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The effect of eight weeks of resistance training on some serum and metabolic markers of bone mass in postmenopausal women

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Abstract

Purpose: Osteoporosis is a multifactorial disease of the skeletal system and the main cause of fractures and death in elderly people, especially postmenopausal women. The purpose of this study was to investigate the effect of eight weeks of resistance training on some serum and metabolic markers of bone mass in postmenopausal women. **Methods:** 24 inactive postmenopausal women with an age range of 46-58 years participated in this study. Subjects were assigned to resistance training and control groups. Before and after the training period, weight, body mass index, alkaline phosphatase, calcium, serum phosphorus and bone density of lumbar vertebrae were measured (by Dexa method). The training protocol consisted of upper and lower body resistance training in 3 sets of 8 to 12 repetitions for 8 weeks and 3 sessions per week. Data were analyzed using SPSS software version 26 and independent t and paired t statistical tests. **Results:** The results of this research showed that the experimental group had a significant increase in the amount of alkaline phosphatase (p=0.041), serum calcium (p=0.035) and bone density of the lumbar vertebrae (p=0.11) and a significant decrease in weight compared to the control group. (p=0.035, and body mass index p=0.021). The results also showed no significant change in the amount of serum phosphorus (p=0.071). **Conclusion:** According to the findings of the present study, in order to maintain or prevent the decrease in bone density of postmenopausal women, resistance exercises can be recommended.

Keywords: Resistance training, Metabolic markers, Bone mass, Postmenopausal, Women.

Introduction

Changes in physiological characteristics during aging, such as stress-causing factors, deteriorating mitochondria, deformity in body posture, less produced hormones, and a decrease in the total possible energy consumption cause gradual damage to nerve cells, decrease in bone density, and decrease in muscle mass and strength (Wang et al., 2024). Osteoporosis or osteoporosis is a common disease that leads to thinning and weakening of bones, or in fact to bone atrophy, and it usually affects people from middle age onwards (Fasihi, Tartibian, Eslami, & Fasihi, 2022). According to the definition of the World Health Organization (WHO), osteoporosis is a disease whose characteristic feature is a decrease in bone density and a change in the microscopic structure of bone tissue, which leads to an increase in bone fragility and increases the risk of fracture (Tartibian, Fasihi, & Eslami, 2022). Today, osteoporosis is considered a great threat in the world and its annual mortality is more than all types of cancer (Pouresmaeili, Kamalidehghan, Kamarehei, & Goh, 2018). The most damage and loss caused by this disease is considered to be fracture, one out of every 3 women and 1 out of every 8 men over the age of 50 has experienced a fracture caused by osteoporosis (Rinonapoli et al., 2021). It is estimated that about two hundred million people in the world suffer from osteoporosis. are infected (Enitan et al., 2023). Based on statistics, it has been shown that the prevalence of osteoporosis is higher in the hip and spine (Salari et al., 2021). In Iran, 50% of men over fifty years old and 70% of women over fifty years old have osteoporosis (Fahimfar et al., 2020).

The analysis of bone turnover markers is a new tool that detects the dynamics of bone regeneration, including bone formation and resorption (Di Medio & Brandi, 2021). Bone regeneration is regulated by the activation of osteoclasts and osteoblasts, and these biomarkers reflect the current state of the bone turnover rate (Duda et al., 2023). Bone turnover can be estimated by analyzing bone-specific alkaline phosphatase and calcium 5 times more than men have an initial fracture, but the risk of subsequent fractures within three years after the first

