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Systematic Review

Effect of Aerobic Exercise on Dynamic Balance in Menopausal Women: A Systematic Review

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ABSTRACT

Background: *Menopause is a natural biological phase in women characterized by a decline in estrogen levels, which contributes to musculoskeletal deterioration and impaired balance function. Reduced dynamic balance in menopausal women increases the risk of falls and may affect functional independence. Aerobic exercise has the potential to serve as a non-pharmacological intervention to improve postural stability and neuromuscular function. This study aimed to systematically review the effects of aerobic exercise on improving dynamic balance in menopausal women.*

Methods: *This study employed a systematic literature review based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Literature searches were conducted in Google Scholar, Semantic Scholar, and PubMed databases for articles published between 2015 and 2025. The inclusion criteria included experimental studies involving menopausal or postmenopausal women receiving aerobic exercise interventions with outcomes related to balance, mobility, or fall risk. Studies were excluded if they were reviews, conference papers, non-experimental designs, did not involve aerobic exercise, or had incomplete data.*

Results: *Four studies met the inclusion criteria. The findings indicated that aerobic exercise, either as a standalone intervention or combined with strength and balance training, was associated with improvements in dynamic balance, functional mobility, and a reduction in fall risk among menopausal and postmenopausal women.*

Conclusion: *Aerobic exercise is effective in improving dynamic balance in menopausal women and may be recommended as a non-pharmacological physiotherapy intervention to prevent balance decline and reduce fall risk.*

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INTRODUCTION

Menopause constitutes a natural biological epoch, principally defined by the cessation of menses for an uninterrupted duration of no less than twelve consecutive months. This physiological state arises from diminished concentrations of the hormones oestrogen and progesterone, thereby demarcating a female's transition from the

reproductive to the non-reproductive continuum (Meutia et al., 2024). The chronological age at which this phenomenon manifests is subject to variance; however, it customarily transpires between the ages of 45 and 55, with the global median resting at approximately 51 years. Within the Republic of Indonesia, the customary onset spans from 51 to 54 years of age (Aulya et al., 2024). The physiological alterations inherent to this juncture are frequently concurrent with sundry somatic afflictions, encompassing musculoskeletal derangements and a discernible attenuation in motor functionality, which may profoundly subvert corporeal equilibrium (Norfitri & Zubaidah, 2024).

On a global scale, projections suggest that upwards of one billion females shall enter menopause by the year 2025, constituting approximately 12% of the terrestrial populace (Rehman et al., 2024). Across the Asian continent, the demographic of menopausal females has registered a conspicuous expansion escalating from 107 million to 373 million individuals over recent decades with an anticipated trajectory of further augmentation (Roseyanti et al., 2023). A parallel circumstance is observed in Indonesia, wherein the populace of menopausal females equated to roughly 14 million individuals in 2022, representing 14% of the national populace, and is forecast to swell to 60 million by 2025 (Mauliati & Kurniawati, 2022). Such an escalation irrefutably designates menopause as a demographic phenomenon bearing extensive ramifications for public health.

The diminution of oestrogen concentrations during the menopausal transition operates as the cardinal physiological catalyst precipitating musculoskeletal derangements and a concomitant deterioration in the body's capacity to preserve equilibrium. Such an infirmity demonstrably amplifies the peril of postural instability and subsequent fall events amongst females aged 50 to 65 years (Van Iseghem et al., 2023). Subsequent to their fortieth year, females endure an annual skeletal mass depletion of approximately 0.5%, a figure which precipitously accelerates to 3% per annum upon the onset of menopause (Chan et al., 2024). Furthermore, the menopausal phase is hallmarked by an accretion of intra-abdominal adiposity, overall ponderal augmentation, and a discernible degradation in both muscular mass and sheer fortitude (Espírito Santo et al., 2021). This depletion of osseous mass, when coupled with impaired neuromuscular proficiency, irrevocably heightens the susceptibility to falls (Ahisha & Paker, 2025).

Furthermore, menopause is intimately correlated with a decline in oestradiol levels, which subsequently incites muscular degeneration, a diminution of both muscular volume and utility, and a heightened prevalence of sarcopenia (Geraci et al., 2021). The attenuation of oestrogen during the nascent postmenopausal phase concurrently escalates bone resorption, thereby serving as a precursor to osteoporosis (Charde et al., 2023). The amalgamation of sarcopenia and osteoporosis termed the osteosarcopenia phenotype further exacerbates the probability of falls and engenders deleterious clinical outcomes for the postmenopausal demographic (Zhu et al., 2024). Confounding variables, including muscular debility, vestibular perturbations, curtailed mobility, and visual impairments, exert a direct and detrimental influence upon functional mobility and the retention of equilibrium amidst quotidian exertions.

