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Relationship between the Components of the Metabolic Syndrome and Measures of Bone Mineral Density in Post-Menopausal Women

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Abstract

***Aim*: To examine the association between individual components of metabolic syndrome (MetS) and bone mineral density (BMD) among postmenopausal women. *Methods*: A total of 177 postmenopausal women participated in a cross-sectional study. They were interviewed to collect anthropometric and demographic characteristics. BMD was measured and biochemical parameters were estimated in fasting blood samples. Univariate and multivariate analyses were used to examine the association between individual components of MetS and BMD. *Results*: Among 177 postmenopausal women, 116 (66%) had MetS. Women with MetS had significantly higher mean values of BMD and T scores at the total hip ($P < 0.05$) compared to women without MetS, which disappeared after adjustment for body weight, but not for age ($P < 0.05$). Features of the MetS other than waist circumference were not significantly related to BMD values at the three skeletal sites, except for diastolic blood pressure association with BMD at the femoral neck ($r = 0.150$, $P < 0.05$). BMD at the total hip was also positively associated with both of triglycerides ($r = 0.157$, $P < 0.05$) and fasting blood glucose ($r = 0.193$, $P < 0.01$). To identify the independent factors affecting the BMD at the 3 skeletal sites according to metabolic states, stepwise multiple linear regression analysis was performed. *Conclusions*: Body weight and osteocalcin were more strongly associated with bone mass than any other component of MetS in postmenopausal women. However, further studies seem to be needed to confirm their observation.**

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Keywords

Bone Mineral Density, Metabolic Syndrome, Osteocalcin, Postmenopausal Women

1. Introduction

Metabolic syndrome (MetS) is defined by a cluster of cardiovascular risk factors that are also associated with an increased risk of diabetes mellitus [1]. The association between these risk factors and the presence of osteoporosis has been reported previously, but the results of these studies are inconsistent [2]-[4].

Whilst overweight and obesity appear to protect against excessive bone loss in aging [5], osteopenia and osteoporosis are associated with central adiposity [6]. Hyperglycemia is a predictor of bone loss and osteoporotic fractures, but the association between high blood glucose levels or insulin resistance with bone mineral density (BMD) is inconclusive [7]. Circulating insulin concentrations were reported to be the principal determinant of BMD at femoral neck and lumbar spine [8]. Reports of associations between high triglycerides or low HDL levels with BMD are inconsistent [3]. There have also been inconsistent reports on the relationship between hypertension and BMD [3].

It has been suggested that low-grade inflammation is a common pathogenic mechanism in patients with insulin resistance [9] and/or increased risk of fracture [10].

Little is known about the factors that may give rise to the potential relationship between MetS and osteoporosis, and it is unclear whether patients with the MetS have increased or decreased fracture risks. The aim of this study was to examine the association between the individual components of the MetS and BMD among community dwelling ambulatory postmenopausal women.

2. Methodology

A total of 177 postmenopausal women aged between 48 to 88 years participated in a cross-sectional study. The subjects were recruited from King Abdulaziz University Hospital (KAUH) during visits for education purposes, or routine checkups, or for evaluation of cardiovascular risk factors. The study was approved by the ethical review board of KAUH. All subjects agreed to participate in the study and gave informed consent.

Postmenopausal status was defined as cessation of menstruation for at least 1 year. Exclusion criteria include subjects with liver or renal diseases, inflammatory diseases, vascular disease (*i.e.*, peripheral vascular disease, cerebro-vascular disease), established osteoporosis, or with evident endocrine disorders, or on any form of drug treatment with possible effect on bone metabolism like bisphosphonate, or estrogen replacement therapy, oral contraceptives, statins, aspirin, antioxidants, vitamin D or calcium supplementations.

All subjects underwent a structured medical interview and a thorough medical examination. Medical records were consulted to fulfill inclusion and exclusion criteria. Each subject was interviewed to complete a standardized questionnaire to determine their demographic characteristics, smoking habits, physical exercise, exposure to sunlight, medication use and history of previous medical or surgical diseases.

