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Effect of Smoking, Alcohol Consumption, and Obesity on Bone Metabolism: A Study on Post-Menopausal North-Cypriot Women

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Abstract

BACKGROUND/AIMS: Obesity and osteoporosis are prevalent and intricate health conditions involving multiple etiological factors. Although obesity is traditionally considered beneficial to bone health, the pathophysiological relationship between obesity and bone health is controversial. This study aimed to evaluate the effect of obesity on osteoporosis in postmenopausal North Cypriot women.

MATERIALS AND METHODS: A total of 241 postmenopausal North Cypriot women were included in the study. The height and weight of the patients were recorded, and the body mass index (BMI) was calculated for each patient. The T-scores and bone mineral density (BMD) of the femoral neck and total femur were recorded. Patients were questioned about their history of oral contraceptive and supportive medication (Ca, bisphosphonates, vitamin D), alcohol consumption, and smoking habits.

RESULTS: The patients' ages were approximately 36-84 years (mean: 61.5±9.11), and their BMI was 16.8 kg/m^2 and 47.4 kg/m^2 (28.55±5.26 kg/m^2). Mean T-scores at the femoral neck and total femur were -1.06±0.96 and -0.86±1.01, respectively. The mean BMDs at the femoral neck and total femur were 0.839±0.115 kg/m^2 and 0.880±0.122, respectively. There was a statistically significant correlation between age and T-score and BMD of the femoral neck and T-score and BMD of the total femur. There was a statistically significant correlation between BMI and the femoral neck T-score and BMD of the femoral neck. There was a statistically significant correlation between BMI and total femur T-score and BMD of the total femur. No statistically significant difference was detected in the mean T-scores and BMD values between the groups regarding the use of oral contraceptive or supportive medication and smoking or alcohol consumption.

CONCLUSION: Our results show that obesity has a positive effect on BMD in postmenopausal North Cypriot women. Further studies with larger patient groups are needed to better understand the impact of obesity on bone health.

Keywords: Obesity, osteoporosis, osteopenia, body mass index

INTRODUCTION

Osteoporosis is a systemic skeletal disease that causes deterioration in the microarchitecture of bone tissue, leading to increased bone fragility.[1] The prevalence of this disease is rising worldwide, with an aging population and prolonged life expectancy.[2,3] The major complication of osteoporosis is insufficiency fractures, which lead to morbidity, mortality, decreased quality of life, and a substantial economic burden on society.

Considering the factors affecting bone metabolism, osteoporosis is simply classified as primary (postmenopausal and age-related) or

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secondary.[4,5] Bone mineral density (BMD) was used to predict fracture risk.[6,7] Age, gender, smoking, alcohol consumption, steroid use, and diseases affecting bone metabolism increase the risk of osteoporotic fractures regardless of BMD.[7-11]

Obesity, which can be referred to as the age epidemic, is defined as the excessive accumulation of fat in the body and is considered a chronic metabolic disease related to both environmental and genetic factors.[2] Body mass index (BMI) is widely used to determine the degree of obesity.[6] Obesity and osteoporosis are potentially preventable and treatable conditions that are often referred to as "silent diseases" because they may not exhibit warning signs until complications arise. Various mechanical, biochemical, and hormonal mechanisms have been proposed to explain the relationship between adipose tissue and bone. In general, evidence suggests that obesity may have a protective effect against postmenopausal osteoporosis.[12-15] However, it is worth noting that there are also studies that report contradictory results.[16-18]

Smoking and alcohol consumption are well-known causes of osteoporosis. There are some direct and indirect pathophysiological mechanisms discussed in the literature to explain the effect of smoking on bone health (inhibitor effect on osteogenesis and angiogenesis, alteration in body weight, alteration in parathyroid hormone, oxidative stress, etc.).[19,20] High alcohol intake is related to increased fracture risk, but there seems to be a threshold effect, as alcohol consumption of 2 units or less per day does not cause an increase in osteoporotic fractures.[10]

In fact, a complex pathophysiological relationship between obesity, smoking, alcohol consumption, and bone that is still not fully understood.

