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The Preventive Role of Resistance Training in Perimenopausal Women: A Literature Review

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Abstract

Background:
Perimenopause is associated with profound hormonal fluctuations that accelerate musculoskeletal decline, fat redistribution, and metabolic dysfunction in women. These changes increase the risk of sarcopenia, osteoporosis, and metabolic syndrome—conditions that substantially impair quality of life and elevate long-term morbidity. Despite the proven health benefits of physical activity, resistance training (RT) remains underutilized in this population.

Aim:
This review aimed to evaluate the role of resistance training as a preventive strategy against age-related muscle loss, bone density reduction, and metabolic disorders in perimenopausal women.

Material and Methods:
A narrative literature review was conducted using articles sourced from PubMed and Google Schoolar. Eligible studies included randomized controlled trials, systematic reviews, and meta-analyses published between 2010 and 2025, focusing on the impact of resistance training on bone mineral density, muscle mass and function, insulin sensitivity, and body composition in perimenopausal populations.

Results:
Resistance training was consistently associated with improved muscle mass, strength, and functional capacity, reducing the incidence and progression of sarcopenia. High-intensity RT protocols (≥70% 1-RM) also led to significant improvements in bone mineral density at critical skeletal sites. Moreover, RT enhanced basal metabolic rate, reduced visceral adiposity, improved insulin sensitivity, and positively influenced lipid profiles and systemic inflammation. Adherence was higher in supervised, flexible, and socially supportive environments.

Conclusions:
Resistance training is a potent non-pharmacological intervention that counteracts the adverse musculoskeletal and metabolic effects of perimenopause. Given its wide-ranging benefits and favorable safety profile, RT should be integrated as a foundational component of preventive healthcare strategies for midlife women. However, further high-quality research is warranted to refine population-specific protocols and improve implementation strategies.

Keywords: perimenopause, resistance training, sarcopenia, osteoporosis, metabolic syndrome

Introduction

Aging is a progressive process driven by interconnected biological mechanisms—referred to as "hallmarks"—such as genomic instability, mitochondrial dysfunction, telomere attrition, cellular senescence, and epigenetic alterations. These hallmarks not only impair cellular homeostasis and tissue function but also interact in self-reinforcing cycles that accelerate aging [1]. Although chronological age is a strong predictor of chronic disease, disability, and mortality, it does not uniformly reflect an individual's biological condition. Older adults exhibit wide variability in health status—while some experience significant physical decline by their 70s, others maintain functional independence and avoid major age-related deterioration even into very advanced age. This highlights the importance of factors beyond age alone, such as genetics, lifestyle, and physical activity, in determining aging outcomes.

On average, women have a longer life expectancy than men and tend to exhibit slower biological aging based on molecular biomarkers. However, this survival advantage is paradoxically accompanied by greater frailty and a higher burden of age-related disability near the end of life. Despite men generally demonstrating superior performance in physical function tests, women live longer—a disparity often referred to as the "male–female health-survival paradox." [2].

Current understanding of sex-specific aging patterns remains limited, in part due to historical underrepresentation of women in biomedical research. Safety concerns—particularly regarding reproductive health—and hormonal variability have often led to the exclusion of women from clinical trials [3]. This knowledge gap underscores the need for a more sex-specific approach in aging research and clinical prevention, particularly regarding conditions disproportionately affecting women, such as osteoporosis, sarcopenia, and metabolic syndromes in midlife and beyond. Understanding how lifestyle interventions—such as resistance training—interact with biological aging in women may open new avenues for health promotion and disease prevention.

Metabolic disorders such as central obesity, dyslipidemia, hypertension, and insulin resistance become increasingly prevalent with age and pose a significant health burden among middle-aged and older women. Notably, women between the ages of 55 and 64 exhibit the highest rates of metabolic syndrome, a trend linked to hormonal shifts during menopause and associated changes in body composition and vascular function hese age- and sex-specific vulnerabilities highlight the importance of early lifestyle interventions [4].

Sarcopenia and osteoporosis are other diseases that increase in likelihood with age. Sarcopenia refers to the progressive decline in muscle mass and strength that commonly occurs with aging, leading to reduced mobility, impaired physical performance, and a heightened risk of falls. This condition is driven by a gradual degeneration of α-motoneurons and insufficient reinnervation of muscle fibers, leading to a marked reduction in both the number and size of muscle fibers. Additionally, age-associated changes at the cellular level—such as impaired coordination between contractile proteins, mitochondria, and the sarcoplasmic reticulum—further compromise muscle quality and performance. Although sarcopenia affects both sexes, it presents a particularly important concern for aging women due to their generally lower baseline muscle mass and the added impact of hormonal changes during menopause [5].