Height and weight were measured in participants wearing light clothing and no shoes (Detecto, Webb city, Mo. USA). Body mass index (BMI) was calculated as body weight (in kilograms) divided by height (in meters squared). Using a tape measure, waist circumference (WC) (midway between the lower rib margin and the iliac crest) and hip circumference (HC) (the maximal circumference over the buttocks) were measured to the nearest 0.1 cm. The WC has been used as an index of central obesity and race specific cutoffs values for WC are suggested separately for males and females [11]. Waist-hip ratio (WHR), calculated as waist circumference divided by hip circumference, was used as an indicator of abdominal visceral fat [12].

Blood pressure was measured in millimeters of mercury (mmHg) and was taken as the average of 2 consecutive measurements after at least 5 minutes of sitting (BPTRU Medical Devices, unit 1, 1850 Hartley avenue, Canada).

BMD was measured in g/cm^2 by dual-energy X-ray absorptiometry (DXA) using a Lunar DPX-IQ (Lunar, Madison, WI, USA) according to the standard protocol for the anterior-posterior lumbar spine (L1-L4), mean of right and left femur neck, and total hip, and calibrated daily using a standard phantom provided by the manufacturer. BMD measurements were compared as T scores expressed in standard deviations (SD) using the peak

bone mass from the manufacturer's reference population. Z score indicates deviation from the normal age- and sex-matched mean in SD. Osteoporosis was defined in accordance with the WHO [13], as BMD at any site greater than 2.5 SD below the young adult mean, and osteopenia as BMD 1 to 2.5 SD below the young adult mean. In addition to densitometry, information regarding the metabolic status of bone was obtained by measurement of serum levels of osteocalcin (OC), calcium, phosphate, intact parathyroid hormone, bone-specific alkaline phosphatase.

Blood samples were obtained after a 12-hour fast. Lipid profile and fasting blood glucose levels were determined using standard enzymatic colorimetric assays (Ortho-Clinical Diagnostics—Johnson & Johnson Co., USA). Low-density-lipoprotein (LDL) cholesterol was estimated using the Friedewald formula [14]. Serum calcium and phosphate levels were measured by standard laboratory methods.

Fasting plasma insulin was determined by a sandwich chemiluminescence immunoassay method and the test was performed on the Liaison analyzer (DiaSorin Inc, Stillwater, MN, USA). Osteocalcin was measured with a commercially available ELISA kit provided by Nordic Bioscience Diagnostics A/S (Denmark) using a COBAS-e-411-Hitachi immunoassay autoanalyzer (Roche Diagnostics, GmbH, D-68298, Mannheim, Germany).

Participants were classified as having the metabolic syndrome, according to the American Heart Association/National Heart, Lung and Blood Institute (AHA/NHLBI) report, by the presence of abdominal obesity (waist circumference greater than 88 cm in women) with at least two of the following: triglycerides of 150 mg/dl (1.7 mmol/L) or greater, HDL cholesterol levels less than 50 mg/dl (1.29 mmol/L) in women, fasting glucose of 110 mg/dl (6.1 mmol/L) or greater, or blood pressure of 130/85 mmHg or greater [15].

Data were expressed as mean ± SD. An unpaired t-test was used to compare continuous variables between two groups. Comparisons of categorical variables were made using chi-square test. An evaluation of normality was performed with Kolmogorov-Smirnov test, and logarithmic transformations were performed for serum osteocalcin concentrations due to a positively skewed distribution.

Univariate and multivariate analysis were used to examine the association between individual components of the MetS and BMD. A stepwise multiple linear regression analysis was used to estimate which component of MetS has a dominant effect on BMD at the lumbar spine, femoral neck and total hip in the study population.

