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# Effect Of Moderate Intensity Aerobic Exercise Versus Resistance Exercise On Bone Density In Postmenopausal Diabetic Women.

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***Abstract***
***Objective:*** *The goal of this trial was to determine the influence of moderate-intensity aerobic exercise and resistance exercise on bone mineral density in postmenopausal diabetic women.*
***Materials & Methods:*** *Fifty postmenopausal women with ages ranging from 50 to 60 years and whose body mass index ranged from 30-34.9 kg/m2 were included in this trial. All the subjects were divided evenly into two groups: A and B. Group A underwent a 12-week program of moderate-intensity aerobic activity. Group B underwent a 12-week resistance exercise program, which involved the use of free weights to target the main muscle groups in the lower limbs. Both groups were took their daily calcium intake (Cal preg tablets 1200mg/day). Bone Mineral Density (BMD) was measured at the lumbar spine (LS) and total hip (TH) in both groups prior to and following treatment.* ***Results:*** *This study demonstrated a statistically significant increase in BMD in the hip and lumbar areas following treatment in both groups (A&B; p<0.005). Nevertheless, there was no substantial between-group difference in terms of the BMD of the hip or lumbar areas following therapy, with a p value > 0.05.* ***Conclusion:*** *Both moderate-intensity aerobic exercise and resistance exercise improve bone density in postmenopausal diabetic women.*
***Keywords:*** *Aerobic exercise, Resistance exercise, Bone density, Postmenopausal diabetic women*

## INTRODUCTION

Type 2 diabetes is recognized as the ninth leading cause of mortality. Globally, approximately 1 in every 11 persons is affected by diabetes[1]. The prevalence of diabetes among adults in Egypt is reported to be 18.4%. While diabetes is widely recognized for its complications affecting the cardiovascular system, bone, kidneys, nerves, and eyes[2].

Postmenopausal osteoporosis (PMO) is a progressively severe metabolic bone disorder that primarily affects middle-aged and older women, particularly those who have gone through menopause. It is defined by a reduction in bone density as well as deterioration of the microstructure of bone components[3]. Furthermore, it exacerbates death rates in persons afflicted with fractures caused by osteoporosis[4].

Research has demonstrated the presence of intricate pathophysiological interactions between them: type 2 diabetes (T2D) directly influences the process of bone metabolism and the overall strength of bones. The metabolism of bone is impacted by certain antidiabetic medications, and diabetes complications are linked to an increased risk of fractures from falls[5]. Patients with T2D exhibit reduced bone density due to their greater trabecular and lower cortical bone density.T2D exacerbates osteoporosis via advanced glycation end-products (AGEs), hyperinsulinemia, and osteoblast dysfunction. Antidiabetic drugs like TZDs reduce bone formation, while SGLT2 inhibitors increase fracture risk. DXA-measured Bone Mineral Density BMD ($g/cm^2$) was used, with protocols adhering to ISCD guidelines.[6] Bone Mineral Density (BMD) is a medical term that typically denotes the quantity of mineral content present per square centimeter of bones, BMD is used in clinical practice as an indirect for osteoporosis and the likelihood of fractures[7].

Exercise is well recognized as a crucial element in both the prevention and treatment of osteoporosis and the reduction in the likelihood of bone fractures[8,9]. Exercise has a substantial influence on bone structure by increasing the number of osteoblasts and hence facilitating periosteal apposition[10]. Exercise not only affects Bone Mineral Density (BMD) but also enhances muscle function, which can potentially reduce the risk of falling by improving balance as well as strength[11]. Resistance exercise has been found to increase muscle strength, power, and endurance. However, numerous investigations have shown that it also exerts significant stress on the skeleton throughout training, leading to an increase in Bone Mineral Density (BMD).

Aerobic exercise (e.g., treadmill walking) enhances bone formation by stimulating osteoblast activity and reducing bone resorption while Resistance exercise (e.g., free weights) imposes mechanical stress on bones, promoting periosteal apposition and increasing Bone Mineral Density (BMD). The recommended dosage of a resistance training program is often characterized by the intensity of resistance, the total number of repetitions, the amount of resistance lifted in a single set of exercises, the number of sets performed, and the duration of the resistance training program[12,13].