North Cyprus has a unique geographical location with ethnic diversity. To our knowledge, no study has investigated the effects of obesity, smoking habits, and alcohol consumption on BMD in patients living in North Cyprus. In this article, we aimed to investigate the effects of these factors on postmenopausal osteoporosis in North Cypriot women.

MATERIALS AND METHODS

The study was conducted in accordance with the ethical standards of the Near East University Institutional Research Committee, and IRB approval (approval number: 2020/85-1182, date: 26.11.2020) was obtained. Patients provided informed consent regarding the publication of their data.

For this cross-sectional study, a questionnaire was administered to 509 North Cypriot women who were referred for Dual-energy X-ray absorptiometry examinations at the radiology department of our hospital between January 2021 and December 2021. Questionnaires were asked about their menstrual status, the presence of conditions that could contribute to osteoporosis, alcohol consumption and smoking habits, history of oral contraceptive use, and the use of supportive medications such as calcium, bisphosphonates, and vitamin D. Two hundred sixty-eight patients (58 premenopausal patients and 210 post-menopausal patients, those receive anti-osteoporosis treatment or suffering from diseases that may cause secondary osteoporosis) were excluded, and the remaining 241 postmenopausal treatment-naive patients were included in the study (Figure 1). For each patient, their height and weight were documented, and the BMI was computed (kg/m^2). Additionally, T-scores and BMD measurements of the femoral neck and total femur were recorded.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 28 (SPSS, Chicago, IL, USA). Statistical significance was set at $p<0.05$. "Shapiro-Wilk test" was used to determine whether the data had a normal distribution. Because the data showed a normal distribution $p>0.05$), "t-test for independent samples" was used in comparisons between the groups and "Pearson correlation analysis" was used to examine the relationships between variables.

RESULTS

The patients in the study had a wide age range, ranging from 36 to 84 years, with a mean age of 61.5 years [±9.11 standard deviation (SD)]. BMI varied from 16.8 kg/m^2 to 47.4 kg/m^2, with an average BMI of 28.55 kg/m^2 (±5.26 SD).

Among the participants, 63 patients (26%) reported a history of oral contraceptive use, and 56 patients (23.2%) reported being smokers (54 reported to be current smokers, and only 2 of them had a history of smoking). Among the 241 patients, 5 patients reported consuming alcohol more than twice a week (group 1), 9 of them less than twice a week (group 2), and 36 less than once a month (group 3). One hundred and ninety-one patients were non-drinkers (group 4). Because of the low number of patients in groups 1 and 2, with the recommendation of the statistician we worked with, patients were divided into two groups: non-drinkers (n=191, 79.3%, group 4) and drinkers (n=50, 20.7%, groups 1, 2 and 3). Vitamin D levels were recorded in only 105 of the 241 (43%) patients, and the values were approximately 4-110 ng/mL, in a wide range.

The clinical and demographic characteristics of the patients are summarized in Table 1, and the duration of menopause was demonstrated in Figure 1.

The T-scores at the femoral neck were between -2.9 and 3.2 (mean, -1.060.96±). The BMDs at the femoral neck were between 0.617 kg/m^2 and 1.33 kg/m^2 (mean, 0.8390.115±). T scores at the total femur were between -3.3 and 3.2 (mean, -0.861.01±) and BMD at the total femur were between 0.586 kg/m^2 -1.355 kg/m^2 (mean, 0.8800.122±).

A statistically significant negative correlation was observed between age and both the femoral neck T-score and the BMD of the femoral neck ($r=-0.2133$, $p<0.001$ and $r=-0.2568$, $p<0.001$, respectively), as shown in Figure 2. Additionally, there was a weak but statistically significant negative correlation between age and both the total femur T-score and the BMD of the total femur ($r=-0.1359$, $p=0.035$ and $r=-0.148$, $p=0.022$, respectively), as indicated in Figure 3.

There was a statistically significant positive correlation observed between BMI and both the femoral neck T-score ($r=0.2858$, $p<0.001$) and the BMD of the femoral neck ($r=0.2783$, $p<0.001$), as shown in Figure 4. Furthermore, a statistically significant positive correlation was found between BMI and both the total femur T-score ($r=0.4487$, $p<0.001$) and the BMD of the total femur ($r=0.4446$, $p<0.001$), as presented in Figure 5.

