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Effect of Aerobic Exercise and Low Calorie Diet on Bone Density in Obese Elderly Women

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Abstract:

The purpose of this study was to examine the impact of aerobic exercise and low calorie diet on bone mineral density (BMD) as well as anthropometric measures (weight, body mass index, waist/hip ratio) among older women who are obese. Participating were sixty overweight senior women, ages 60 to 70 years old, who were allocated into two equal groups at random. Group A comprised 30 patients who were directed to adhere to low calorie diet while being closely monitored by medical professionals. Group B comprised 30 patients who were instructed to adhere to an exercise regimen in conjunction with low calorie diet. Anthropometric measures (weight, height, BMI, waist/ hip ratio) as well as BMD of the femur, the measurements were obtained at the onset of the research and 12 weeks later (post study). The participants engaged in aerobic workouts for a duration of 30-40 minutes by walking on a treadmill at a moderate intensity level, specifically targeting 60-70% of their maximal heart rate. **Results**: there were no substantial differences ($p > 0.05$) among the characteristics of both groups pre study. Post study the findings indicated a substantial decrease ($p < 0.05$) in anthropometric measures (weight, BMI, waist/ hip ratio) in both groups with greater reduction in group B. The BMD did not show a significant improvement in group A, however in group B, there was a substantial improvement in BMD. **conclusion**: In obese older women, the combination of aerobic exercise and low calorie diet resulted in weight reduction, decreased BMI, and reduced waist/hip ratio. This approach also had a sustained effect on BMD when compared to using a diet alone through a period of 12 consecutive weeks.

Keywords: Bone mineral density, Body mass index, diet, aerobic exercises.

Introduction

Osteoporosis is a highly detrimental condition, with its occurrence in the older population having risen to 21.7%. [1] The prevalence of obesity among the elderly is expected to rise to approximately 57.8% by 2030. It is worth noting that osteoporosis and obesity can coexist in this population, but the relationship among the two conditions is complex and vulnerable to conflicting perspectives. [2]

Aging is a significant and separate risk factor for osteoporosis. [3] Regarding changes in body composition, it is worth noting the progressive accumulation of fat mass and the decline in bone and muscle mass [4], accompanied by a decrease in the number as well as the size of type II muscle fibers. [5]

Obesity is a chronic condition characterized by the excessive buildup of fat, which can negatively impact one's health. Obesity is becoming more common in the majority of countries globally, including developed as well as developing nations. Simultaneously, the global population of elderly individuals is also increasing. Approximately 38% of persons aged 60 and above in the United States are obese, and similar patterns can be observed in Canada & the United Kingdom. Obesity is linked to a higher likelihood of death (mortality) and illness (morbidity) also, it poses particular dangers for older individuals, such as disability and frailty. Additionally, it imposes a financial stress. [6]

Menopause has an adverse impact on bone development. Typically, bones undergo a process known as bone remodeling, in which old bone is substituted with new bone cells. However, the body's capacity to manage this process alters as one ages. By approximately the age of 35, there is a decrease in bone development. Estrogen has a role in the absorption of calcium into the bones. Therefore, when estrogen levels decrease, women will have a faster decline in bone density. Decreased bone density indicates a heightened vulnerability to fractures**.** [7] After experiencing premenopausal, perimenopause, and menopause, women will reach the final stage of their reproductive journey known as the postmenopausal phase. During this time, hormonal fluctuations may still occur in women's bodies, potentially prolonging symptoms. In addition to hormonal factors, specialists have also identified extrinsic factors. [8]

Bone Mineral Density (BMD) is a medical term that typically denotes the quantity of mineral content present per square centimeter of bones. It is employed in clinical practice as an indirect marker of osteoporosis and the likelihood of fractures. [9] BMD exhibits a positive correlation with BMI among postmenopausal women, as well as to a lesser extent among premenopausal women. [10] It is widely accepted that there is a strong correlation between low BMD as well as the risk of fractures among postmenopausal women with osteoporosis. [11] Therefore, understanding the variables that regulate the characteristics of bone mass is essential in the prevention and management of osteoporotic disease. Among the various factors considered, body weight has been demonstrated to be the most significant in postmenopausal women. [12]

There is a conspicuous lack of research examining the impacts of low daily caloric intake on bone health in elderly women of normal weight. To achieve and maintain a specific body shape and reduce the risk of obesity, these women may consistently follow a diet that lacks sufficient calories, proteins, and minerals, which could potentially harm their bone health. Prior research has shown that overweight or obese women who are postmenopausal and follow calorie-restricted diets experience a simultaneous decrease in bone mass. Nevertheless, multiple studies have indicated that premenopausal women who are overweight or obese and follow moderate caloric-restricted diets do not experience any bone loss. The discrepant findings in overweight or obese females indicate variations among older postmenopausal women as well as younger premenopausal women. [13]