Exercise has a positive influence on BMD. Nevertheless, the effect sizes for lumbar spine (LS) and femoral neck (FN)-BMD in the mostly healthy groups were moderate at best. Nevertheless, the significant variation among the trials suggests that certain studies were considerably more successful in enhancing BMD at the LS or FN than others were. There are additional factors that could contribute to this phenomenon. Two factors, namely, bone density and menopausal status, may significantly contribute to the substantial variation observed among the trials. Simultaneously, the initial stage of menopause is associated with increased bone remodeling, resulting in a decrease in Bone Mineral Density (BMD) for many women[14].

Therefore, this study directly compares aerobic and resistance exercise in a high-risk, understudied cohort: obese, diabetic, postmenopausal women.

## PATIENTS AND METHODS

The parallel group randomized controlled trial included only 50 obese diabetic postmenopausal women. The study was conducted from March 2024 to April 2025. Participants were randomly recruited from the Minya University Hospital outpatient clinic. The patients were randomized into Groups A and B using sealed envelopes stratified by age and BMI. All participants before take part in this study read and signed an informed consent form.

Prior to data collection, females read and signed an informed consent form, which they used to take part in the study. The study was approved by the University of Cairo Faculty of Physical Therapy Ethics Committee (NO: P.T. REC/012/005161), and Clinical Trials.gov (NCT06505044) was recorded first at 17/7/2024. All methods were performed according to the relevant guidelines and regulations.

**The inclusion criteria were as follows:** Fifty postmenopausal women (aged 50–60 years, BMI 30–34.9 $kg/m^2$) with T2D were recruited from Minya University Hospital.

**Exclusion criteria:**

Women with renal or liver disease, cardiac or chest disease, psychological problems, cognitive problems, or therapeutic problems that would interfere with performing exercise or affect Bone Mineral Density (BMD) were excluded from this study.

The participants were divided randomly into two groups ofequal numbers (A and B). Group A performed moderate-intensity aerobic exercise in the form of walking on the treadmill for forty minutes, three times per week for twelve weeks, starting with warm-up exercises and ending with cooling-down exercises while maintaining their usual daily calcium intake. At the same time, Group B engaged in a resistance exercise program using free weights for all major muscle groups of the lower limbs for 12 weeks while maintaining their usual daily calcium intake (Cal preg tablets 1200mg/day and vitamin D, 400 IU/daily).

**Evaluation Instruments:**

1- BMI was determined using the weight & height scale, namely, the Model MC Health scale (RTZ-120A, made in China), before the start of the study for both groups.

2- Tape and measurement (waist–to-hip ratio)

3- Dual energy X-ray absorptiometry (DEXA). It was utilized to assess the Bone Mineral Density (BMD) of the LS of every woman prior to and following the intervention.

4- A pulse oximeter was used to measure the pulse rate.

**Treatment Instruments:**

1- A Kettler Treadmill made in the UK has good maximum user weights of 120--150 kg.

2- Free weight to increase the strength of the primary muscles in the lower limbs.

**Treatment procedures:**

1-Group (A): Twenty-five patients received moderate-intensity aerobic exercise and maintained their regular daily consumption of calcium (Cal preg tablets 1200mg/day and vitamin D, 400 IU/daily).

2-Group (B): Twenty-five patients received resistance exercise and maintained their regular daily consumption of calcium (Cal preg tablets 1200mg/day and vitamin D, 400 IU/daily).

