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## **Effect of interval training exercises on bone mineral density indices in elderly women**

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**Abstract**--Background: In most situations, postmenopausal osteoporosis is a silent medical condition without significant or apparent symptoms till the existence of a fracture. Purpose: The goal of this study was to see how effective interval aerobic exercise is at improving bone mineral density indices in the cases of elderly women. Materials and methods: The current study is randomized, controlled trial. During 12-weeks of intervention, 40 subjects with age ranging from 60 to 70 years were randomly subdivided into two main groups: the exercise group (n=20) and the control group (n=20). Exercise group performed the interval exercises program which consisted of high intensity interval exercise (70%maxHR) with intensity lower (50% max HR) workloads were interchanged within 2 min, for 30 -40 minutes per session, 3 times per week for 12 weeks. Control Group did not receive any form of physical therapy intervention, but this group was instructed and encouraged to be remaining active. Outcomes: There are some factors to be considered; Bone mineral density (T score from DEXA), vitamin D levels, and Estrogen levels in the body. Results: Post-intervention, exercise group can show results that are considered superior to those produced by control group ( $p > 0.05$ ) in terms of improving bone mineral density, blood levels of

vitamin D and estrogen by (4.8%, 24.23%, 23.65% respectively) in elderly women. Conclusion: It has been found that 12-week of three times weekly treadmill interval aerobic training have improved bone mineral density, vitamin D, and Estrogen levels in elderly women.

**Keywords**---Interval Training, Bone Mineral Density, postmenopausal Women.

## Introduction

Low bone density and high fracture risk describe osteoporosis. It is simply a skeletal, systemic and metabolic disorder featured with low bone density and high fracture risk. The outcome of this health complication is a high chance of fracture and weak bones <sup>(1, 2)</sup>. World Health Organization (WHO) ranks osteoporosis to be the fourth most hazardous disease coming after the three most dangerous diseases of Heart disease, Cancer, and Diabetes <sup>(1,2)</sup>.

Menopause is described as the lasting cessation of menstrual cycles following the loss of ovarian follicle development as a result of general ageing in the female reproductive system <sup>(3)</sup>. After menopause, Estrogen insufficiency is the leading cause of bone loss. During the climacteric period, Estrogen levels drop, causing a rise in RANK-ligand (RANKL) and a decrease in osteoprotegerin (OPG) secretion by osteoblasts. The RANK receptor on the surface of pre-osteoclasts is activated by RANKL, which causes differentiation and activation. The previously mentioned disparity results in bone loss and fractures <sup>(4,5)</sup>.

Vitamin D and its metabolites play a vital role in bone absorption and production. Vitamin D is important for bone cell maturation, mineralization and resorption <sup>(6)</sup>. Furthermore, significant vitamin D insufficiency has a correlation with adult osteomalacia <sup>(7)</sup>. Subsequently, a vitamin D deficit would raise the risk of bone loss in postmenopausal women through boosting bone resorption <sup>(8)</sup>. Vitamin D receptors (VDRs) are found in the ovaries, endometrium, and placenta, among other reproductive organs <sup>(9)</sup>. Furthermore, various studies have figured out that Vitamin D is an effective treatment for osteoporosis caused by postmenopausal circumstances by increasing bone mineral density (BMD) <sup>(7,10)</sup>.

According to international osteoporosis guidelines, exercise is a potential intervention approach utilized to prevent bone loss. Physical activity, particularly physical exercise, can help postmenopausal women reduce their overall clinical fracture risk. Dedicated exercise routines, unlike pharmaceutical medicines, may have an impact on fracture characteristics. Those characteristics include fall risk, fall impact, and bone strength <sup>(10-14)</sup>.

The advantages of exercise include not just raising BMD but also boosting muscle strength to reduce the hazard of falling. Various types of exercise have been the subject of numerous meta-analyses. According to Kelley's research, aerobic exercise had a relatively beneficial effect on BMD <sup>(15,16)</sup>, whereas resistance training had no effect on BMD maintenance or improvement <sup>(17)</sup>. The majority of

research suggests that combined exercise regimens can effectively protect BMD in postmenopausal women <sup>(18)</sup>.

