swimming and cycling offer limited skeletal benefits [15]. 8. Balance training (e.g., Tai Chi, dancing, tandem walking, book-balancing walks, sit-to-stand exercises) reduces fall frequency in PMOP patients [22,25]. 9. Traditional Chinese exercises (e.g., Baduanjin, Wuqinxi, Taijiquan) are recommended alone or combined with conventional exercises to improve bone mineral density, reduce pain, enhance balance, and decrease fall risk [18-19].

Exercise intensity and duration: 10. Weekly moderate-to-high intensity progressive resistance training is recommended, gradually increasing load to 65-85% of 1RM (one-repetition maximum), performing 2-3 sets of 8-12 repetitions [26,29,32]. 11. Combined resistance and impact exercises should last 30-60 minutes per session, 3 times weekly, for at least 10 months [28,31]. 12. Lifelong regular weight-bearing aerobic exercise is recommended (e.g., 30-minute walks including 5-10 minutes of cool-down stretching, or 30 minutes daily of moderate-to-high intensity balance training such as Tai Chi or social dancing, 3-4 times weekly) [1,26]. 13. Postmenopausal women should initiate and maintain long-term exercise as early as possible [28].

Health education: 14. Warm-up exercises (e.g., stretching and walking) should precede exercise sessions [27]. 15. PMOP patients should be encouraged to engage in regular, progressive, structured exercise [15,20]. 16. Previously sedentary individuals unfamiliar with resistance training or at high fracture risk should start with lower intensity and gradually progress [24]. 17. Provide safety training on exercise posture, range of motion, and lifting techniques [18-19].

Precautions: 18. Excessive exercise in premenopausal women may cause weight loss and amenorrhea, leading to osteoporosis [23]. 19. Advanced PMOP patients should participate in multicomponent group or home-based exercise programs focusing on fall prevention and physical therapy. 20. Patients with vertebral osteoporosis or kyphosis should avoid trunk flexion and rotation during daily activities (especially during bending, rowing, yoga, Pilates, bowling, and sit-ups) [1,24,26,27]. 21. High-fracture-risk patients, particularly those with vertebral osteoporosis, poor balance, or osteoarthritis, should avoid high-impact

activities requiring rapid, twisting, or sudden movements (e.g., racquet sports, golf, jumping), substituting with low-to-moderate intensity activities like brisk walking, stair climbing, or seated weightlifting [15,24,26]. 22. If post-exercise muscle soreness persists beyond 2 days, discontinue exercise; resume at reduced intensity after pain subsides [27].

3.1 Comprehensive Pre-Exercise Assessment Ensures Safety and Effectiveness

Evidence recommends evaluating PMOP patients' comorbidities, medication history, fracture/fall risk factors, current activity level, pain severity, and self-efficacy before exercise [24,26] to comprehensively understand their physical and psychological status. Internationally recommended fracture risk assessment tools include FRAX (Fracture Risk Assessment Tool), Garvan Fracture Risk Calculators, and QFracture Calculator [15,16], which evaluate clinical risk factors such as prior fracture history, family osteoporosis history, arthritis, and falls to stratify fracture risk and guide targeted exercise prescriptions. These tools demonstrate higher sensitivity than bone mineral density alone for predicting osteoporotic fractures in postmenopausal women and are widely used internationally, though their generalizability in Chinese populations requires validation through large-scale prospective studies [34]. In clinical practice, healthcare providers should combine fracture risk assessment results with bone mineral density values and bone turnover markers for multifaceted risk analysis, consulting physiotherapists or exercise specialists to develop exercise protocols for high-risk patients. Guidelines recommend using the Berg Balance Scale and Morse Fall Scale to assess balance and fall risk, and the Visual Analogue Scale for pain evaluation [18-19]. For patients with impaired balance or gait, exercise should be performed when sedative effects are minimal and cognitive/emotional status is optimal, ensuring environmental and patient safety. The Osteoporosis Self-Efficacy Scale (OSES) can assess patients' confidence in exercise behaviors, and incorporating patient needs and preferences can enhance exercise adherence.

