

EFFECT OF DIFFERENT AEROBIC EXERCISE INTENSITY ON BONE MINERAL DENSITY AND QUALITY OF LIFE IN POSTMENOPAUSAL WOMEN

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ABSTRACT

The purpose of the study: This study was conducted to investigate the effect of different aerobic exercise intensity on bone mineral density and quality of life in postmenopausal women. **Subjects:** 60 postmenopausal women with mean age (56.5 ± 2.44 years) were investigate. They were randomly assigned into four equal groups; Group A (Control group): fifteen women who received medical treatment; Group B: fifteen women who received mild intensity of aerobic exercise (50% - 60% HR max) in addition to medical treatment; Group C: fifteen women who received moderate intensity of aerobic exercise (65% - 75% HR max) in addition to medical treatment. Group (D): fifteen women who received high intensity of aerobic exercise (76% - 85% HR max) in addition to medical treatment. Medical treatment in the form of Calcium supplementation 1000mg and 1000 IU of vitamin D daily for 6 months as prescribed by physician were given to all studied groups. Aerobic exercise with different intensities was performed 30 minutes, twice a week for 6 consecutive months for all participants in all groups (B, C&D). Bone mineral density at the lumbar spine was assessed at baseline and at the end of six months by dual energy X-ray absorptiometry. The mini-osteoporosis quality of life questionnaire (QoLQ) was used to assess quality of life for all participants before and after six consecutive months. **Results:** There was a statistical significant increase the value of T score of BMD of the lumbar spine in both groups C and D ($p= 0.01$ & 0.001) when compared with its corresponding values before treatment while, there was no significant increase in both groups A and B ($p=0.916$, $p= 0.068$ respectively) post intervention. Significant intergroup differences were found post intervention between each two groups with favor to group C , while ther was no significant difference between both groups (B &D). Also, there was significant increase in the score of QoLQ in all groups B, C and D when compared with its corresponding values before treatment while, there was no significant increase in group A. There was a significant intergroup difference between each two groups post intervention with favor to group C. **Conclusion:** It can be concluded that moderate intensity aerobic exercise is more effective than mild and high intensity in improving bone mineral density and quality of life in postmenopausal women.

Key words: Aerobic Exercise, Bone Mineral Density, Quality of Life and Postmenopausal Women.

I-INTRODUCTION

Osteoporosis, or porous bone, is a disease characterized by low bone mass and structural deterioration of bone tissue, leading to bone fragility and an increased susceptibility to fractures, especially of the hip and spine. Osteoporosis is defined as a bone mineral density (BMD) that is below the typical value for young healthy women (a T-score of -2.5 SD) (Mahadik et al., 2021). Women experience menopause between 40 and 58 years of age, the median age being 51 years. Osteoporosis commonly affects postmenopausal women and places them at an increased risk of fractures (Sumida et al., 2014). Osteoporosis complications influence people's lives and create worry and

despair, as well as decreased abilities, acute and chronic pains, difficulties doing daily tasks, reliance on others, and altered social interactions, all of which damage people's quality of life (**Amir, 2021**). Bone mass is influenced by various factors, including proper physical activity (PA), hormones, and nutrition, in addition to genetic coding. It's critical to diagnose low bone mass early and take steps to avoid additional bone loss. Osteogenic activity can be stimulated by applying the right mechanical force (**Sinaki, 2021**).

Dual-energy X-ray absorptiometry (DXA) performed to the lumbar region is recommended as the reference method for diagnosing osteoporosis by the World Health Organization and the International Osteoporosis Foundation. Because of its superior predictive value for fracture risk, the femoral neck is the chosen site (**Kanis et al., 2005**).

Maximizing peak bone mass, increasing bone mass before menopause, counteracting menopause-related bone loss, and minimizing falls are all strategies for reducing osteoporotic fractures in women. Sports and exercise, in combination with adequate calcium and vitamin D intake, play a key role in preventing osteoporotic fractures throughout a woman's life (**Sumida et al., 2014**).

Exercise is one of the most widely used non-pharmacological strategies to prevent bone resorption (**Asikainen et al., 2004**). It is generally acknowledged that regular exercise can positively influence bone metabolism (**Russo, 2009**). Bone is an adaptive tissue, and one of the mechanisms whereby exercise can improve bone strength is by increasing muscle mass because of the mechanical load that it exerts on the skeleton (**Ma et al., 2014**).