Successful bone-strengthening exercise programs must be done regularly. A conflict may take place with the onset of age-related restrictions, even in highly motivated individuals. As a result, it is a fascinating topic if an exercise program can produce long-term favorable benefits on bone mineral density (BMD) especially if it is constantly tailored to the challenges and priorities e.g., the growing importance of “fall risk” of advanced age. Because of the diverse exercise protocols utilized in the research, such as resistance or aerobic, the outcomes could have been different. As a result, the current study highlights the effects of interval aerobic training on bone mineral density, vitamin D levels in the blood, and Estrogen levels in aged women.

## **Materials & Methods**

### **Trial Design**

The current study is a controlled trial. All methods involving human participants in this study were carried out in line with the institutional research committee's ethical standards. Those standards are credited and approved by Research Ethical Committee, Faculty of Physical Therapy, Cairo University, Egypt. The serial number of approval is P.T.REC/012/001485. Taking into account the principles of 1964's Helsinki Declaration, participants have signed an informed consent for participation.

### **Participants**

Advertisements in regional hospitals and personal contacts were used to recruit participants from local health facilities. The intervention was received at El-Sahel Teaching Hospital, Cairo, Egypt, from February 2019 to september 2020. All participants were screened by a main investigator prior to the start of the study procedures to rule out women who did not satisfy the inclusion criteria and to confirm that participants were sage to participate in the exercise program.

All participants were given an overview of the study's extensive evaluation and training processes during the introductory session. All of the subjects were volunteers who had the option to leave the study at any time. The criteria for inclusion are: Body mass index (BMI) ranges from 30 to 34.9 kg/m<sup>2</sup> and age ranges from 60 to 70 years (class 1 obese). There was no evidence of cardiac or pulmonary dysfunction in any one of the women. Women with musculoskeletal or neurological disorders, cancer or treatment for cancer of any kind, hormonal replacement therapy, smokers, hypertension complications, heart failure and arrhythmia, problems to stand or to walk, or any other issues that might hinder performing the exercises. Furthermore, participants who were late for the program for more than two weeks or requested to postpone or to end the program were also excluded.

## Randomization and Sample Size

After completing the baseline evaluation, participants were allocated to either the exercise group (n=20) or the control group (n=20) who did not receive any type of physical therapy intervention. Patients were given even and odd numbers. The participants with even number were assigned to the exercise group. However, those with odd numbers were assigned to the control group. The numbers were organized through the use of sealed envelopes. The participants were asked to open the envelopes to determine which group they would be assigned to. Figure 1 highlights the number of participants at each step using the CONSORT diagram. Prior to the study, sample size was calculated using G\*POWER statistical software, version 3.1.9.2; Franz Faul, Universitat Kiel, Germany [F tests-ANCOVA, =0.05, =0.2, large effect size], which figured out that n=40 is the exact sample size.

