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Review Article

Effect of resistance exercises on bone density in postmenopausal women

Konstantinos Zemadanis

Faculty of Medical School, National and Kapodistrian University of Athens, Greece

Abstract

On the field of non-pharmaceutical prevention and treatment of postmenopausal women's bone mineral density (BMD), exercise is undoubtedly a fundamental component, having a beneficial effect on a number of health parameters. Resistance training seems to adequately stimuli the musculoskeletal system on the physiology of bone tissue response. The study's objective was to analyze the most recent research on the clinical uses of resistance training in therapy regimens for postmenopausal women while analyzing and criticizing the data in light of the growing research heterogeneity. Data collection was carried out through electronic databases PubMed. Forty related meta-analysis and systematic reviews published on the last five years, were included as the sample for analysis. Studies regarding pharmaceutical and/or diet intervention were excluded. Results demonstrated that resistance training, either alone or in combination with other forms of exercise, significantly improved postmenopausal women's BMD. The workout criterion that suggests acceptable future study designs and exact research technique is intensity, which appears to be the most intriguing.

Keywords: Biomarker, BMD, Postmenopausal women, Resistance exercise, Resistance training

Introduction

Resistance training (RT) seems to stand out among other types of training, as it is associated with the greater response of the musculoskeletal system stimulation of postmenopausal women (PW). Under this framework, recent research data regarding the effect of resistance training on this specific population are examined, aiming to record, interpret and criticize data. The emerging research heterogeneity and the main intervening variables are nutrition, pharmacotherapy, age, exercise or different exercise types .

Overall health, independence, and quality of life are all impacted by age-related sarcopenia, which is connected to loss of muscular mass and strength. Low bone mineral density and an increased risk of fractures and falls are connected with sarcopenia[1-5]. Insufficient protein synthesis, ongoing inflammation, and a lack of oxidative activities are all linked to inactivity[6]. Quality of life improvement, should be the main goal of every therapeutic protocol that postmenopausal women follow and this is applicable with daily exercise and physical activity as a basic element. Improving health criteria, such as muscular strength, balance and falls prevention, episodes of hot flushes reduction, hypertension and other metabolic indicators improvement reflects the field of exercise effect .

The purpose of this review is to examine and analyze the contemporary published data of the last five years, regarding the effect of resistance training on postmenopausal women health, through meta-analyses and systematic reviews. This type of exercise seems to be beneficial, mainly as an individual intervention but also as an element of combined interventions. Emphasis is placed on the research design of the included studies and the statistical analysis, as the investigated dependent variables determine the results.

Material and Methods

With regard to the reported RT impact in postmenopausal women, recent meta-analyses were gathered while

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Corresponding author: *Konstantinos Zemadanis, PT, MD, Faculty of Medical School, National and Kapodistrian University of Athens, Greece*

E-mail: *kostas_zema@yahoo.gr*

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removing confounding factors such nutrition, pharmacology, nutritional supplements, and other types of exercise (Non resistance-NR). Between October 2021 and October 2022, data were gathered using the electronic databases Embase, Scopus, Sport-discus, Pub-med, and Cochrane Central Register of Controlled Trials (CENTRAL). The search terms were "postmenopausal women", "resistance exercise", "resistance sport", "weight lifting", "resistance training", "bone", "BMD", "micro-architecture", "QCT", "pQCT", "HR-pQCT", "biomarker", and "biochemical marker". Meta-analyses and comprehensive reviews of recent human and animal studies published in English were the kind of papers that were looked up. Variety of exercise types also justifies the different terminology observed in the data causing confusion and research heterogeneity. Terms such physical exercise, resistance exercise, strength training, weight training, resistance training programs, progressive loading exercise and compound exercise were taken under consideration, (needs to be controlled).

Research design relied on examining single resistance exercise or in the context of a multifactorial program with other forms of exercise. Different forms of exercises included free weights, body weight, dynamic movements (eg jumping), static movements. Types of training such as circuit or stations, at home or in the gym, supervised or unsupervised cover all reports.