Osteoporosis is a metabolic disorder characterized by decreased bone density and deterioration of bone microstructure, which increases bone fragility and susceptibility to fractures [6]. Traditionally, it has been viewed as a condition largely affecting postmenopausal women due to hormonal changes that accelerate bone loss during this period. Globally, women over 50 are affected by osteoporosis at rates nearly four times higher than men of the same age, making it the leading cause of fractures in the aging population [7,8].

Resistance training is particularly crucial for perimenopausal women as it effectively counteracts the age-related decline in muscle mass, bone density, and metabolic health that often accompanies hormonal changes. Implementing resistance training protocols—such as free weights, bodyweight exercises, or resistance bands—can therefore play a vital role in bolstering musculoskeletal integrity, reducing the risk of osteoporosis and sarcopenia, and improving metabolic function during midlife transitions [9].

Purpose

The purpose of this review is to critically examine the current scientific evidence regarding the role of resistance training in mitigating the physiological consequences of perimenopause. Specifically, the article aims to explore how resistance training influences muscle mass preservation, bone mineral density, and metabolic health in women undergoing the menopausal transition. By synthesizing findings from randomized controlled trials, meta-analyses, and clinical guidelines, the review seeks to highlight the preventive and therapeutic potential of structured resistance training protocols in reducing the risk of sarcopenia, osteoporosis, and metabolic disorders in perimenopausal women, while also identifying research gaps and informing future exercise recommendations.

1. Key physiological changes in perimenopausal women

Menopause is permanent cessation of menstruation after 12 months of amenorrhea. Naturally occurs between ages 45–56. The phase preceding it, known as **perimenopause**, usually spans 4 to 7 years but can extend up to 14 years. During this transition, the female body undergoes significant changes largely due to the gradual decline in ovarian activity and the resulting drop in estrogen and progesterone levels [10].

As perimenopause sets in, fluctuating hormone levels give rise to a wide array of distressing symptoms, including prolonged menstrual bleeding, mood disturbances such as anxiety and depression, weight gain, shifts in sexual desire, muscle pain, sleep difficulties, and vasomotor symptoms like hot flashes and night sweats.

1.1 Hormonal changes

Historically, **follicle-stimulating hormone (FSH)** has been used as a surrogate marker of ovarian reserve; however, its clinical utility is limited due to wide intra- and inter-individual variability and a lack of consistent correlation with menopausal symptoms. FSH levels may rise intermittently even years before menstrual irregularities begin, primarily in response to early declines in **inhibin B**, a peptide produced by ovarian granulosa cells that suppresses FSH through negative feedback. This rise in FSH during early perimenopause occurs independently of estradiol levels, which tend to decrease more significantly only during the late menopausal transition, as the frequency of anovulatory cycles increases.

In addition to inhibin B, a later reduction in **inhibin A** is also observed, marking further decline in follicular function. **Estradiol (E2)** levels, though often thought to steadily decline, actually fluctuate considerably in early perimenopause and only fall predictably closer to the final menstrual period (FMP). These hormonal shifts contribute to the onset of vasomotor symptoms, although symptom severity and timing do not always correlate directly with hormone concentrations.

Anti-Müllerian hormone (AMH) has emerged as a promising marker of ovarian reserve. Secreted by small antral follicles, AMH reflects the quantity of remaining follicles and declines gradually with age. While longitudinal studies suggest that changes in AMH can predict the timing of menopause within a four-year window, limitations in assay sensitivity currently preclude its routine clinical use [11].

Changes in **progesterone** and its urinary metabolites have also been documented across the transition, reflecting an increase in anovulatory cycles. Contrary to widespread belief, **androgens** such as testosterone do not decline sharply during perimenopause. Instead, reductions in **sex hormone-binding globulin (SHBG)** may lead to stable or even elevated free androgen levels. **DHEAS**, an adrenal androgen, may transiently increase in some women during the later stages of the transition [10].

