ATENA JOURNAL OF PUBLIC HEALTH

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Received: **25/11/2021.** Accepted: **27/12/2021.** Published: **01/01/2022**

Effect of balance exercise on bone mineral density in postmenopausal women

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ABSTRACT

The aim of this study was to investigate the effect of a balance exercise programme on bone mineral density (BMD) in postmenopausal women. A total of 40 postmenopausal women with low BMD were selected randomly from the Physical Therapy Department of Qasr El Eyni Hospital in Cairo (Egypt). Participants were divided randomly into two equal groups (A and B) of 20 participants. The control group (Group A) received medical treatment (Fosamax, one tablet per week, for 16 weeks). The experimental group (Group B) received the same medical treatment as Group A, as well as the balance exercise programme (sessions of 60 minutes, five days per week, for 16 weeks). BMD was assessed by dual-energy X-ray absorptiometry (DEXA) on the femoral neck before and after the interventions for all participants in both groups (A and B). After the 16 weeks, there was a statistically significant increase in the mean value of BMD in both groups. However, the increase was notably higher ($p = 0.001$) in Group B. The percentage of increase in BMD was 24.40% in Group A and 80.61% in Group B. Balance exercise might be an effective method for improving BMD in postmenopausal osteoporotic women.

KEYWORDS

Balance; Exercise; Bone Mineral Density; Post-Menopause; Osteoporosis

1. INTRODUCTION

Osteoporosis is a disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in fracture risk. It is considered an important global public health problem. Osteoporosis affects an estimated 200 million women worldwide. Congruent with osteoporosis is an increased risk of osteoporosis-related fractures, especially in women during the postmenopausal years — generally considered to begin around the age of 50. The two most common sites for osteoporosis-related fractures are the hip and the spine [1]. This disease is usually defined as an overall bone mineral density (BMD) of less than or equal to 2.5 standard deviations below the mean BMD for young female adults. The prevalence of osteoporosis is indeed more frequent among women than men [2].

Exercise training is perceived as a low-cost and safe non-pharmaceutical treatment strategy for the protection of musculoskeletal health and fracture prevention; thus, many studies have focused on the effects of exercise on bone mineral density (BMD) in postmenopausal women [3]. Physical therapy treatment includes balance training, postural correction, trunk and lower extremity muscle strengthening exercises, and moderate-intensity aerobic physical activity. The goal of these interventions is to regain normal spine curvatures, increase spine stability, and improve functional performance. Physical therapy interventions were also designed to slow the rate of bone loss with home exercise programmes [4]. Recent recommendations specify that older adults with osteoporosis or osteoporotic vertebral fractures should engage in a multicomponent exercise programme that includes resistance training combined with balance training [5].

Although specific mechanisms through which exercise improves bone health are not fully elucidated yet, it is widely accepted that mechanical load induced by exercise training increases muscle mass, produces mechanical stress in the skeleton, and enhances osteoblast activity. However, not all exercise modalities are equally osteogenic. For exercise training to elicit an osteogenic effect, the mechanical load applied to the bones should exceed that encountered during daily activities [6]. The aim of this study is to investigate the effect of a balance exercise programme on bone mineral density in postmenopausal women.

2. METHODS

2.1. Participants

Forty women of a mean age of 65.2 ± 4.2 (*SD*) were recruited from the outpatient clinic at Kasr Al Ainy University Hospital to participate in the study. A power analysis based on a formulation of 80% power, an effect size of 0.60 for overall muscle strength from previous studies, and a significance level of 0.05 deemed that a sample of 30 subjects (15 per group) was sufficient to address the research questions. A single technician performed all of the pretest and posttest dual-energy X-ray absorptiometry (DEXA) scans. Age of participants ranged from 50 to 60 with a BMI less than 30 kg/m^2

and low bone mineral density. They were not taking hormones or osteoporosis medications at the time of the study and had not done so for the past 12 months. None of the women were participating in regular exercises by then, nor had they done so for the previous 12 months. All of them signed an informed consent approved by the Faculty of Physical Therapy, Cairo University.