No statistically significant differences were observed in the mean T-scores and BMD of the femoral neck and total femur when considering

Table 1. Clinical and demographic characteristics of the patients		
Female, (n)		241
Age (years) (mean ± SD)		36-84 (61.59.11±)
BMI kg/m² (mean ± SD)		16.8-47.4 (28.555.26±)
Smoking cigarette n (%)		56 (23.7)
Consumption of alcohol, n (%)		50 (20.7)
BMD kg/m² (mean ± SD)	T-scores at the femoral neck	0.617-1.33 (0.8390.115±)
	T-scores at the total femur	0.586-1.355 (0.8800.122±)
Oral contraceptive use, n (%)		63 (26)
Supportive medication, n (%)		156(64.7)
SD: Standard deviation, BMD: Bone mineral density, BMI: Body mass index.		

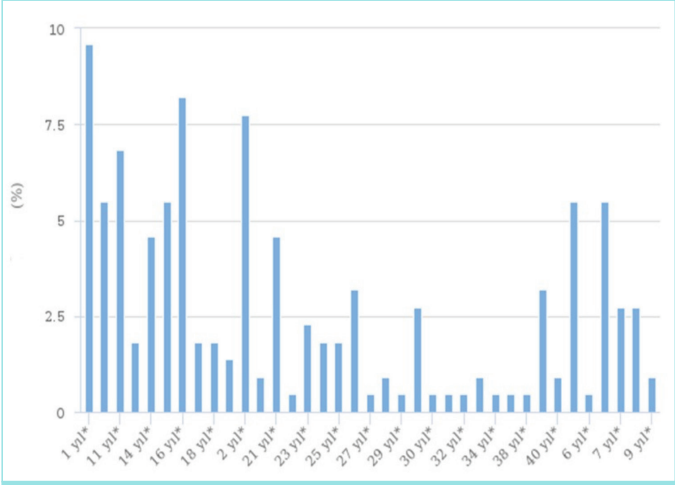

Figure 1. Duration of menopause of the patients.

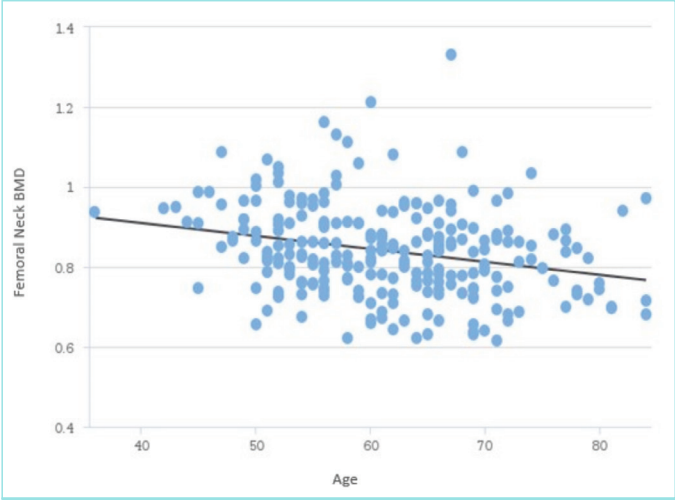

Figure 2. Correlation between age and BMD of femoral neck (kg/m²).

BMD: Bone mineral density.

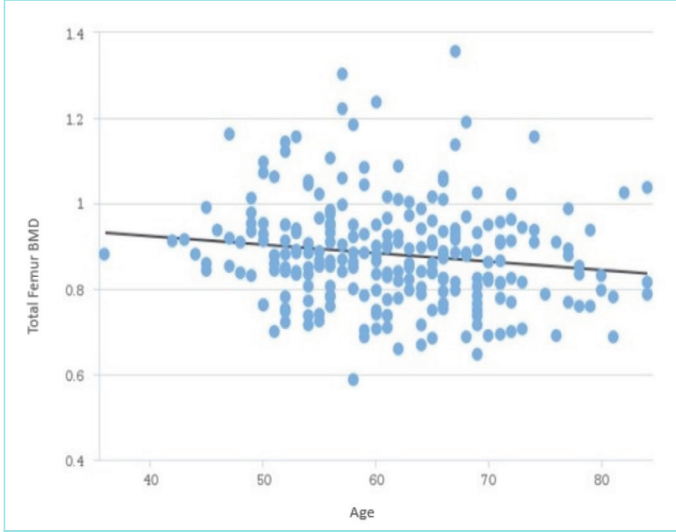

Figure 3. Correlation between age and BMD of total femur (kg/m²).