1.2 Muscle mass decline and bone resorption

With aging, both muscle and bone mass naturally decline, elevating the risk of developing sarcopenia and osteoporosis later in life. Menopause-related hormonal fluctuations—particularly the reduction in estrogen—are a well-established factor contributing to bone loss by increasing bone turnover, where bone resorption outpaces bone formation [12]. Previous studies have consistently demonstrated a gradual decrease in hip bone mineral density (BMD) from the premenopausal to the postmenopausal stage, with this decline significantly associated with rising FSH levels or decreasing estradiol concentrations [13]. Some research also indicates that hormonal changes around menopause may contribute to a reduction in lean mass (LM) among middle-aged women, a process that appears to persist for up to two years following the final menstrual period [14].

1.3 Metabolic changes

The transition from premenopause to menopause—encompassing the perimenopausal period—is associated with profound alterations in body composition and metabolic health. A wealth of longitudinal evidence demonstrates that visceral adipose tissue (VAT) increases markedly during this phase, even before the final menstrual period, and contributes to escalating insulin resistance and metabolic risk. Prospective data from the SWAN-Heart Study and similar cohorts show that **VAT accelerates by approximately 6–8% per year**, beginning about two years prior to menopause, independent of chronological aging or total fat mass. In a four-year longitudinal observational study, only women who reached menopause experienced a **significant rise in VAT**, while both menopausal and uninterrupted premenopausal groups gained subcutaneous fat, though visceral accumulation was distinct to the menopausal transition [15].

Estrogen deficiency during the perimenopausal transition contributes to a shift in fat distribution from peripheral (gluteofemoral) regions to a more central pattern, favoring visceral and abdominal fat accumulation. This shift is partly due to the impaired regulation of lipoprotein lipase (LPL) activity—hypoestrogenemia reduces LPL stimulation in femoral adipocytes while simultaneously diminishing lipolysis in abdominal fat cells, ultimately promoting visceral fat storage. Additionally, the gradual loss of lean body mass commonly observed in this period leads to a decrease in resting metabolic rate. As a result, both energy expenditure and fat oxidation decline—not only at rest but also during physical activity—further increasing the risk of weight gain.

Estrogens also support glucose metabolism by enhancing insulin secretion, improving insulin sensitivity, and reducing inflammation through the suppression of cytokines like TNF-α and IL-6. During menopause, hypoestrogenemia weakens these protective effects, leading to increased insulin resistance and a higher risk of metabolic disturbances [16].

2. The Impact of Resistance Training on Health Outcomes in Perimenopausal Women

2.1. Mechanisms of resistance training in muscle hypertrophy and bone remodeling

Resistance training stimulates muscle hypertrophy through three primary mechanisms: mechanical tension, muscle damage, and metabolic stress. Mechanical tension generated during resistance exercises activates intracellular signaling pathways, particularly the mechanistic target of rapamycin (mTOR), which plays a central role in promoting protein synthesis and muscle growth. Muscle damage from training induces inflammatory responses that stimulate repair processes, while metabolic stress triggers hormonal and cellular adaptations. Additionally, resistance training activates satellite cells—muscle stem cells—that proliferate and differentiate, contributing new nuclei to muscle fibers, which supports muscle repair and enlargement.

In bone tissue, mechanical loading from resistance training applies strain that is sensed by osteocytes, the primary mechanosensors of bone. This stimulates osteocytes to signal osteoblasts, promoting bone formation and remodeling. Key signaling pathways, such as Wnt/β-catenin, are activated in response to mechanical strain, leading to increased production of bone matrix and mineralization. These cellular and molecular responses drive the adaptation of bone to mechanical load by increasing bone mass and strength [17].

2.2. Effects on basal metabolic rate and insulin sensitivity

Resistance training has been demonstrated to increase basal metabolic rate (BMR) in perimenopausal women primarily by promoting skeletal muscle hypertrophy. Since muscle tissue has a higher resting energy expenditure than adipose tissue, increased muscle mass elevates BMR, which may help counteract the metabolic slowdown commonly observed during perimenopause. Furthermore, resistance training improves insulin sensitivity by enhancing glucose uptake and utilization in skeletal muscles through increased expression of glucose transporter type 4 and improvements in mitochondrial function. These adaptations lead to better glycemic control and reduced insulin resistance, mitigating the risk of metabolic syndrome and type 2 diabetes prevalent in this population [18].

