



การศึกษาความหนาแน่นของมวลกระดูกในสตรีวัยหมดประจำเดือน ร่วมกับกลุ่มอาการเมตาบอลิก

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Bone Mineral Density Study in Postmenopausal Women with Metabolic Syndrome

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บทคัดย่อ

วัตถุประสงค์: เพื่อประเมินความแตกต่างของค่าความหนาแน่นของมวลกระดูกในสตรีวัยหมดประจำเดือนที่มีกลุ่มอาการอ้วนลงพุงเปรียบเทียบกับกลุ่มที่ไม่มีและประเมินปัจจัยที่ส่งผลต่อค่าความหนาแน่นของมวลกระดูก

วิธีการศึกษา: การศึกษาเชิงสังเกต ประชากรคือสตรีวัยหมดประจำเดือนอายุ 45 – 65 ปี ที่เข้ารับการรักษที่โรงพยาบาลศรีนครินทร์ในระหว่างเดือนพฤษภาคม 2558 ถึงกุมภาพันธ์ 2559 วินิจฉัยกลุ่มอาการอ้วนลงพุงตามเกณฑ์ NCEP ATP III 2001 และตรวจมวลกระดูกที่คอกระดูกต้นขา กระดูกสันหลังส่วนเอวและกระดูกข้อสะโพกโดยใช้รังสีเอ็กซ์ 2 พลังงาน

ผลการศึกษา: สตรีวัยหมดประจำเดือนที่มีกลุ่มอาการอ้วนลงพุงจำนวน 125 รายและไม่มีกลุ่มอาการอ้วนลงพุงจำนวน 125 รายเข้าร่วมการศึกษา อายุเฉลี่ย 57.9 ± 4.2 และ 56.6 ± 4.1 ปีตามลำดับ พบว่าสตรีที่มีกลุ่มอาการอ้วนลงพุงมีค่าความหนาแน่นของมวลกระดูกมากกว่าเมื่อทำการวิเคราะห์โดยควบคุมปัจจัยอายุ แต่เมื่อควบคุมปัจจัยดัชนีมวลกายพบว่าไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ การวิเคราะห์ถดถอยเชิงเส้นพหุคูณพบว่าค่าดัชนีมวลกายเป็นตัวแปรอิสระที่มีอิทธิพลในทางบวกต่อคอกระดูกต้นขา กระดูกสันหลังส่วนเอวและกระดูกข้อสะโพก และพบว่าเบาหวานเป็นตัวแปรอิสระที่มีอิทธิพลในทางบวกต่อกระดูกข้อสะโพก

สรุป: ค่าความหนาแน่นของมวลกระดูกในสตรีวัยหมดประจำเดือนที่มีกลุ่มอาการเมตาบอลิกนั้นได้รับอิทธิพลจากค่าดัชนีมวลกายซึ่งเป็นองค์ประกอบที่ส่งเสริมการเกิดกลุ่มอาการเมตาบอลิกเป็นหลัก พบว่าตัวแปรอิสระที่มีอิทธิพลในทางบวกต่อมวลกระดูกนอกจากค่าดัชนีมวลกายแล้วยังได้แก่ภาวะเบาหวาน ซึ่งเป็นไปได้ว่าอาจเป็นผลที่มาจากการมีค่าดัชนีมวลกายที่สูงขึ้นในสตรีในกลุ่มนี้

คำสำคัญ: สตรีวัยหมดประจำเดือน, กลุ่มอาการอ้วนลงพุง, ค่าความหนาแน่นของมวลกระดูก, ดัชนีมวลกาย

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Abstract

Objectives: To compare bone mineral density (BMD) in postmenopausal women with and without metabolic syndrome (MS) and evaluate the association of the MS components with BMD.

Materials and Methods: The cross-sectional study evaluated postmenopausal women aged between 45 to 65 years old, who visited Srinagarind Hospital, Khon Kaen University between May 2015 and February 2016. MS is diagnosed according to NCEP ATP III 2005 criteria. BMD was measured at the femoral neck, lumbar spine, and total hip by dual-energy X-ray absorptiometry.

Results: A total of 125 postmenopausal women with MS and 125 without MS were enrolled. Mean age $\pm$ SD was 57.9 $\pm$ 4.2 and 56.6 $\pm$ 4.1 years, respectively. Postmenopausal women with MS had significantly higher BMD compared to those without MS in age-adjusted analysis. Further adjustment for BMI, there was no difference in BMD between both groups. In a multiple linear regression analysis, BMI was a significant positive predictor of BMD at all sites, while DM was a significant positive predictor of total hip BMD.