Equilibrium is defined as the organism's intrinsic aptitude to uphold postural stability across both static and dynamic modalities. Dynamic equilibrium, specifically, denotes the capacity to sustain corporeal alignment whilst executing movements or navigating positional transitions; it remains a quintessential requisite for the preservation of autonomy in daily living (Laspa et al., 2020). Extant literature elucidates that roughly 58.1% of postmenopausal females afflicted with sarcopenia exhibit a prodigious

degradation in equilibrium, as quantified by the Berg Balance Scale (BBS) and the Timed Up and Go Test (TUG) (Lee et al., 2024).

This attenuation of dynamic balance is inexorably tethered to an augmented susceptibility to falls and a concomitant erosion in the quality of life. Structured physical exertion stands as a paramount stratagem for the amelioration of balance, the enhancement of physical robustness, and the mitigation of fall risks within the geriatric cohort (Zhao et al., 2020). From a physiological standpoint, physical training refines neuromuscular efficacy by virtue of optimized synchronization between the neurological circuitry and the musculature, thereby imparting a highly propitious effect upon postural governance and somatic stability. Moreover, physical exertion is instrumental in fortifying the musculature of the lower extremities, a factor that contributes unequivocally to the enhancement of dynamic equilibrium (Zhao et al., 2020).

Within the purview of physiotherapeutic praxis, physical conditioning most notably aerobic exertion is enshrined as an integral facet of promotive, preventative, curative, and rehabilitative endeavours designed to cultivate, preserve, and rehabilitate locomotive functionality throughout the human lifespan, as formally codified in the Regulation of the Minister of Health of the Republic of Indonesia Number 80 of 2013. A multiplicity of scholarly investigations has evidenced that low-impact and aerobic regimens are efficacious in augmenting muscular potency and equilibrium amongst females, irrespective of their menopausal classification (Svensen et al., 2025; Utami et al., 2020).

Nevertheless, whilst diverse modalities of physical conditioning spanning resistance training, balance regimens, and composite aerobic protocols have been exhaustively scrutinised, the empirical literature pertaining specifically to the efficacy of aerobic exercise upon dynamic equilibrium in menopausal females remains fragmentary and has yet to be subjected to systematic synthesis (Walsh, 2021). This circumstance illuminates a salient lacuna within the academic discourse, underscoring the imperative for a systematic appraisal to amalgamate and appraise the extant empirical data. Consequently, the overarching objective of this systematic literature review is to rigorously and comprehensively interrogate the scientific evidence concerning the restorative impact of aerobic exercise on the enhancement of dynamic equilibrium in menopausal women.

Despite the growing number of studies on exercise interventions in menopausal women, most research has focused on general outcomes such as bone density, cardiovascular fitness, and overall physical performance. Evidence specifically examining the role of aerobic exercise in improving dynamic balance in menopausal women remains limited and has not been systematically synthesized. Therefore, the novelty of this study lies in its focus on evaluating the specific contribution of aerobic exercise to dynamic balance among menopausal women through a systematic literature review.

The aim of this study is to systematically review and synthesize scientific evidence regarding the effects of aerobic exercise on dynamic balance in menopausal and postmenopausal women. This study contributes to the existing literature by providing evidence-based insights into the potential role of aerobic exercise as a non-pharmacological intervention to improve dynamic balance and reduce fall risk in menopausal women, which may support physiotherapists and health practitioners in developing appropriate exercise programs.

MATERIALS AND METHOD

Research Design

The present scholarly undertaking employed a systematic literature review methodology, meticulously predicated upon the strictures of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. The implementation of the PRISMA directives was mandated to guarantee that the explication of this systematic review was executed in an eminently structured, pellucid, and methodical fashion. Such rigorous adherence unequivocally augments both the scholarly calibre and the empirical reproducibility of the resultant syntheses (Page et al., 2021).