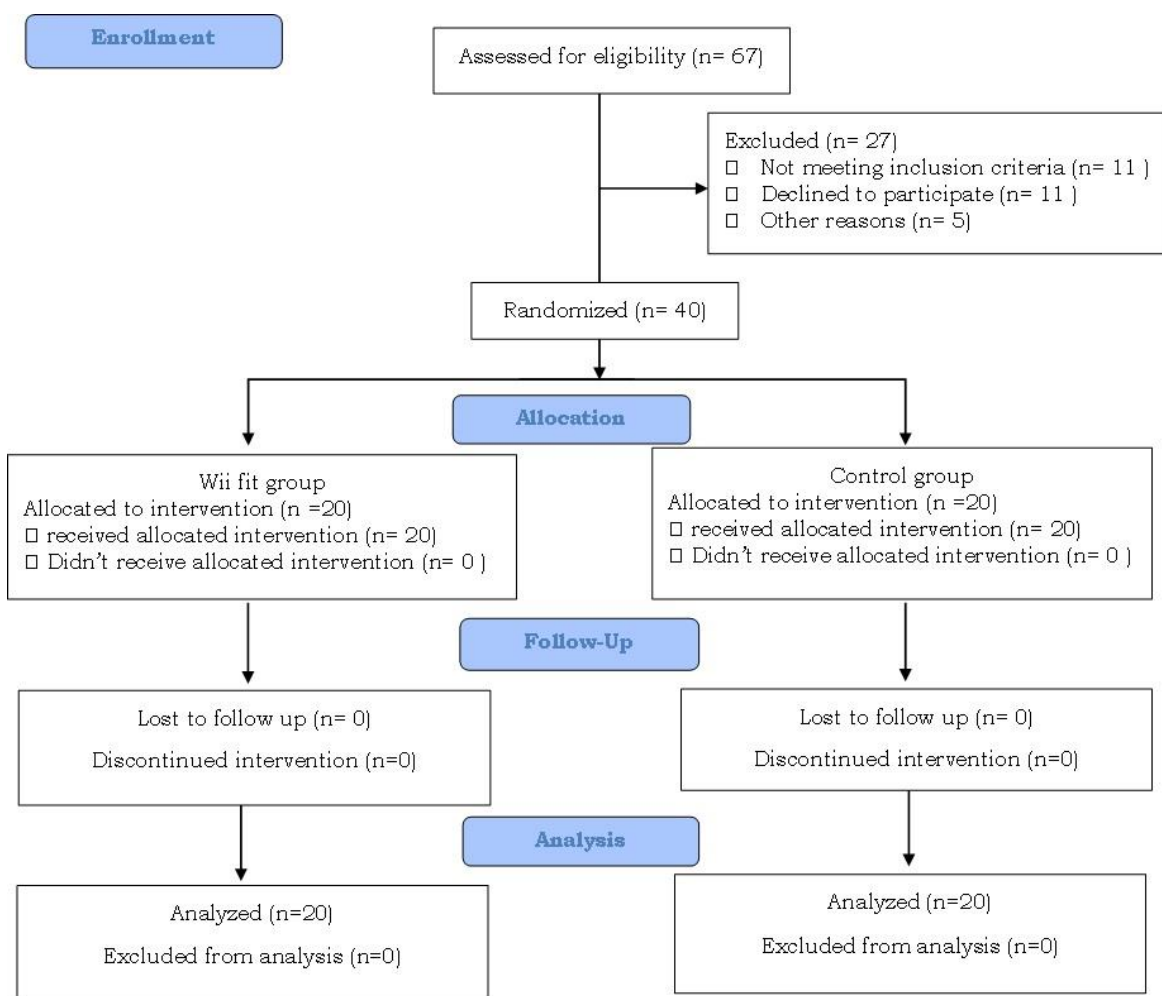


Fig 1. Consort 2010 Flow Diagram

## **Outcome Measures**

Bone mineral density, Estrogen, and vitamin D levels were measured before the commencement of the intervention (baseline) and after the intervention (postintervention) (12weeks). A scale for both weight and height was utilized so as to examine height and body mass. Participants were weighed barefoot and in light clothing. In barefoot state, standing height was measured. Subjects with BMI from 30 to 34.9 kg/m<sup>2</sup> were selected according to the formula: BMI= weight (kg) / height (m<sup>2</sup>)<sup>(19)</sup>.

As for the BMD, it was calculated through using dual-energy X-ray absorptiometry (DEXA) (moon corp, model DPX USA). The treatments were carried out with the patient lying supine in accordance with the device's instructions. The data was compared to typical bone and soft tissue thickness models using DEXA software, which can measure high and low intensity X-ray beams. All measurements were taken and analyzed according to the manufacturer's specified protocols.

The participants were reported to the laboratory in the morning after a 12-hour overnight fast. The serum was separated and analyzed for serum Estrogen (E2) and vitamin D. Blood samples were obtained from medial cubital vein, and serum was separated and tested for serum Estrogen (E2) and vitamin D. The samples have been centrifuged after thirty minutes of clotting at room temperature. Portions of serum supernatant were frozen and stored at -80 °C. The portions were analyzed in single batch.