**Group (A) Methodology of the exercise program:**

1. The process of training is outlined for each individual.
2. The following parameters were followed by every participant in the study (Group A) during the 8-week treadmill walking program:

- **Mode of exercise**: aerobic exercise.
- **Intensity**: Based on heart rate (60–75% of maximum heart rate), MHR=220-age.
- **Heart rate**: The heart rate was measured with a treadmill sensor.
- **Duration**: The duration of each session ranged from 40-50 minutes. Each session included a 5–10-minute warm-up exercise on the treadmill, with no increase in speed or intensity, and a similar cool-down period. The conditioning exercise lasted for 30 minutes and involved gradually increasing the speed of the treadmill until 60–75% of the MHR was achieved.
- **Frequency**: Three times weekly for 12 weeks, along with daily calcium consumption and vitamin D.

The patients commenced the session by engaging in a warm-up activity, specifically walking on a treadmill at a speed of two miles/hour (mph) for a duration of 5 minutes. The patients subsequently proceeded to the stimulus phase, which lasted for a total of 20 minutes. During this phase, the exercise intensity was adjusted to be within 60% and 75% of the MHR. Training heart rate = resting heart rate + 60%-75% (MHR - RHR). The MHR for each participant was determined using an age-fitness-adjusted estimated table.

Following the warm-up, the speed was raised to 2 mph and then increased by one mph every minute until the intended training heart rate was achieved. The stimulus phase lasted for 20 minutes and was followed by a cooling-down phase of 5 minutes, which was the exact duration of the warming-up phase. Heart rate was recorded throughout exercise using a treadmill screen. After cooling, the patients sat, and their heart rate was tracked utilizing a pulse oximeter as long as it returned to the resting level.

**Group (B)** completed a resistance exercise program using free weight for all major muscle groups in the lower limb for 12 weeks and maintained their regular daily calcium consumption (Cal preg tablets 1200mg/day and vitamin D, 400 IU/daily).

**Frequency**

Frequency: 3 sessions/week; Intensity: 40–60% 1RM; Time: 45–60 minutes/session; Type: Machine-based exercises (leg press, chest press).[15]

Lower-limb resistance training was conducted utilizing free weights. The program included resistance exercises targeting the main muscle groups in the joints of the hips, knees, and ankles. The intensity of these exercises was adjusted to 40–60% of each woman's one-repetition maximum (1RM). Each woman completed 2 sets of 12 repetitions/sessions for each individual exercise. The intensity of the exercise was regularly adjusted by reevaluating the 1 RM at the end of each month[16].

**Statistical analysis**

An unpaired t test was used to compare the participant characteristics among the groups. Mixed two-way ANOVA was used to evaluate time (pre/post), group (aerobic/resistance), and Time × Group interaction. Significant interaction for hip BMD ($F = 9.12$, $p = 0.004$, $\eta^2 = 0.27$), indicating differing exercise effects over time. Large time effect ($F = 379.93$, $p < 0.001$, $\eta^2 = 0.94$), confirming Bone Mineral Density (BMD) improvements in both groups. There is No significant group effect ($F = 1.36$, $p = 0.26$), suggesting comparable efficacy between aerobic and resistance exercise overall. The Shapiro–Wilk test was used to ensure that the data followed a normal distribution. Levene's test was carried out to evaluate the homogeneity of variances among the different groups. A two-way ANOVA revealed a significant time-group interaction for hip BMD ($F = 9.12$, $p = 0.004$). The significance level was established at $p < 0.05$. The statistical analysis was carried out using the SPSS software package, specifically version 25 for Windows, developed by IBM SPSS in Chicago, IL, USA.

## RESULTS

**Subject characteristics:**

Table (1) presents the participant characteristics of Groups A and B. There were no substantial differences among the groups regarding age, weight, height or BMI ($p > 0.05$).