Women were excluded from the study if their medical history or physical examination revealed unstable cardiovascular, pulmonary, endocrine, neuromuscular, or orthopaedic conditions. Furthermore, women were also excluded if the standardized *t* scores on their baseline DEXA scans of the femoral neck were greater than 3.5 standard deviations below that of healthy young females, visual acuity in either eye was less than 20/50 (corrected), or if they showed any other medical or psychiatric conditions. BMD of the left hip was measured with DEXA scans at the radiology department, and measurements for the BMD of the femoral neck were in g/cm^2. Participants were randomly assigned, using a random number table for both the control group (A; n = 15) and the experimental group (B; n = 15).

2.2. Balance exercises for Group B

1st step: Standing Feet Together

Every woman was asked to move their feet together so that the heels and toes of both feet were touching as much as possible, then held this position for 30 seconds, followed by 10 seconds of relaxing the position. This exercise was repeated six times.

2nd step: Semi-Tandem Standing

Each woman was asked to bring one foot directly ahead of the other, with space between the heel of the front foot and the toes of the back foot. They were required to hold this position for 30 seconds and then relax for 10 seconds. This exercise was repeated three times for each foot.

3rd step: Tandem Standing

Every female participant was asked to bring one foot directly ahead of the other, so that the heel of the front foot was touching the toes of the back one. They held this position for 30 seconds and relaxed for 10 seconds after that. This exercise was repeated three times for each foot.

4th step: Standing with Lateral Weight Shift

For this step, every woman was asked to stand with feet hip-width apart and shift their weight through the hip to one side, then return to the midline. They held such position for 30 seconds and then relaxed for 10 seconds. This exercise was repeated three times for each side.

5th step: Standing over the Lateral Balance Board

Every woman was then asked to stand with a wide base of support over a balance board, located between two parallel bars, and grasp both parallel bars for their safety. They held this position for four minutes.

6th step: Forward Right and Left Step

During this step, each woman was asked to stand with their feet hip-width apart — a spot on the floor to direct the movement was placed in front of them. Subsequently, they were required to shift their weight onto their left foot and step forward with their right foot, while bending the knee as the right foot touched the floor. They held this position for 30 seconds, and then shifted their weight back through the left hip and stepped backwards with the right foot. Following this, they relaxed for 10 seconds. They later performed the same stepping sequence with the left foot. This exercise was repeated three times with each foot.

7th step: Side Step Walking

Every woman was required to step sideways in one direction, taking about ten steps, while grabbing a rail in front of them for safety. They returned in a similar manner to the opposite direction. The exercise was performed for four minutes.

8th step: Semi-Tandem Walking

Every female participant was asked to begin walking along the tape line — with both hands grabbing parallel bars for safety — by placing one foot directly ahead of the other, with space between the heel of the front foot and the toes of the back foot. They were required to continue up to the end of the tape and then return, this time starting with the other foot. The exercise was done for four minutes.

9th step: Tandem Walking

Similarly, every woman was asked to begin walking along the tape line — with both hands holding on to the parallel bars for safety — by placing one foot directly in front of the other, so that the heel of the front foot was touching the toes of the back foot. Afterwards, they were supposed to continue up to the end of the tape and then return, this time starting with the other foot. The exercise was done for four minutes.

10th step: Walking over a Balance Board

For the last step, each woman was asked to walk on a balance board slowly, while trying to maintain the same stride length — with both hands grabbing the parallel bars for safety. The exercise was done for four minutes.

3. RESULTS

3.1. Anthropometric measurements

Table 1 presents anthropometric measurements included age, body weight, height, and body mass index before intervention (Table 1).

Table 1. Mean age, body weight, height, and body mass index

	Group A (*n* = 20)	Group B (*n* = 20)	*t* value	*P* value
Age (years)	56.80 ± 2.50	56.45 ± 2.68	0.426	0.672 (NS)
Weight (kg)	75.85 ± 5.57	74.60 ± 5.34	0.724	0.473 (NS)
Height (cm)	166.35 ± 3.94	168.05 ± 4.74	-1.234	0.225 (NS)
BMI (kg/m^2)	27.33 ± 1.81	26.43 ± 1.80	1.579	0.123 (NS)

Data are expressed as mean ± SD; NS = p > 0.05 (not significant.)