2.3. Anti-inflammatory effects and reductin of oxidative stress

Resistance training has been shown to modulate inflammatory responses and reduce oxidative stress, which are crucial factors in the health of perimenopausal women. A systematic review and meta-analysis published in 2024 investigated the impact of resistance training (RT) volume on body adiposity, metabolic risk, and inflammation in postmenopausal women. The study found that high-volume RT (approximately 77 sets/week) resulted in greater reductions in C-reactive protein (CRP) levels, a marker of systemic inflammation, compared to low-volume RT (approximately 44 sets/week). This suggests that more intensive RT may be more effective in reducing inflammation in this population [19].

3. Resistance Training and Sarcopenia Prevention

3.1. Definition and Relevance of Sarcopenia in Perimenopausal Women

Since Irwin Rosenberg first introduced the term in 1989, sarcopenia has been widely studied; however, a universally accepted definition, diagnostic threshold, and standard measurement protocol remain under development [20]. Contemporary research characterizes sarcopenia as a progressive, generalized loss of skeletal muscle mass and strength. Therefore, diagnosis requires both the quantification of muscle mass and an evaluation of muscle function [21].

The prevalence of sarcopenia among older adults ranges from **8% to 40%**, largely due to the use of varying diagnostic criteria across studies [22]. Sarcopenia is not exclusive to the very elderly; it can also be detected in middle-aged, independently mobile adults.

The onset of sarcopenia during perimenopause is characterized by a gradual decline in muscle mass and strength, often preceding the more pronounced effects observed in postmenopausal women. This early onset underscores the importance of early detection and intervention to mitigate the progression of sarcopenia and its associated risks, such as increased frailty, falls, and fractures.

Since sarcopenia primarily involves loss of skeletal muscle mass and function, appendicular lean mass (ALM) is commonly used as a key measurement to assess muscle quantity.

In a study of 144 women aged 30–70, appendicular lean mass index (ALMi) was significantly lower in late perimenopausal women (6.1 ± 0.8 kg/m^2) compared to early perimenopausal women (6.8 ± 0.8 kg/m^2). Sarcopenia prevalence (ALMi ≤ 5.67 kg/m^2) increased sharply from 3% in early perimenopause to 30% in late perimenopause. ALMi was inversely correlated with FSH levels ($r = -0.28$, $P = 0.003$), but not with estradiol. This underscores the importance of considering hormonal changes, particularly FSH elevations, in the early detection and management of sarcopenia during the perimenopausal period [23].

3.2. Resistance Training as a Preventive Strategy

Resistance training effectively combats sarcopenia, by stimulating muscle protein synthesis and promoting muscle hypertrophy. This helps counteract the natural decline in muscle mass that occurs with aging, improving both muscle strength and physical function.

Because there are currently no approved medications for sarcopenia, implementing resistance training (RT) alongside proper dietary measures is essential. According to the 2024 International Clinical Practice Guidelines for Sarcopenia (ICFSR), progressive RT performed 2–3 times per week, targeting all major muscle groups, significantly improves appendicular lean mass, muscle strength, and physical performance. These effects are mediated through enhanced neuromuscular recruitment, increased anabolic signaling (e.g., mTOR pathway activation), and improvements in motor function. Importantly, the benefits of RT are dose-dependent—higher training volumes produce more substantial gains in muscle mass and strength. Clinical trials cited in the guidelines consistently demonstrate that RT increases gait speed, grip strength, and chair-rise ability while reducing the risk of frailty. Given its robust efficacy, RT is strongly recommended as a frontline strategy to counteract the muscle decline observed in aging populations, including perimenopausal women [24].

3.3. Practical Approaches to Training

Training protocols: frequency, intensity, and type

Evidence synthesized in a 2022 meta-analysis by López et al. supports that RT performed **two to three times per week** over **12 to 16 weeks** leads to significant improvements in muscle strength and lean mass in middle-aged women. Most effective protocols employed **moderate to high intensity loads** ranging from **60% to 80% of one-repetition maximum (1RM)**. These intensities are sufficient to induce hypertrophic and neuromuscular adaptations that counteract sarcopenia.

In terms of exercise selection, **multi-joint compound movements** (such as squats, lunges, and presses) were more beneficial than isolated exercises alone, as they simultaneously target multiple muscle groups and elicit greater mechanical and metabolic stress. However, combining compound with **single-joint exercises** (e.g., leg extensions, biceps curls) appears to optimize hypertrophic response, especially in undertrained or aging muscle.