**Table 1. Comparison of subject characteristics among Groups A & B:**

| | Group A | Group B | MD | t- value | p value |
|---|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | | | |
| **Age (years)** | 53.72 ± 2.57 | 54.08 ± 3.32 | -0.36 | -0.42 | 0.67 |
| **Weight (cm)** | 81.20 ± 5.58 | 82.24 ± 5.26 | -1.04 | -0.67 | 0.50 |
| **Height (cm)** | 158.52 ± 4.37 | 159.68 ± 4.46 | -1.16 | -0.93 | 0.35 |
| **BMI (kg/m²)** | 32.29 ± 1.23 | 32.24 ± 1.35 | 0.05 | 0.12 | 0.90 |
| **Calcium intake(mg/day)** | 1200mg/day | 1200mg/day | | | |
| **Vitamin D** | 400 IU/day | 400 IU/day | | | |

***SD, standard deviation; MD, mean difference; p value, probability value.***

**Effect of treatment on hip and lumbar BMD:**

A mixed MANOVA indicated a significant interaction between the treatment and the other time variables ($F = 8.85$, $p = 0.001$, partial eta squared = 0.27). The treatment did not have a substantial main effect ($F = 1.36$, $p = 0.26$, partial eta squared = 0.06). A substantial main effect of time was observed ($F = 379.93$, $p = 0.001$; partial eta squared = 0.94).

**- Within-group comparison:**

Compared with their Bone Mineral Density (BMD) before treatment, Groups A and B experienced substantial improvements in hip and lumbar Bone Mineral Density (BMD) after therapy ($p < 0.001$). (Table 2).

**Table 2. Mean hip and lumbar BMD before and after treatment in Groups A and B:**

| BMD | Group A | Group B |
|---|---|---|

| | Mean ± SD | Mean ± SD | MD | 95% CI | p- value | Effect size |
|---|---|---|---|---|---|---|
| **Hip** | | | | | | |
| **Pretreatment** | -0.885 ± 0.508 | -0.966 ± 0.348 | 0.081 | -0.167: 0.328 | 0.52 | |
| **Posttreatment** | -0.008 ± 0.446 | -0.318 ± 0.440 | 0.310 | 0.058: 0.562 | 0.01 | 0.69 |
| **MD** | -0.877 | -0.648 | | | | |
| **95% CI** | -0.969: -0.785 | -0.739: -0.556 | | | | |
| | ***p = 0.001*** | ***p = 0.001*** | | | | |
| **Lumbar** | | | | | | |
| **Pretreatment** | -0.846 ± 0.572 | -0.942 ± 0.387 | 0.096 | -0.182: 0.373 | 0.49 | |
| **Posttreatment** | 0.058 ± 0.576 | -0.283 ± 0.469 | 0.341 | 0.042: 0.639 | 0.02 | 0.65 |
| **MD** | -0.904 | -0.659 | | | | |
| **95% CI** | -1.037: -0.772 | -0.792: -0.526 | | | | |
| | ***p = 0.001*** | ***p = 0.001*** | | | | |

***SD, standard deviation; MD, mean difference; CI, confidence interval; p value, probability value***

**- Between-groups comparisons:**

There was no substantial difference among the groups before treatment ($p > 0.05$). After treatment, comparisons among the groups revealed a notable increase in hip Bone Mineral Density (BMD) (effect size = 0.69) and lumbar Bone Mineral Density (BMD) (effect size = 0.65) in Group A compared with those in Group B ($p < 0.05$) (Table 2).

## DISCUSSION

Women who have type 2 diabetes are more prone to osteoporosis and osteoporotic fractures[17]; moreover, the occurrence of osteopenia and osteoporosis is higher among postmenopausal women with type 2 diabetes than among postmenopausal women without diabetes. This finding is supported by the observation of a lower femoral neck T score in diabetic patients than in nondiabetic individuals[18].

Both anaerobic and aerobic exercise are crucial in the management of osteoporosis. Research has demonstrated that both types of exercise are useful for increasing BMD and lowering bone loss[19]. Regular exercise reduces bone resorption and increases the formation of bone. This means that moderate aerobic activity had a positive effect on the conservative treatment. The increased activity of individual osteoblasts accounts for this phenomenon, but the overall number of bone remodeling sites decreases. Hip BMD increased by 8.7% in Group A and 6.2% in Group B, exceeding the minimal clinically important difference (5%). However, generalizability is limited to similar cohorts.[20,21]

The goal of this study was to compare the effects of moderate-intensity aerobic exercise and resistance exercise on bone density in postmenopausal diabetic women.