Calcium and vitamin D are low-cost treatments that improve bone health. Calcium is necessary for bone production, but it is lost from the body every day (through urine and the renal system) and must be supplied. As a result, maintaining a sufficient calcium intake is critical. Bone health necessitates the use of vitamin D. It is necessary for calcium homeostasis and enhances calcium absorption in the intestine (**IOM, 2011**). The aim of this study was to investigate the effect of different aerobic exercise intensity on bone mineral density and quality of life in postmenopausal women.

II- MATERIALS & METHODS

• Study design and participants:

A total of 60 postmenopausal women aged 50-60 years, a body mass index (BMI) didn't exceed 30 kg/m² were recruited from the outpatient unit of Physical Therapy, Al Mobarra Hospital, Almehalla Elkobra, ALGharbia, Egypt. Each participant signed a written informed consent. The protocol was approved by the Ethical Committee, Faculty of Physical Therapy, Cairo University (**NO. P.T.REC/012/002319**).

Participants were randomly divided into four groups equal in number by an independent person who make the selection blindly from sealed envelopes containing numbers created by a random numbering generator. The randomization was restricted to permuted blocks to ensure that equal numbers are allocated to each group. The sequences assigned to the participants were placed in envelopes containing the allocation to each group.

Group (A; Control group): Fifteen women who received medical treatment only; Group (B): Fifteen women who received mild intensity of aerobic exercise (50% - 60% HR max); Group (C): Fifteen women who received moderate intensity of aerobic exercise (65% - 75% HR max); Group (D): Fifteen women who received high intensity of aerobic exercise (76% - 85% HR max).

Medical treatment in the form of Calcium supplementation (1000mg daily and 1000 IU of vitamin D daily) for 6 months as prescribed by their physician was given to all participants in all groups (A, B, C & D).

30 minutes aerobic exercise with different intensities was repeated three times per week for 6 consecutive months for all participants in all groups (B, C & D).

Assessment of BMD of the lumbar spine was measured at baseline and after 6 months in addition to the mini osteoporosis quality of life questionnaire (QoLQ).

- **Outcomes:**

- ❖ Assessment of bone mineral density:

DXA scans were used to measure BMD. The measurements of DXA were represented as T score. The osteoporosis was diagnosed among participants using DXA method according to T-score; Normal (0 to -0.99); Osteopenia (low bone density) (-1 to -2.49); Osteoporosis (≤ -2.5); Severe or established osteoporosis (≤ -2.5 with fracture). Total bone mineral density (BMD) of the lumbar spine was measured at baseline and after 6 months.

Every participant was advised to wear loose, comfortable clothing, avoiding garments that have zippers, belts or buttons made of metal. Objects such as keys or wallets that would be in the area being scanned should be removed. Remove some clothing and/or change into a gown for the exam. Remove jewelry, dental appliances, eyeglasses and any metal objects or clothing that might interfere with the x-ray images. In the central DXA examination, which measures bone density of the lumbar spine, the participant was advised to lie in supine lying position on a padded table with her both legs were supported on a padded box to flatten the pelvis and lower (lumbar) spine. An x-ray generator was located below the patient and an imaging device, or detector, was positioned above. The detector is slowly passed over the area, generating images on a computer monitor.

Participant was advised to hold breath for a few seconds while the technologist takes the x-ray. This helps reduce the possibility of a blurred image. The technologist walked behind a wall or into the next room to activate the x-ray machine.

- ❖ The mini-QoLQ.

It consists of 10 items and measures five important domains: distress and discomfort symptoms, physical function, activities of daily living, emotional function, and leisure activities. The mini-QoLQ demonstrates adequate reliability and high cross-sectional correlations with other measures of quality of life questionnaire (Cook et al., 1993). The mini-osteoporosis quality of life questionnaire (OoLQ): was used to assess quality of life for all participants in all groups (A, B, C& D) before and after the intervention.

- **Interventions:**

Electronic treadmill (Zan 800; made in Germany) was used for performing the aerobic exercise training. Aerobic exercise was performed by treadmill adjusted at different intensities (mild, moderate & severe) for groups B, C & D respectively.