Results

After applying our inclusion and exclusion criteria to the 128 relevant papers that our initial search turned up, we were left with 45 relevant articles for the review. The key workout parameter for our investigation is intensity. Therefore, whether resistance training is utilized by athletes or patients, monitoring exercise intensity is crucial to guaranteeing its safety and effectiveness. When performing resistance training, the Borg scale (6–20) and CR–10 are frequently used to assess perceived exhaustion (RPE). They are basic, simple to use, and appropriate for both patients and non-patients to exercise[7]. In order to prescribe training intensities, direct daily doses, and track training progress, Rating-of-Perceived-Exertion (RPE) scales have been successfully used[8]. Elastic bands are one type of resistance training tool that is often used[9]. Different types of exercise and training methods provide similar functional and strength improvements , but also biomarker's serum changes[10,11]. In order to identify specific exercise effects, new scales of perceived exertion, needs to be examined[12].

Discussion

Muscle metabolism and hormones

Recent work, examined the effect of 40-min resistance training, 3 times/wk, for 12 weeks on the metabolic profile, insulin resistance, and metabolic syndrome of obese postmenopausal women, who were divided into study and control groups. Dependent variables were: insulin, glucose, blood lipid profile, BP and anthropometry. Significant improvements in all measures were found only on the exercise group[13].

Exercise Intensity

There have been several meta-analyses on the effect of exercise on BMD published in the past decades, some of which were limited to a single type of exercise and/or different types[14,15]. Main skeletal benefits of progressive resistance training (PRT) have been detected with progressively increased resistance of high load, targeting lumbar spine and hip muscles. Few have addressed the role of exercise intensity on effect size and these have been limited to either resistance training alone or in resistance of two intensity categories, high and low[15,16]. Similarly, other current suggestions of prescribed exercise are summarized in a frequency of four times/week, a dynamic pattern of execution (resistance + speed), intensity on 70-90% of 1 RM, with six repetitions of strong muscle contractions to activate type II muscle fiber[17,18]. The finer gradation into three intensity categories is favorable, identifying most effective exercise program. Lack of high-intensity exercise data appears to be due to the traditionally conservative approach where a perceived high risk of injury is associated with high magnitude loading in postmenopausal women. However, current shows no greater risk compared with lower intensity exercise[17,18].

Fifty-three studies with sixty-three interventions (19 low, 40 moderate, 4 high intensity) were included in a recent systematic review. High intensity exercise protocol (HIEP) was an eight-month program that included three free weight exercises (dead lift, back squat, overhead press), one high impact exercise (jump), and two balance exercises. It combined resistance and high intensity axial loading. Loads were progressively increased up to 80% to 85% 1RM (repetition maximum) or a score of ≥16 on the 20-point Borg scale. Results showed that in the lumbar spine HIEP yielded greater BMD results compared to moderate and low intensity. Exercise of low and moderate intensity had an equal impact on the femoral neck while exercise of high intensity had no noticeable impact. Low-intensity exercise did not raise total hip BMD, whereas moderate activity did. Exercises with medium resistance produced the best results for the femoral neck. Data on the impact of vigorous exercise on the whole hip were limited. The fracture risk meta-analysis findings are consistent with those of earlier meta-analyses, which discovered risk reductions of 51% and 39%. Exercise at a high intensity has insufficient impact on the whole hip. Despite the paucity of high-intensity exercise intervention data, a recent thorough meta-analysis reveals similar favorable benefits on hip[18].

To ascertain the influence of various forms of exercise, including impact training alone, resistance training alone, and combined training, subgroup analyses were carried out. For each exercise intensity (low, moderate, high) and each BMD area, meta-analyses were carried out. High-intensity axial loading loads and moderate-intensity resistance training produced the best outcomes in the lumbar spine (LB). The lack of sufficient studies prevented comprehensive analysis of high-intensity (HI). When all 55 interventions were combined, there was significant heterogeneity between the research results (I2=59%). minimal intensity interventions (HI) had minimal heterogeneity (I2=0%), moderate intensity interventions (MI) had substantial heterogeneity (I2=68%), and high intensity interventions (HI) had moderate heterogeneity (I2=33%).