Conclusion: The higher BMD in the MS group may be affected mainly by the influence of MS's contributing factors, such as BMI. The significant positive predictors for BMD in postmenopausal women were not only BMI but also DM, which may be partly attributable to the increase in BMI.

Keywords: postmenopausal women, metabolic syndrome, bone mineral density, body mass index

Introduction

Osteoporosis is a systemic skeletal disorder characterized by decreased bone mass, and microarchitectural deterioration of bone tissue, with a consequent increase in bone fragility, as a result, the bones become more fragile^{1,2}. It is associated with an increased risk of fractures and death in the elderly.³ The diagnosis of osteoporosis is based on measuring bone mineral density (BMD) with dual-energy X-ray absorptiometry (DXA) of the hip or spine, using a T-score of -2.5 or lower.⁴ Osteoporotic fractures increase morbidity and mortality rates, resulting in significant physical and financial strain on healthcare systems. Therefore, preventing osteoporosis is crucial for both men and women.

Metabolic syndrome (MS) is associated with systemic inflammatory response. It is a cluster of diseases, including abdominal obesity, hypertension, lipid abnormalities, and hyperglycemia.⁵ MS was reported to be associated with an increased risk of type 2 diabetes mellitus (type 2 DM) and cardiovascular disease.⁶ The primary pathogenic mechanism of MS is linked to insulin resistance, chronic low-level inflammation, and oxidative stress.⁷ The earlier studies reported the importance of inflammatory cytokines in MS such as tumor necrosis factor- α (TNF- α), interleukin-6 (IL-6) and high sensitivity-C-reactive protein (hs-CRP) are inducing bone resorption, increased bone turnover and decreased BMD.⁸⁻¹⁰ While some studies reported lower BMD^{11,12} or no difference¹³ in women with MS compared with no MS, others showed women diagnosed with MS have higher BMD, indicating a potential protective effect of MS on bone health.¹⁴⁻¹⁷

The effect on BMD varies among each component of MS. The effect of hyperglycemia, insulin resistance, and obesity in diabetes may be positive or negative on bone metabolism, leading to variable effects on bone mass.¹⁸ In abdominal obesity, high mechanical loading and high estradiol levels may protect bone¹⁹, but pro-inflammatory cytokines and adipokines may lead to increased skeletal fragility.¹⁸

The association between MS and osteoporosis has been widely studied but remains inconclusive due to inconsistent findings. One explanation is that the effect of MS on bone metabolism may be

influenced by several factors, such as ethnicity, lifestyle, and the difference in components and details of MS in each population.

Therefore, it is very interesting to conduct a cross-sectional study to compare the BMD of postmenopausal women with MS and without MS, specifically in Thai women, and to determine the association between the MS components and BMD. The results would provide additional information that could be applied to our medical care.

Materials and methods

Study population

Postmenopausal women aged between 45 and 65 years who visited Srinagarind Hospital, Khon Kaen University for their health checkups or treatment of MS between May 2015 and February 2016 were enrolled in the study. Menopause, naturally or surgically, is characterized by the absence of menstrual periods for a minimum of 12 consecutive months, at the age of 45 years or older. The study was approved by the institutional review board of the Khon Kaen University Ethics Committee in Human Research.

Postmenopausal women were classified into two groups: (a) with MS and (b) without MS group. Postmenopausal women who were the same age but did not reach the criteria for MS diagnosis were included in the without MS group. Patients were excluded if they had previously used hormone replacement therapy for a period longer than 6 months, used medication for osteoporosis includes Bisphosphonates, Teriparatide, Denosumab, Selective estrogen receptor modulators (SERMs), and Menopause hormonal therapy, used steroids more than 3 months, as well as those who suffered from any of the following conditions: rheumatoid arthritis, thyroid disease, malignancy, end-stage renal disease, immune deficiency, cardiovascular failure, cerebrovascular disease, dementia, psychiatric disease, and difficulty communicating due to disability. All participants provided written informed consent and completed a comprehensive questionnaire, clinical, obstetric, and gynecologic history before enrollment. Participants completed a questionnaire to determine their smoking habits (current, past, or never), alcohol intake (three or more

glasses, more than three times per week), coffee intake (three cups of coffee per day), exercise (at least 30 minutes, three times a week), calcium supplement (the regular or continuous use of calcium supplements for a period of more than 6 months), and vitamin D supplement (the regular or continuous use of Vitamin D supplements for a period of more than 6 months), and previous medical or surgical diseases. Two hundred and fifty women were included in the study and underwent BMD assessment by dual-energy X-ray absorptiometry.