fracture is relatively lower (Ivaska et al., 2022). Age is also effective in increasing the risk, and as the age increases, the incidence of osteoporosis increases according to the statistics of the World Health Organization In people over the age of 65, the prevalence of hip fractures increases, which usually occurs as a result of very minor injuries and mostly after normal falls (Su, Xiao, Sun, Xu, & He, 2024). Also, with increasing age, the level of hormones (testosterone in men and estrogen in women) and bone density decrease reduces and makes bones more fragile (Rinonapoli et al., 2021). It is known that the content of bone minerals increases during childhood and reaches its maximum during puberty, after the third decade of life, the overall reduction of bone begins and with increasing age, this decrease in bone mass progresses, bone strength due to the decrease in density (Hereford, Kellish, Samora, & Nichols, 2024). Bone decreases, as a result of increasing age, bone removal is more than its repair, which causes a decrease in bone mass (Bolamperti, Villa, & Rubinacci, 2022). These cases make chronological age one of the main risk factors for the prevalence of osteoporosis (Tartibian, Fasihi, & Eslami, 2023). Also, another effective indicator in osteoporosis is weight, the lower the body weight, the less force is applied to the bones and the bone density decreases (Gkastaris, Goulis, Potoupnis, Anastasilakis, & Kapetanos, 2020). On the other hand, the effect of body weight and fat mass can be another factor to stimulate bone formation. In addition, fat tissue acts as a storage source of steroid hormones. Studies confirm that estrogen has inducing effects on the expression of osteoblast genes (Niwczyk et al., 2023). On the other hand, bone is the main source of calcium and progenitor cells in the body (Kangari, Talaei-Khozani, Razeghian-Jahromi, & Razmkhah, 2020). Among the various biological tests to estimate the activity of osteoblasts, measuring the amount of alkaline phosphatase is an important test (Makris, Mousa, & Cavalier, 2023). Alkaline phosphatase is an ectoenzyme produced by osteoblast cells that hydrolyzes organic phosphates at alkaline pH (Vimalraj, 2020). Calcium and phosphate are important components of inorganic bone matrix and the main factors in maintaining bone health. Serum alkaline

phosphatase ALP levels are a strong predictor of bone loss (Nizet, Cavalier, Stenvinkel, Haarhaus, & Magnusson, 2020). Phosphate deficiency can also lead to bone damage and clinical disease (Tartibian, Fasihi, & Eslami, 2021). On the other hand, various studies have mentioned the effect of physical activity in the prevention of bone tissue analysis, and considering that 40-44% of the bone density of an adult is achieved during adolescence, the effect of physical activity is especially important during growth. and maturity have shown on bone density (Pinheiro et al., 2020). Sports activity is a factor that maintains and stimulates bone formation, which leads to a reduction in the risk of bone fractures through the accumulation of minerals, strengthening muscles, and improving a person's balance (Anderson, Stender, Rondano, Bishop, & Duckett, 2022). The effect of physical activity and the resulting mechanical pressure on increasing bone density has been proven, the mechanical pressures applied to bones through tendons and muscles have a direct effect on bone formation and deformation (Hughes & Centner, 2024). Sports activities transfer force to bones in two ways: muscle tension and gravity (Herrmann et al., 2020). These forces can cause an increase in bone density, if people who follow an active life have significantly more bone mass than inactive people of the same age, and this benefit is maintained until their seventh and even eighth decade of life (Tartibian et al., 2023). As far as we know, few studies have investigated the effect of aerobic exercise on bone metabolic markers (alkaline phosphatase and calcium) in elderly women; Therefore, this study was designed to investigate the long-term effects of aerobic exercise on metabolic markers in elderly women. According to previous studies, it seems that the use of exercise methods in rehabilitation and improvement of metabolic markers of alkaline phosphatase and bone calcium has been less considered, considering the mentioned materials and also the many contradictory results that have been found among the studies about the use of There are aerobic exercises, the effort of this research was the answer to many of these uncertainties. Therefore, the aim of the present study was to investigate

the effect of eight weeks of resistance training on some serum and metabolic markers of bone mass in postmenopausal women.