Exercise is an important component in treating osteoporosis despite the fact that there have only been a small number of studies on the topic. The results indicate that high-intensity exercise is more beneficial for lumbar spine BMD but has no impact on the femoral neck[19]. The definition of intensity classification and associated high thresholds for high vs moderate intensity exercises were found to have little impact on high-intensity tasks. Published intensity gradations include previous meta-analyses defined high intensity as 80% 1RM or more, 8 to 12 repetitions at 60-70% 1R or used the term high strength for progressive resistance strength training without further specification of intensity[20,21]. Therefore, high intensity in current meta-analyses, was classified as moderate intensity in the present meta-analysis. The response to exercise was found to be larger at high intensity than at moderate or low of it, using varied thresholds of high intensity.

Applying research to daily life, moderate to high intensities of progressive resistance training alone or in combination with axial loading (impact) exercises are associated with the best exercise prescription for postmenopausal women. In otherwise healthy women with low to extremely low T-scores (up to -3.9), including a history of osteoporotic fractures, high-intensity resistance training appears to be safe. Close monitoring is advised, though, for those who have comorbid conditions or are at very high risk of fracture[22].

In the second part of the aforementioned review, 120 exercise interventions were examined (57 were low intensity, 57 moderate and 6 high intensity)[23]. Duration of the exercise interventions ranged from six months to three years (mean: 52 wk). Training frequency ranged from twice a week to three times a day (average 2-4 sessions/week). It was found that low-intensity exercise was not an effective stimulus for increasing bone mass, while moderate-to-high-intensity interventions, particularly those combining high-intensity resistance and impact training, were more beneficial for bone mass, while only high-intensity exercise appeared to improves structural parameters of bone strength. The quality of papers varied widely and risk of bias determinations were accompanied by insufficient reporting details. DXA was the most common method to assess BMD or BMC, lumbar spine (71), femoral neck (69), trochanter (35), whole hip (31), whole body (21). HR -pQCT was not applied in any study. According to biomarker measurements, osteocalcin was reported in 27 trials, and to a lesser extent on C-telopeptide cross- linked type 1 collagen, bone-specific alkaline phosphatase, and N-telopeptide cross-linked type 1 collagen, as the most frequent related variables[23]. Resistance exercise related to statistically significant alterations of bone marker, (e.g. P1NP/CTX serum ratio increase, p=0.09), indicating stimulation of bone formation[24].

On a whole, low-intensity exercise did not affect the dependent variables. There is also insufficient evidence to evaluate the effect of low intensity on bone structure , while data on the effect on biomarkers are limited. Of the few high- intensity trials on variables of structural bone changes (micro-architecture, geometry, and turnover, via QCT), found a positive effect compared to lower intensity exercise[24,25].

The effect of high-intensity exercise on BMD is determined by the small number of interventions, as of the five high-quality tasks, the effectiveness was from high to zero (Lumbar spine BMD bone, femoral neck). In contrast, effectiveness in total hip BMD is only supported by lower data quality and no data to suggest efficacy in the trochanter. The effect of high-intensity exercise on bone micro-architecture is questionable due to lack of studies[26].

Resistance training and axial loading-impact were combined in all high-quality interventions assessing moderate intensity, as well as two efficient high-intensity interventions, demonstrating that both exercise types serve as appropriate stimuli[26]. In all outcomes, lumbar spine appeared to respond more than other regions something that agrees with previous meta-analyses[27].

The effect of age in relation to exercise at menopause cannot be determined from the current analysis due to the wide age-range of the participants[27].

Critical Consideration of included studies

Data criticism is oriented to the methodological and statistically limited aspect of the literature, and less to the content of the exercise variables, as study design affects statistical significance. Exercise is a complex phenomenon that interacts with laws of biophysics, biochemistry and biomechanics. Therefore, it more closely resembles in real life when is included in a multifactorial program, along with other interventions, but reduced internal validity. Moreover, there is a lack of long-term studies (longitudinal) with reliable and valid statistical tests.

There is a lack of studies that mention the type of contraction performed during the execution of the exercises (concentric-isometric-eccentric contraction) and also application of exercise periodization[28]. A disconnection between the theoretical framework of the effect of mechanical loading on bones and the clinical application is observed. The majority of published trials does not translate findings on a design of bone- targeted exercise interventions, and most interventions are characterized as low-intensity, incapable of inducing adaptations.

