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Bone Mineral Density Contributors, Body Mass Index and Calcium Intake in Postmenopausal Women

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Obesity is one of today's controversial public health problems. While obesity increases the risk of morbidity due to diseases such as diabetes and hypertension, a high Body Mass Index (BMI) is protective against bone loss. On the other hand, calcium individually is an important mineral that makes the bone structure firm. This cross-sectional study was conducted to assess the association between BMI and dietary calcium intake with Bone Mineral Density (BMD) among 299 postmenopausal women aged 50-65 years old. This study obtained information on demographic factors, energy and nutrient intake using pre-tested interviewer administrative questionnaire. Respondents were measured for weight, height and bone mineral density. Participants were categorized based on BM into normal (N), overweight (Ow) and obese (Ob). ANOVA and multiple logistic regression models were created to examine the associations between dependent and independent variables. The relationship between variables was tested with pearson's correlation test. Of postmenopausal women, 26.6% were in N group and 73.4% were in Ow/Ob groups. Of the respondents, 67.2% had normal BMD and 32.8% had osteopenia/osteoporosis. Calcium intake higher than Dietary Reference Intakes (DRI) was a significant protective factor against osteopenia/osteoporosis (spine, 95% CI: 0.003-0.198) (femoral neck, 95% CI: 0.011- 0.289). There was no significant BMD difference between three BMI groups (p>0.05) and the relationship between calcium intake and BMI (normal, overweight and obese) was not statistically significant (p>0.05). It was concluded that in postmenopausal women, lower calcium dietary intake increases osteoporosis. Moreover, in the cases of adequate calcium intake, higher BMI may not affect BMD.

Key words: Postmenopausal woman, osteoporosis, bone mineral density, body mass index, dual energy X-ray absorptiometry

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INTRODUCTION

Osteoporosis has become a global public health concern due to the increasing population of the elderly (Aghaei Meybodi *et al*., 2008). As life expectancy increases, the risk of osteoporosis increases among postmenopausal women, who spend about half of their lifetime after menopause (Keramat *et al*., 2008; Nordin, 2009). Despite the increasing prevalence of osteoporosis, insufficient data exists on the bone health status of postmenopausal women in developing countries. Risk of osteoporosis in Lebanon, Turkey and Iran was reported to be 31, 33.3 and 37.4%, respectively (Maalouf *et al*., 2007; Tuzun *et al*., 2012). In Iran, about 8000 osteoporotic hip fractures were reported annually (Maalouf *et al*., 2007). In addition, in 2003, the mortality rate due to osteoporotic hip fracture was 8% in Iranian elderlies (over 65 years old) (Larijani *et al*., 2007).

Overweight and obesity which are defined as excess body weight and body fat, have recently become global health problems. While obesity was previously considered as the problem of rich populations, it has now become more prevalent in low and middle income populations (WHO, 2011). For example, the prevalence of obesity was reported to be higher in Middle East, Eastern Europe and North America compared to other countries (Willig *et al*., 2003; WHO/IASO/IOTF, 2000). Prevalence of overweight and obesity in Iranian older adult women was reported to be 36 and 31.1%, respectively (James *et al*., 2001). Obesity was shown to have a high correlation with the incidence of morbidity and mortality (Bahat *et al*., 2012). Moreover, obesity is associated with chronic diseases, depression and subsequently poorer health outcomes (WHO, 2011). It is hypothesized that high BMI has a protective effect against osteoporosis. This hypothesis was proposed based on the findings of studies that showed that body weight contributes to higher bone mineral density (BMD) (Willig *et al*., 2003; WHO/IASO/IOTF, 2000), moreover, a slower rate of bone loss was reported in overweight postmenopausal women compared to normal weight women (James *et al*., 2001; Andreyeva *et al*., 2007; De Laet *et al*., 2005; Cummings *et al*., 1995).

Low weight and low BMI are well known risk factors for bone loss and fractures (Farrell, 2008; Tang *et al*., 2007). Weight loss of about 10% can decrease bone mass up to 2% (Compston *et al*., 1992; Hyldstrup *et al*., 1993). Low BMI (<21 kg m^{-2}) is associated with lower BMD and increased risk of fractures (WHO, 2006; Farrell *et al*., 2009). Quantifying the association between BMI and bone health status and its relationship with BMD enables physicians to provide postmenopausal women with proper advice on lifestyle improvement (De Laet *et al*., 2005; Kanis *et al*., 1997).