Aerobic endurance training incorporates cyclic workouts for a long duration with little or no external loads. It aims to boost respiratory and cardiovascular function. Maximum oxygen consumption (VO2 max) is an important indication of cardiovascular health and aerobic endurance training adaptations. So aerobic training is perhaps the most important for elders. Aerobic training maintained and/or reduced bone mass loss, thus we should include it when programming elderly bone quality therapies. [14]

So, this study conducted to compare the effects of low calorie diet alone versus aerobic exercises and low calorie diet on bone mineral density, body weight, BMI as well as waist/hip ratio among obese old women Following a duration of 12 weeks.

Subjects and methods

Sixty elderly women who were obese were recruited from the various outpatient clinics of the Faculty of Physical Therapy at Minia University as well as Deraya University for this study. They were between 60 and 70 years old. Their BMI is between 30 to 34.9 kg/m2. The study excludes women who have diabetes mellitus, hypertension, heart disorders, psychiatric difficulties, or cognitive problems. The study lasted for a period of 5 months, starting from December 2023 and ending in April 2024. The participants were randomly allocated into two groups, A and B, with equal numbers in each group. Group A received a 12-week of low calorie diet along with to their regular daily calcium consumption. Group B engaged in aerobic activity by walking on a treadmill for 30-40 minutes, three times/week, during a period of 12 weeks. The exercise sessions started with warm-up exercises and finished with cool-down exercises. Additionally, Group B maintained their regular daily calcium intake and low calorie diet.

This research was approved by the ethics committee of Deraya University's Faculty of Physical Therapy in Egypt. The reference number for this approval is [PT/REC/230003]. At the time of enrollment, the patient was required to sign a consent form. We used a recording data sheet to document all of the information.

Producers:

A- Evaluation procedures:

1- Anthropometric Measurements:

The weight and height were measured using a Burer digital scale as well as tape, respectively, in order to determine the BMI. The participant's physical characteristics, including weight in kg and height in m, were evaluated using a weight and height scale. Additionally, their BMI was calculated using the formula kg/m^2. The assessment was performed with the established anthropometric method specified in the formula provided below: BMI is calculated as follows: weight (kg) /height (m^2).[15]

2- Bone mineral density measurement: (ultrasonometer (5000 KHz) device.)

Every member of groups A and B had their right femur BMD measured both before and following the study.

The day before the test, the women were told to eat normally and abstain from taking any calcium supplements. The women were asked to take off any eyeglasses, jewelry, detachable dental appliances, or metal anything that could potentially distort the X-ray pictures. The patient was briefed on its purpose and intended use before its administration so that they could become accustomed to the test. While seated with her back supported, the participant was asked to place her foot on the designated spot on the silicon sheet for approximately one minute. A brace was used to rotate the patient's hip inward in order to evaluate the hip. [16]

3- Tape measurement: Measure the circumference of the hips, and waist using an ordinary, non-stretching measuring tape.

All participants were measured Waist hip ratio (WHR) prestudy and poststudy after 12 weeks by dividing waist circumference (in cm) by hip circumference (cm).[17] The examiner provided instructions. Avoid providing support to the body or leaning forward, since this can disrupt the accuracy of the measurement. Also, instructed the participants don't hold their breath or suck their stomachs, as this will give an inaccurate reading. Participants wore very little or no clothing. The measures were taken at the period between the end of exhalation and the start of inhalation since it is the most precise, according to the examiner.[18] Waist circumference was measured at the end of several consecutive natural breaths, at the level parallel to the floor, midpoint between the top of the iliac crest and the lower margin of the last palpable rib in midaxillary line, hip circumference was measured at a level parallel to floor, at the largest circumference of the buttocks. The cutoffs points (Caucasian) of WHR used (>1 in men and >0.85 in women). [19] The clinical standard involves taking a second measurement of the waist and hips to account for variations caused by breathing. [18]

A- Treatment procedures:

Group A: participants were given low calorie diet only for a duration of 12 weeks, along with their regular daily calcium consumption.