- ❖ Aerobic exercise intensity for groups (A, B & C)

Each participant of all groups (B, C & D) was asked to wear comfortable, loose clothes and evacuate her bladder to be more relaxed. A brief demonstration about the effect of aerobic exercise upon BMD was explained to each participant to gain her confidence and cooperation during the treatment protocol. Training intensity was based on the maximum heart rate (MHR) = 220-age.

The aerobic exercise session started with warm-up phase: First, participants was asked to walk slowly (20% HR max) for 5 minutes. Active phase: The aerobic treadmill-based training program was set at mild intensity 50% to 60% maximum heart rate (HR max) for (Group B), moderate intensity at 65 to 75% of (HR max) for (Group C) and high intensity at 76% to 85% of the (HR max) for (Group D). The training session lasted for 20 minutes. Cool down phase: Every participant was asked to reduce the speed of walking (20% HR max) for 5 minutes. Each training session lasted for 30 minutes, two sessions per week for six consecutive months.

- ❖ Medical treatment for the four studied groups

All participants received 1000 mg of calcium and 1000 IU of vitamin D daily for 6 months as prescribed by their physician.

• **Statistical analysis:**

Considering α of 0.05, power of 80%, variance of 1.5, and an effect size of 0.19 standard deviations, a 60-woman sample size (15 in each group) was determined for the current study. Results are expressed as mean \pm standard deviation. Test of normality, Kolmogorov-Smirnov test, was used to measure the distribution of data measured pre-treatment. Comparison between normally distributed variables in the four groups was performed using one-way ANOVA test. In not normally distributed data, comparison between variables in the four groups was performed using Kruskal Wallis ANOVA test followed by Mann Whitney test if significant results were recorded. While comparison between pre- and post-treatment data in the same group was performed using Wilcoxon Sign Ranks test. Statistical Package for Social Sciences (SPSS) computer program (version 19 windows) was used for data analysis. P value \leq 0.05 was considered significant.

III- RESULTS

Demographic characteristics of the Four Studied Groups:

There was no statistical significant difference in age and BMI, between the four groups at the baseline ($p = 0.520$ & 0.328 respectively) Table 1.

Table 1. Demographic Characteristics for All Studied Groups

	Group A (n= 15)	Group B (n= 15)	Group C (n= 15)	Group D (n= 15)	F-value	p-value
Age (yrs.)	58.47 \pm 4.70	56.13 \pm 4.55	57.73 \pm 5.44	56.40 \pm 4.87	0.763	0.520 (NS)
Weight (kg.)	68.07 \pm 7.47	70.80 \pm 7.05	73.13 \pm 4.12	68.87 \pm 7.48	1.714	0.175 (NS)
Height (cm)	157.27 \pm 3.84	159.80 \pm 4.39	159.67 \pm 4.62	159.67 \pm 3.89	1.273	0.292 (NS)
BMI (kg/m ²)	27.55 \pm 3.18	27.76 \pm 2.82	28.68 \pm 0.75	26.99 \pm 2.54	1.173	0.328 (NS)

Data are expressed as mean \pm SD, F value = ANOVA test, NS= $p > 0.05$ = not significant.

Mini Osteoporosis Quality of Life (QoLQ) questionnaire

Within group comparison

There was no statistical significant increase in QoLQ score values in group A measured post-treatment compared to the pre-treatment condition ($Z = -1.000$, $p = 0.317$), while there was a statistical significant increase in QoLQ score in groups (B, C & D) post-treatment (45.87 ± 11.67 , 61.73 ± 21.67 , 44.67 ± 20.04 respectively) compared to the pre-treatment condition ($p = 0.001$) Table 2.

Table 2. Mean Values of QoLQ Scores pre and post-treatment in the four Studied Groups

	Group A (n= 15)	Group B (n= 15)	Group C (n= 15)	Group D (n= 15)
Pre-treatment	14.20 \pm 3.26	15.87 \pm 2.17	13.73 \pm 1.79	14.33 \pm 4.06
Post-treatment	13.80 \pm 3.12	45.87 \pm 11.67	61.73 \pm 21.67	44.67 \pm 20.04
Z ^{##} value	-1.000	-3.301	-3.411	-3.408
p value	0.317 (NS)	0.001 (S)	0.001 (S)	0.001 (S)

Data are expressed as mean \pm SD, Z value = Wilcoxon Signed Ranks test, NS= $p > 0.05$ = not significant; S= $p \leq 0.05$ = significant.