3.2 Resistance-Based Combined Exercise is Recommended

Multiple high-quality evidence sources recommend diversified exercise programs emphasizing resistance training combined with weight-bearing, impact, aerobic, and balance exercises for PMOP patients [1,15,16,17,20,21]. Resistance training promotes bone formation and reduces resorption through muscle traction and gravitational stimuli, thereby increasing bone mineral density and muscle strength. Common modalities include weight-bearing resistance exercises and strength training equipment [18-19]. Single exercise modalities have limited effects on bone density enhancement; for example, walking improves physical function but has uncertain effects on bone mineral density and quality of life, requiring combination with resistance training for skeletal benefits [35]. Bone adaptation to stimuli is site-specific rather than systemic [7], and osteoporosis locations vary among patients, necessitating targeted exercise stimuli for specific

skeletal regions. Watson et al. demonstrated that high-intensity resistance combined with impact training (including jumping push-ups, squats, and sit-ups) effectively improved femoral neck and lumbar spine bone mineral density and back/leg muscle strength in PMOP patients [36]. Although recommended combined exercise types vary across evidence sources, all include resistance training as a core component. Therefore, evidence translation should involve individualized, targeted combined exercise interventions with resistance training as the foundation to maximize effectiveness. Emerging modalities such as whole-body vibration training remain controversial; while some studies demonstrate osteogenic effects from vibration-induced mechanical signals [18-19], others question the safety of high-intensity vibration regarding fall risk [17], likely due to variations in duration, frequency, and sample sizes across studies requiring further high-quality validation.

3.3 Long-Term Progressive Moderate-to-High Intensity Exercise is Recommended

Multiple high-quality evidence sources indicate that progressive moderate-to-high intensity exercise provides effective skeletal stimuli, promotes estrogen secretion, and optimally enhances bone formation and bone mineral density as intensity gradually increases with skeletal adaptation [15,17,25,26,29,32]. However, excessive intensity may cause endocrine dysfunction and degenerative joint changes. Guidelines recommend at least 150-300 minutes of moderate-intensity or 75-150 minutes of high-intensity exercise weekly, or a combination thereof [17], including resistance plus impact exercises (30-60 minutes, 3 times weekly) and weight-bearing aerobic or balance training (30 minutes, 3-4 times weekly) for a minimum duration of 10 months [27,28,31]. Hettchen et al. validated these recommendations through a 13-month intervention in PMOP patients involving 4 days weekly of 60-minute progressive high-intensity exercise (60-85% 1RM), including jumping step-ups, barbell lifts, back extensions, and aerobic dance, which significantly improved lumbar spine bone mineral density [37]. Currently, few high-intensity exercise intervention studies for PMOP patients exist in China; therefore, implementing these recommendations requires individualized adjustment of exercise duration and frequency based on patient status, with additional comparative studies needed to establish culturally adapted interventions.

3.4 Health Education Promotes Exercise Adherence

Evidence recommends providing PMOP patients with exercise-related health education [18-19] emphasizing long-term regular exercise, pre-exercise warm-up, and exercise safety. This recommendation is highly practical because exercise interventions, unlike pharmacotherapy, require sustained practice before producing significant changes. Health education can enhance patient understanding of PMOP exercise interventions, improve self-efficacy, reduce exercise-related fear, promote adherence, ensure adequate exercise dosage, and prevent injuries from

falls or excessive loading [15]. Studies show that patients are more likely to maintain exercise programs under physiotherapist or exercise specialist supervision without adverse events [38]. When instructing PMOP patients, providers must address site-specific fracture risks; for example, patients at high risk for vertebral fractures with back pain should avoid flexion and rotation exercises to reduce spinal compressive loads, instead performing extension exercises in supine or prone positions. Traditional text-based health education lacks visual appeal and patient acceptance; more effective approaches include group lectures, videos, and WeChat links combining graphics and text to enhance engagement and motivation.

4 Limitations

This evidence summary provides a theoretical foundation for exercise interventions in PMOP patients but has several limitations. First, only Chinese and English literature was included, potentially omitting high-quality studies in other languages. Second, evidence recommendation levels were not determined. Third, most included literature originated from foreign sources. Finally, some evidence was low-level and remains controversial. Therefore, healthcare professionals should consider clinical context when applying these findings and select evidence judiciously. Future domestic research should identify exercise types, intensities, and durations that are more acceptable and effective for Chinese PMOP populations to develop culturally adapted exercise guidance protocols.

Author Contributions: Wang Xixi, Shen Rui, and Xu Niying developed the search strategy, conducted literature searches, screening, and quality appraisal. Wang Xixi extracted and synthesized evidence and drafted the manuscript. Wang Junjie revised the manuscript, provided quality control, and assumed overall responsibility for the article.

Conflict of Interest: The authors declare no conflict of interest.

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Note: Figure translations are in progress. See original paper for figures.