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Dietary Calcium Intake and Socioeconomic Status Are Associated with Bone Mineral Density in Postmenopausal Women

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Abstract: Osteoporosis is characterized by a decrease in the strength and density of bone and is a major cause of premature death in elderly. This cross-sectional study aimed to determine the relationship between bone mineral density and calcium intake and socioeconomic factors among postmenopausal women in Tehran, Iran. Postmenopausal women (50 to 65 years old) who were referred to the National Iranian Oil Company (NIOC) Central Hospital were recruited in this study. Socio-demographic, dietary information, anthropometric measurements and bone mineral density (BMD) assessment were obtained from participants. A total of 299 healthy postmenopausal women (mean age of 56.34 ± 4.46 years) participated in this study. The BMD of lumbar spine (L2-L4) was 1.08 ± 0.14. About 2/3 of the respondents had normal BMD at lumbar spine while others were either osteopenic (32.1%) or osteoporotic (1.3%). Only, about one fourth of respondents met the DRI (Dietary Reference Intake) for calcium. Higher intake of calcium (OR, 0.993; CI, 0.990-0.996) and higher household income per capita (OR, 0.997; CI, 0.995-0.99) were shown to be significantly protective against osteopenia/osteoporosis. About one third of women had osteopenia/osteoporosis at lumbar spine. Lower socioeconomic status might limit adequate consumption of calcium intake and subsequently contribute to poor bone health.

Key words: Geriatrics · Internal medicine · Nutrition assessment · Postmenopausal woman · Osteoporosis

INTRODUCTION

It has been estimated that more than 840 million people over the age of 60 will live in developing countries by the year 2025, representing 70% of all older people worldwide [1]. With increasing life expectancy, osteoporosis risk could increase among postmenopausal women [2-5]. Osteoporosis may lead to osteoporotic fracture which is a major cause of morbidity and premature deaths in elderly [2]. Annually one out of every two women and one in four men older than 50 years experience an osteoporosis-related fracture in their lifetime [6].

Developed countries are at higher risk of osteoporosis compared to African or Southeast Asian countries [7] While the prevalence of osteoporosis in Lebanon and Turkey was reported to be 31% and 33.3%, respectively [1, 8] the prevalence of osteopenia and osteoporosis was reported to be 58% and 8.1% in UK respectively and 33.67% and 46.63% in Italy [9,10]. Several studies have shown that women in Tehran aged 60-75 years, lose 18.5% of femoral BMD and 19.6%-24.5% of spinal BMD [11, 12]. In a national representative survey in Iran (N = 6000), the prevalence of osteoporosis at lumbar spine and femoral neck in women (20-76 years old) was 28.8% [2].

Adequate calcium and vitamin D intake were shown to have important role in prevention of osteoporosis and osteopenia in women [13-15]. Despite its importance for postmenopausal women, calcium intake in Iranian women over 50 years old is low [11, 13]. Calcium intake of the

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Iranian women older than 50 years was previously reported to be between 17.7% and 33.8% of the recommended intake and the vitamin D intake to be as low as 3.1% of recommended intake [11, 13]. However, data on calcium intake in Iran for postmenopausal women or women in all age groups are still inadequate [11, 13]. Based on many studies in developing countries, calcium intake among all age groups of people was lower than DRI [16-18]. African-American and Lebanese menopause women reported calcium intake less than 700 and 900 mg, respectively [16, 17]. Fifty percent of Malaysian women also had calcium intake less than the recommended level [18].

Calcium intake and bone mineral density are influenced by many factors such as socio-economic (i.e. age, household size, household income and educational level). Even though there is not enough information among developing countries, studies in developed societies showed that higher socio-economic status had association with higher BMD and calcium intake [19, 20].

To the best of our knowledge there is insufficient data on the association of socioeconomic status and the BMD of postmenopausal women in Iran. It is hypothesised that demographic status and inadequate income may result in reduced calcium intake in postmenopausal women and can lead to osteoporosis. This study aimed to determine calcium intake and socioeconomic factors related to BMD among postmenopausal women in the national oil company (NIOC) hospital, Tehran, Iran.