## **Intervention:**

### **Exercise Group: Interval Training Exercises**

Every lady agreed to do 30 - 40 minutes of treadmill interval aerobic activity three times every week for twelve weeks-period. The treatments were carried out with one to three patients at the same time. The treatment process was done under the supervision of expert physical therapists. To ensure adequate warm-up, general flexibility exercises were done as a post-training program. It was followed by 30 minutes of high intensity interval exercise (70 percent maxHR) with intensity lower than 50 percent maxHR. Workloads were interchanged within 2 minutes at each session<sup>(7,16)</sup>.

All of the women were told to stand on the machine and grasp it with both hands. The walking shoes have a well-cushioned heel, excellent arch support, and flexible slip-resistant outsole. They were asked to wear weather-appropriate loose-fitting, layered clothing. Moreover, they were asked to Maintain good posture by looking forward (rather than at the ground) and keeping your chin and head up. The shoulders were relaxed and the chest was kept up (shoulder down, back and relaxed).

Women were asked to perform the following steps: tighten your abdominal muscles and buttocks, flatten your back, and push your pelvis forward slightly. By taking little steps, you can walk in a straight path. Focus on landing on your heel, rolling through the step, and pushing off with your toes while pushing off

with your toes. To move the body forward, use the natural spring of the calf muscles. Breathing normally, as if you were walking, deep rhythmic breathing to receive the most oxygen into your respiratory system. Not too strident, shoulders that aren't hunched. Carry no hand weights or place ankle weights.

### Control Group:

During the intervention period, control group subjects were asked to follow their normal daily activities without the participation in any other exercise program. The patients were followed up monthly via a phone call. After the evaluation period, control group participants were allowed to participate in the training program.

### Statistical Analysis:

The data are presented with mean standard deviations. IBM SPSS (Statistical Package for Social Sciences (SPSS), Version 24, Chicago, IL) was used to conduct statistical analyses. Shapiro-Wilk test was used to ensure that all data was normally distributed. The dependent paired t-test was utilized to examine within-group changes before and after the test. Considering the two groups, the independent t-test was used to look into the differences and values. At the 5% level, statistical significance was acknowledged.

### Results

The flow diagram for all of the patients in the trial is highlighted in Figure (1) As for Table 1, it figures out patients' demographic features at the initial stage of the study. It has been found that there is no clear disparity in the demographic criteria between the participants of the two groups. After 12 weeks of intervention, statistically significant differences in T score, Vit D, and Estrogen levels were identified in favor of the exercise group, as indicated in Table (2).

**Table 1.** Baseline Demographic Features of the two groups (N=40)

|                               | <b>Exercise Group</b> | <b>Control Group</b> | <b>T value</b> | <b>p-value</b> | <b>Sig</b> |
|-------------------------------|-----------------------|----------------------|----------------|----------------|------------|
|                               | $\bar{x} \pm SD$      | $\bar{x} \pm SD$     |                |                |            |
| <b>Age (years)</b>            | 64.3±2.13             | 64.3±2.13            | 0.000          | 0.999          | NS         |
| <b>Weight (kg)</b>            | 83.8±4.11             | 84.65±3.34           | -0.717         | 0.478          | NS         |
| <b>Height (cm)</b>            | 161.35±2.32           | 162.45±2.28          | -1.511         | 0.139          | NS         |
| <b>BMI (kg/m<sup>2</sup>)</b> | 32.18±1.36            | 32.072±1.11          | 0.276          | 0.784          | NS         |

$\bar{x}$ = Mean; **SD**: Standard deviation, **p value**: Probability value, **NS**: Non significant