Population and Sample

The overarching population for this inquiry comprised scholarly treatises concerning the interplay between aerobic exertion and dynamic equilibrium amongst menopausal females, painstakingly collated from a multiplicity of electronic academic repositories. The definitive sample of this investigation was constituted by those select manuscripts that successfully navigated a rigorous distillation process, governed by strictly predetermined inclusionary and exclusionary parameters. The precise criteria dictating said inclusion and exclusion are comprehensively delineated within Table 1.

Table 1. Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Publication year	Articles published within the last 10 years (2015 2025)	Articles published more than 10 years ago (<2015)
Study design	Experimental studies such as randomized controlled trials, quasi-experimental studies, or pretest-posttest designs	Non-experimental studies such as cross-sectional studies, observational studies, qualitative studies, case reports, or literature reviews
Type of intervention	Studies using aerobic exercise as the main intervention, either as a single intervention or combined with other non-pharmacological interventions	Studies that did not use aerobic exercise interventions
Study population	Women in the perimenopause, menopause, or postmenopause phase	Populations other than perimenopausal, menopausal, or postmenopausal women
Outcome	Dynamic balance or related indicators (*postural balance, functional balance, gait, fall risk, mobility*)	Studies that did not assess balance or only evaluated other outcomes such as bone density, cardiovascular outcomes, or hormonal outcomes
Article language	Articles written in Indonesian or English	Articles written in languages other than Indonesian and English
Article access	Articles available in full text	Articles that could not be accessed in full text

Materials and Research Tools

The systematic interrogation of the literature was executed across a triumvirate of scholarly electronic repositories, to wit: Google Scholar, Semantic Scholar, and PubMed, achieved through the strategic amalgamation of highly pertinent terminology. These databases were selected because they provide extensive coverage of biomedical, health science, and interdisciplinary research. PubMed is widely recognized as one of the most authoritative databases for medical and health-related literature, ensuring access to peer-reviewed and high-quality publications. The foundational nomenclature deployed encompassed the phrases "aerobic exercise," "dynamic balance," and "menopause," supplemented by an array of cognate expressions. The orchestration and syntactical grouping of these lexica were meticulously calibrated to concurrently expand and distil the investigative yield in strict accordance with the stipulated aims of this review, entailing bespoke modifications requisite for the idiosyncratic architecture of each respective database.

Collection or Research Stages

The triage of scholastic manuscripts within this systematic literature review adhered assiduously to the precepts of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The preliminary canvassing yielded an aggregate of 288 manuscripts. Subsequent to the purgation of duplicated records, a corpus of 275 treatises was retained. A rigorous filtration predicated upon the scrutiny of titles and abstracts precipitated the elimination of 271 documents, owing to their failure to satisfy the preordained inclusionary strictures.

The residual quartet of articles was subsequently subjected to an exhaustive full-text appraisal, whereupon all four unequivocally satisfied the requisite criteria for advanced scrutiny. Ergo, four manuscripts were assimilated into the ultimate analytical synthesis of this review. In the present treatise, the systematic literature review (SLR) paradigm was harnessed to methodically unearth, distil, and isolate germane scholarship. This procedural architecture was demarcated by several cardinal phases: identification, screening, appraisal of eligibility, and final incorporation, as visually delineated in Figure 1.