The nature of exercise applied is either therapeutic or preventive, so attention should be paid to studies with a study group of postmenopausal women with osteoporosis or not, as it is a critical variable producing different data and therefore not directly comparing results. A profound limitation is the assessment of muscle strength based on 1RM for both upper and lower body exercises, with an estimate (e.g. 3RM) or an actual calculation (1 RM), and it is a measuring method with qualitative characteristics.

The lower scores on Pedro scale are due to lack of a control group. Studies in which reasons for dropping out of the program are not reported by the participants limit external validity, the reproducibility of the design and the extraction of clinical exercise recommendations , while a threat to internal validity is the lack of report changes in general daily physical activity and the duration of the implementing protocols.

Effect of Exercise

An exercise intervention with an average period of 15 weeks (2-3 training sessions/week), duration ranging from 15 to 60 minutes, number of sets 1-4, and repetitions per set 1 to 20 was found to be beneficial for body composition (BC), muscle strength (MS), and functional fitness (FF) in postmenopausal women in a meta-analysis of a total sample of 2519 participants with a mean age of 66.89 4.91 years[29]. More specifically, improvements on functional tests (timed up-and-go test, number of chair sit-stands in 30 s, and walking or gait speed) were documented for FF and MS, respectively. For MS, these improvements included enhanced muscle activation, increased isometric hand grip strength, and increased isokinetic torque of the knee. For BC, a decrease in body fat percentage was noted[29].

Once the maximum number of consecutive repetitions was achieved in the sessions, the majority of treatments (n=17/38 or 45%) raised training intensity following the ACSM recommendations by a specific percentage for the upper and lower body. Using indicators like Omni (n=5) or Borg (n=5), i.e. ratings of perceived exertion (RPE) (10/38 or 26%), a smaller number of studies increased the intensity by increasing the number of pounds applied when the maximum number of repetitions was completed in consecutive sessions (n=3/38 or 8%). Interventions lasting longer than 8 weeks were a part of all studies. The majority of the studies examined for this study demonstrated gains in lean body mass, lean muscular strength, and functional fitness[29].

A meta-analysis analyse the importance of accelerometer as a measure to quantify the intensity and frequency of exercise loading in a sample of ten trials of moderate methodological quality. Significant changes were found in BMD of the lumbar spine and femoral neck of postmenopausal women after applying high-intensity impact exercise and whole-body vibration, while the heterogeneity of the protocols was high[30]. Previous data findings suggest combined protocols of resistance and high axial load (impact) exercises, because only resistance protocols (with a constant frequency of 2/week moderate to high intensity), with repetitions of 70-80% 1 RM , had non- significant positive effects in the prevention of bone loss[31].

Low intensity exercise will be effective only if applied at higher frequencies and longer duration[32]. Significant improvements in hip BMD are associated with a threshold number of less than 100 accelerations , above 3.9 g/d, (27), but also lower accelerations (1.1 g and above) are also positively related to improved bone structure . Therefore, while high intensities appear to be associated with BMD, lower intensities affect bone geometry and bone metabolism[33]. No correlation has been found between duration (6-24 months) and effect on BMD, due to loading intensity and type of exercise. High - intensity resistance training , alone or in combination, produced a BMD benefit of 1% to 2% at the lumbar spine and femoral neck[33]. In a longer period of time interventions (24 months) strength training (28 reps of major muscle groups at 80% RM, 2 d/week), combined with 20 to 30 minutes of intense walking at 70% MHR (four times a week) , BMD results were non-significant in the postmenopausal period of women[34,35].