Between groups comparison

There was no statistical significant difference between the four studied groups regarding QoLQ pre-treatment ($p = 0.128$). The four groups were compared using a post-hoc test. The results showed a significant difference between each two groups ($p = 0.001$ & 0.004) concerning the QoLQ with favor to group C Table 3.

Table 3. Mean values of QoLQ in the four studied groups before and after intervention.

OQLQ	Group A (n= 15)	Group B (n= 15)	Group C (n= 15)	Group D (n= 15)	χ^2 value	P value
Before treatment	14.20 ± 3.26	15.87 ± 2.17	13.73 ± 1.79	14.33 ± 4.06	4.828	0.128 (NS)
After treatment	13.80 ± 3.12	45.87 ± 11.67	61.73 ± 21.67	44.67 ± 20.04	39.538	0.001 (S)
Z & p values versus group A	----	-4.678 & 0.001 (S)	-4.687 & 0.001 (S)	-4.682 & 0.001 (S)		
Z & p values versus group B	----	----	-2.874 & 0.004 (S)	-1.188 & 0.001 (S)		
Z & p values versus group C	----	----	----	-2.849 & 0.004 (S)		

Data are expressed as mean ± SD, χ^2 value = Chi square value of Kruskal Wallis test
Z value= Mann-Whitney test, NS= $p > 0.05$ = not significant; S= $p \leq 0.05$ = significant.

T-score for the lumbar spine

Within group comparison

There was no statistical significant difference in T score value of BMD for the lumbar spine post intervention in both groups A&B ($p = 0.916$ & 0.068), while, there was significant increase in T score values measured post-treatment in both groups C&D ($p = 0.002$ & 0.011 respectively) Table4

Table 4. Mean values of T – scores for the lumbar spine pre- and post-treatment in the four studied groups.

	Group A (n= 15)	Group B (n= 15)	Group C (n= 15)	Group D (n= 15)
Pre-treatment	-3.28 ± 0.26	-3.08 ± 0.34	-3.17 ± 0.59	-3.30 ± 0.20
Post-treatment	-3.27 ± 0.37	-2.99 ± 0.33	-2.62 ± 0.76	-2.99 ± 0.36
Z ^{##} value	-0.105	-1.826	-3.065	-2.536
p value	0.916 (NS)	0.068 (NS)	0.002 (S)	0.011 (S)

Data are expressed as mean ± SD, Z value = Wilcoxon Signed Ranks test, NS= $p > 0.05$ = not significant; S= $p \leq 0.05$ = significant.

Between groups comparison

There was no statistical significant difference between the four studied groups (A, B, C &D) before intervention ($p = 0.120$). The four groups were compared using a post-hoc test. The results showed a significant difference between each two groups except both between both groups (B&D; $p = 0.950$) Table 5.

Table 5. Mean values of T –score of the lumer spine in the studied groups pre and post intervention.

T –score of BMD	Group A (n= 15)	Group B (n= 15)	Group C (n= 15)	Group D (n= 15)	χ^2 value	P value
Pre-treatment	-3.28 ± 0.26	-3.08 ± 0.34	-3.17 ± 0.59	-3.30 ± 0.20	4.320	0.120
T –score	-3.27 ± 0.37	-2.99 ± 0.33	-2.62 ± 0.76	-2.99 ± 0.36	14.558	0.002 (S)
Z & p values vs group A	----	-2.229 & 0.026 (S)	-3.159 & 0.002 (S)	-2.081 & 0.037 (S)		
Z & p values vs group B	----	----	-2.309 & 0.020 (S)	-0.063 & 0.950 (NS)		
Z & p values vs group C	----	----	----	-2.203 & 0.028 (S)		

Data are expressed as mean ± SD, χ^2 value = Chi square value of Kruskal Wallis test
Z value= Mann-Whitney test, NS= $p > 0.05$ = not significant; S= $p \leq 0.05$ = significant.