All statistical tests were two-tailed, and statistical significance was defined as $p<0.05$. Statistical analyses were performed using SPSS Version 12.0 (SPSS Inc, Chicago, IL, USA).

3. Results

Among 177 postmenopausal women, 116 (66%) had MetS. **Figure 1** shows the number of MetS components among the study subjects. The baseline characteristics of the study subjects are presented in **Table 1**. The mean value of body weight, BMI, HC, WHR ($P < 0.0001$ in all of them), WC, and SBP ($P < 0.01$ for both) were significantly higher in women with MetS than in women without MetS. Physical inactivity was more prevalent among women with MetS than those without MetS (66% vs. 48%; $P < 0.05$) whereas more women without MetS were exercising ≥ 3 times per week than their counterparts with MetS (38% vs. 22%, $P < 0.05$).

The differences in biochemical parameters between both groups were compared in **Table 2**. Serum TG, FBG, and insulin were significantly higher among women with MetS compared with their control counterparts ($P < 0.0001$). Women without MetS had significantly higher mean levels of HDL-C ($P < 0.0001$) and osteocalcin ($P < 0.001$) than did their counterparts with MetS. Furthermore, BMD at any site was inversely correlated with serum osteocalcin levels among postmenopausal women with MetS (**Figures 2(a)-(c)**).

The results for BMD are presented in **Table 3**. Based on T-scores of lumbar spine, femoral neck, and total hip subjects were classified into three groups: the normal BMD group (T-score ≥ −1), the osteopenic group (T-score between −1 and −2.5), and the osteoporotic group (T-score < −2.5). When considering BMD values of the total hip, 34% of women with MetS and 41% of their control counterparts were found to be in the osteopenia group, 3% and 12% of women with MetS and without MetS respectively were found to be in the osteoporosis group ($P < 0.05$). In addition, compared with women without MetS, women with MetS had significantly higher mean values of BMD and T scores at the total hip ($P < 0$ 0.05), which disappeared after adjustment for body weight, but not for age ($P < 0.05$), in the study population.

The relationship between BMD and features of the MetS in postmenopausal women are shown in **Table 4**. Features of the MetS other than WC were not significantly related to BMD values at the three skeletal sites,

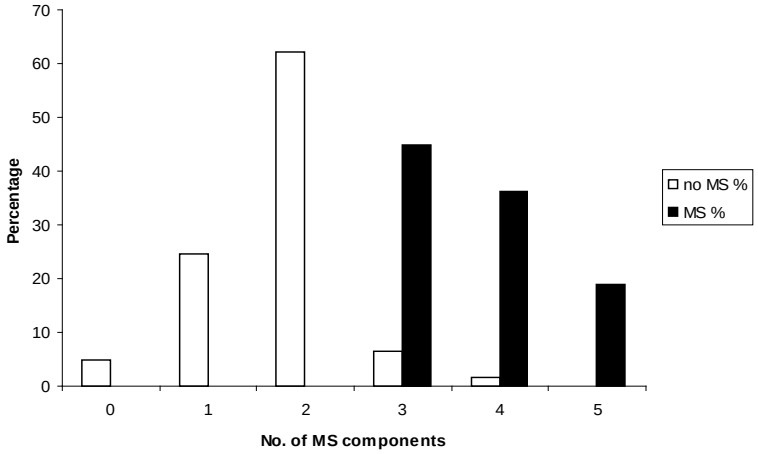

Figure 1. Proportion (%) of the study subjects according to the number of components of metabolic syndrome.