**Table 2.** Comparison between pre-study and post-study mean values of the studied variables of both groups.

|                | <b>Groups</b>   | <b>Pre-study Mean±SD</b> | <b>Post-study Mean±SD</b> | <b>T value</b> | <b>p-value</b> | <b>% of improvement</b> |
|----------------|-----------------|--------------------------|---------------------------|----------------|----------------|-------------------------|
| <b>T score</b> | <b>Exercise</b> | -2.02±0.17               | -1.67±0.11                | -14.888        | <b>0.0001*</b> | 4.8%                    |
|                | <b>Control</b>  | -1.96±0.17               | -1.82±0.14                | -9             | <b>0.0001'</b> | 1.9%                    |

|                     |                 |             |               |         |                      |
|---------------------|-----------------|-------------|---------------|---------|----------------------|
|                     | <b>t-value</b>  | -1.118      | 3.845         |         |                      |
| <b>Among groups</b> | <b>p-value</b>  | 0.271       | <b>0.000*</b> |         |                      |
| <b>Vit D</b>        | <b>Exercise</b> | 14.55±1.45  | 17.235±1.99   | -10.687 | <b>0.0001</b> 24.23% |
|                     | <b>Control</b>  | 14.605±1.53 | 15.915±1.61   | -9.599  | <b>0.0001</b> 18.12% |
|                     | <b>t-value</b>  | -0.117      | 2.307         |         |                      |
| <b>Among groups</b> | <b>p-value</b>  | 0.908       | <b>0.027*</b> |         |                      |
| <b>EST</b>          | <b>Exercise</b> | 24.42±5.15  | 29.87±4.85    | -21.727 | <b>0.0001</b> 23.65% |
|                     | <b>Control</b>  | 25.32±4.08  | 26.68±3.85    | -8.186  | <b>0.0001</b> 20.39% |
|                     | <b>t-value</b>  | -0.613      | 2.304         |         |                      |
| <b>Among groups</b> | <b>p-value</b>  | 0.544       | <b>0.027*</b> |         |                      |

**SD:** Standard Deviation, **t-value:** unpaired t value, **P-value:** Probability Level, **\***: Significant

## Discussion

The study's hypotheses were supported by the findings and outcomes which showed that interval aerobic training (exercise group) can improve bone mineral density, blood levels of vitamin D, and Estrogen ( $p > 0.05$ ) by (4.8%, 24.23%, 23.65% respectively in the exercise group versus 1.9%, 18.12%, 20.39% respectively in the control group) in older women.

The results and findings of this study are consistent with those of other studies that suggest aerobic exercise promotes bone mineral density [20-24]. The bone density in the femoral neck rose by 2% in postmenopausal women after 24 weeks of walking training, according to Silverman et al. [20]. Alghadir et al. [21] postulated that moderate-intensity aerobic exercises may maintain bone and cartilage by regulating body trace elements involved in bone matrix synthesis and limiting bone resorption through the proposed anti-free radical mechanism. Wen et al. [22] have discovered that short-term group-based step aerobics exercises increase bone metabolism while reducing bone resorption activity.

Another study [23] found similar results when comparing inactive to active postmenopausal women (treadmill walking for 30 minutes + step climbing for 10 minutes): lumbar and femoral neck pain reduced by 2.0 percent ( $p > 0.05$ ) and 6.8 percent ( $p < 0.05$ ) in the training group, respectively. Basat and cols. [24] looked at 42 postmenopausal women who were randomized to one of two groups: strengthening, high-impact activity, or no exercise (control). After 6 months, the high-impact group demonstrated a significant increase in BMD at the lumbar spine ( $p = 0.017$ ) and femoral neck ( $p = 0.013$ ) when compared to the strengthening and control groups. Serum osteocalcin (OC), a bone formation marker, increased ( $p = 0.033$ ) only in the high-impact group, while NTx, a bone resorption measure, decreased significantly ( $p = 0.034$ ). These data imply that impact forces are significant in stimulating bone metabolism.

The following are the basic mechanisms behind the use of aerobic exercise training to improve bone mineral density: aerobic exercise significantly increases

biomarkers of bone remodeling, reduces bone resorption, and increases the rate of bone formation, and combined resistance and aerobic training significantly stimulates the increase in BMD.