MATERIALS AND METHODS

Subjects: This cross-sectional study was carried out among healthy postmenopausal women in Tehran, Iran from June to September 2009. Respondents were recruited from physician referrals to the NIOC Central Hospital in Tehran, Iran. Selection criteria included postmenopausal women who aged between 50 and 65 years and had no menstruation for at least five years. Women were excluded if they had history of medical problems or chronic diseases that affect BMD, were on Hormone Replacement Therapy (HRT), oophorectomy or hysterectomy as well as positive history for fractures or being immobile.

This study was approved by the Medical Research Ethics Committee, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia and NIOC Central Hospital management. Informed consent was obtained from respondents prior to the commencement of the study.

Measurements

Anthropometry: Body weight of the respondents was measured using calibrated Seca digital scale to the nearest 0.1kg. The Seca body meter was used to measure the height of the respondents to the nearest 0.1cm. Subjects were instructed to stand erect, bare footed with hands hanging by the side and the head parallel to the Frankfurt plane. Each respondent was measured twice and the mean of the measurements was used for the analysis. Body mass index (BMI) was calculated using weight and height equation (kg)/ (m^2). BMI was then categorized based on the international classification of World Health Organization (1995) [21].

Dietary Intake: Dietary intakes of the respondents were assessed using 24-hour dietary recall for two days (one weekday and one weekend). Respondents reported the type and amount of food and beverages consumed over the past 24 hours. Common household measurements were used to aid respondents estimate the portion sizes of consumed foods. The Nutritionist IV_3.5.2 (First Data Bank, USA) software was used to analyze the dietary intake data.

The semi-quantitative Food Frequency Questionnaire (SFFQ) which consisted of 43 food sources of calcium that were commonly consumed by Iranians was used to determine the consumption of food sources of calcium [22, 23]. Respondents were required to report the frequency and portion sizes of their usual intake of foods over the last 2 months based on a nine point scale ranging from ‘0’ indicating never, ‘1’ indicating less than once/ week, to ‘9’ indicating more than 3 times/ day. Food frequencies were converted to times/day. The amount of calcium intake was estimated from the fractional portion size of each food consumed per day and multiplied by its calcium content. The calcium content of foods was obtained from the national food composition table [24]. The values were then summed up to obtain an estimate of an individual's total daily calcium intake. The following formula was used to calculate the total calcium intake:

Total dietary calcium intake (mg) = Average consumption of food (g) X calcium content (per 100 g) [22].

Bone Mineral Density: Regional bone mineral density of lumbar spine (L_2-L_4) was measured using DPX-IQ scanner (Lunar Radiation Corp., Madison, Wisconsin, USA) that uses Dual Energy X-ray Absorptiometry (DEXA). Lumbar spine DEXA scan was performed and analyzed in accordance with manufacturer recommendations by dividing the mass of bone (g) by the total area of bone

(square centimeter) within the region measured. A trained operator analyzed the bone scans using software which was provided by the manufacturer (Lunar Corp, version 8C). The T-score values of the DEXA results were categorized according to WHO guideline [25] into Normal (-1 SD and above), Osteopenia (-1 SD to -2.5 SD) and Osteoporosis (-2.5 SD and lower).

Other Variables: Other factors including demographic and socio-economic factors of the respondents (age, date of birth, educational level, occupation, household size, monthly income and income per capita) as well as reproductive factors (parity, number of children, age at menopause and duration of menopause) were obtained using a pre-tested interviewer-administered questionnaire.