Not only during adult life is the influence of calcium intake on BMD, one of the important factors contributing to osteoporosis but also in the late postmenopausal period (Feskanich *et al*., 2003; Heaney, 2006). Daily calcium requirement might increase with increasing age due to age related reduction in renal tubular and intestinal absorption of calcium (NAMS, 2006). Calcium deficiency can increase the risk of hip fracture (Bonjour *et al*., 2009). Low levels of calcium intake can decrease the serum level of calcium and trigger the secretion of the parathyroid hormone which in part results in bone resorption followed by reduced bone mass and osteoporosis (Foo *et al*., 2009; Al-Rahawi, 2008; Ho *et al*., 2004).

Moreover, calcium has a role as a messenger in cell signals and in regulating of parathyroid hormone (PTH) (Kamycheva *et al*., 2004). On the other hand, BMD has a positive and direct association with PTH (Foo *et al*., 2009). Several studies reported a negative association between intake of calcium and body weight (Zemel *et al*., 2004; Varenna *et al*., 2007; Lin *et al*., 2000). The aim of the present study was to determine the association between bone mineral density, BMI and calcium intake in postmenopausal women. Since many studies showed that BMI was a better predictor of osteoporosis compare to weight, BMI was selected to represent this association rather than weight (Johnell *et al*., 1995; Kanis *et al*., 1999; Janghorbani *et al*., 2007).

MATERIALS AND METHODS

This cross-sectional study was conducted in the National Iranian Oil Company (NIOC) Central Hospital in Tehran, Iran from 6 June, 2009 to 30 September, 2009. Subjects were recruited based on convenience sampling. Participants were women (aged 50-60 years) in postmenopausal period, with no menstruation during the last 5 years. Women with significant chronic or degenerative diseases, history of fracture and on Hormone Replacement Therapy (HRT) were excluded from this survey.

This study was approved by the Medical Research Ethical Committee, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia (UPM). Permission to conduct this study and hospital approval was also obtained from the Manager of the NIOC Central Hospital. The respondents' participation was voluntary and written informed consent was also obtained before beginning of the study.

MEASUREMENTS

Anthropometry: The body weight and height of the participants were measured twice using calibrated conventional Seca digital scale and Seca body meter, respectively. Weight of the participants was measured in light clothes and barefooted. The average of the values was used in the analysis. Weight and height were used to calculate body mass index:

$$\frac{\text{Body weight (kg)}}{\text{Height}^2\ (\text{m}^2)}$$

Participants were then categorized into underweight, Uw, (<18.50), normal, N, (18.50-24.99), overweight, Ow, (25.00-29.99), obese, Ob, (= 30.00) groups based on the international classification of WHO (1995).

Dietary intake: Dietary intakes of the participants were obtained using a pre-tested 24 h dietary recall method (Gibson and Ferguson, 1999). All women were interviewed twice and 24 h dietary recall was obtained for one weekday and one weekend. Possible use of oral dietary supplements were also taken into account in order to determine calcium intakes. The respondents were asked on the time, type and amount of foods and beverages consumed over the past 24 h. Food photo album and household measures with standard portion sizes such as cup, jars and pieces were utilized to improve the precision of the 24 h recall. The Nutritionist IV software (First Data Bank, USA) version 3.5.2 was used to analyze dietary intake data. This software contains energy and calcium content of foods according to USDA database.

Bone mineral densitometry: Bone densitometry was performed using Dual Energy X-ray Absorptiometry (DEXA) with a DPX-IQ scanner (Lunar Radiation Corp., Madison, Wisconsin, USA) at two sites: lumbar spine (L_2- L_4) and femoral neck (left and right sides). DEXA scan uses a constant potential X-ray source to achieve a congruent beam of stable dual-energy radiation. BMD was recorded as the average of left and right side for each spine and femoral neck and was expressed in g cm^{-2}. According to WHO (1994), T-score as a bone health status indicator can evaluate osteoporosis of the respondents. T-score was calculated using the manufacturer's reference values (white adult American population of 30 years old). T-Score was then categorized as Normal (= -1 SD), Osteopenia (-1 to -2.5 SD) and Osteoporosis (= -2.5 SD) according to WHO (1994).