In Shojaa's meta-analysis through PRISMA, DRT (dynamic resistance training) of intervention duration ≥6 months is examined, with at least one exercise group and one control group in aBMD of the lumbar spine and proximal femur of postmenopausal women . A total of 17 articles with 20 exercise groups and 18 control groups was the total sample size. Interestingly, while subgroup analysis for proximal hip BMD revealed no differences in the dependent measurement variables, lower frequency training (<2 sessions/week) resulted in statistically significant changes in BMD lumbar spine and total hip, compared to higher frequency (≥2 sessions/week). In addition, free weight training was significantly superior to DRT devices in improving total hip BMD. Most work has focused on supervised group exercise or semi-supervised individual gym[35]. Subgroup analysis showed the largest statistically significant effect for the lowest training frequency (<2/wk). Exercise had a substantial impact on femoral neck bone mineral density (FN-BMD; p=0.005) but not on the lumbar spine (p=0.260). There were no differences between the subgroups for exercise intensity, with four groups exercising at low (65% 1RM), seven at moderate (65–80% 1RM), and seven at high relative intensity (80% 1RM). The lower frequency was superior probably because of higher exercise intensity compensation or vice versa, i.e. a high frequency combined with a high intensity can lead to an incomplete adaptation to the exercise. It is important to determine the need or not for resistance exercise machines, as it can be omitted, without disrupting the success of the programs, mainly for the effect on the hip and less on the spine. For elderly people, free weights are more favorable (despite common perception to the contrary) for increasing functionality and especially strength of the extensor muscles of the limb, which correlates with mobility limitations[36,37].

In addition to a rise in body fat percentage, a decrease in lean muscle mass, and an increase in blood pressure, menopause is accompanied by age-related hormone decline. In particular, postmenopausal women have lower amounts of estrogen, growth hormone (GH), insulin-like growth factor-1 (IGF-1), and dehydroepiandrosterone sulfate (DHEA-S). Low DHEA-S and IGF-1 levels are linked to increased body fat percentage and sarcopenia in postmenopausal women, whereas low estrogen levels are linked to an increased prevalence of hypertension[38,39]. In a recent study, a study group, as opposed to a control group, followed a regimen of strength training with elastic bands for 2 weeks, 3 times per week, for 60 minutes per session. Training program intensity was set at 60% to 80% of 1RM , with a gradual increase every 4 weeks. A significant improvement was found in levels of estradiol, GH, IGF-1 and DHEA-S in the study group, as well as systolic BP, body mass index - BMI and body fat percentage which were significantly reduced after exercise. A possible mechanism of estradiol increase is related to satellite activation of muscle tissue cells with a role of repair[40]. Reduced estradiol negatively affects the skeletal muscle contractility[41]. Estradiol up - regulates endothelial nitric oxide synthase (eNOS), increasing NO[42].

Exercise is regarded as the primary non-pharmacological treatment for the prevention of osteoporosis and fractures because it limits sarcopenia and osteoporosis and improves muscle mass, muscle strength, and physical performance[43-46]. Higher levels of muscle mass are associated with a lower frequency of low bone density because muscle tissue impacts bone health and hormones such as myokines assist in bone signaling[47,48].

In terms of muscle-bone interaction, recent meta-analysis examined 16 RCTs with a total number of 1028 patients for changes in strength of dorsal muscles of the thoracic spine and lower limbs and a significant correlation was found in the improvement of BMC[49]. Muscle strength improved, which has been linked to falls prevention, and correlation with exercise intensity (80 to 85% 1RM)[49]. Shojaa et al.'s meta-analysis (2020) found no evidence that dynamic muscle strengthening exercise was superior for BMD in postmenopausal women when compared to protocols with various intervention duration and intensities. However, a significant positive effect on bone quality was found from free weight exercise of reduced frequency (<2 sessions/week). Loading characteristics with proven benefits to bone tissue are resistance exercise that is dynamic rather than static (i.e. cyclic rather than continuous), high bone loads, relative velocity, interval type exercise[50].

For postmenopausal women, moderate to high impact loads (>2 times body weight) and procedures that are progressive and multi-directional may promote osteogenesis[51]. Women's musculoskeletal response requires only a small number of sessions (10–50 repetitions per day, three times per week), but additional benefit could come from more frequent exposure (4–7 days per week)[52]. When compared to the lumbar spine, the hip appears to respond more to impact loading[53].

High-load resistance training (HLRT) significantly increased BMD in the lumbar spine, femoral neck, and total hip in 259 patients with osteoporosis and osteopenia, compared to 236 patients in the control group according to a meta-analysis of nine RCTs[54]. Most noticeable improvements in BMD were seen during the first 5 to 6 months of a 12- to 18-month intervention because of relative adaptations. Others, however, have reported that a gradual fitness program led to a linear rise in BMD[55].