Statistical Analysis: Data were analyzed using the Statistical Package of Social Sciences (SPSS) Version 20.0 (IBM Inc, Chicago, Ill). Descriptive analyses including percentage, mean and standard deviation (SD) were used for all variables. As distribution of continuous variables was normal, data normalization was not required. Independent-sample t-test was used to compare study variables between normal and osteopenia/osteoporosis women as well as between respondents with adequate vs. inadequate calcium intake. Chi-square was used to assess relationship between BMI groups and osteoporosis status. Stepwise logistic regression was carried out to determine factors associated with the risk of osteopenia/osteoporosis. All of the covariates were continuous except for occupation. Odds ratio (OR) with 95% confidence intervals (CI) were reported for the logistic regression analysis. The level of statistical significant was considered as $p < 0.05$.

RESULTS AND DISCUSSION

A total of 299 postmenopausal women participated in this study. Mean age of the respondents was 56.34 ± 4.46 years. Characteristics of the participants were shown in Table 1. The mean age at menopause was reported as 48.56 ± 3.60 years and respondents were in average at least at their 7th postmenopausal year. The mean household income per capita was 263.29 ± 1.97 USD which was less than poverty line income (788 USD) in Iran [26]. Educational level in women with osteopenia/osteoporosis was less than women in normal status, however the difference was not significant (p=0.26) (Table 1). There was no significant difference between age at menopause (p=0.06), duration of menopause (p=0.11), number of pregnancy (p=0.43) and children (p=0.24) among women in normal or in osteopenia/osteoporosis status (Table 1).

Improvements in the economic status of the developing countries contributed to increasing prevalence of obesity as a result of increased dietary intake [27]. The mean BMI of the participants was 27.33 ± 4.01 kg/m^2 and 52.9% of the participants were overweight and 20.5% of women were obese while the prevalence of obesity among Iranian postmenopausal women was previously reported to be 28% [28, 29]. The difference in prevalence of obesity between the current study and previous studies might be due to the recruitment of subjects from urban area of a large metropolitan centre. The other possible reason for high prevalence of obesity was low level of physical activity. Begum *et al*. [30] and Mora *et al*. [31] reported that higher levels of BMI were associated with lower levels of physical activity, regardless of a healthy diet. A study by Flegal *et al*. [32] reported that among US non-Hispanic

Table 1: The comparison of Socio-demographic factorsamong women with or without osteoporosis

		Lumbar spine L_2L_4(t-score)(Mean ± S.D.)			
Variables	Total Mean ± S.D.	Normal (n = 213)	Osteopenia/Osteoporosis (n = 86)	t	*p*
Age (years)	56.34 ± 4.46	56.74 ± 4.36	55.34 ± 4.59	2.48	0.01*
Education (years)	10.33 ± 4.03	10.50 ± 3.97	9.93 ± 4.18	1.11	0.26
Monthly household income per capita (USD)¶	263.29± 1.97	274.61 ± 196.29	234.71 ± 197.56	1.55	0.12
Age at menopause (years)	48.56 ± 3.60	48.81 ± 3.53	47.95 ± 3.72	1.873	0.06
Duration of menopause (years)	7.77 ± 2.74	7.93 ± 2.84	7.38 ± 2.43	1.56	0.11
Number of pregnancy	3.45 ± 1.45	3.41 ± 1.44	3.55 ± 1.48	-0.77	0.43
Number of children	3.21 ± 1.26	3.15 ± 1.21	3.34 ± 1.38	-1.16	0.24

* p <0.05

¶ 1USD = approx. 10,000.00 Rials

Table 2: Comparison of dietary intake, body mass index and bone mineral density among women with or without osteoporosis