Methods

This research was semi-experimental with a pre-test and post-test design. Postmenopausal women aged 48 to 59 years constituted the statistical population of the research. After initial evaluation and confirmation of osteoporosis based on DEXA test, 24 postmenopausal women were selected as available. The inclusion criteria for the study included: no smoking, no regular physical activity in the last year, no orthopedic, cardiovascular and blood pressure diseases, and having general health that the subjects were examined by a doctor, at least one year since their last menstrual period. passed and their menopause period is not more than 10 years. Exclusion criteria include: not participating in regular sports training, taking any medication that affects bone metabolism, and having menstruation. The subjects then completed the consent form and the medical-sports awareness questionnaire and were randomly assigned to two resistance training groups of 12 people and a control group of 12 people. Each of the subjects of the training group participated in the 8-week sports program, three sessions a week. Each training session lasted for 90 minutes. The program of a training session including warm-up phase, resistance training and cooling phase was carried out. The rest interval between two exercises was 5 minutes.

In order to measure the blood samples, the subjects were asked not to do any sports activities and also not to consume caffeine 24 hours before blood collection. Blood sampling was done 48 hours before and after 8 weeks of the training program, between 8-9 am in the laboratory and in the presence of a specialist. Anthropometric indices including weight and body mass index (BMI), and metabolic indices including alkaline phosphatase, phosphorus and calcium levels were measured from both groups. Also, from all the subjects, a scan was taken from the lumbar vertebrae (L4-L2) by a bone densitometer, model T DEXXUM,

Osteosys company, made in Iran. After the device was calibrated, the bone mineral density in this area, measured and calculated.
The Kolmogorov-Smirnov test was used to check the normal distribution of the data, and the Lune test was used to check the homogeneity of the groups. In the data that had a normal distribution ($p<0.05$), paired t statistical method was used to examine intra-group changes and independent t-test was used to examine inter-group changes. SPSS software was used.

Results

At the beginning of the study, there was no significant difference between the resistance training and control groups in the comparison of anthropometric characteristics ($p>0.05$)). After the intervention of strength training for 8 weeks, the results indicated a significant difference in the subjects' weight ($p=0.035$) and BMI ($p=0.021$) values (Table. 1).

Table 1: Variables related to the subjects' anthropometric characteristics

variable	exercise group			control group		
	Mean±SD			Mean±SD		
	pre-test	post-test	P	pre-test	post-test	P
age (years)	54.37±4.40	54.37±4.40	-	53.87±4.45	53.87±4.45	-
Height (cm)	157.47±4.47	157.47±4.47	-	155.07 ± 4.75	155.07 ± 4.75	-
weight (kg)	62.75±5.36	58.12±4.94	0.035	63.75±5.10	62.62±5.39	0.094
BMI (kg/m2)	25.47±3.92	24.96±1.23	0.021	25.07±3.88	25.71±3.96	0.060

The results of the correlated t test showed that after the intervention of 8 weeks of resistance training, the amount of calcium in the post-test increased significantly compared to the pre-test ($p=0.035$).

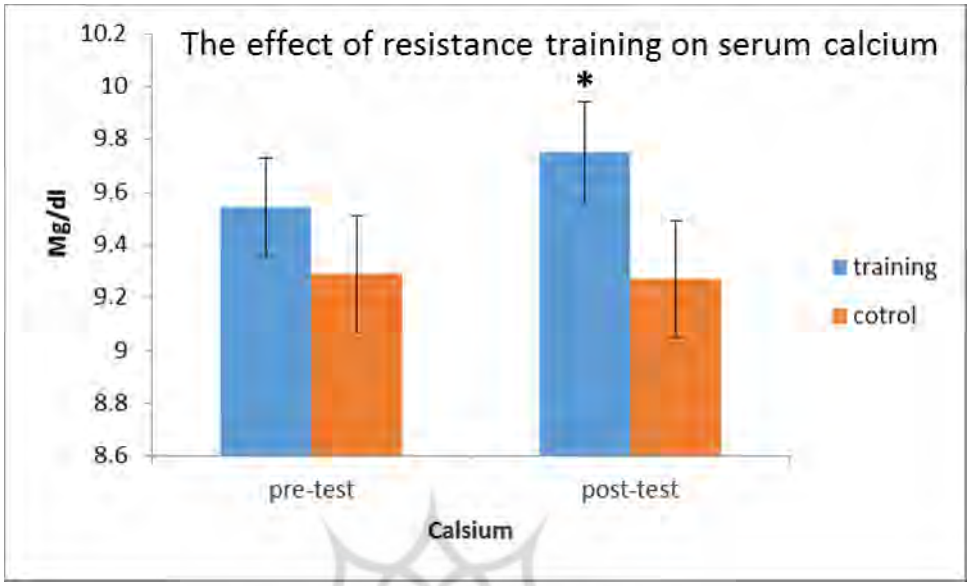

Figure 1: Serum calcium level before and after resistance training intervention in the control and training groups (*: compared to baseline, P<0.035)