BMD: Bone mineral density.

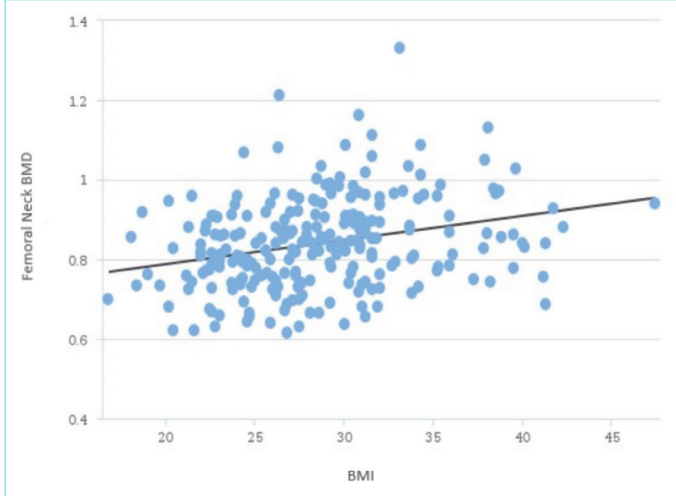

Figure 4. Correlation between BMI (kg/m²) and BMD of the femoral neck (kg/m²).

BMI: Body mass index, BMD: Bone mineral density.

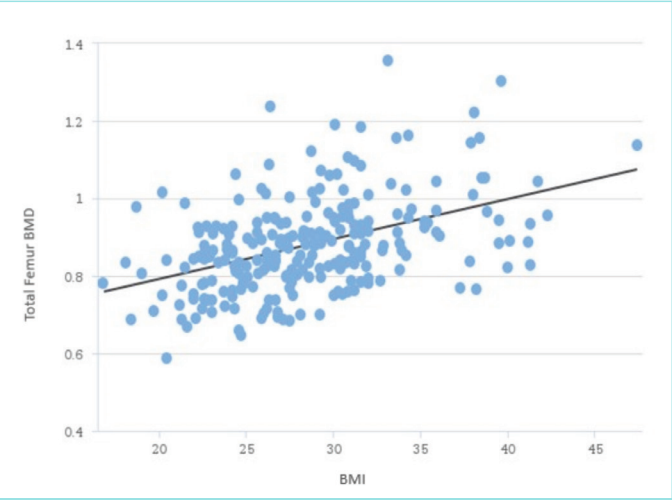

Figure 5. Correlation between BMI (kg/m²) and BMD of total femur (kg/m²).

BMI: Body mass index, BMD: Bone mineral density

the use of oral contraceptives (p=0.051, p=0.052, p=0.079, p=0.080). There were no statistically significant differences in the mean T-scores and BMD of the femoral neck and total femur with smoking (p=0.390, p=0.577, p=0.714, p=0.834) or alcohol consumption (p=0.903, p=0.681, p=0.529, p=0.609).

DISCUSSION

Based on our findings, several conclusions can be drawn regarding the etiology of osteoporosis: 1) Age and osteoporosis: We observed a correlation between older age and a higher prevalence of osteopenia and osteoporosis. This suggests that as women age, they are at an increased risk of developing these conditions. 2) Obesity and osteoporosis: Our study supports the widely accepted idea that obesity has a beneficial effect on osteoporosis. Postmenopausal osteoporosis was found to be less common in women with obesity. This suggests that a higher BMI may offer some protection against the development of osteoporosis in post-menopausal women. 3) Alcohol intake, smoking, and oral contraceptives: Our analysis did not find any significant effects of oral contraceptive use, alcohol intake, or smoking on the development of postmenopausal osteoporosis. This implies that these factors may not be significant contributors to the risk of developing osteoporosis in postmenopausal women, at least in the context of our study.