An investigation of the osteogenic potential of various exercises for loading the femoral neck in 14 postmenopausal women (mean age 64 years) found that jumping, running (5-9 km/h), and intense walking (5-6 km/h) produced higher compressive and tensile stresses than walking at 4 km/h, which was regarded as the minimum level of bone preservation[56]. In addition, vigorous walking, running, and leaping have been reported to transfer compressive and tensile stresses in the upper femoral neck region that are significant enough to probably trigger an osteogenic response. The contradictory results regarding the effects of resistance training on hip BMD may be explained by the fact that all resistance exercises (extension and flexion, abduction and adduction hip) produced forces that were equal to or lower than those reported for walking at 4 km/h when performed at 40-80% of maximal muscle force.

As a result of a decrease in the rate of intra-cortical bone loss (or an increase in intra-cortical bone formation), there is evidence to support maintenance- or exercise-induced increases in cortical area or tibial thickness. However, no study mentioned the deposition of periosteal tissue in postmenopausal women[57]. This is crucial because, with or without increases in BMD , minor changes in bone size (periosteal deposition) can result in significant improvements in bone strength[58].

Hot flashes

On the base of β-endorphin release during exercise thermo-regulation improvement, study shows that on postmenopausal women, ≥45 years followed a 15-week exercise program three times/week, with six resistance machine exercises and two body-weight exercises (ACSM, 2009), at 15–20 RM with 15–20 repetitions in the first three weeks had a 43% reduction in hot flashes, compared to 2% in the non-exercise group[59].

Fracture risk

The exercise effect on fracture risk determination, hardly can be found because of concomitant drug therapy. Resistance exercise can prevent fracture even when it starts after menopause[60]. Strengthening exercises reinforce antigravity muscles that oppose excessive thoracic spine position[61]. The exercise of thoracic extensor muscles reduces long-term vertebral fractures in postmenopausal women, even in the absence of increased bone mass[62] .

In a recent meta-analysis, postmenopausal women (aged>60 years, n=16) were shown to have BMD at the lumbar spine (LS) and femoral neck (FN) with no benefit from strength training and negative effects from aerobic weight-bearing activity[63]. It is generally uncertain how the effect may affect bone mineral density. Shogaa et al. (2020) conducted a sub-analysis based on a recent meta-analysis on the effects of exercise on BMD in postmenopausal women to confirm these findings. Exercise was categorized as weight-bearing exercise (WB), combined weight-bearing and dynamic resistance exercise (DRT), and dynamic resistance exercise (DRT). Exercise's impact on LS-BMD was examined in 16 DRT exercise groups, 26 WB exercise groups, and 33 combined WB and DRT exercise groups. Similarly high levels of variability were found across all exercise types (I2=76.3–76.5%). In postmenopausal women, there were significant increases in BMD at the lumbar spine, femoral neck, and total hip following various forms of exercise. The combined effect of the WB&DRT group was not superior on BMD compared to DRT. One can assume that the rather high number of study groups included in the analysis subgroups probably balance out individual differences. An important limitation of the meta-analysis is the failure to categorize the exercise intensity/strain magnitude variables into exercise types in order to perform a sub-analysis for each of these parameters[63].

From a practical point of view, high - intensity exercise may require special equipment and closer supervision , while low-intensity exercise may require increased repetitions associated with greater discomfort and higher cardiovascular stress[64].

In order to assess the safety and effectiveness of an 8-month, 30-minute duration, and frequency of 2/week targeted high-intensity progressive resistance training (HiPRT) on postmenopausal women with low to very low bone mass[65], Watson et al. (2015) reviewed the widely used LIFTMOR method. The program was complex and included axial loading movements and free weights (80-85% 1RM). The control group followed a 30-minute, 2/week program at home. HiPRT was found to be safe and sufficient to improve bone mass and significantly improve fitness. An important observation was the net improvement in height by an average of 0.7 cm in the study group due to the reduction of kyphosis[65].