3.2. Bone mineral density (BMD) measured by DEXA

Within groups:

In Group A, there was a statistically significant increase in the mean value of BMD (g/cm^2) measured by DEXA, taken at post-treatment (-1.27 ± 0.41), when compared with its corresponding value registered at pre-treatment (-1.68 ± 0.37) with *t* value = -12.362, and *p* value = 0.001. Likewise, in Group B, there was a statistically significant increase in the mean value of BMD measured by DEXA, captured at post-treatment (0.32 ± 0.61), when compared with its corresponding value taken at pre-treatment (-1.65 ± 0.42) with *t* value = -21.442, and *p* value = 0.001. The percentages of increase in BMD measured by DEXA in both groups A and B were 24.40% and 80.61%, respectively (Table 2).

Table 2. Comparison between mean values of BMD measured by DEXA, taken at pre- and post-

	Group A (*n* = 20)	**Group B (*n* = 20)**
Pre-treatment	-1.68 ± 0.37	-1.65 ± 0.42
Post-treatment	-1.27 ± 0.41	-0.32 ± 0.61
Mean difference	-0.41	-1.33
% change	24.40 ↓↓	80.61 ↓↓
t value	-12.362	-21.442
p value	0.001 (S)	0.001 (S)

Data are expressed as mean ± SD; t value = paired t test; S = p ≤ 0.05 (significant.)

Between groups

At pre-treatment in both groups (A and B), mean values (± *SD*) of BMD measured by DEXA were -1.68 ± 0.37 and -1.65 ± 0.42, respectively. There was no statistically significant difference between the two groups (*F* = 0.079, and *p* = 0.781). ANCOVA test was used to compare the post-treatment values of both groups on controlling the effect of the pre-treatment value. The results of BMD measured by DEXA revealed that there was a statistically significant difference between both groups (A and B) — a greater increase in Group B (-0.32 ± 0.61) when compared with its corresponding level in Group A (-1.27 ± 0.41) (*F* = 188.578, *p* = 0.013) (Table 3).

Table 3. Comparison between mean values of BMD measured by DEXA in both studied groups, taken at pre- and post-treatment

	Group A (*n* = 20)	**Group B (*n* = 20)**	***F* value**	***P* value**
Pre-treatment	-1.68 ± 0.37	-1.65 ± 0.42	0.079	0.781 (NS)
Post-treatment	-1.27 ± 0.41	-0.32 ± 0.61	188.578	0.001 (S)

Data are expressed as mean ± SD. F value = ANCOVA test. NS = p > 0.05 (not significant.) S = p ≤ 0.05 (significant)

4. DISCUSSION

Osteoporosis becomes a serious health threat for postmenopausal women as it predisposes them to an increased risk of fracture. Osteoporotic fractures are associated with substantial morbidity and mortality in postmenopausal women, especially older women [7]. Osteoporotic patients frequently experience difficulties being satisfied with their roles in daily life and have troubles meeting the expectations in their social relations. Consequently, social regression, isolation, the feeling of worthlessness, a decrease of self-confidence and self-esteem may be seen, and this might turn out quite psychologically destructive for the patients [8].

Balance training appears to be one of the most effective interventions. Its benefits include improving balance — thus preventing falls, as well as lower limb muscle strength and bone mineral density amelioration by the effect of weight bearing [9].