Group B: An aerobic exercise regimen was implemented for every woman in this group, which consisted of thirty minutes of treadmill walking at the first four weeks then increased to forty minutes of treadmill walking from the fifth week till the end of the study. The exercise was categorized as follows: The warm-up phase consists of five to ten minutes. of walking on the treadmill at a low pace. This is followed by Twenty minutes of walking at a moderate intensity, which corresponds to 60-70% of the MHR. The cool-down phase involves five to ten minutes of walking on the treadmill at a low speed, similar to the warm-up phase. The treatment session was conducted three times per week for a duration of twelve weeks along with their usual daily calcium intake in addition to low calorie diet, heart rate was mounter on a treadmill screen. Kettler treadmill device with a moderate level of exertion, specifically targeting 60-70% of their maximal heart rate.[20]

Statistical analysis

To compare the subject characteristics between the groups, an unpaired t-test was used. The Shapiro-Wilk test was used to ensure that the data followed a normal distribution. To ensure that the groups were similar to one another, we used Levene's test for homogeneity of variances. To examine the treatment effect on weight, BMI, WHR, as well as BMD, a mixed MANOVA was used. Following that, multiple comparisons were performed using post hoc tests with the Bonferroni correction. All statistical tests were set to have a significance level of $p < 0.05$. For this study, we used SPSS 25 for Windows (IBM SPSS, Chicago, IL, USA) to carry out all of our statistical analysis.

- Results

- *Subject characteristics*:

Table (1) shows the subject characteristics of both the A and B groups. Both the age as well as BMR of the groups were not significantly different ($p > 0.05$).

Table 1. Comparison of subject characteristics between group A and B:

	Group A	Group B			
	Mean ±SD	Mean ±SD	MD	t- value	p-value
Age (years)	63.63 ± 2.47	62.93 ± 2.87	0.7	1.01	0.31
BMR (Cal)	1961.13 ± 157.07	1948.97 ±166.74	12.16	.029	0.77

SD, Standard deviation; MD, mean difference; p value, Probability value

Basil Metabolic Rate (BMR) in women = 447.593 + 3.098 x (length) + 9.247 x (weight) - 4.330 x (age). [21]

Effect of treatment on weight, BMI, WHR and BMD:

Mixed MANOVA revealed a substantial interaction effect of treatment as well as time (F = 58.42, p = 0.001, Partial eta squared = 0.81). There was a substantial main effect of treatment (F = 3.56, p = 0.01, Partial eta squared = 0.21). There was a substantial main effect time (F 716.23, p = 0.001, Partial eta squared = 0.98).

Within group comparison

There was a substantial reduction in weight, BMI as well as WHR following therapy, as opposed to before, in both groups (p > 0.001). Group B showed a substantial improvement in BMD after therapy as opposed to before treatment (p > 0.001) Whereas group A did not have any substantial change in BMD. (p > 0.05). (Table 2).

Between group comparison

Group B experienced a substantial reduction in weight, BMI, as well as WHR contrasted to group A after treatment (p < 0.01). Group B exhibited a substantial improvement in BMD contrasted to group A after the treatment (p < 0.001). (Table 2).

Table 2. Mean weight, BMI, WHR and BMD pre and post treatment of group A and B:

	Pre treatment	**Post treatment**			
	Mean ±SD	**Mean ±SD**	**MD (95% CI)**	**% of**	**p value**
Weight (kg)					
Group A	82.37 ± 6.22	77.63 ± 5.95	4.74 (3.66, 5.81)	5.75	0.001
Group B	83.83 ± 5.46	73.23 ± 5.13	10.6 (9.53, 11.67)	12.64	0.001
MD (95% CI)	-1.46 (-4.49, 1.56)	4.4 (1.53, 7.27)			
	p = 0.33	***p = 0.003***			
BMI (kg/m²)					
Group A	32.15 ±1.73	30.31 ± 1.74	1.84 (1.45, 2.24)	5.72	0.001
Group B	32.36 ± 1.88	28.29 ± 2.13	4.07 (3.67, 4.47)	12.58	0.001
MD (95% CI)	-0.21 (-1.14, 0.72)	2.02 (1.01, 3.02)			
	p = 0.65	***p = 0.001***			
WHR					
Group A	1.30 ± 0.04	1.10 ± 0.08	0.20 (0.17, 0.21)	15.38	0.001
Group B	1.31 ± 0.03	1.02 ± 0.05	0.29 (0.27, 0.31)	22.14	0.001
MD (95% CI)	-0.01 (-0.03, 0.006)	0.08 (0.05, 0.12)			
	p = 0.19	***p = 0.001***			
BMD (g/cm²) Group A	0.97 ± 0.06	0.98 ± 0.07	-0.01 (-0.01, 0.004)	1.03	0.21
Group B	0.98 ± 0.05	1.03 ± 0.06	-0.05 (-0.06, -0.04)	5.10	0.001
MD (95% CI)	-0.01 (-0.04, 0.02)	-0.05 (-0.09, -0.02)			
	p = 0.67	***p = 0.001***			