Statistical analysis: Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 16.0.0 (IBM SPSS Chicago, Illinois). Mean and Standard Deviation (SD) was used to describe the data. As data were normally distributed one-way ANOVA was performed to compare means of variables between BMI categories. Pearson's Correlation was used to determine the association between two continuous variables. Multiple logistic regression analysis was performed to determine factors associated with risk of osteopenia/osteoporosis with BMI (Normal versus Overweight/Obese) and calcium intake (less/more than DRI) as factors and other continuous variables as covariates. The results of logistic regression were reported as Odds Ratio (ORs) with 95% Confidence Intervals (CI). The confidence interval was considered as 95% and p values less than 0.05 were considered statistically significant.

RESULTS

The study population consisted of 299 postmenopausal women. Participants' socio-demographic factors and dietary intake are shown in Table 1 and 2, respectively. Table 3 represents characteristics including anthropometry and bone mineral density. Mean (SD) for age of participants was 56.34 (±4.46) years. Most of the participants (96.3%) did not meet DRI for energy intake for their age; the majority of them (72.9%) failed to meet DRI for calcium (food and supplement). The mean (SD) for BMI was 27.33±4.01 kg m^{-2}; 52.9% of the participants were

Table 1: Socio -demographic factors of respondents

Factors	Mean±SD	Range
Age (years)	56.34±4.46	50-65
Education (years)	10.33±4.03	1-22
Monthly household income per capita (USD)	263.29±1.97	57.14±1000.00
Age at menopause (years)	48.56±3.60	42- 59
Duration of menopause (years)	7.77±2.74	5-21.7

1USD: Approx, 10,000.00 Rials

Table 2: Dietary intake of respondent

	n (%)	Mean±SD	DRI	DRI (%)
Energy (kcal)		1378.00±325.00	1978	69.6
<DRI	288 (96.3)			
= DRI	11 (3.7)			
Total Calcium (mg)		965.33±396.42	1200	80.4
<DRI	218 (72.9)			
= DRI	81 (27.1)			
Vitamin D (µg)		3.98±2.50	10	39.8
<DRI	299 (100)			
= DRI	0			

Dietary reference Intake (2002)

overweight and 20.5% were obese. Mean (SD) for BMD at lumbar spine (L_2-L_4) and femoral neck (average of left and right sides) were 1.08±0.14 and 0.97±0.08 g cm^{-2}, respectively. About two-thirds of participants had T-score>-1 (normal) in either spine (66.6%) or femoral neck (67.9%). The prevalence of osteoporosis in both sides was almost the same (p<0.05).

Table 4 describes the demographic factors, dietary intake and BMD of the participants amongst three BMI groups Normal (N), Overweight (Ow) and Obese (Ob). No significant difference was found in mean age, BMD of spine and intake of vitamin D between groups (p>0.05). Significant differences were shown in terms of age at menopause (F = 4.89, p<0.05) and duration of menopause (F = 8.07, p<0.01). In addition, mean years of education and household income per capita in the N group were significantly higher than Ob group (F = 14.84, p<0.01) and (F = 20.24, p<0.01), respectively. Moreover, a significantly higher energy intake was found in Ob group in comparison to N group (F = 10.30, p<0.01). Calcium intake was also significantly higher in Ob group compared to N group. Femoral neck BMD in N group was significantly higher than that in Ow and Ob groups (F = 3.76, p<0.05).

In addition, the Pearson's correlation (Table 5) shows that there was an inverse relationship between increasing age and BMD of lumbar spine (r = -0.180, p = 0.002). All variables were significantly correlated to BMD of lumbar spine and femoral neck (p<0.05) except of duration of menopause and weight of women. However, BMI was significantly correlated to BMD of femoral neck (r = -0.141, p = 0.015) it was not significant for lumbar spine.