The results of the correlated t test showed that after the intervention of 8 weeks of resistance training, the amount of alkaline phosphatase in the post-test increased significantly compared to the pre-test (p=0.041). (Figure 2)

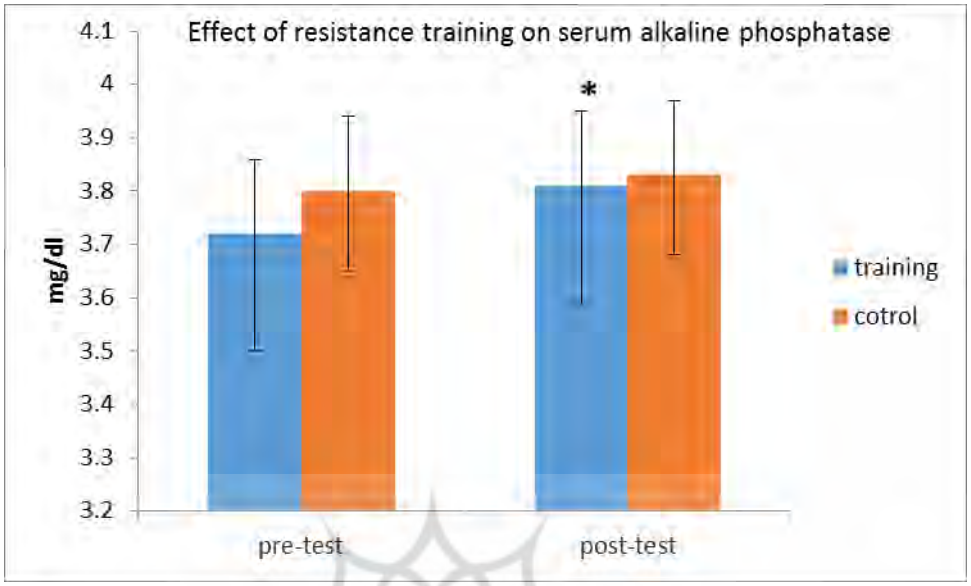

Figure 2: Alkaline phosphatase levels before and after intervention in control and exercise groups (*: compared to baseline, P=0.041)

The results of the correlated t-test after the 8-week resistance training intervention did not show a significant increase in phosphorus levels in the post-test compared to the pre-test. (p=0.071). (Figure 3)