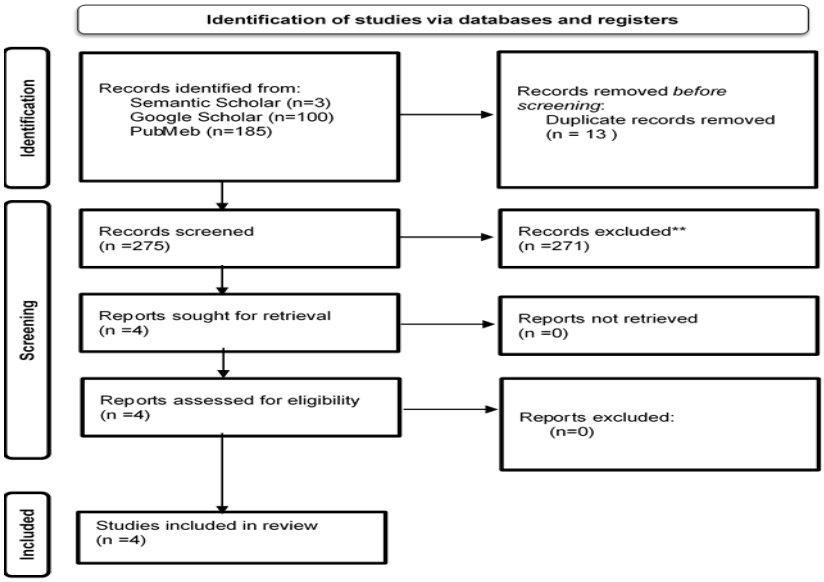


Figure 1. Systematic literature review diagram

In the present treatise, the systematic literature review (SLR) paradigm was harnessed to methodically unearth, distil, and isolate germane scholarship. This procedural architecture was demarcated by several cardinal phases: identification, screening, appraisal of eligibility, and final incorporation, as visually delineated in Figure 1.

Phase I: Identification of Studies

During the inaugural phase of identification, a comprehensive trawling of the literature was enacted across the aforementioned electronic repositories namely, Semantic Scholar, Google Scholar, and PubMed. This investigative foray culminated in the procurement of 288 articles *in toto*, comprising a distribution of 3 records originating from Semantic Scholar, 100 from Google Scholar, and 185 courtesies of PubMed.

Phase II: Extirpation of Duplicates

The entirety of the identified corpus was thereafter subjected to exacting scrutiny to excise any redundant entries. During this juncture, 13 duplicate manuscripts were successfully expunged, thereby bequeathing a refined repository of 275 articles poised for the ensuing screening phase.

Phase III: Triage of Titles and Abstracts

The surviving sum of 275 articles underwent rigorous evaluation predicated solely upon their titles and abstracts, to ascertain their alignment with the topical imperatives and overarching objectives of this inquiry. The outcome of this vetting process necessitated the exclusion of 271 manuscripts, as their thematic substance was deemed incongruent with the focal paradigm of the research. Consequently, a mere four articles were deemed of sufficient merit to progress to the subsequent evaluative tier.

Phase IV: Exhaustive Full-Text Appraisal

The four treatises that successfully navigated the preliminary screening were subsequently subjected to a comprehensive full-text review. Each manuscript was successfully procured in its entirety and rigorously appraised against the preordained eligibility criteria; zero exclusions were necessitated at this advanced juncture.

Phase V: Final Assimilation of Studies

Predicated upon the meticulous assessment of eligibility, all four scrutinised articles unequivocally satisfied the requisite inclusionary benchmarks. Consequently, they were formally subsumed as the foundational studies undergoing critical analysis within this systematic literature review.

Data Analysis

All included studies were analyzed using a narrative synthesis approach. Methodological quality was assessed using the critical appraisal tools from the Joanna Briggs Institute according to each study design. Randomized controlled trials were evaluated using the JBI Critical Appraisal Checklist for Randomized Controlled Trials, while quasi-experimental or pre–post studies were assessed using the JBI Critical Appraisal Checklist for Quasi-Experimental Studies (Barker et al., 2024).

The appraisal process was conducted independently by two reviewers (KSSM and SPG) to ensure objectivity and reduce potential bias. Both reviewers hold postgraduate

training in health sciences and have experience in evidence-based research and systematic review methodology. Each checklist item was rated as “Yes”, “No”, or “Unclear”. Any disagreement between reviewers was resolved through discussion until consensus was reached.

Table 2. Quality appraisal for randomized controlled trials

Article	Questions													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Marques et al., 2023	Y	Y	Y	Y	TJ	Y	TJ	Y	Y	Y	Y	Y	Y	11
Eslamian et al., 2015	Y	Y	Y	Y	T	Y	TJ	Y	Y	T	Y	Y	Y	10

Notes:
Y = Yes (1); T = No (0); TJ = Unclear (0)
Footnote:
The study by Marques et al. (2023) used a combined training program that included aerobic and strength components. Therefore, the specific contribution of aerobic exercise to dynamic balance could not be fully isolated and the results should be interpreted cautiously.

Table 3. Quality appraisal for quasi-experimental studies

Article	Questions									Total
	1	2	3	4	5	6	7	8	9	
Anek &Bunyaratavej, 2015	Y	Y	TJ	T	Y	Y	Y	Y	T	6
Martínez-Carbonell et al. (2024)	Y	Y	T	T	Y	Y	Y	Y	T	6

Notes:
Y = Yes (1); T = No (0); TJ = Unclear (0)

RESULTS

Based on the article selection process using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, four studies that met the inclusion criteria were analyzed in this systematic literature review. These studies consisted of two randomized controlled trials (RCT) and two quasi-experimental studies involving menopausal and postmenopausal women aged 50 79 years. In general, all studies showed a consistent pattern of findings indicating improvements in dynamic balance and functional mobility after aerobic exercise interventions compared with control groups or pre-intervention conditions. Aerobic exercise was reported to be beneficial when provided as a single intervention as well as when included as part of a combined exercise program involving strength and balance training. Several studies applied multicomponent interventions; therefore, the observed effects could not be fully attributed to aerobic exercise alone.