Consistent with the findings of our study, previous studies have demonstrated a positive effect of higher BMI on BMD in most cases.[2,14,15,21-23] Notably, Zhang and Pu[14] identified a positive relationship between obesity and BMD, while underscoring the importance of maintaining a moderate BMI level (approximately 24.3 kg/m²) in adults over the age of 50 to achieve an optimal balance between BMI and BMD. Additionally, Ma et al.[15] identified a BMI saturation value (approximately 26 kg/m²) for femoral and spinal BMD in all participants aged 50 years and older. Collectively, these findings suggest that a high BMI can have a positive impact on bone density, especially in older adults. However, there may be an upper limit or saturation point beyond which the benefits of a higher BMI on bone density plateau. These insights are valuable for understanding the complex relationship between body composition and bone health in aging populations.

The findings from the meta-analysis by Qiao et al.[2] are consistent with our study results, indicating that adults with obesity tend to exhibit higher BMD levels than individuals with healthy weight. Similarly, a study conducted by Mazocco and Chagas[21] reported that obese women had a lower prevalence of osteopenia and osteoporosis than those who were normal weight or overweight. This suggests the potential protective effect of obesity against bone-related conditions. Additionally, Saarelainen et al.'s[22] long-term study on postmenopausal women supports these observations. Their research indicated that obesity delayed the onset of osteopenia by approximately 5 and 9 years at the spine and femoral neck, respectively, in postmenopausal women. These findings emphasize the significant role of obesity in influencing the timeline of bone health changes, particularly in postmenopausal women.

Indeed, there is an ongoing debate and evolving research surrounding the relationship between increased fat mass (obesity), smoking, and alcohol consumption and the risk of osteoporotic fractures. Nicotine inhibits osteogenesis and angiogenesis. Smoking also has indirect effects on bone health through the loss of appetite, causing alteration of body weight, parathyroid hormone, and increased oxidative stress. Studies have also shown that smokers have a greater risk of hip fractures than non-smokers.[24] High alcohol intake was also shown to be associated with a significant increase in hip fracture risk, but no significant risk was reported at intakes of 2 units and less daily.[10] While some studies have suggested the potential protective effects of high body fat on bone health, recent findings have raised questions about these assumptions.[16-18,25,26] Song et al.[25] showed that BMI can have different effects on various parts of the skeletal system. For instance, a higher BMI was positively associated with lumbar and calcaneal BMD, but it had no significant effect on femoral neck and forearm BMD.[25] Compston et al.[16] indicated that obesity does not necessarily protect against fractures in postmenopausal women. In fact, it increases the risk of ankle and upper leg fractures.[16] Gnudi et al.[26] found that the relationship between BMI and fracture risk varied according to fracture site. For instance, increased BMI was associated with a higher risk of humerus fractures but lower risk of hip fractures. No significant relationship was observed between BMI and wrist or ankle fractures.[26] Although vertebral fractures are generally considered rare in individuals with obesity, some studies, like the one by Pirro et al.[27], have suggested an increased risk, particularly in postmenopausal women. In summary, the impact of obesity on bone health is multifaceted, and the relationship between obesity and fracture risk is not uniform across all bone sites. Obesity does appear to increase the risk of falls, especially in individuals older than 60 years, which can contribute to fractures. Additionally, the fracture pattern varies, with obese individuals experiencing more fractures at certain sites (e.g., ankle, leg, humerus) and fewer at others (e.g., wrist, hip, pelvis). These findings emphasize the need for personalized healthcare and risk assessment when considering the effects of obesity on bone health.[12,27-32]