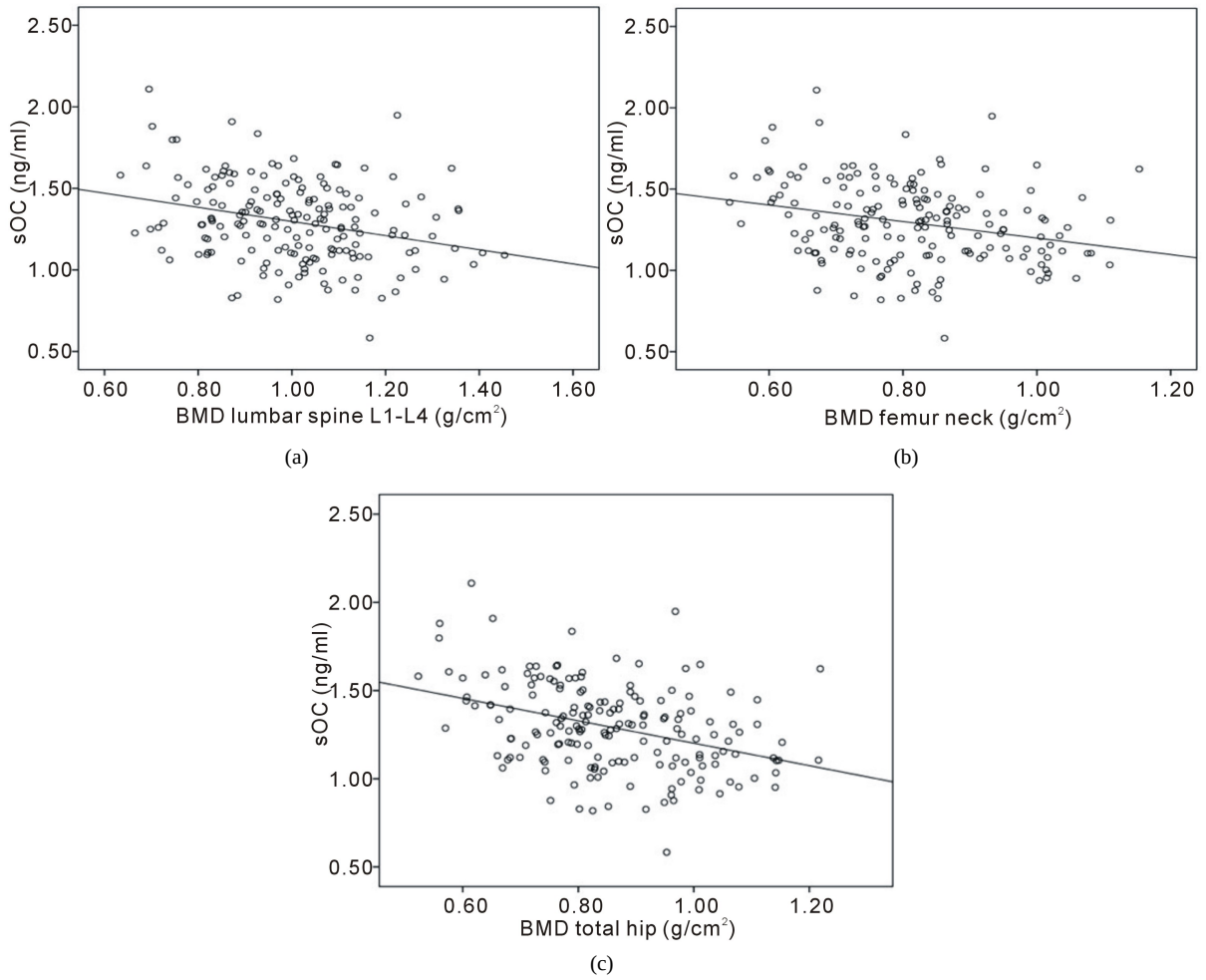

Figure 2. (a) Scatter plot demonstrating correlation between serum osteocalsin after logarithmic transformations and BMD at the lumbar spine L1-L4 in 177 postmenopausal women ($r = -0.276$, $P < 0.0001$). (b) Scatter plot demonstrating correlation between serum osteocalsin after logarithmic transformations and BMD at the femur neck in 177 postmenopausal women ($r = -0.255$, $P < 0.001$). (c) Scatter plot demonstrating correlation between serum osteocalsin after logarithmic transformations and BMD at the total hip in 177 postmenopausal women ($r = -0.352$, $P < 0.0001$).