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p value, Probability value

Discussion

Osteoporosis is a progressive condition affecting the bones characterized by diminished bone strength, compromised microstructure, heightened vulnerability, and an elevated likelihood of fractures. [22] Osteoporosis is a condition that weakens bones and makes individuals more susceptible to fractures, particularly in the hip, spine, as well as other areas.[23]

Researchs has shown a direct correlation between BMI and BMD, suggesting that individuals with a greater body weight may have a lower risk of developing osteoporosis[24]. Recent literature has shown a strong association between general obesity as well as bone fractures. [25]

Exercise is crucial in the management of osteoporosis. Both anaerobic as well as aerobic exercise have demonstrated efficacy in enhancing BMD and decreasing bone loss. [26]

The aim of this study to find out the impact of aerobic exercises as well as low caloric diet on bone density among obese elderly women.

The study was carried out on a sample of sixty older women who were classified as obese. The participants were randomly allocated into two groups, A and B, with an equal number of individuals in each group. Group A was given a 12-week diet along with their regular daily calcium consumption. Group B engaged in aerobic activity by walking on a treadmill for 30 minutes, 3 times a week, over a period of twelve weeks. The exercise sessions began with warm-up workouts and finished with cool-down exercises. Additionally, Group B maintained their regular daily calcium intake, which was the same as Group A, while following a low-calorie diet.

The BMD of the right femur was measured using an ultrasonometer (5000 KHz) equipment before and after treatment for all women in both the A and B groups.

The findings of our study indicated a substantial improvement in the BMD regarding group B after treatment, as compared to the BMD before treatment ($p > 0.001$). Conversely, there was no substantial alteration in BMD for group A ($p > 0.05$). Furthermore, it is worth noting that all women in the two groups (A and B) saw a substantial decrease in anthropometric parameters, including weight, BMI, as well as waist/hip ratio. This reduction was particularly evident in group B, with a statistically significant p-value of less than 0.05. The findings of this study corroborated the research conducted by **(Mohamed et al., 2018)**[27], which showed that aerobic exercise is highly efficacious in enhancing BMD among lean postmenopausal women. The findings were consistent with the study conducted by **(Kristin et al., 2022)**[28]**,** which showed that implementing both low-calorie diets and exercise program is both practical and beneficial for promoting weight loss in older individuals who are overweight.

In addition, our research was consistent with that of **(Kelley et al., 2022)**[29]**,** which proposed that exercise enhances the trochanteric BMD of the femur in calcium-replete postmenopausal women.

Furthermore, the findings were corroborated by **(Yamazaki et al., 2004)**[30]**,** who demonstrated the efficacy of treadmill running in preventing bone loss. Specifically, the trabecular thickness was maintained in rats that underwent treadmill running. Exercise has been proposed as a means to inhibit bone loss, with the extent of inhibition varying depending on the loading conditions.

Additional research conducted by (**Gozansy et al., 2004)**[31] and **(Bowen et al., 2004)**[32] supported the findings of this study, showing that the aerobic training group experienced a notable decrease in body weight. The first study reported a reduction of 4.1% over a six-month period, while the second study reported a reduction of 11.39% over a two-month

period. Furthermore, several studies corroborate our findings that engaging in moderate aerobic activity can enhance BMD even among older individuals. BMD was evaluated utilizing BMD measures, that are reliable methods utilized in the management of osteoporosis. BMD measurements provide insights into the potential for fractures and the accessibility of therapeutic interventions that may enhance BMD. [33] According to **(Mervat et al., 2008)**[34], all the women within the two intervention groups lost weight, had a lower BMI, and had a smaller waist-to-hip ratio. The biggest drops were seen in group II (11.39%, 9.83%, and 20.15%) compared to group I (7.56%, 8.32%, and 6.63%). This was due to a combination of diet and exercise. The results indicate that group I (diet) saw a substantial drop in BMD by 2.15% after a period of three months, but group II showed a substantial improvement in BMD by 3.2%, which is consistent with our findings.

Our findings countered the conclusions of **(Breverley et al., 2011)**[35], who discovered that moderate types of exercise, such as walking, have not proven effective therapies. Attempts to enhance BMD) through longer and faster walking have proven ineffective, with the exception of the calcaneus.

(Liang et al., 2011)[36] contradicted the results by stating that aerobic exercises, such as walking, have low intensity and hence provide minimal mechanical stimulation to muscles, resulting in an insignificant impact on bone mass.

Conclusion

Based on the results of this study: The use of both aerobic activities and low calorie diet resulted in significant weight reduction, reduced BMI, and improved waist/hip ratio in obese older women over a period of 12 consecutive weeks. Additionally, this combination approach had a positive impact on bone mineral density (BMD) compared to using a diet alone.

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Informed Consent: A written informed consent was obtained from all participants.

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