As shown in Table 6, all variables were analyzed by multiple logistic regression model and the outcome variables were calcium intake (classified as less/more than DRI), lumbar spine BMD (classified as normal and osteopenia/osteoporosis) and femoral neck BMD (classified as normal and osteopenia/osteoporosis). Dietary calcium intake was found to have a significant protective effect (OR = 0.025, CI = 0.003-0.198) against osteopenia/osteoporosis in the lumbar spine. Postmenopausal women with calcium intake s higher than DRI had 97.5% less probability of having osteopenia/osteoporosis in lumbar spine. Concordantly, dietary calcium intake was a significant preventive factor (OR = 0.038, CI = 0.011-0.289) against osteopenia/osteoporosis producing 96.2% protection for postmenopausal women with calcium intake being higher than DRI.

Moreover, Table 6 indicates that postmenopausal in the Ow and Ob groups were less likely to have osteopenia/osteoporosis in lumbar spine and femoral neck. However, the relationships were not statistically significant (p>0.05). In addition, there was no statistically significant relationship between calcium intake and BMI groups (p>0.05).

Table 3: BMI and BMD of respondents

Parameters	n (%)	Mean±SD
Anthropometry		
Weight (kg)		68.44±10.75
Height (m)		1.58±0.050
BMI (kg m^{-2})[1]		27.33±4.010
Underweight	0.0	
Normal range	79 (26.6)	
Overweight	157 (52.9)	
Obese	61(20.5)	
Bone mineral density[2]		
Spine (L_2-L_4)		
BMD (g cm^{-2})		1.08±0.140
Normal	199 (66.6)	
Osteopenia	96 (32.1)	
Osteoporosis	4 (1.3)	
Femoral neck[3]		
BMD (g cm^{-2})		0.97±0.080
T-score		-0.70±0.760
Normal	203 (67.9)	
Osteopenia	92 (30.8)	

[1]WHO (1995)[2], T-score classification by WHO (1994), Normal: (>-1 SD and above), Osteopenia: (-1 to-2.5 SD) and Osteoporosis: (-2.5 SD and lower) and [3]Average of left and right sides of femur

Table 4: Comparison of factors between three BMI groups (N, Ow. and Ob)

Characteristic	Groups Normal (n = 79)	Overweight (n = 157) Mean±SD	Obesity (n = 61)	F	p-value
Age (years)	56.11±4.08	56.69±4.60	55.65±4.56	1.297	0.275
Age at menopause (years)	47.48±3.02	48.97±3.75	48.85±3.67	4.896	0.008
Duration of menopause (years)	8.63±3.28	7.71±2.52	6.79±2.19	8.076	0.000
Years of education	11.69±4.18	10.52±3.72	8.14±3.78	14.849	0.000
Monthly household income per capita (USD)	375.80±270.46	232.42±140.17	194.26±148.98	20.242	0.000
Calcium (food and supplements) (g)	1047.55±492.83	954.26±344.07	888.67±374.44	2.925	0.055
Energy (Kcal)	1245.91±333.22	1411.47±298.10	1467.41±331.48	10.307	0.000
Spine BMD (g cm^{-2})	1.10±0.16	1.08±0.13	1.06±0.14	1.200	0.303
Femoral neck[2] BMD (g cm^{-2})	0.97±0.10	0.96±0.07	0.95±0.09	3.762	0.061

USD: Approx. 10,000.00 Rials, BMD: Average of left and right sides of femur

Table 5: Relationship between variables and BMD of lumbar spine and femoral neck

Variables	BMD of lumbar spine r (p)	BMD of femoral neck r (p)
Age	-0.180 (0.002)*	-0.107 (0.064)
Education	0.171 (0.003)*	0.140 (0.016)*
Monthly household income per capita	0.139 (0.018)*	0.173 (0.003)*
Age at menopause	0.171 (0.003)*	0.140 (0.016)*
Duration of menopause	-0.068 (0.242)	-0.009 (0.881)
Energy	0.130 (0.025)*	0.164 (0.005)*
Calcium	0.825 (0.000)*	0.667 (0.000)*
Vitamin D	0.461 (0.000)*	0.232 (0.000)*
Weight (kg)	-0.029 (0.618)	-0.068 (0.240)
Height (m)	0.134 (0.021)*	0.163 (0.005)*
BMI	-0.086 (0.138)	-0.141 (0.015)*

*p<0.05

Table 6: Odds ratio (95% confidence interval) of factors related to risk of osteopenia/osteoporosis in lumbar spine and femoral neck