Metabolic syndrome

The criteria for clinical diagnosis of MS based on the National Cholesterol Education Program-Adult Treatment Panel III (NCEP ATP III) 2005, required the presence of at least 3 of the following components:^{20,21}

1. Waist circumference ≥ 80 cm (≥ 31 inches), criteria for Asian women
2. Elevated triglycerides ≥ 150 mg/dL (1.7 mmol/L) or on drug treatment
3. Reduced HDL-c < 50 mg/dL (1.3 mmol/L) in women or on drug treatment
4. Elevated blood pressure ≥ 130 mmHg systolic blood pressure or ≥ 85 mmHg diastolic blood pressure or on antihypertensive drug treatment
5. Elevated fasting glucose ≥ 100 mg/dL or on drug treatment for elevated glucose

Assessment of the parameters of MS

The patients were measured for while wearing indoor clothing, but not shoes. Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m). Waist circumference was measured in a standing position, wearing a thin layer of clothing at the level of the top of the iliac crest. Measurement was taken at the end of a normal expiration. Blood pressure was measured in millimeters of mercury (mmHg) using an electronic sphygmomanometer by a trained nurse. The average of 2 consecutive measurements after at least 10 minutes of sitting was used in the analysis. Venous blood was collected after an overnight fast (≥ 12 hours). The participant's blood was tested for fasting plasma glucose (FPG), triglyceride (TG), and high-density lipoprotein cholesterol (HDL-C). FPG levels were measured using the enzymatic reference method with hexokinase and

serum TG and HDL-C were assessed using an enzymatic color test (Roche/Hitachi).

BMD measurements

BMD was measured by dual-energy X-ray absorptiometry (DXA) at the lumbar spine, femoral neck and total hip in g/cm^2 , using GE Lunar Health Care, Madison, Wisc., USA, machine calibrated daily with a standard phantom provided by the manufacturer. The least significant change (LSC) in our institute is $0.029 \text{ g}/\text{cm}^2$. Lumbar spine BMD was the mean of lumbar vertebrae BMD 1 to 4. However, the spines with local structural change or artifacts were initially excluded from the statistical analysis. BMD was measured by an experienced technician in the Nuclear Medicine Division, Department of Radiology, Khon Kaen University.

Statistical analysis

A power calculation indicated that 125 patients in each group were necessary to have a 95% chance of detecting a 3.4 % difference in mean BMD. The sample size calculation allowed 80% power of the study. The significance level was set at 0.05.

Results are expressed as mean $\pm$ SD or percentages, as appropriate. Baseline characteristics of the postmenopausal women with and without MS were compared using the χ^2 test or Fisher's exact test for categorical variables, and Student's t-test for continuous variables. Analysis of covariance (ANCOVA) was performed to compare the BMD levels of participants with and without MS after adjusting for BMD-related covariates including age, BMI, alcohol intake, cigarette smoking, calcium and vitamin D intake, exercise, and hormonal contraception. Subgroup analysis was also performed. Analysis of variance (ANOVA) was used to compare the mean of BMD among (a) 1 - 5, (b) 5 - 10, and (c) more than 10 years since menopause. A multiple linear regression analysis was used to analyze the association between MS and its components with BMD. Age and the duration of menopause were coded in years, type 2 DM as 1 = yes / 0 = no, DLD as 1 = yes / 0 = no, HT as 1 = yes / 0 = no, SBP in mmHg, AC in centimeters, BMI in kg/m^2 , FPG in mg/dL and HDL in mg/dL. All statistical analyses were performed using SPSS for the Windows Statistical Package Version 21.0 (SPSS Inc, Chicago, IL., USA).