			Lumbar spine L_2L_4 (t-score)(Mean ± S.D.)			
Variables	n (%)	Total Mean ± S.D.	Normal (n = 213)	Osteopenia/Osteoporosis (n = 86)	t	*p*
Dietary Intake						
Energy		1378 ± 325	1411 ± 334	1296 ± 287	2.77	<0.001*
< DRI	288 (96.3)					
≥ DRI	11 (3.7)					
Calcium		965.33 ± 396.42	1108.12 ± 362.70	611.69 ± 212.70	11.88	<0.001*
< DRI	218 (72.9)					
≥ DRI	81 (27.1)					
Vitamin D		3.98 ± 2.50	4.66 ± 2.48	2.31 ± 1.64	8.079	<0.001*
< DRI	299(100)					
≥ DRI	0					
Protein		53.08 ± 13.60	51.85 ± 13.95	56.37 ± 12.11	-2.64	<0.001*
<10%	51 (17.1)					
10-15%	132 (44.1)					
>15%	116 (38.8)					
Sodium		6232.64 ± 1915.62	6330.57 ± 1926.88	5990.10 ± 1876.65	1.39	0.16
< DRI	3 (1.0)					
≥ DRI	296 (99.0)					
BMI(kg/m^2)¶		27.33 ± 4.01	27.17 ± 3.96	27.71 ± 4.11	-1.06	0.28
Normal			59 (74.7)	20 (25.3)		
Overweight			112 (71.3)	45 (28.7)		
Obesity			40 (65.6)	21 (34.4)		
			χ^2 (299,2)=1.403, p=0.496 ?			
BMD (g/cm2)		1.08 ± 0.14				
T-score§		-0.44 ± 1.09				
Normal	199 (66.6)					
Osteopenia/ Osteoporosis	100 (33.4)					

¶ WHO (1995)

? Chi Square test was used to compare the frequency distribution of Osteoporosis amongst BMI categories

§T-score classification by WHO (1994): Normal (> -1 SD and above), Osteopenia (-1 SD to -2.5 SD) and Osteoporosis (-2.5 SD and lower)

* p <0.05

Table 3: Calcium intake of respondents from food and dietary supplement (n = 299)

Calcium intake	n(%)	Mean ± S.D.	% Total intake/day	%DRI
Calcium supplement				
Yes	159 (53.2)			
No	140 (46.8)			
Calcium from food		664.70 ± 2.19	68.1	55.33
Calcium from dietary supplement		302.31 ± 3.39	31.9	25.07

women (60 years old and above), eating as part of a sedentary life style could lead to energy imbalance and obesity. Moreover, type of consumed foods can also affect weight gain. Low intake of fruit and vegetables among Finnish women leaded to obesity [33]. It is therefore recommended for further researchers to conduct studies with the focus on physical activity as well as dietary intakes.

Comparison of variables including dietary intake and BMI between healthy women and women with osteopenia/osteoporosis was shown in Table 2. In the current study, there was no significant difference between normal and osteoporosis/osteopenia groups in terms of the distribution of BMI categories (χ^2 = 1.403, p = 0.496).

The mean daily calcium intake of the participants was 967.01 ± 3.02 mg/day based on the 24-hour recall which was approximately similar to FFQ result (938.17mg/day) (data not shown). The results in this study indicated that about 96.3% of the respondents did not meet the DRI for energy intake. In addition, the mean intake of calcium supplement was 302.31 ± 3.39 mg, which was about 1/3 of the total daily calcium intake of the respondents. Calcium intake from food was 664.70 ± 2.19 mg (Table 3). It was shown that higher rate of supplement consumption

is attributable to higher intake of calcium and vitamin D [34, 35]. Consumption of supplements resulted in 30% increase in calcium intake of the respondents in this study.

Pritchard *et al.* [34] showed that among postmenopausal women in Canada, the mean intake of calcium was 1831 ± 788 mg/ day, upon which calcium intake from supplement was about 30% of total calcium intake. In addition, Wu *et al*. [35] reported that the mean calcium intake among American postmenopausal women was 1777 mg/day and that about 44% of women took calcium supplements. These findings indicate that although the consumption of supplements in Iranian post-menopausal women is comparable to that of the developed countries, the total intake of calcium is still lower than the DRI. It was previously shown that lower education level, unhealthy dietary habits in different geographic regions and also availability of dietary calcium sources were considered as the main reasons for low calcium intakes of the Iranian women [36-38].