Adherence strategies tailored to midlife women

Sustained engagement in RT remains a critical determinant of long-term efficacy. Programs that included **supervision by professionals** and a **group-based format** were associated with significantly higher adherence rates—up to 15–20% greater compared to unsupervised or home-based interventions. Structured guidance not only ensures correct technique and safety but also fosters motivation and accountability.

Moreover, **flexible scheduling**, **shorter session duration (30–45 minutes)**, and **availability of home-based options** have been identified as key facilitators of participation among midlife women managing competing social and professional responsibilities. Regular **progress monitoring**, such as performance testing or strength assessments, can also reinforce motivation and goal-directed behavior [25].

4. Resistance Training and Bone Health

4.1. Impact on bone mineral density (BMD) in perimenopausal women

Osteoporosis is a common metabolic bone disease, affecting over 50% of women around the age of 50. The onset of menopause triggers a rapid decline in bone mineral density (BMD), primarily due to decreased estrogen levels and increased osteoclastic activity. Within the first 5 to 10 years post-menopause, trabecular bone mass may decline by 25–30%, and cortical bone by 10–15% [26].

In a study of 714 asymptomatic perimenopausal women with an average age of 49.7 years, dual-energy X-ray absorptiometry (DXA) measurements at the lumbar spine and femoral neck revealed that 37.6% had osteopenia and 10% had osteoporosis. Specifically, osteopenia was present in 35.2% at the femoral neck and 41.6% at the lumbar spine, while osteoporosis was found in 8% and 12% of women at these sites, respectively. Overall, 48% of the women exhibited low bone mass, indicating that significant bone loss can begin during perimenopause, often before menopause onset. These findings highlight the importance of early bone health assessment and intervention in perimenopausal women [27].

4.2. Guidelines for safe and effective training to prevent and treat osteoporosis

Currently, there are no standardized guidelines for the treatment and prevention of osteoporosis specifically in perimenopausal women. For those with a high risk of fracture or who require osteoporosis treatment, therapy decisions should be personalized based on individual patient factors.

Resistance training (RT) is an effective strategy for preventing and treating osteoporosis in perimenopausal women, who experience accelerated bone loss due to declining estrogen levels. Studies, including a meta-analysis of 17 randomized controlled trials, have shown that high-intensity RT (≥70% of one-repetition maximum), performed at least three times per week for sessions of 40 minutes or more, significantly improves bone mineral density (BMD) in critical areas such as the lumbar spine, femoral neck, and total hip. RT works by applying mechanical strain that stimulates bone formation and counteracts the increased bone resorption typical of menopause. Guidelines recommend incorporating RT early during the perimenopausal period to reduce rapid bone loss, with exercise programs tailored to individual health status and fracture risk. Combining RT with balance and flexibility exercises may further decrease fall risk and fractures [28]. Overall, resistance training provides a safe, accessible, and effective non-pharmacological approach to maintaining skeletal health in perimenopausal women.

5. Resistance Training and Prevention of Metabolic Disorders

5.1. Resistance training and glucose homeostasis

Resistance training (RT) has been shown to significantly improve glucose homeostasis in perimenopausal and postmenopausal women, populations at increased risk for insulin resistance and type 2 diabetes due to hormonal changes. Studies have demonstrated that RT enhances insulin sensitivity, reduces fasting glucose levels, and improves insulin secretion. For instance, a study involving elderly women found that RT improved the suppression of endogenous glucose production during insulin stimulation, indicating enhanced hepatic insulin sensitivity . Additionally, a meta-analysis of randomized controlled trials indicated that RT positively affects insulin sensitivity in older adults, as measured by HOMA-IR and HbA1c levels . These findings underscore the importance of incorporating RT into lifestyle interventions for perimenopausal women to mitigate the risk of metabolic disorders [29].

5.2. Effects on lipid profile and body fat distribution

Resistance training (RT) has been shown to positively influence lipid profiles and body fat distribution in perimenopausal women, populations at increased risk for metabolic disorders due to hormonal changes. A systematic review and meta-analysis of randomized controlled trials indicated that 12 weeks of RT led to significant reductions in total cholesterol, low-density lipoprotein cholesterol (LDL-C), and triglycerides, while increasing high-density lipoprotein cholesterol (HDL-C) levels in obese postmenopausal women [30].