Results

Of the 250 participants, 125 were placed in postmenopausal women with MS group and the other 125 were placed in postmenopausal women without MS group. The baseline characteristics of the study populations are presented in Table 1. The mean age was 57.9 ± 4.2 years in the MS group and 56.6 ± 4.1 years in the without MS group ($p = 0.015$). The mean duration of menopause in the postmenopausal

women with MS and postmenopausal women without MS were 7.6 ± 4.7 and 6.4 ± 4.2 years, respectively ($p=0.023$). Subjects in the MS group had higher blood pressure, waist circumference, BMI, serum concentration of FPG, and TG but lower serum HDL-C. Both groups had similar numbers of calcium and vitamin D supplements, alcohol consumption, and smoking. Baseline characteristics are shown in Table 1.

Table 1 Baseline characteristics and laboratory parameters of the study participants

	With MS (n = 125)	Without MS (n = 125)	p-value
Age (years)	57.9 ± 4.2	56.6 ± 4.1	0.015
Age at menopause (years)	50.3 ± 2.9	50.3 ± 2.8	0.982
Duration of menopause (years)	7.6 ± 4.7	6.4 ± 4.2	0.023
Natural menopause (%)	116 (92.8%)	118 (94.4%)	0.463
Systolic blood pressure (mmHg)	135.2 ± 14.8	122.1 ± 15.1	< 0.001
Diastolic blood pressure (mmHg)	75.8 ± 9.7	70.4 ± 10.4	< 0.001
Waist circumference (cm)	91.3 ± 10.1	79.0 ± 8.7	< 0.001
Weight (kg)	64.5 ± 10.3	55.8 ± 8.8	< 0.001
Body mass index (kg/m^2)	26.9 ± 4.1	23.3 ± 3.4	< 0.001
Fasting plasma glucose (mg/dL)	118.6 ± 40.7	89.5 ± 12.2	< 0.001
Triglyceride (mg/dL)	155.5 ± 78.6	101.5 ± 36.3	< 0.001
HDL-C (mg/dL)	56.9 ± 15.7	72.6 ± 22.0	< 0.001
Diabetes mellitus (%)	60 (48%)	3 (2.4%)	< 0.001
Hypertension (%)	82 (65.6%)	14 (11.2%)	< 0.001
Dyslipidemia (%)	94 (75.2%)	18 (14.4%)	< 0.001

Data are presented as the mean $\pm$ the standard error or the percentage with the standard error in *parentheses*
MS metabolic syndrome, HDL-C high-density lipoprotein cholesterol

For unadjusted analysis, the BMD of the femoral neck and total hip was significantly higher in the MS group. The Analysis of covariance (ANCOVA) demonstrated that age and BMI were the significant covariates for lumbar, femoral neck, and total hip BMD. After aged adjusted analysis, women with MS had significantly higher BMD at all sites compared to those without MS. However, after further adjustment for BMI, there was no statistically significant difference in BMD between the two groups, as shown in Table 2. When subgroup analysis by the duration of menopause was performed, there was no statistically significant difference in either group. BMI was

categorized into underweight, normal weight, and overweight groups, but there were no significant differences found between them. (Data not shown)

To identify the multiple independent factors affecting the BMD, we performed a multiple linear regression analysis. Univariate analysis was performed to detect and include significant factors for further multivariate analysis, variable inclusion with $p < 0.05$ and exclusion with $p > 0.10$. Multiple regression was calculated by using the enter method to predict if a component of MS significantly predicted participants' BMD at the lumbar spine, femoral neck, and total hip. (Table 3)

Table 2 Bone Mineral Density according to the presence or absence of metabolic syndrome^a

	With MS (n = 125)	Without MS (n = 125)	Mean difference	95% confidence interval	p-value
Lumbar spine					
Unadjusted	1.018±0.015	0.980±0.014	0.038±0.020	-0.001 to 0.087	0.055
Age adjusted	1.024±0.014	0.973±0.014	0.051±0.020	0.013 to 0.090	0.009
Age + BMI adjusted	1.007±0.014	0.991±0.014	0.016±0.021	-0.026 to 0.057	0.453
Femoral neck					
Unadjusted	0.860±0.011	0.830±0.009	0.031±0.014	0.002 to 0.059	0.035
Age adjusted	0.865±0.010	0.826±0.010	0.039±0.014	0.011 to 0.067	0.006
Age + BMI adjusted	0.849±0.010	0.841±0.010	0.008±0.015	-0.022 to 0.038	0.598
Total hip					
Unadjusted	0.939±0.011	0.890±0.011	0.049± 0.016	0.018 to 0.080	0.002
Age adjusted	0.943±0.011	0.885±0.011	0.058± 0.016	0.028 to 0.089	0.000
Age + BMI adjusted	0.921±0.011	0.907±0.011	0.014± 0.016	-0.017 to 0.046	0.379