The mean intake of vitamin D was 3.98 ± 2.5 µg which was less than the DRI. The mean intake of energy, calcium and vitamin D were significantly higher in normal group as compared to osteopenia/osteoporosis group ($p < 0.05$). Contrarily, protein intake in women with osteopenia/osteoporosis was significantly higher than normal group. Lack of sunlight exposure due to body covering could contribute to vitamin D deficiency among women [39-41]. Based on the findings of the previous studies, it is hypothesized that the responders of this study were also at risk of low vitamin D levels due to low availability of sea products and vitamin D fortified foods in Iran and low sun exposure [39-41]. In a study among healthy Iranian postmenopausal women in Tabriz (north-western Iran), 38.3% of women had vitamin D intake less than the DRI [42]. Moreover, Bertone-Johnson *et al*. [43] indicated that the vitamin D intake of US postmenopausal women was 20.4% less than recommended intake (10 ug/day).

Mean and SD for BMD and t-score value for lumbar spine (L2-L4) were 1.08 ± 0.14 g/cm2 and -0.44 ± 1.09, respectively. About two-third of respondents (66.6%) had t-score above -1 (normal), however one-third of women had osteopenia-osteoporosis. Women with adequate calcium intake (> 1200 mg/day) had significantly higher BMD compared to women with inadequate calcium intake (1.25 ± 0.08 vs. 1.02 ± 0.10, respectively). This means that postmenopausal women with higher calcium intake had higher spinal BMD. These findings were in line with findings of the previous studies [44-46]. Several studies reported that the effect of calcium on bone density was due to a variety of factors including interactions between calcium intake and nutrients, amount of calcium intake and region of bone density measurement [44-46]. Calcium was shown to have a positive effect on lumbar spine, due to the higher metabolic activity of lumbar spine area [47].

Table 4: Odds ratio (%95confidence interval) of factors related to risk of osteopenia/osteoporosis in lumbar spine

Factors	Adjusted OR (95% C.I.)	P value
Age	0.994 (0.848-1.165)	0.938
Years of education	1.047 (0.919-1.192)	0.492
Household income per capita	0.997 (0.995-0.999)	0.021*
Number of pregnancy	1.207 (0.639-2.279)	0.562
Number of children	0.621 (0.295-1.310)	0.211
Age at menopause	1.057 (0.884-1.264)	0.543
Duration of menopause	0.923 (0.839-1.015)	0.099
Energy	0.998 (0.996-1.001)	0.173
Protein	1.052 (0.984-1.124)	0.136
Calcium	0.993 (0.990-0.996)	0.000*
Sodium	1.000 (1.000-1.000)	0.224
Vitamin D	0.688 (0.678-0.732)	0.248
Weight	1.240 (0.639-2.405)	0.525
Height	0.757 (0.415-1.382)	0.365
BMI	0.545 (0.101-2.942)	0.480

* $p < 0.05$

Table 5: Association between socioeconomic status and calcium intake

	Standardized coefficient	
Variables	Beta	p
Age	0.167	0.004**
Years of education	0.166	0.004**
Household income per capita	0.191	0.001**
Number of pregnancy	-0.040	0.495
Number of children	-0.128	0.027*
Age at menopause	0.164	0.005**
Duration of menopause	0.058	0.321

* $p <0.05$; ** $p < 0.01$

The present study showed no significant association between vitamin D and BMD of lumbar spine (Table 4). In contrast, several studies found that, vitamin D are positively associated with BMD of spine [48-50]. Vitamin D intake as well as calcium intake was shown to increase bone density [39-41, 51]. The difference between the findings of this study and the previous studies might be due to the low intake of vitamin D in all respondents of this study that resulted in the neutralization of the effect of adequate vitamin D intake on BMD and therefore lack of significant findings.