In an extension of the aforementioned meta-analysis researchers evaluated the morphology of vertebrates' body mass, Cobb angle and degree of thoracic posture on LIFTMOR study sample with the association of vertebral fracture risk[66]. After the intervention, it was discovered that the HiRIT group had less thoracic kyphosis than the control group, with no changes in the incidence of vertebral fracture, but the control group had a new isolated sphenoid deformity. So, in postmenopausal women with poor bone mass, supervised HiRIT was not linked to a higher risk of vertebral fracture[66].

Muscle-Bone Biomarkers

When compared to aerobic activity, resistance training raises irisin by a factor of two. In postmenopausal women, resistance training (RT) has been demonstrated to increase muscular growth and strength[67,68]. Myostatin and follistatin (markers of muscle aging) serum concentrations change[2]. Myostatin regulates the proliferation of myoblasts[1]. Reduces protein synthesis and increases muscle protein breakdown via the forkhead box O (FOXO) and mTORC1 (mTORC1) signaling pathways, thereby limiting muscular growth[69]. RT reduces serum myostatin concentrations inhibiting SMAD signaling, increasing Akt, down-regulating FOXO and Tuberous Sclerosis Complex 2 -TSC2[69].

Moreover, two weeks of exercise in experimental animals caused high levels of messenger FNDC5 on mice bone tissue, while a recent study in postmenopausal women (n=30), found an increase in IGF-1, follistatin, BCAA and a decrease in myostatin after 8 weeks of resistance exercise[70]. Resistance exercise is a stimulus for muscle protein synthesis and can work synergistically with adequate dietary protein intake[71]. A key molecular pathway is the counterpart of mTOR, with critical roles in protein synthesis, favoring the development of therapeutic interventions for muscle loss in healthy postmenopausal women[72]. Proliferation signaling of muscle satellite cells is mediated through estrogen receptor-a (ER-α) which activates IGF-1, NO, PI3K/AKT protein synthesis signaling pathways. In animal models it has been shown that mechanical bone stimulation inhibits the production of sclerostin by osteocytes and this inhibition is associated with thickening of the bone cortex[72].

In a recent meta-analysis, researchers looked at the levels of inflammatory biomarkers (IL-6, TNF, CRP, and antiponectin) in a group of postmenopausal women before and after a 4-week exercise intervention[73]. The sample consisted of 1510 postmenopausal women from 32 studies with 38 intervention groups. In comparison to control groups, resistance training dramatically decreased IL-6, TNF-, CRP, and elevated antiponectin. Possible mechanisms are related to adipose tissue, as an important source of pro-inflammatory cytokines secretion, whose reduction by exercise leads to the observed changes. In addition, exercise training down-regulates TLRs in macrophages causing the phenotype switch M1 to M2 and reduced expression of pro-inflammatory cytokines in adipose tissue[74,75]. In addition, pro-inflammatory cytokines such as IL-6 and TNF-α are the main stimulus for CRP production in the liver[76].

In a related investigation, a frequency exercise program was followed twice weekly for three months by 33 postmenopausal women aged 50 and older who had total hip BMD T-scores, or BMSS, between 1 SD and 2.5 SD. Pro-collagen type 1 N-terminal peptide (P1NP) and the number of osteocytes (OCs) increased significantly after three months of training, while collagen type 1 cross-linked C-telopeptide (sCTX) did not rise significantly. The increased number of immature circulating OCs was significantly associated with improvement in 1RM and thus a correlation of depended variables of combined exercise, osteogenetic biomarkers and muscle strength. The increased number of circulating OCs after exercise suggests enhanced recruitment of stem cells from bone marrow[77,78]. In the muscle-bone cross-talk communication, both systems act as endocrine organs secreting respectively “myokines” and “osteokines” , which are increased by exercise with anabolic effects in muscle and the osteoblast lineage by enhancing the differentiation and osteocyte formation activity[78].

Conclusions

The present review outlines the beneficial effect of resistance training in postmenopausal women , preventative and therapeutically. The optimal program has not yet been determined. Heterogeneity of studies creates ambiguity in the production of guidelines. Higher-quality studies provide evidence that axial loading at moderate to high intensities combined with progressive resistance training is the most efficient stimulus for enhancing bone strength in the spine and hip. Even for women with low to extremely low BMD, high-intensity exercise seems to be a safe treatment strategy when done under the right supervision.

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