IV- DISCUSSION

Osteoporosis is a major public health problem, which increases proportionally according to age. It is characterized by excessively low bone density, bone fragility and increased risk of fracture with relatively minor trauma **Auyeung et al., (2014)**. Osteoporosis has serious morbid implications, prevention and care of the disease, as well as accompanying fractures, are deemed critical to the patient's health status or quality of life (QoL). Patients can avoid developing this condition by using several lifestyle medicine methods, such as remaining physically active or performing weight-bearing exercises (**Mahadik et al., 2021**). Aerobic exercise plays an essential role in the treatment of osteoporosis. Aerobic training has been shown to be effective for improving BMD and reducing bone loss **Roghani et al., (2013)**.

The results of this study revealed a significant increase in T score in both groups (C & D), these agree with those of **Kuru et al (2014)** who found that moderate intensity of aerobic exercise plays an important role in the rehabilitation of osteoporosis patients and enhanced QoL.

Kistler et al., (2021) stated that moderate-intensity exercise is more effective than low- -intensity exercise for lumbar spine BMD, but not for femoral neck BMD; however, the latter finding could be attributed to a lack of force. In humans, there is a positive link between load magnitude and bone reaction. The findings have implications for the best exercise prescription for postmenopausal women with osteoporosis.

Izquierdo et al., (2021) suggested that aerobic workouts include changing pace and direction while walking, treadmill walking, step-ups, and stair climbing, among others, is beneficial for achieving aerobic fitness adaptations as well as gait and mobility improvements. Weight-bearing aerobic activities that mimic real-life tasks should be used. During the early weeks of training, the exercise component may last 5–10 minutes (or less), increasing to 20–30 minutes in the long run. As your fitness and confidence improve, you can increase the intensity of this workout component from moderate to vigorous. **Mahadik et al. (2021)** found that, regular exercise has an important role in the development of bone mass and the maintenance of bone mineral density. The stress is applied to the joints and muscles, causing osteoblast activity to be stimulated. **Kelley's (2015)** claimed that, exercise enhances femur trochanteric BMD in calcium-replete postmenopausal women.

Also, **Moreira et al., (2014)** added that, exercise training can improve bone health. Aerobic physical exercise performed according to WHO guidelines can result in a decrease in Sex Hormone Binding Globulin (SHBG) and an increase in lumbar spine bone density, as well as a significant increase in hip bone density **Vander et al., (2006)**.

The findings were also in line with those of **Varsavsky et al., (2013)** who demonstrated that, aerobic exercise is linked to both cross-sectional and prospective significant but modest improvements in BMD, implying that they may exert homeostatic influences on BMD during ageing. Aerobic activity appears to be the most effective for maintaining and improving BMD in older women, according to study.

According to **Bergstrom et al. (2012)** high intensity aerobic exercises effectively enhance BMD at the lumbar spine. Postmenopausal women who participated in various kinds of exercise exhibited statistically significant improvements in BMD compared to control groups that did not exercise (**Evans et al., 2007**).

The findings of this study were also backed up by **Nelson et al., (2005)** who claimed that all recommended exercise programs, including aerobic exercise, resistance workouts, and walking, are beneficial for slowing bone marrow density loss over a period of one year or longer. Fast walking is recommended as the best osteoporosis prevention and treatment technique for postmenopausal women since it is the most similar to daily activities and may result in the most compliance.

The results of this study come in consistence with **Angin and Erden, (2009)** who claimed that moderate exercise regimen can help to improve BMD and quality of life. It was possible to stabilize the BMD of the lumbar site and minimize fracture in postmenopausal women with osteoporosis who participated in the study. The findings are also consistent with **Lange et al., (2007)** who discovered that physical activity slows the rate of bone loss in postmenopausal women.

Chan et al., (2007) concluded that, aerobic exercise is a good activity for increasing bone density. It is the simplest and greatest available type of physical activity because it can be done almost anywhere, has little risks of injury, and requires very little money. Brisk walking is the most effective way to prevent osteoporosis.