Linear regression was carried out to determine the relationship between socioeconomic factors and dietary calcium intake (Table 5). Results indicated that

Table 6: Comparison of socioeconomic status and bone mineral density among women with adequate or inadequate calcium intake

Variables	Dietary calcium intake (Mean ± S.D.) < 1200mg/day (n = 218)	= 1200mg/day (n=81)	*t*	*p*
Age	56.02 ± 4.54	57.19 ± 4.17	-2.02	0.04*
Years of education	10.03 ± 3.86	11.16 ± 4.38	-2.15	0.03*
Household income per capita (USD)	244.73 ± 181.56	312.61 ± 227.53	-2.63	0.00*
Number of pregnancy	3.43 ± 1.50	3.50 ± 1.33	-0.37	0.71
Number of children	3.27 ± 1.33	3.06 ± 1.05	1.26	0.20
Age at menopause (years)	48.33 ± 3.66	49.17 ± 3.39	-1.78	0.07
Duration of menopause (year)	7.68 ± 2.64	8.02 ± 2.75	-0.95	0.34
BMD of spine (g/cm^2)	1.02 ± 0.10	1.25 ± 0.08	-17.65	<0.001*

* $p < 0.05$

respondents with higher calcium intake were more likely to be older, having higher education as well as higher income per capita and reported menopause at an older age. However, postmenopausal women with more children were more likely to have less calcium intake. On the other hand, comparison of women with adequate and inadequate calcium intake (Table 6) confirmed that women with higher intake of calcium had higher income per capita and were more educated ($p < 0.05$).

Logistic regression analysis revealed a significant protective effect against osteopenia/osteoporosis for higher household income per capita (OR=0.997, CI=0.995-0.999) and higher intake of calcium (OR=0.993, CI=0.990-0.996). Women with more income and higher calcium intake had less risk of osteopenia/osteoporosis compared to women in lower socioeconomic status (Table 4).

This finding was in line with the findings of the previous studies [20, 52, 53]. Income level was found to be directly associated with health, nutrition and also BMD [54]. Obviously, low level of income and education can result in poorer health outcomes [20,52]. Moreover, a significant positive association between income level and BMD was reported in studies by Brennan *et al*. [54], that examined BMD of the lumbar spine (n = 1116) and a study by Demeter *et al*. [55] that assessed the association between income and BMD in 107 women aged 50 years old and over. Several other studies showed that higher income level affects nutritional status and subsequently bone health [56-59]. The findings of this study indicated that women with lower income had lower calcium intake. Families in poverty have insufficient ability for adequate nutrient intake. Zalilah and Khor [60] also mentioned that food insecurity due to poor economic status of the household may result in food insufficiency.

A limitation of this study was the underreporting of energy and nutrients intake is common in 24-hour dietary recall especially in overweight individuals. Underreporting could be related to the ability of women to recall diet and portion sizes. However, for minimizing these problems, face to face interview and using food photo album with standard portion sizes was utilized. Moreover, since the present study was cross-sectional, it could not assess the long term effect of calcium intake on bone health status. In other words, this study cannot provide evidence on cause and effect relationship. Cohort study is a better alternate for the development of chronic diseases such as osteoporosis and can determine the relationship between bone mineral density with socio-economic, nutritional, anthropometry and lifestyle factors in postmenopausal women. Despite these limitations, the findings of this study can benefit government and non-government sectors, health professionals, individuals and be used by future studies by researchers as reference.

This study found that calcium was significantly and positively associated with BMD at lumbar spine in postmenopausal women. This study also found that high economic status can prevent osteoporosis due to the higher accessibility to sources of calcium and vitamin D. This study suggests that, low dietary calcium intake increases the risk of osteopenia in postmenopausal women. Since calcium intake is important for bone density, more efforts are needed to increase public awareness of the importance of calcium intake from calcium rich foods and calcium supplements. Promoting variety in dietary intake to ensure adequate nutrients can lead to better bone health. In addition, as prevention, some strategies should be aimed earlier in life such as during childhood before peak bone mass is attained.

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