Table 1. Baseline characteristics according to the presence or absence of metabolic syndrome in 177 postmenopausal women.

	Postmenopausal women without MetS (n = 61)	Postmenopausal women with MetS (n = 166)	P
Age (years)	63.8 ± 8.47	62.78 ± 8.13	NS
Age at menopausal (years)	50.67 ± 6.01	50.85 ± 5.01	NS
Body weight (Kg)	70.51 ± 16.11	78.30 ± 14.29	<0.0001
Body height (cm)	151.26 ± 7.4	152.92 ± 6.07	NS
BMI (Kg/m^2)	30.7 ± 5.9	33.43 ± 5.49	<0.0001
BMI classes			
Normal (18.5 Kg/m^2 - 24.99 Kg/m^2)	5 (8)	2 (2)	
Overweight (25 Kg/m^2 - 29.99 Kg/m^2)	28 (46)	351 (30)	<0.01
Obese (≥30 Kg/m^2)	28 (46)	79 (68)	
WC (cm)	93.27 ± 11.3	103.7 ± 12.8	<0.0001
HC (cm)	103.7 ± 10.8	109 ± 13.7	<0.01
WHR	0.90 ± 0.07	0.96 ± 0.13	<0.0001
SBP (mmHg)	134.08 ± 22.6	145.28 ± 21.9	<0.01
DBP (mmHg)	76.25 ± 12.5	77.53 ± 12.2	NS
Marital status			
Married	31 (51)	61 (53)	
Widowed	25 (41)	52 (45)	NS
Divorced	5 (8)	2 (2)	
Education level			
Illiterate	31 (51)	75 (65)	
Intermediate	21 (34)	24 (21)	NS
High school	4 (7)	12 (10)	
University	5 (8)	5 (4)	
Occupation			
House wife	57 (94)	114 (98)	
Administrative	3 (5)	1 (1)	NS
Director/physician	1 (2)	1 (1)	
Type of residency			
Traditional housing	16 (26)	31 (27)	
Apartment	42 (69)	73 (63)	NS
Villa	3 (5)	12 (10)	
Exposure to sunlight			
<1 time	45 (74)	90 (78)	
1 - 2 times	13 (21)	16 (14)	NS
>3 times	3 (5)	10 (9)	
Veil type			
Covering hair only	17 (28)	38 (33)	
Eyes shown only	43 (71)	77 (66)	NS
Full cover	1 (2)	1 (1)	
Physical activity			
<1 time	29 (48)	77 (66)	
1 - 2 times	8 (13)	14 (12)	<0.05
>3 times	23 (38)	25 (22)	
Smoking status			
Non-smoker	57 (93)	110 (94)	
Former smoker	1 (2)	3 (3)	NS
Current smoker	3 (5)	3 (3)	

Data are given as the mean ± SD or as the number of subjects with percentages given in parentheses, as appropriate. Categorical data are compared by χ^2 test, continuous variables are compared by unpaired t-test. BMI: body mass index, DBP: diastolic blood pressure, HC: hip circumference, NS: not significant, SBP: systolic blood pressure, WC: waist circumference, WHR: waist-to-hip ratio.

Table 2. Biochemical parameters according to the presence or absence of metabolic syndrome in 177 postmenopausal women.