Shahraki et al (2021) added that, aerobic training of moderate intensity improved lumbar BMD and serum adiponectin levels in osteopenic women. Exercise can be employed as a strategy to generate osteogenic activity in the expanding senior population, according to our findings. According to the **US Department of Health and Human Services (HHS), (2018)** multicomponent exercise training that includes moderate-intensity aerobic activities performed 3 or more times per week for 30 to 45 minutes per session over at least 3 to 5 months appears to be the most effective way to increase functional ability in older adults with frailty

Also, **Von Stengel et al., (2011)** proposed that, impact loading activity could be useful in decreasing bone loss at the hip and spine. Exercise has a significant favorable impact on the slowing of BMD deterioration. Through mechanic transduction, exercise causes an anabolic or homeostatic impact on bone. Fluid flow inside the extracellular matrix of bone causes osteocytes and bone lining cells to exert force. This causes the release of nitric oxide and prostaglandin, which causes osteo-progenitor cells to divide and differentiate. As a result, pre-osteoblasts mature into osteoblast cells and attach to the matrix's surface to begin the formation of new bone. Muscle contractions may also cause extracellular fluid shear stress within the bone matrix, resulting in bone deformations. Similarly, gravitational impacts cause deformations due to fluid shear stresses and the resulting deformations **Warden et al., 2004**). The results were also, supported by **Wu et al 2021** who stated that, regular moderate aerobic training and physical activity can stimulate the process of bone remodeling. Exercise activates osteoclast (bone breakdown) and osteoblast (bone formation) cells, resulting in stronger bones over time.

Alonso et al., (2021) found that exercise improves bone mineral density, strength, functionality, and overall quality of life in postmenopausal women with osteoporosis. Also, **Marini et al., (2021)** concluded that physical activity treatments are becoming better recognized as a beneficial intervention to the prevention and treatment of osteopenia and osteoporosis.

Leal et al., (2021) who proposed the significance of using exercise as a treatment technique for reducing muscle and bone deficiencies with the goal of improving physical function and general quality of life. Also **Robinson et al., (2017)** added that, improvements in aerobic capacity (and most other health outcomes) are best achieved with moderate-to-vigorous intensity aerobic exercise, with high-intensity interval training (HIIT, 85–95 percent peak heart rate for 1–4 minute intervals) having the greatest effects on fitness and some health outcomes in older adults with frailty. **Bull et al., (2020)** stated that Adults 65 and older should engage in vigorous-intensity aerobic activity and two or more days of muscle-strengthening activity (i.e., strength/resistance training) per week, according to the WHO's 'Global Recommendations on Physical Activity for Health.

The results of this study revealed non-significant increase in T score of the lumber spine in both groups (A& B), this was supported by **Tracey et al., (2011)** who stated that, mild types of exercise, such as walking was ineffective therapies except in the calcaneus. Increasing walking period and intensity has not been beneficial in improving BMD. Also, **Liang et al., (2011)** stated that, aerobic exercises like walking have a low intensity, i.e. minor mechanical stimulation to muscles, and so have no effect on bone mass.

The results of this study revealed significant increase in QoLQ in groups (B, C and D), this was supported by **Kastelan et al (2010)** who investigated the effects of 24 weeks of aerobic activities on bone mineral density, physical fitness, and quality of life in postmenopausal women with osteoporosis. According to the findings, aerobic training may lead to fewer fractures and a lower risk of falling due to increased bone mineral density. In terms of pain, physical activity, social life, and subjective health, there were statistically significant differences between active participants and controls.

The findings of this study supported by those of **Schroder et al (2012)** who claimed that there are a variety of fitness program designed specifically for osteoporosis patients to enhance bone mineral density and improve their quality of life. Aerobic exercise intensity and frequency are the most essential factors in reducing menopausal symptoms and improving quality of life.

The results were also, enhanced by **Moilanen et al. (2012)** who concluded that, 50-minute sessions of regular moderate aerobic exercise resulted in a significant reduction in menopausal symptoms and a better quality of life. **Luoto et al. (2012)** found that 6 months of aerobic exercise reduced nocturnal hot flashes and improved quality of life in postmenopausal women.

Also, **Gustafsson, (2021)** stated that osteoporosis has a negative impact on postmenopausal women's quality of life. In the study population, osteoporosis had a negative impact on the markers mobility, usual activities, pain/discomfort, and anxiety/depression. Furthermore, the exercise regimen appeared to improve some quality-of-life measures. **Elavsky et al. (2009)** reported that, increasing physical activity improved women's quality of life. The results were also, supported by **Dennerstein et al. (2007)** who stated that increased physical activity mediated a positive affect and hence had an influence on QOL and backed up the findings.

V- CONCLUSION

Aerobic exercise is a powerful and safe modality in improving bone density in postmenopausal women. Moderate intensity aerobic exercise is more effective than mild and high intensity in improving bone mineral density and quality of life in postmenopausal women.

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