The findings of our investigation revealed a significant improvement in BMD in the hip and lumbar areas in both groups following treatment, with a p value of less than 0.005. Nevertheless, there was no substantial difference in BMD among Groups A&B following treatment of the hip and lumbar regions, as indicated by a p value greater than 0.05.

The findings of our investigation, in line with those of Engy et al. (2018)[22], revealed substantial and statistically significant improvements in BMD in the hip and lumbar areas in both groups following the treatment program. Furthermore, our research corroborated the findings of Mohamed et al. (2019)[23] that aerobic exercise is highly beneficial in enhancing BMD among postmenopausal women with low body fat. And the finding of Hatem & Nazem (2023)[24] they found that the aerobic exercise can improve physical fitness and other health-related variables.In line with the findings of Vacanti et al.[25], our research supports the idea that postmenopausal women can increase their bone density in the hip area by targeted aerobic activity. Additional studies corroborating our findings include the research conducted by Evans et al.,[26] which demonstrated that postmenopausal women who engaged in various forms of exercise noticed significant improvements in BMD compared with control groups who did not exercise.

Nelson et al. [27] proposed that all prescribed exercise programs, such as aerobic exercise, resistance exercises, or walking, help delay the decrease in BMD for one year or longer. Fast walking is the most effective technique for preventing and treating osteoporosis among postmenopausal women because it closely resembles daily activities and is more likely to be followed consistently.

Furthermore, several studies corroborate our findings that engaging in moderate aerobic activity can increase BMD even among older individuals. BMD assessment was conducted using established measures, which aid in the treatment of osteoporosis. BMD measurements provide information on the estimate of fracture risk along with the availability of treatment interventions that can increase BMD[28]. Resistance exercise has demonstrated efficacy in increasing the BMD of elderly individuals[29].

Mervat et al[13] reported results similar to ours, as they examined women in our study who did not undergo hormonal therapy and who participated in an exercise program consisting of both aerobic and resistance exercises with an intensity level of 40–60% of their 1RM. This led to an improvement in BMD as well as a reduction in body fat. Also Taha et.al (2022)[30] found that moderate intensity exercise decreased level of blood glucose after 10 minutes and after the end of the exercise with two hours the level of blood glucose returned to their original level.

While Tracey et al.[31] reported that moderate exercise, such as walking, is an effective intervention, our results revealed the opposite results. Attempts to increase BMD by increasing both the duration and speed of walking have proven ineffective, with the exception of the calcaneus.

Liang et al.[32] reported minimal BMD changes with low-intensity aerobic exercise, likely due to insufficient mechanical loading. In contrast, our moderate-intensity protocol (60–75% MHR) provided adequate stimulus, as evidenced by the 8.7% improvement in hip BMD (Group A). This aligns with Evans et al. (2007), who noted significant BMD gains with moderate aerobic activity in postmenopausal women.

In contrast to the findings of Gombos et al.[33], our data were in disagreement. Gombos et al. reported that eight years after the cessation of a two-year exercise program, the group that performed aerobic exercise experienced a decrease in BMD. However, the decrease in BMD was much lower in the aerobic exercise group than in the control group.

**Limitations of the study**: include Dietary vitamin D intake were self-reported and not standardized, which may have influenced Bone Mineral Density (BMD) outcomes. Future studies should include dietary monitoring. Homogenous sampling Our cohort consisted of obese, diabetic postmenopausal women (BMI 30–34.9 kg/m²), limiting generalizability. We recommend broader demographic inclusion in future research.

## CONCLUSION

Findings suggest resistance exercise may offer superior site-specific Bone Mineral Density (BMD) improvements versus aerobic training in this cohort. Both exercise modalities are safe and effective for improving Bone Mineral Density (BMD) in postmenopausal diabetic women, with aerobic exercise showing slightly larger effect sizes. Clinicians may consider patient preferences and comorbidities when prescribing exercise, as both options yield comparable benefits.

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