Nevertheless, the findings indicate that the presence of an aerobic component in exercise programs contributes to improvements in dynamic stability, postural control, and a reduction in fall risk among postmenopausal women. In addition, there was a tendency for higher exercise frequency to be associated with more optimal dynamic balance outcomes, as reported in studies with exercise frequencies of three sessions per week compared with two sessions per week. Overall, these findings indicate the potential of aerobic exercise to support improvements in dynamic balance among menopausal women, although the results should be interpreted cautiously due to variations in intervention design and the involvement of multicomponent exercise programs.

Table 4. Summary of reviewed studies

No.	Author & Year	Design	Population	Intervention	Comparison Group	Duration	Measurement Tools	Results
1	A. Kaur et al. (2023)	Randomized Clinical Trial	Postmenopausal women aged 50 79 years (mean 59.3 ± 8.0)	Combined aerobic and strength training supervised by professionals	Control group without exercise	16 weeks	Dynamic and static stability, gait speed, muscle strength, aerobic capacity, body composition	Aerobic strength exercise potentially improves dynamic stability, postural control, and gait performance in postmenopausal women, although some results should be interpreted cautiously due to low statistical power
2	Anek & Bunyaratavej (2015)	Quasi-experimental study (*pre-test and post-test control group design*)	Community-dwelling postmenopausal women aged 50 65 years	*Circuit aerobic step* program combining aerobic exercise, light lower-extremity and trunk strengthening, and balance training	Control group without exercise program	8 weeks (3×/week)	*Berg Balance Scale* (BBS), *Timed Up and Go Test* (TUG), lower extremity muscle strength	The *circuit aerobic step* program improved postural balance, reduced fall risk, and increased lower-extremity muscle strength in postmenopausal women
3	Martínez-Carbonell et al. (2024)	Comparative experimental study (*quasi-experimental*)	Community-dwelling postmenopausal women aged 50 70 years	Multicomponent training including aerobic, strength, balance,	Training frequency 2×/week vs 3×/week	12 weeks	*Timed Up and Go Test*, *Functional Reach Test*, muscle strength,	Both groups showed improvements in balance and physical fitness, but the 3×/week training frequency produced greater

No.	Author & Year	Design	Population	Intervention	Comparison Group	Duration	Measurement Tools	Results
				coordination, and flexibility exercises			aerobic capacity, BMI	improvements, particularly in dynamic balance and TUG
4	Eslamian et al. (2015)	Randomized Controlled Trial	90 postmenopausal women with severe osteopenia and primary osteoporosis aged 50 59 years	*Weight-bearing aerobic exercise* (60 80% HRmax) and strengthening exercises using *theraband* and weights	Control group receiving medication without exercise	9 months	Balance (*Biodex Balance System*, TUG), bone mineral density (DXA), quality of life (SF-36)	Aerobic and strengthening exercises improved balance and quality of life compared with controls, with greater improvements in dynamic balance in the aerobic exercise group

DISCUSSION

The empirical synthesis derived from this systematic literature review delineates the instrumental function of aerobic exertion in the amelioration of dynamic equilibrium amongst menopausal females. Such statements are incontrovertibly congruent with established physiological paradigms, which posit that the precipitous attenuation of oestrogen concentrations intrinsic to the menopausal transition precipitates a concomitant degradation in muscular mass, sheer corporeal fortitude, and neuromuscular efficacy; these deficits consequently subvert the organism's intrinsic capacity to preserve equilibrium. Aerobic conditioning serves to rectify these physiological detriments by means of refining neuromuscular synchrony, augmenting the muscular robustness of the lower extremities, and bolstering postural governance amidst dynamic kinematic undertakings.