	Calcium intake			Spinal osteopenia/osteoporosis		
Factors	Crude OR	Adjusted OR	p-value	Crude OR	Adjusted OR	p-value
BMI						
N	Ref.	Ref.		Ref.	Ref.	
Ow	1.988 (0.924-4.276)	1.503 (0.722-3.99)	0.079	0.464 (0.310-1.343)	0.359 (0.052-1.474)	0.635
Ob	1.252 (0.615-2.546)	1.191 (0.362-1.83)	0.536	0.765 (0.407-1.439)	0.708 (0.185-1.710)	0.759
Calcium intake						
= DRI	-	-	-	Ref.	Ref.	
<DRI	-	-	-	0.032 (0.011-0.283)	0.025 (0.003-0.198)	0.000

	Femoral osteopenia/osteoporosis		
	Crude OR	Adjusted OR	p-value
BMI			
N	Ref.	Ref.	
Ow	0.700 (0.331-1.479)	0.689 (0.399-1.872)	0.689
Ob	0.807 (0.423-1.542)	0.767 (0.494-1.195)	0.800
Calcium intake			
= DRI	Ref.	Ref.	
<DRI	0.046 (0.031-0.391)	0.038 (0.011-0.289)	0.000

DISCUSSION

Data from 24 h dietary recall indicated that over a quarter of the respondents had higher calcium intakes than DRI. According to a study among Iranian postmenopausal women in rural and urban areas, only 20% of the women had an adequate intake of calcium (Maddah and Sharami, 2009). Bekheirnia *et al*. (2004) showing that calcium intake was lower than DRI (846.7±382.5 mg) due to lactose intolerance.

The results of the current study suggest that low dietary calcium intake had significantly negative effect on BMD at both sides (lumbar spine and femoral neck) among postmenopausal women. Calcium intake is vital for maintaining healthy bones and preventing osteoporosis and insufficient calcium intake leads to bone loss in aging. The previous literature indicated that calcium intake can make the bones denser and low calcium intake is associated with bone loss fractures (Nieves *et al*., 2010; Kolahi *et al*., 2011). This study also revealed that calcium intake is a protective factor against osteopenia/osteoporosis among postmenopausal women. Kolahi *et al*. (2011) found that calcium intake reduced bone loss due to reduction in bone resorption among post menopausal women.

The results of the current study stated that 73.4% of the postmenopausal women were overweight and obese. This finding was comparable with the study in Iran by Shabani *et al*. (2009) that reported the prevalence of 75.0% for overweight and obesity in older adult women. Body mass was identified as a predictor of BMD in previous studies among post menopausal women (Cadarette *et al*., 2001; Hawker *et al*., 2002). Body weight and bone loading can affect positively on BMD (Hejazi *et al*., 2009; Barrera *et al*., 2004; Tarquini *et al*., 1997). On the other hand, several studies have indicated that overweight postmenopausal women had less bone loss (El Hage *et al*., 2009; Papakitsou *et al*., 2004; Tremollieres *et al*., 1993). In this study, the chance of getting low bone density was also found to be reduced by 46% with increasing BMI at spine and by 9% at the femoral neck; however, the relationship was not statistically significant. This study also revealed that the prevalence of osteoporosis at either spine or femoral neck was lower in overweight women (48 and 21%, respectively). De Laet *et al.* (2005) showed that low BMI increased the risk of fractures in women especially hip fractures. Similar study by Fawzy *et al.* (2011) and Baheiraei *et al.* (2005) reported that women with lower BMI had lower BMD.

Several recent observations claimed that dietary calcium intake has a role in controlling adiposity and body weight. Furthermore, some studies indicated that there is an inverse relation between BMI and calcium intake (Zemel *et al.*, 2004; Lin *et al.*, 2000). Moreover, this study showed a negative and significant association between BMI and calcium intake among postmenopausal women. Heaney (2006) declared a negative relation between calcium intake and body fat and weight in older women. This study revealed that participants in the Ow and Ob groups had higher BMD. This finding was in line with the current literature that increased BMI has a positive effect on BMD (Hejazi *et al.*, 2009; Ho *et al.*, 2008; Lei *et al.*, 2004; Barrera *et al.*, 2004). The logistic regression models showed no significant relation between BMD and BMI. The reason might be due to Ow and Ob groups' lower calcium intakes which had consequently led to lower bone density.

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