Furthermore, a study examining the effects of 16 weeks of periodized RT in middle-aged men and women found significant decreases in total cholesterol and LDL-C levels, suggesting RT's potential to reduce cardiovascular risk factors even in the absence of changes in body mass and body mass index [30-31].

In terms of body fat distribution, a study focusing on perimenopausal women reported that RT led to significant reductions in waist and abdominal circumferences, indicating a favorable shift in fat distribution . Additionally, a prospective study of perimenopausal women found that menopause was independently associated with increased central obesity, highlighting the importance of interventions like RT to counteract these changes [32].

Collectively, these studies underscore the importance of incorporating resistance training into lifestyle interventions for perimenopausal women to mitigate the risk of metabolic disorders.

5.3. Influence on visceral fat and cardiovascular risk

Resistance training (RT) has been shown to significantly reduce visceral fat and improve cardiovascular risk factors in perimenopausal and postmenopausal women. Visceral fat accumulation is a key contributor to cardiovascular risk, and its reduction is particularly important during the menopausal transition.

Recent research demonstrates that structured RT programs can effectively counteract these adverse changes. For example, Forti et al. (2023) found that a 15-week RT intervention in perimenopausal and early postmenopausal women significantly decreased visceral adipose tissue and the visceral-to-total abdominal fat ratio—both strong predictors of cardiovascular risk. These changes were accompanied by enhanced insulin sensitivity and reduced systemic inflammation, which tend to worsen during perimenopause [33].

The decline in estrogen during the menopausal transition contributes to elevated CVD risk by adversely affecting vascular function, lipid metabolism, and inflammatory processes. This period represents a critical window of accelerated cardiovascular aging, increasing vulnerability to hypertension, dyslipidemia, and atherosclerosis. Recognizing perimenopause as a pivotal phase for cardiovascular health highlights the importance of preventive strategies, including physical activity and resistance training, to reduce long-term cardiovascular morbidity and mortality [34].

Additionally, a study published in *BMC Women's Health* (2024) confirmed that a 15-week RT program improved cardiovascular risk markers and reduced moderate-to-severe vasomotor symptoms in postmenopausal women, although the benefits diminished two years after the intervention [35].

6. Barriers and Facilitators to Resistance Training in Perimenopausal Women

Qualitative research involving women aged 40–62 with mild-to-moderate menopausal symptoms identified key themes shaping adherence to regular exercise, including resistance training. Women described daily routine disruptions, competing family and work responsibilities, and lack of accountability as primary **barriers** to consistent exercise. In contrast, maintaining behaviors through structured routines, internal motivation, and social support (e.g., exercising with others) emerged as strong **facilitators** of adherence [36].

A systematic meta-synthesis of studies on women's strength training motivations found that **social stigma**, misconceptions about weight training (e.g., fear of "looking manly"), and lack of knowledge and confidence serve as significant deterrents. Effective strategies to enhance motivation include **women-only training environments**, accessible and flexible program designs (e.g. home-based or group formats), and educational initiatives delivered by health professionals to build confidence and correct misconceptions [37].

Addressing psychosocial barriers through structured, socially supportive, and educationally informed resistance training programs can significantly enhance adherence among perimenopausal women.

7. Practical Recommendations

Effective resistance training protocols for perimenopausal women require careful consideration of frequency, intensity, volume, and exercise selection to optimize muscle strength, bone health, and metabolic function. The Tabele 1 summarizes the key practical recommendations for resistance training protocols tailored to perimenopausal women.

Tabele 1. Suggested resistance training protocols

Parameter	**Recommendation**
Frequency	2–3 sessions per week. Studies show moderate-to-high frequencies (especially 3×/week) effectively preserve bone density and reduce visceral fat. [33]
Intensity	Moderate (~65–80% 1-RM); occasional high-intensity (≥70% 1-RM) for bone and muscle adaptations. [28, 33]
Volume	2–3 sets per exercise, totaling ~6–10 sets per major muscle group weekly; higher volumes (>10 sets) may benefit muscle hypertrophy, particularly in postmenopausal women. [28]
Exercise Types	Emphasize multi-joint, free-weight or functional movements (e.g., squats, deadlifts, presses) to simultaneously target muscle, bone, and metabolic outcomes [38,39]
Session Duration	40–60 minutes per session, including warm-up, RT, and cool-down, aligns with protocols that improved BMD and body composition [28, 38].
Duration	Continue for at least 12 months to observe and stabilize bone and muscle adaptations; optimal bone improvements often require up to 48 weeks [28].
Progression	**Begin with moderate loads, increase intensity or volume every 4–6 weeks based on individual progression and tolerance.**