Another notion is that the ground response force and strain force produced by diverse muscle contractions during exercise stimulate the bone, improving its strength and biochemical properties. Correctly applied mechanical stresses can stimulate bone development, increase BMD, and postpone the onset of osteoporosis [26]. According to the findings of a review by Yuan et al. [26], exercise improves BMD, bone mass, bone strength, and bone mechanical properties. One marker for formation and resorption [26].

Physical activity appears to have a direct and indirect impact on all bone cells, as well as many aspects of bone remodeling. According to data, exercise promotes mesenchymal stem cell proliferation, osteogenic differentiation, and osteoblast and osteocyte activities; the exercise mechanical load, as well as the Wnt-Catenin and bone morphogenetic proteins pathways, all play a role. In addition, exercise-induced elevations in hormone levels such as parathyroid hormone (PTH), Estrogen, and prostaglandin E2 resulted in greater osteogenic differentiation and bone formation.

The findings of this study are consistent with prior research demonstrating that aerobic exercise increases vitamin D levels [27-31]. 25(OH)D levels increased by 21.5 nmol/L (8.6 ng/mL) in older persons who undertook an 8-week aerobic program combined with antioxidant supplementation [27]. Some investigations have discovered an increase in circulation 1,25(OH)2D after exercise [27,28]. This could be explained by a brief decrease in ionized calcium and phosphate followed by an increase in parathyroid hormone, which boosts 1,25(OH)2D synthesis [28,29]. Exercise can boost 25(OH)D production and release from the liver.

Nonetheless, there is less information on this issue. A rat study investigated the effects of exercise found that 25(OH)D degradation might be minimized. Immobilized rats had higher levels of 24,25(OH)2D, showing that physical activity suppresses 25(OH)D catabolism [30]. Another study found that persons who exercise often or have greater VO2max levels have higher circulating 25(OH)D concentrations than people who are more sedentary, regardless of sun exposure duration [31].

Increases in vitamin D metabolites from physical exercise may lead to: First, a drop in blood phosphate may affect vitamin D serum levels (phosphate suppresses the production of activated vitamin D via a negative feedback system [27,32]. Second, a decrease in ionized calcium during exercise may stimulate parathyroid hormone release, resulting in kidney calcitriol synthesis (the active form of vitamin D) [27].

Twelve weeks of aerobic and anaerobic exercise boosts the amount of circulating Estrogen in overweight postmenopausal osteoporotic women, according to the findings of a prior study conducted by Razzak. [33] Despite a loss in adipose tissue, which is known to be a source of Estrogen release, another study by Ketabipour found that aerobic exercise raised Estrogen levels [34] Another study discovered

that aerobic exercise helps to reduce Estrogen levels by increasing fat metabolism and decreasing fat mass [35]. Exercise may regulate P450 cytochrome enzymes, which are important for modulating Estrogen hydroxylation and catechol Estrogen methylation, which is one mechanism by which exercise modulates Estrogen metabolism [34].

The limited sample size has an impact on the accuracy of our findings; also, due of the nature of this study, patients were not blinded to the rehabilitation program, thus they may have been biased. Third, due to the short follow-up period, it was impossible to determine whether the improvements were sustained over time. As a result, academic research is inevitable so as to examine the long-term impacts. Nutrition altogether with physical activity were not assessed as part of the intervention, and it's possible that these factors influenced the outcome. Patients should wear an accelerometer or pedometer during the intervention and follow dietary advice in subsequent investigations. We were unable to acquire information on individual sun exposure, therefore UV-B could be blamed for the observed disparities in vitamin D levels.

There is a need for more work and academic research in the near future to assure these findings in a bigger sample size. Furthermore, examining the role of nutritional support and vitamin D supplementation in conjunction with exercise to optimize bone mineral density gain is highly recommended. Tracing the efficiency of various exercises, durations, and timing to determine the best workout routine for elderly women is also urgently needed. Finally, it has been figured out through the current study that 12 weeks of treadmill interval aerobic exercise program have improved bone mineral density, vitamin D, and Estrogen levels in elderly women.

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