The controversial findings in the relationship between obesity and osteoporosis can be attributed to a complex interplay of factors. These factors include the multifactorial interaction between bone and adipose tissue, which involves both metabolic and mechanical effects. Additionally, ethnic and cultural differences, social and economic conditions, and environmental factors may all contribute to

the varying associations between obesity and osteoporosis. The World Health Organization (WHO) recommends specific BMI thresholds for defining overweight and obesity, which can vary across populations. In Western populations, the WHO recommends using BMI ≥25 kg/m^2 for the definition of overweight and BMI ≥30 kg/m^2 for obesity.[33] However, for Asian populations, including Asians in North Cyprus, the WHO, in collaboration with the International Association for the Study of Obesity and the International Obesity Task Force, has proposed lower BMI cutoff values. These include 23.0-24.9 kg/m^2 for classifying individuals as overweight and ≥25.0 kg/m^2 for identifying obesity.[34] Variations in the BMI cutoff values used to define overweight and obesity across different ethnic groups can indeed have implications for discussions regarding the relationship between obesity and osteoporosis. It is important to recognize that these differences may impact how researchers and healthcare professionals assess and interpret the association between obesity and bone health in diverse populations. However, it is worth noting that as of now, specific studies addressing the appropriate cutoff values for overweight and obesity in the Middle East, including North Cyprus. The absence of region-specific data highlights the need for further research to better understand how these classifications apply to populations in this geographical region and to assess their impact more accurately on health outcomes like osteoporosis.

Study Limitations

This study has several limitations that should be considered when interpreting the findings. The most significant limitation of this study is the relatively small sample size, which may not be fully representative of the entire population of North Cyprus. As a result, the generalizability of the study's results to the broader population may be limited. Another important limitation of this study was its focus on the BMD values of the femur, with BMD values of the lumbar vertebrae not included in the analysis. Because BMD measurements at different skeletal sites can provide valuable insights into bone health, the omission of lumbar vertebral data represents a limitation. Additionally, the exclusion of men and premenopausal women, as well as its restriction to BMD values of the femur alone, may limit the breadth of the conclusions. The wide sample size is another limitation for the study to draw conclusions. Because of the low number of patients with records of vitamin D values (105 of 241 patients, 43%) comparing the levels of vitamin D, their effect on BMD would not represent the entire study group and was therefore not studied.

In summary, although this study offers valuable insights, it is essential to acknowledge these limitations and consider them when interpreting the results. Future research endeavors with larger and more diverse participant groups, as well as comprehensive BMD measurements, will contribute to a more thorough understanding of the mechanism of osteoporosis. Including a more diverse participant group in terms of sex, menopausal status, and vitamin D values and considering BMD values at both lumbar vertebrae and femur sites would provide a more comprehensive understanding of the relationship between different etiologic factors and osteoporosis.

CONCLUSION

This study is an important milestone as the first research of its kind conducted in postmenopausal North Cypriot women. The study findings revealed a notable trend: as age increased, the prevalence of osteoporosis also increased. In addition, the study observed that obese women had a lower prevalence of osteoporosis. These findings contribute to our understanding of the association between BMI and osteoporosis in this specific population and provide valuable insights into bone health in postmenopausal women in North Cyprus. These conclusions highlight the complex interplay between various factors, including age and BMI, in the development of postmenopausal osteoporosis. Further research and larger studies may provide deeper insights into these relationships.

MAIN POINTS

- Postmenopausal osteoporosis is less common in obese North Cypriot women than in normal-weighted ones.
- Region-specific studies with larger study groups are needed to understand the complex relationship between obesity and osteoporosis.
- Alcohol consumption, smoking, and supportive medication appear to have no effect on postmenopausal osteoporosis development.

ETHICS

Ethics Committee Approval: The study was conducted in accordance with the ethical standards of the Near East University Institutional Research Committee, and IRB approval (approval number: 2020/85-1182, date: 26.11.2020) was obtained.

Informed Consent: Patients provided informed consent regarding the publication of their data.

Authorship Contributions

Surgical and Medical Practices: Y.K., M.T., Concept: Y.K., M.T., Design: Y.K., M.T., Data Collection and/or Processing: Y.K., M.T., Analysis and/or Interpretation: Y.K., M.T., Literature Search: Y.K., M.T., Writing: Y.K., M.T.

DISCLOSURES

Conflict of Interest: No conflict of interest was declared by the authors.

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