The quantifiable enhancements in dynamic equilibrium chronicled across the scrutinised literature are ostensibly tethered to the robust stimulation of the sensorimotor apparatus, a phenomenon inherently induced by aerobic exertion. Aerobic modalities most notably those necessitating iterative locomotive patterns and weight-bearing configurations possess the profound capacity to optimize the synthesis of the visual, vestibular, and proprioceptive networks, thereby fortifying postural stability throughout locomotive execution. This enhancement is empirically mirrored in the elevated metrics of the Berg Balance Scale (BBS) and the Timed Up and Go Test (TUG), as chronicled in antecedent scholarly investigations (Lorenzo-García et al., 2024).

From a practical standpoint, these findings carry significant implications for clinical and community-based physiotherapy practice. Aerobic exercise may be regarded as a feasible, accessible, and cost-effective non-pharmacological intervention to enhance dynamic balance and mitigate fall risk among menopausal women. The incorporation of structured aerobic training into rehabilitation programs or preventive health strategies may support the maintenance of functional independence and overall quality of life in this population. Furthermore, the integration of aerobic exercise within multicomponent training programs appears to offer additional benefits, suggesting that a holistic approach addressing strength, balance, and endurance may yield more optimal outcomes (Zhao et al., 2020).

Furthermore, aerobic training engenders substantive advancements in both the muscular fortitude of the lower appendages and holistic aerobic capacity, both of which constitute quintessential determinants in the preservation of dynamic equilibrium. Martínez-Carbonell et al. (2024) have formally articulated that an escalated frequency of physical conditioning yields correspondingly superior advancements in equilibrium proficiency, thereby intimating a putative dose-response corollary betwixt the intensity or periodicity of exertion and the resultant amelioration of balance functionality. These empirical revelations unequivocally undergird clinical prescriptions advocating for habitual physical exertion as an indispensable constituent of fall-mitigation stratagems tailored for the postmenopausal demographic (Geraci et al., 2021).

Moreover, the amalgamation of aerobic regimens with concurrent strength and balance conditioning ostensibly precipitates more superlative clinical outcomes than interventions predicated solely upon a singular modality of exercise. Such a multifaceted methodological stratagem affords the simultaneous cultivation of diverse facets of somatic utility, encompassing sheer strength, intricate coordination, and resolute postural stability. This paradigm is of paramount relevance to menopausal females, who are

habitually encumbered by a deleterious convergence of sarcopenia, compromised osseous density, and an overarching impairment of equilibrium (Hsu et al., 2024).

Nevertheless, several limitations inherent to this review must be acknowledged. The relatively limited number of included studies, coupled with heterogeneity in intervention protocols such as variations in exercise type, frequency, duration, and the incorporation of multicomponent training, constrains the generalisability of the findings. Additionally, the inclusion of studies employing combined exercise interventions precludes the precise isolation of the independent effects attributable solely to aerobic exercise. The restriction to English and Indonesian language publications may have also introduced a degree of publication bias, thereby potentially excluding pertinent evidence from other sources.

In light of these findings, future research is warranted to strengthen the existing body of evidence through the implementation of high-quality randomized controlled trials with larger sample sizes and standardized intervention protocols. Further investigations should aim to elucidate the isolated effects of aerobic exercise, as well as to determine the optimal frequency, intensity, and duration of training required to achieve maximal improvements in dynamic balance. Additionally, exploring long-term outcomes and innovative delivery methods, such as home-based or technology-assisted exercise programs, may enhance adherence and broaden accessibility for menopausal populations.

CONCLUSION

Based on the existing body of scientific evidence, aerobic exercise demonstrates beneficial effects in improving dynamic balance among menopausal and postmenopausal women. Aerobic training, whether performed independently or combined with strength and balance exercises, is associated with improvements in postural stability, functional mobility, and a reduced risk of falls. In addition, studies indicate that higher exercise frequency and adequate duration contribute to greater optimization of dynamic balance. Therefore, aerobic exercise can be recommended as an effective non-pharmacological physiotherapy intervention to support balance maintenance and fall prevention in menopausal populations. Overall, this review provides an evidence-based foundation for developing community-based and clinical exercise programs for menopausal women and highlights the need for future research to determine the most effective and safe aerobic exercise protocols.

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DECLARATION OF USE OF AI IN SCIENTIFIC WRITING

AI tools were used solely for grammar and language editing. The authors take full responsibility for the content and integrity of the manuscript.

CONFLICT OF INTERESTS

The authors declare that they have no conflicts of interest that may have influenced the findings of this study.

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