	Postmenopausal women without MetS (n = 61)	Postmenopausal women with MetS (n = 166)	P
TC (mmol/L)	4.63 ± 0.99	4.66 ± 0.97	NS
TG (mmol/L)	1.30 ± 0.57	2.21 ± 1.08	<0.0001
HDL-C (mmol/L)	1.47 ± 0.30	1.22 ± 0.29	<0.0001
LDL-C (mmol/L)	2.55 ± 0.89	2.46 ± 0.87	NS
AI= (TC/HDL-C)	3.24 ± 0.85	3.99± 1.11	NS
FBG (mmol/L)	6.00 ± 0.93	8.66 ± 0.54	<0.0001
Serum insulin (μU/ml)	12.15 ± 9.38	17.68 ± 18.15	<0.01
Serum albumin (g/L)	40.70 ± 2.95	40.17 ± 3.60	NS
Serum calcium (mmol/L)	2.36 ± 0.15	2.36 ± 0.13	NS
Serum phosphate (mmol/L)	1.34 ± 0.18	1.34 ± 0.18	NS
Serum intact PTH (pmol/L)	6.40 ± 3.12	6.45 ± 3.41	NS
Serum bone specific-ALP (U/L)	95.23 ± 2.92	102.39 ± 3.4	NS
Serum osteocalcin (ng/ml)	26.79 ± 13.58	21.67 ± 16.98	<0.001

Data are given as the mean ± SD. Continuous variables are compared by unpaired t- test. AI: atherogenic index, Bone-specific ALP: bone specific alkaline phosphatase, FBG: fasting blood glucose, HDL-C: high density lipoprotein-cholesterol, Intact PTH: intact parathyroid Hormone, LDL-C: low density lipoprotein-cholesterol, NS: not significant, TC: total cholesterol, TG: triglycerides.

Table 3. Bone Mineral Density according to the presence or absence of metabolic syndrome in 177 postmenopausal women.

	Postmenopausal women without MetS (n = 61)	Postmenopausal women with MetS (n = 166)	P
BMD Lumbar spine L_1-L_4(g/cm^2)	0.97 ± 0.16	1.02 ± 0.16	NS
Age-adjusted	0.81 ± 0.96	1.11 ± 1.00	NS
Weight-adjusted	1.005 ± 0.99	1.01 ± 1.00	NS
Lumbar spine L_1-L_4 T-score	−1.11 ± 1.41	−0.69 ± 1.4	NS
Normal	30 (49)	69 (60)	
Osteopenia	22 (36)	39 (34)	NS
Osteoporosis	9 (15)	8 (7)	
BMD Femur neck (g/cm^2)	0.80 ± 0.13	0.82 ± 0.13	NS
Age-adjusted	0.69 ± 0.92	0.88 ± 1.03	NS
Weight-adjusted	0.82 ± 0.99	0.82 ± 1.00	NS
Femur neck T-score	−1.12 ± 1.12	−0.88 ± 1.07	NS
Normal	30 (49)	62 (53)	
Osteopenia	22 (36)	47 (41)	NS
Osteoporosis	8 (13)	6 (5)	
BMD Total hip (g/cm^2)	0.82 ± 0.15	0.87 ± 0.14	<0.05
Age-adjusted	0.61 ± 0.89	0.96 ± 1.03	<0.05
Weight-adjusted	0.84 ± 0.99	0.84 ± 1.00	NS
Total hip T-score	−0.99 ± 1.22	−0.55 ± 1.19	<0.05
Normal	28 (46)	72 (62)	
Osteopenia	25 (41)	39 (34)	<0.05
Osteoporosis	7 (12)	4 (3)	

Data are given as the mean ± SD or as the number of subjects with percentages given in parentheses, as appropriate. Categorical data are compared by χ^2 test, continuous variables are compared by unpaired t-test. BMD: bone mineral density. WHO criteria: a T-score between −1 and −2.5 is indicative of osteopenia, while a T-score of −2.5 and below reflects osteoporosis; a T-score of −1 and above is considered normal.

Table 4. Correlation between Bone Mineral Density and features of the metabolic syndrome in 177 postmenopausal women.