^aObtained by analysis of covariavariance (ANCOVA)**Table 3** Multiple linear regression analysis with BMD as a dependent variable, and metabolic syndrome as independent variables^a

BMD sites	Predictor variable	β	t	p	R ²
Lumbar spine	BMI	0.011	2.737	0.007	0.166
Femoral neck	Duration of menopause	-0.005	-2.200	0.029	0.196
	BMI	0.007	2.454	0.015	
Total hip	Duration of menopause	-0.006	-0.227	0.015	0.261
	BMI	0.012	0.405	< 0.001	
	DM	0.053	0.183	0.027	

^aVariable inclusion with p < 0.05 and exclusion with p > 0.10 β Standardized regression coefficient, t corresponding t values, R² percentage variance explained by each variable

A significant regression equation of lumbar spine BMD was found ($F(8, 241) = 5.985$, $p < 0.001$) with an R^2 of 0.166, a constant of 1.084. BMI was a significant predictor of lumbar spine BMD ($\beta = 0.011$, $p = 0.007$). For femoral neck BMD, a significant regression equation was found ($F(10, 239) = 5.844$, $p < 0.001$) with an R^2 of 0.196, constant 0.870. The duration of menopause was a significant predictor of femoral neck BMD ($\beta = -0.005$, $p = 0.029$), as was BMI ($\beta = 0.007$, $p = 0.015$).

For total hip BMD, a significant regression equation was found ($F(9, 240) = 9.394$, $p < 0.001$) with an R^2 of 0.261, constant 0.818. The significant predictors of total hip BMD were the duration of menopause ($\beta = -0.006$, $p = 0.015$), type 2 DM ($\beta = 0.053$, $p = 0.027$), and BMI ($\beta = 0.012$, $p < 0.001$).

Discussion

Our study found that postmenopausal women with MS had higher BMD at the lumbar spine, femoral neck, and total hip compared to those without when adjusted for age. However, after adjustment for BMI, this association disappeared. Based on the ANCOVA results, it was found that both age and BMI had a significant impact on BMD in both the spine and hip. However, the analysis showed that BMI had a greater effect on BMD compared to age. These findings suggest that the difference in BMD between the two groups may not be directly influenced by the MS diagnosis but rather by BMI.

While some studies reported lower BMD^{11,12} or even no difference¹³ in women with MS compared with those without, other studies showed that women diagnosed with MS had higher BMD, which indicating a potential protective effect of MS on bone health.¹⁴⁻¹⁷

In Camargo Cohort Study conducted by Hernandaz et al.¹⁵, postmenopausal women with MS had greater BMD at all sites in comparison to those without MS. However, after adjusting for BMI, this difference was eliminated at the spine and femoral neck, but a marginal statistical significance was still observed at the total hip. They concluded that this association was mainly driven by higher body weight. von Muhlen et al.¹⁶ also reported that total hip BMD was higher in postmenopausal women with MS. However, after adjusting for BMI, the result was reversed. The association of MS with higher BMD was explained by their higher BMI. Moreover, the data from the National Health Information Database (NHID) of the Korea National Health Insurance Service (NHIS) reported that postmenopausal obese women with MS have a high prevalence of osteoporosis.²²

MS consists of multiple pathologies, specifically from a cardiovascular perspective. Due to the establishment of MS not primarily aimed at addressing bone health issues, the comparison of BMD between patients with and without MS is complicated, resulting in differences in study outcomes. Previously published meta-analyses on the association between MS and BMD included Xue et al.,²³ who found a positive impact of MS on spine BMD. Another study by Zhou et al.,²⁴ observed a negative effect of MS on BMD in men but not women, while the latest

meta-analysis in 2021 compared normal BMD to osteopenia and osteoporosis and found no proof of a link between MS and lowered BMD.²⁵ The discrepancies observed in the studies could be attributed to variations in population features, age, diagnostic criteria for metabolic syndrome, and statistical fluctuations. However, the heterogeneity of pathologies in particular MS patients should be considered, and an individualized approach should be taken.

The relationship between bone health and metabolic syndrome and its characteristics is not well understood. To examine any potential independent correlation between the components of MS or other associated factors with BMD, we conducted a multiple linear regression analysis and found that BMI was a significant positive predictor of BMD at all sites, while DM was a significant positive predictor of hip BMD. Meanwhile, the duration of menopause was significantly negatively correlated with BMD at FN and total hip.