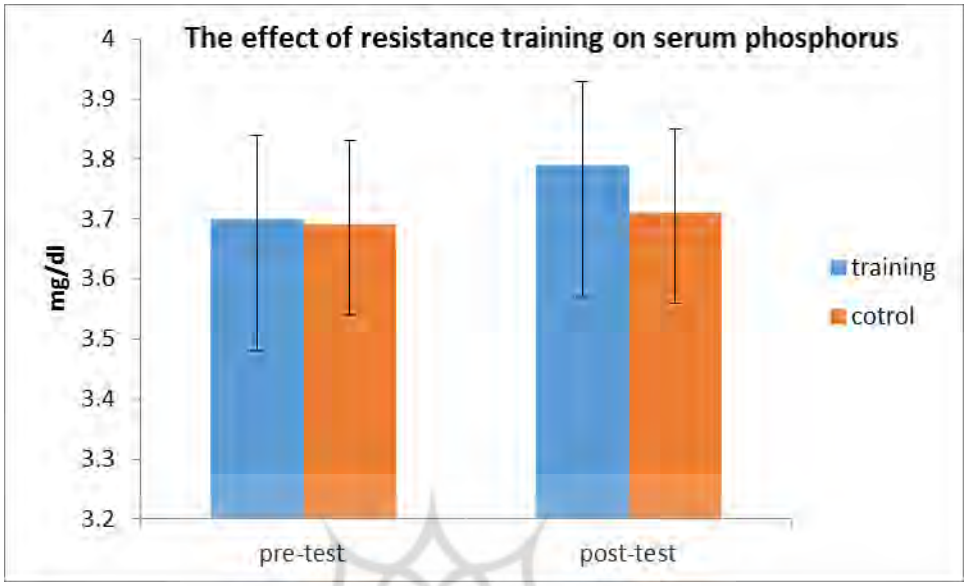

Figure 3: Alkaline phosphatase levels before and after intervention in control and exercise groups (compared to baseline, P=0.071)

The results of the correlated t test showed that the density of minerals in L4-L2 lumbar bones in the training group increased significantly after 8 weeks of resistance training (p=0.11). (Figure 4)

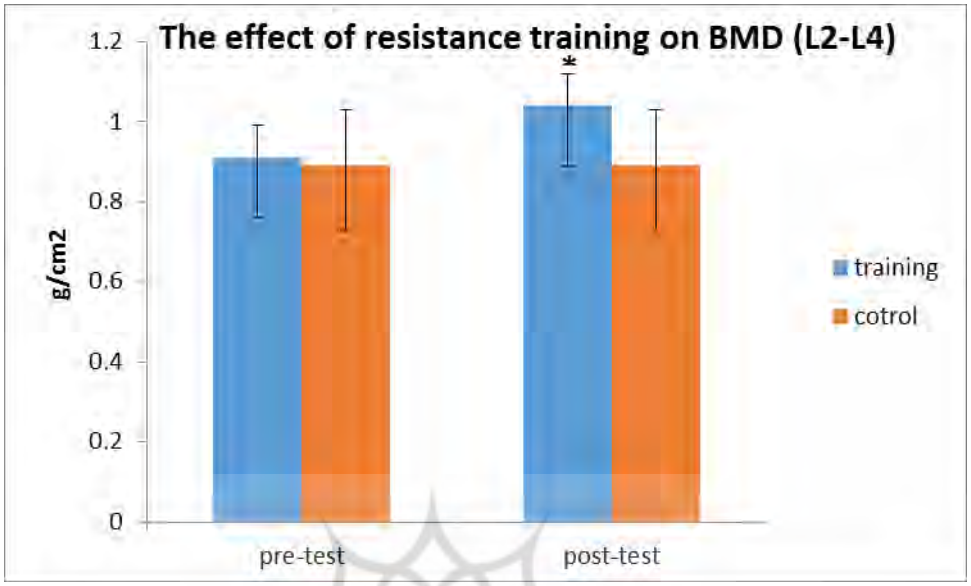

Figure 4: Bone mineral density of lumbar vertebrae (L2-L4) before and after 8 weeks of resistance training intervention (*: compared to baseline, P=0.011)

Discussion

The present study showed that 12 weeks of resistance training caused a significant improvement in body mass index, weight, alkaline phosphate, calcium and bone density in the lower back of the training group compared to the baseline. There was no significant change in serum phosphorus levels. In the training group, calcium levels, bone density in the lumbar region and body composition indicators showed a significant improvement after the training period compared to the control group. The results of the present study were consistent with the findings of Hidarnia et al (2016) study, which was conducted with the aim of investigating the effect of combined exercise on bone density in premenopausal women (Hidarnia, Kashfi, Ghasemi, & Askari, 2016). In their study, they reported an increase in serum calcium, bone density of lumbar vertebrae and femoral neck, a significant decrease in weight, fat percentage and body mass index in the experimental group compared to the control group. They also observed no significant change in serum phosphorus in the exercise group. In the study of