	Lumbar spine		Femur neck		Total hip	
	r	**P**	**r**	**P**	**r**	**P**
WC	**0.271**	**<0.0001**	**0.163**	**<0.05**	**0.222**	**<0.01**
TG	0.109	0.149	0.104	0.171	**0.157**	**<0.05**
HDL-C	−0.048	0.525	−0.073	0.337	−0.097	0.200
FBG	0.084	0.264	0.103	0.176	**0.193**	**<0.01**
SBP	0.118	0.117	−0.032	0.678	−0.009	0.903
DBP	0.062	0.413	**0.150**	**<0.05**	0.094	0.216

Significant correlations are shown in bold font. DBP: diastolic blood pressure, FBG: fasting blood glucose, HDL-C: High-density lipoprotein cholesterol, SBP: systolic blood pressure, TG: triglycerides, WC: waist circumference.

Table 5. Stepwise multiple linear regression analysis of factors independently associated with BMD including metabolic syndrome components as independent variables in 177 postmenopausal women.

	Predictor variable	ß	P	95% CI for ß	
Lumbar spine	Age	−0.165	0.012	−0.006	−0.001
Total R^2 = 33.8%	Body weight	0.295	<0.0001	0.002	0.005
	Serum TC	0.130	0.049	0.000	0.044
	Serum calcium	−0.210	0.001	−0.408	−0.102
	Serum osteocalcin	−0.220	0.001	−0.004	−0.001
	Residency type	0.216	0.001	0.027	0.099
	Frequency of sunlight exposure	−0.161	0.014	−0.079	−0.009
Femur neck	Age	−0.269	<0.0001	−0.006	−0.002
Total R^2 = 39.8%	Body weight	0.341	<0.0001	0.002	0.004
	WHR	−0.157	0.011	−0.315	−0.041
	Serum osteocalsin	−0.212	0.001	−0.003	−0.001
	Residency type	0.193	0.002	0.017	0.073
	Veil type	0.131	0.036	0.002	0.069
Total hip	Age	−0.314	<0.0001	−0.008	−0.004
Total R^2 = 46.7%	Body weight	0.354	<0.0001	0.002	0.005
	Serum osteocalsin	−0.286	<0.0001	−0.004	−0.002
	Residency type	0.174	0.022	0.016	0.074
	Veil type	0.150	0.011	0.011	0.080

ß = standardized regression coefficient, R^2 = percent variance explained by each variable. Stepwise variable inclusion with $P < 0.05$ and exclusion with $P > 0.10$. 95% CI: confidence intervals. TC: total cholesterol, WHR: waist hip ratio.

except for DBP association with BMD at the femoral neck ($r = 0.150$, $P < 0.05$). BMD at the total hip was also positively associated with both of TG ($r = 0.157$, $P < 0.05$) and FBG ($r = 0.193$, $P < 0.01$).

To identify the independent factors affecting the BMD at the 3 skeletal sites according to metabolic states, stepwise multiple linear regression analysis was performed (**Table 5**). In these models, the predictive factors for the BMD of the lumbar spine were age, body weight, serum levels of TC, calcium, osteocalcin, type of residency, and times of sunlight exposure. Predictive determinants for the BMD of the femoral neck were age, body weight, WHR, serum osteocalcin, type of residency, and veil types. Finally, significant predictive factors for the BMD of the lumbar spine were age, body weight, serum osteocalcin, type of residency, and veil types.

4. Discussion

The results from previous studies evaluating the relationship between MetS and bone metabolism in the ageing populations are inconsistent [16]-[18].

It was expected that different components of MetS in individual patients may contribute to these inconsistent results regarding the relationship between MetS and bone status. In this cross-sectional study, we aimed to examine

the association between MetS components and BMD among community dwelling ambulatory postmenopausal women.

The prevalence of MetS who met the AHA/NHLBI criteria was higher than reported by other studies [19]. The values obtained for BMD in our study are comparable with those reported in other local studies among similar study populations [20]-[23].

In our population of postmenopausal women, women with MetS were significantly less likely to have low BMD than were women without MetS independent of age and body weight. We also found a lower prevalence of osteopenia and osteoporosis in participants with MetS compared with their control counterparts, and this remained after adjustments for body weight but not when adjusted for age. Other studies have also reported the protective effect of MetS on BMD [17].