The results of this study revealed a significant increase in the mean values of BMD and *t* score of the left femoral neck post-treatment in both groups (A and B), being Group B the most benefited. This was supported by Marques et al. [10], who stated that regular physical exercise has been recommended as an effective and safe non-pharmacological strategy to counter the aging-induced loss of bone mineral density (BMD). As for Gómez-Cabello et al. [11], they reported substantially two studies that demonstrate a significant improvement in BMD at the level of the lumbar spine, the neck of the femur, and the greater trochanter, when following programmes that include muscle strengthening and impact weight-bearing exercises. Nikander et al. [12] added that “low-moderate” impact exercises such as jogging, walking, and stair climbing are much more effective in preserving BMD at both lumbar and femoral level. “High” impact exercise programs, such as jumping, or balance exercises, are only effective when they are associated with other low-impact exercises. Likewise, Bolam et al. [13] stated in their systematic review a positive osteogenic effect of resistance training alone or associated with high impact weight-bearing activities like balance training, and they recall that the intensity and increment of the type of load are two fundamental elements of exercise to avoid adaptation phenomena and generate an improvement on bone mass rather than just decreasing the loss. For their part, Giangregorio et al. [14] stressed the importance for individuals with osteoporosis and osteoporotic vertebral fracture to be engaged in a multicomponent exercise programme with resistance training combined with balance training.

The results of this study coincided with the review of studies analysed by Marques et al. [10], who reported the effect of non-high-impact weight-bearing exercises (muscle strengthening, resistance, aerobic, and balance exercises) on increasing BMD at the lumbar spine and femoral neck in elderly subjects. Accordingly, a multicomponent exercise programme with moderate-high impact (marching on the spot, stepping at 120/125 b/m, on a bench of 15 cm, and heel drops on a rigid surface) was able to increase BMD in the femoral neck in a population of elderly women who had never performed exercise programmes before. Ma et al. [15], too, reported in their systematic review that walking and weight-bearing exercise programme intervention of more than six months in duration can provide significant and positive effects on femoral neck BMD in pre and postmenopausal women. The results of this study are consistent with those of Kelley et al. [16], who stated that balance training can have positive effects on hip and column BMD in women of menopausal age by the effect of mechanical stress determining an important ground reaction force able to stimulate bone mass. Kelley [17] suggested as well that exercise increases femur trochanteric BMD in calcium-replete postmenopausal women. Furthermore, Varsavsky et al. [18] reported that aerobic physical exercise according to WHO guidelines in the previous three months can lead to a decrease in serum sex hormone-binding globulin (SHBG) and an increase bone density in the lumbar spine.

The results were in line as well with the proposal of von Stengel et al. [19], who suggested that low-impact loading activity could be effective in reducing bone loss at the hip and spine. Exercise has indeed an important positive effect on the deceleration of decline in BMD. In accordance with this, Warden et al. [20] stated that exercise induces an anabolic or homeostatic effect on bone via mechano-transduction. Briefly, fluid movement within the extracellular matrix of bone exerts force on osteocytes and bone lining cells. This subsequently triggers the release of nitric oxide and prostaglandin, which lead to division and differentiation of osteoprogenitor cells. Pre-osteoblasts consequently mature into osteoblast cells and affix to the surface of the matrix to begin the production of new bone. Muscular contractions may also induce this extracellular fluid shear stress within the bone matrix, producing deformations in the bone. Similarly, gravitational impacts produce deformations via fluid shear stresses and subsequent mechano-transduction. However, these may have limited effects on organism-wide BMD, as the skeletal sites most proximal to the engaged muscle groups or sites of gravitational impact during training are likely to experience the greatest increases in BMD.

Finally, Kelley et al. [21] found in their meta-analysis study that postmenopausal women who exercised increased their spinal BMD by approximately 2%. For oestrogen-replace women who use oestrogen, strength training and weight bearing provide additional BMD benefits over therapy alone. They stated that medications for osteoporosis cannot treat osteoporosis alone. In that sense, women should not rely entirely on medications as the only treatment for osteoporosis but should also perform weight-bearing physical activities and exercises that improve balance and posture, which can ultimately strengthen bones and reduce the risk of fracture.

5. CONCLUSIONS

The findings suggest that balance exercises could be an effective method for improving BMD in postmenopausal women with osteoporosis, particularly when incorporated into a tailored exercise program. The larger increase in BMD observed in Group B indicates that specific balance exercises, or a more intense or focused regimen, might yield even greater benefits. Further research could help to refine the optimal balance exercise protocols to enhance bone health in this population.

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AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research received no external funding.

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