Rotstein et al. (2008), the effect of 5 months of training in water and on land on the bone density of postmenopausal women was studied, and the findings indicated a significant increase in bone density of the radius and wrist in the group of training in water and land (Rotstein, Harush, & Vaisman, 2008). The results of the study by Kelley et al. (2002) showed the positive effect of stretching exercises on the lumbar vertebrae, which are consistent with the findings of the present study, with the difference that the statistical sample of the mentioned study was menopausal women and their statistical sample was middle-aged women, in addition In the current research, resistance exercises were considered, while their study was stretching exercises (Kelley, Kelley, & Tran, 2002). The results of the present study are consistent with the findings of Kang et al (2015), with the difference that in the aforementioned study, Pilates exercises were performed in a dry environment on women aged 60 to 65 years (Kang et al., 2021). In the study of Ghasemi et al. (2020), which was carried out in a period of 12 weeks and with weight bearing in water (Ghasemi & Sadeghi, 2020), similar results were reported with the findings of the present study, with the difference that the subjects of Arnold et al (2008) study were sedentary women aged 50 to It has been 70 years and the exercises were done only in the water environment (Arnold, Busch, Schachter, Harrison, & Olszynski, 2008). The results of the present study were consistent with the study of Juesas et al., (2023) in some cases and the type of exercises, and in some variables, they were inconsistent. They investigated the effect of 8 weeks of training in dry and water environments on osteoporosis in postmenopausal women and finally reported an increase in bone mineral density and weight loss and a decrease in body mass index in both water and dry environments (Juesas et al., 2023). The difference between this research and the current research It can be related separately in the environment of research and conducting exercises in both water and land environments. Researchers believe that the changes in plasma calcium and phosphorus are mostly related to hormonal factors that regulate the levels of total calcium (Ciosek, Kot, Kosik-Bogacka, Łanocha-Arendarczyk, &

Rotter, 2021). parathyroid hormone (PTH) is one of the important factors in regulating bone metabolism. The most important physiological function of this hormone is to maintain calcium ion/inorganic phosphate homeostasis through the protein-related receptor in kidney, bone and intestine (Martin, 2016). PTH increases plasma calcium levels by stimulating calcium reabsorption in the intestine and increasing bone reabsorption (Lombardi, Ziemann, Banfi, & Corbetta, 2020). In the kidney, D hormone increases calcium reabsorption in the kidney by increasing the production of 25 hydroxy vitamin 3 (Bhattarai, Shrestha, Rokka, & Shakya, 2020). It is said that sports activities cause better absorption of calcium from the digestive system, and on the other hand, the presence of sufficient amounts of calcium causes a decrease in the production of PTH hormone, thus reducing bone calcium absorption, and this has an effect on the positive changes in bone mass (Hernando et al., 2021). On the other hand, increasing the presence of phosphate ions also causes an increase in PTH levels.

Weight loss caused by diets has decreased bone mass, but weight maintenance training programs have increased this index. In 2021, Mesinovic et al observed that in obese and overweight middle-aged people, along with a weight loss diet, a combination of walking and resistance exercises, no decrease in bone mass was observed compared to the group without exercise (Mesinovic et al., 2021). These researchers introduce the mechanical load applied in training as a suitable factor for the mechanical stimulation of bone-forming cells. It is said that sports exercises have an effect on bone metabolism (Whitton, 2024). (Osteoprotegrin) belongs to the tumor necrosis factor alpha family and acts as an inhibitor for nuclear factor (kB (RANK) ligand). By binding this ligand, osteoclastogenesis increases. Physical activities reduce this factor and it may be considered an important mechanism for people such as the elderly or menopausal women at risk to prevent osteoporosis.

Conclusion

The findings of the present study indicate the effect of resistance training on the bone density of the lumbar vertebrae. In general, according to the results of this research, it can be expected that menopausal women, by performing resistance exercises, while benefiting from better health indicators, will provide the necessary stimulation for some hormonal mechanisms, absorption of minerals and calcium-phosphorus balance in order to reduce It provides bone resorption and probably has beneficial effects on bone metabolism. It is suggested to investigate the bone density of the thigh area and use more subjects and in a longer period of time in future research.

Conflict of interest

The authors declare that there is no conflict of interest.

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