Obesity is known to be a protective factor against excessive bone loss in aging [24]. Visceral fat accumulation is one of the main features of MetS which is often coincident with obesity [11] Of all the features of MetS investigated, BMD measures were significantly associated with WC in our study population. BMI is recognized as one of the strongest predictors for BMD [25], but the evidence regarding the association between central adiposity and BMD is still inconsistent [18]. Taken together, our findings, as well as findings from other studies, suggest that MetS has the potential to increase BMD and reduce the risk of fractures, and thus may not be detrimental to bone health.

Other features of MetS were also correlated with BMD at individual sites; namely TG and FBG with BMD at total hip and DBP with BMD of femur neck. The reason for this may be that a reduction in BMD of the femoral neck occurs at a slower rate than that of the lumbar spine at early menopause [26]. This may be attributed to the protective effect of estrogen on bone. In addition, the onset of estrogen deficiency in women is associated with rapid bone loss, particularly in trabecular bone as in the vertebrae [27]. Cortical bone, as in the long bones, also decreases due to estrogen deficiency, but at a slow rate.

Similar to our data, BMD was not associated with arterial pressure in women [28]. On the other hand, other studies have indicated similar relationships between bone mass and diastolic blood pressure measures among postmenopausal females [29]. The exact reason for this is unclear but it seems that hypertension is related to bone mass due to the changes of serum intact PTH concentration or urinary calcium excretion. TG levels appear to also correlate positively with hip BMD in previous studies [30]. Higher TG level was associated with lower risk of spine and non-spine fractures in some, but not all, studies [3] [31]. Thus its mechanism is not clear. Similar to previous data bone formation was lower in hyperglycemic subjects [32].

To identify which components of MetS were independent factors affecting BMD at the three skeletal sites, stepwise multiple linear regression analysis was performed. However, after multivariate adjustment, these correlations became insignificant and alternatively body weight became significant predictor of BMD at all skeletal sites. Moreover, body weight had similar effects on BMD at the three skeletal sites. Additionally, WHR has also shown to be a significant predictor for BMD at femur neck. Cumulating evidence shows that obesity is beneficial for bone health, with increasing BMD and decreasing fracture rates [24]. The incremental effect of body weight on BMD may be partly explained by other predictor variables like, residency type, frequency of sunlight exposure and veil type in the present study.

It has been argued that the discordant results of the studies analyzing the association between MetS components and bone mass may reflect the heterogeneous character of MetS and partly depend on the different rates of prevalence of individual components of MetS in various cohorts [11].

Serum osteocalcin is known to be a marker of bone metabolism and low levels of this protein promote low osteoblast cell activity [33]. Our findings suggest that osteocalcin might exert a detrimental effect on bone health through a mechanism related to BMD reduction. There seems to be a complex relationship between bone turnover and bone mass, such that high bone turnover is associated with decreased bone mass [34]. Thus it has been suggested that bone markers can predict fractures in elderly women and that the use of a combination of BMD and bone markers can improve fracture prediction [35].

There are several limitations to this study. Like other studies with cross-sectional design, it is also difficult to determine the cause and effect of MetS with respect to BMD. Also, the subjects were recruited from a single center; therefore, the sample does not represent the general female population. Moreover, ethnic differences in fat distribution have not been investigated in our study population as a major contributor to the observed high prevalence of MetS [15].

5. Conclusion

In conclusion, we found that body weight and osteocalcin were more strongly associated with bone mass than any other components of MetS in postmenopausal women. Thus the concept of MetS might not be meaningful in the context of bone metabolism and that the analysis of bone-related variables according to the global criterion MetS may obscure pathophysiologic links of BMD with its individual components. However, further studies seem to be needed to confirm their observation.

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Disclosure Statement

The authors have nothing to disclose.

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