8. Limitations of Current Evidence and Future Research Directions

8.1. Methodological gaps in existing studies

Although numerous studies affirm the positive impact of resistance training (RT) on musculoskeletal and metabolic health in perimenopausal women, several methodological shortcomings constrain the robustness and external validity of current evidence. These include small, often homogenous sample populations, short intervention durations, and considerable heterogeneity in study designs. Notably, inconsistencies in the diagnostic criteria for conditions like sarcopenia and osteoporosis complicate data synthesis and inter-study comparisons [20,22,27]. Resistance training protocols also vary widely in terms of frequency, intensity, supervision, and outcome measures, creating difficulties in establishing standardized guidelines [24,28]. Furthermore, most existing research emphasizes postmenopausal women, with fewer trials designed specifically around the physiological nuances of the perimenopausal transition.

8.2. Need for randomized controlled trials in this specific population

Despite the high prevalence of metabolic dysfunction, sarcopenia, and early bone loss during perimenopause, high-quality randomized controlled trials (RCTs) focusing solely on this subgroup remain scarce. Many studies fail to stratify results by menopausal stage, resulting in pooled data that obscures the unique endocrine environment and responsiveness of perimenopausal women [23,29]. Given the distinct hormonal shifts in follicle-stimulating hormone (FSH), estradiol, and body composition during this stage [13,15], tailored RCTs are essential to understand the dose-response relationship of RT and its interaction with ongoing physiological changes. Longitudinal RCTs extending beyond six to twelve months are also needed to assess sustained effects on bone mineral density (BMD), insulin sensitivity, and lean body mass, as well as long-term adherence and safety.

8.3. Recommendations for future research designs

To bridge these knowledge gaps, future studies should prioritize large-scale, multicenter, and adequately powered RCTs with strict inclusion criteria specific to the perimenopausal population. Protocols should employ consistent training variables (e.g., ≥70% 1-RM intensity, 2–3 weekly sessions, >12 weeks duration) to enable comparability and meta-analytical aggregation [28]. Outcome measures should encompass hormonal biomarkers (FSH, AMH, estradiol), imaging-based assessments (DXA for BMD and lean mass), and functional performance tests (e.g., grip strength, gait speed) [23,24]. Incorporating inflammatory markers such as CRP and IL-6 may also elucidate RT's systemic anti-inflammatory effects [19]. Additionally, mixed-methods approaches that examine psychological, behavioral, and environmental barriers to adherence could help inform more personalized and sustainable exercise interventions [36,37].

9. Conclusion

Perimenopause is a critical transitional phase characterized by profound hormonal, musculoskeletal, and metabolic alterations that significantly elevate the risk of sarcopenia, osteoporosis, and metabolic syndrome in women. The cumulative evidence reviewed in this article highlights resistance training (RT) as a safe, accessible, and highly effective intervention to mitigate these risks. By promoting muscle hypertrophy, preserving bone mineral density, improving insulin sensitivity, and reducing systemic inflammation, RT directly addresses many of the adverse physiological changes associated with declining estrogen levels.

Despite its proven benefits, RT remains underutilized among perimenopausal women, partly due to social, psychological, and logistical barriers. Optimizing adherence requires individualized, evidence-based protocols that consider frequency, intensity, and modality, as well as targeted education to dispel misconceptions about strength training in women.

While the current literature provides compelling support for the implementation of RT during perimenopause, methodological limitations—including heterogeneous study designs, short intervention durations, and the underrepresentation of this specific population in randomized controlled trials—warrant caution. Future high-quality, longitudinal research is essential to refine exercise prescriptions and to elucidate the long-term impact of RT on clinical outcomes in this demographic.

In summary, resistance training should be integrated as a cornerstone of preventive health strategies for perimenopausal women, with the dual aim of promoting functional independence and reducing the burden of age-related chronic conditions.

Disclosure

The authors declare no conflict of interest.

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