The protective effect of BMI on BMD is due to various factors. Firstly, a higher BMI means higher fat mass. Adipose tissue is usually considered a major source of estrogen production after menopause, which helps preserve bone tissue after menopause. Estrone and estradiol production within visceral adipose tissue rises with adiposity. As a result, postmenopausal women may experience an increase in overall estrogen exposure due to an increase in visceral adiposity.²⁶ Zarrabeitia et al. reported a positive correlation between BMI and free estrogen levels in women. Moreover, in postmenopausal women, estrogen levels were shown to be correlated with BMD at the spine and femoral neck.²⁷ Secondly, the data from experimental studies showed that repeated mechanical loading can trigger bone formation.^{28,29} High BMI increases mechanical loading exerted on the skeleton and, as a result, increases bone anabolism and formation. Finally, greater body weight may indicate higher food intake, reducing the likelihood of suffering from poor nutrition, which is a possible cause of osteoporosis. We classified BMI into underweight, normal weight, and overweight categories, but found no significant differences, possibly due to inadequate sample size for subgroup analysis.

The association between type 2 DM and bone health is complex. Meta-analyses showed that BMD was significantly higher in diabetics compared with non-diabetics. There are several mechanisms through which diabetes may have an impact on bone health. BMI seemed to be one of the main determinants for BMD.^{30,31} Body fat and hyperinsulinemia could increase femoral neck BMD in diabetic subjects. It is possible that hyperinsulinemia may promote bone formation.³² Most women with type 2 DM in our study had high BMI, so the influence of DM on BMD in our study may be promoted by the high BMI. However, the progression of type 2 DM may cause reductions in BMD by an accumulation of advanced glycation end products (AGEs), which leads to the consequences of reactive oxygen species and microvascular complications.¹⁸ Despite having a higher body weight and higher BMD, patients diagnosed with type 2 DM are at a greater risk of both hip and non-vertebral fracture.³³ The exact mechanisms by which type 2 DM increases skeletal fragility are still unclear, but it is believed that a combination of factors such as an increased risk of falling, regional osteopenia, and compromised bone quality are involved in contributing to the elevated fracture risk. Moreover, the use of anti-diabetic medications may affect the risk of fractures. Thiazolidinediones, especially in older women, increase the risk of bone loss and fractures. On the other hand, metformin and sulfonylureas may have a negative impact on bone health or even have a protective effect against fragility fractures.³⁴

Other components of MS can have an impact on BMD. One such factor is hypertriglyceridemia, which can cause bone loss through an inflammatory-related mechanism. Conversely, lipid-lowering medications, particularly statins, improved BMD. It is crucial that patients adhere to their treatment schedules and lifestyle modifications.³⁵

We suggest that BMD measurement in postmenopausal women with MS who have high BMI should be performed regarding other risk factors for osteoporosis, based on general osteoporosis guidelines. While BMD measurement should be considered in postmenopausal women with MS and low BMI since the negative influence of diabetes or inflammation on bone mass may be dominant in this group.

Our study examined the association between MS and BMD in postmenopausal Thai women. We were interested in studying a postmenopausal population since estrogen plays an important role in bone remodeling. Thus, the effect of metabolic syndrome on BMD may be unique in this group.

The limitation of this study is this was a cross-sectional study, limiting our ability to determine the cause and effect of MS concerning BMD. Enrolling participants using convenience sampling may lead to selection bias, as the sample may not represent the broader population. Moreover, we only looked at BMD and did not evaluate the fracture risk, which requires a longitudinal study. In addition, covariates including alcohol intake, cigarette smoking, calcium and vitamin D intake, exercise, and hormonal contraception, were classified as dichotomous data. Dose-response effects cannot be assessed.

Conclusion

Overall, postmenopausal women with MS had higher BMD when compared to those without MS in age-adjusted analysis. However, after adjusting for BMI, there was no difference in BMD between both groups, so the effect on BMD may be influenced by BMI. From the results of our study, BMI was the most significant positive predictor for BMD at all sites, especially for the hip. DM was also a significant positive predictor for hip BMD, but the effect may be partly attributable to the increase in BMI. These findings supported that BMI is the most significant factor affecting bone density in postmenopausal women.

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Conflicts of interest All authors have no conflict of interest.

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