Lifestyle factors influencing bone mineral density in postmenopausal Malaysian women

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Abstract: Reduced bone mineral density (BMD) and subsequent osteoporosis is a major public health problem affecting millions of people, especially elderly and postmenopausal women worldwide. Although the key role of a healthy lifestyle on chronic diseases has been established, the importance of these characteristics along with other factors influencing BMD is still controversial. Further, previous studies addressing this issue in postmenopausal Malaysian women are very limited. This study aimed to determine the lifestyle habits that may affect BMD in postmenopausal Malaysian women. In a cross-sectional study, a total of 201 healthy postmenopausal women were interviewed to obtain information on their socio-demographic, reproductive, and lifestyle status. Calcaneal BMD was measured by quantitative ultra sonography (QUS) and was expressed in broadband ultrasound attenuation (BUA) as well as T-score. Food frequency questionnaire (FFQ) was used for calcium intake evaluation and visual analog scale (VAS) was applied for activity level assessment. Correlations of lifestyle factors with BMD were investigated using Pearson's correlation test and multiple regression analysis. A chi-square test and an independent-sample t-test were conducted to compare categorical and continuous lifestyle variables, respectively, in subjects. A hierarchical multiple regression analysis was employed to explore independent variables associated with BMD. All tests were two-tailed, and a 5 percent level of statistical significance was chosen. In a total of the 201 postmenopausal women, 28.4 percent of individuals were osteoporotic and 71.6 percent were normal. BMD was correlated with calcium intake and physical activity while there was no correlation between BMD and coffee consumption. Significant relationships were found between BMD and most investigated socio-demographic and reproductive factors. However, results from a two-step hierarchical multiple regression analysis revealed that the factors that remain significant after adjustment were age, BMI, osteoporosis history, lactation, calcium intake, and physical activity. On the basis of our data, calcium intake and physical activity seem to be major determinants of BMD in post-menopausal Malaysian women.

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1. Introduction

Economic growth has been shown to exert a key role in raising living standards, such as more access to food and services, especially in developing countries. On the other hand, economic development and urbanization may affect lifestyle behaviors inversely in terms of harmful dietary habits, reduced physical activity, and more alcohol and tobacco consumption. Increased incidence of chronic diseases such as osteoporosis are the consequence of these rapid changes in lifestyle patterns following industrialization, especially in countries in economic transition over the past decades. However, this situation could be affected by some socio-demographic factors. For example, people with higher educational levels would have better quality of life with socio-economic changes (WHO, 2009; Hubacek, 2008). One of the countries on the way to rapid modernization is Malaysia, which, after independence, saw vast changes in lifestyle patterns due to the rapid urbanization. For this reason, we are seeing an increase in chronic diseases like osteoporosis in Malaysia (Tee, 1999) as the rate of hip fracture (as the worst complication of osteoporosis) increased from 73 to 90 per 100,000 individuals over age 50 over a decade in this country (Lau, 2001).

Decreased bone mass density and, consequently, osteoporosis is an increasing chronic health issue worldwide, especially in countries with aging populations. Women, particularly in early years of menopause, are more susceptible to lose bone mass (Beitz, 2004; Chan, 2004) as 200 million women face this age- related problem (Lane, 2006). However, a dearth of data is available on the risk factors of osteoporosis in developing countries like Malaysia (WHO, 2003; Baheiraei, 2005; and Handa, 2008). The worst complication of osteoporosis is fracture, which leads to significant morbidity, mortality, and deteriorated quality of life (Wallace, 2005; WHO, 2003). Lifestyle traits are one of the multiple determinants influencing BMD (WHO, 2003; Kanis, 2002; Siris, 2001; Wenya, 2008). Important components of lifestyle that contribute to bone health which are frequently mentioned in literature are nutrition, physical activity, smoking, excessive alcohol usage, and caffeine consumption (Yahata, 2002). the two most important lifestyle variables in development and maintenance of bone density are nutrition and physical activity. Calcium is the main element in nutrition and weight-bearing activity is the effective type of activity for bone preservation. However, the relationship between osteoporosis and lifestyle variables is still controversial.

2. Material and Methods

2.1. Subjects

Women from menopause clinics at Hospital Kuala Lumpur and the National Population and Family Development Board (NPFDB) were recruited. Subjects who were on menopausal hormone therapy during the previous six months or more; taking medication for bone, calcium, and vitamin D supplementation more than one month during the previous year; taking medicines affecting bone density (such as glucocorticoids); and those with diseases affecting bone health (such as hyperparathyroidism) were excluded. A total of 201 postmenopausal, disease-free women were enrolled.

2.2. Data collection

All subjects were interviewed for baseline lifestyle characteristics and reproductive and socio-demographic information using a structured questionnaire. Respondents specified their daily activity based on a 10 cm visual analog scale (VAS) to determine the level of physical activity. A validated food frequency questionnaire was used to determine calcium intake. To obtain respondents' level of BMI, height, and weight, individuals were measured, in light outdoor clothing without shoes, using SECA, a digital scale with height attachment. BMI was calculated by dividing body weight by height squared (kg/m^2). Evaluation of bone status was performed according to calcaneal Quantitative Ultrasound (Osteosys Co. Sonost 2000). Parameters we used for reporting bone mineral density as results of densitometry were broadband ultrasound attenuation (BUA) as a continuous dependent variable where needed and T-score, which is a value without units when a categorical dependent variable was required in certain statistical tests. T-score value lower than < -1.8 was the threshold to determine osteoporosis based on the literature (Arslantas, 2008).

2.3. Statistical analysis

All statistical analyses were performed using SPSS version 18. Results of the description of the study population are expressed as a mean (± S.D.) for continuous variables and a percentage for categorical variables. We used student t-tests for quantitative and chi-squared tests for nominal variables to compare the mean BMD defined as BUA and T-score ≤ 1.8 at calcaneous in women with normal or osteoporotic bones. To examine the association between BMD as a dependent variable and affecting parameters including lifestyle traits with socio-demographic and reproductive characteristics, Pearson's correlation test and multiple regression analysis were applied. Finally, a two-step hierarchical multiple regression analysis was employed to explore variables associated independently with BMD. All tests were two-tailed, and 5 percent level of statistical significance was chosen.

2.4. Ethical approval

All stages of the study were in accordance with the Provisions of the Declaration of Helsinki of 1975. Fully informed consent was obtained from the subjects and ethical approval was issued from Medical Research Ethic Committee (MREC) of Ministry of Health Malaysia and from Ethic Committee of Medical Research, Faculty of Medicines and Health Sciences, Universiti Putra Malaysia (UPM).

3. Results

There were 201 postmenopausal women who met the inclusion criteria. Their ages ranged from 45-71 years, with a mean age of 53.6 ± 3.6 years. Using ultrasonography and the cutoff value of -1.8 to determine osteoporosis and normal bone density, 144 women (71.6 percent) had normal bones and 57 women (28.4 percent) had osteoporotic bones. The basic investigated characteristics of the individuals and their relationship to bone mineral density are presented in Table 1. A significant positive correlation was seen between BUA and physical activity (r= 0.40, p< 0.001), calcium intake (r= 0.58, p< 0.001), body mass index (r= 0.43, p< 0.001), educational level (r= 0.32, p < 0.001), and per-capita income (r=0.26, p< 0.001), and a negative correlation with age (r= -0.20, p< 0.01), family history of osteoporosis (r=0.41, p<0.001), age at the first period (r= -0.22, p<0.01), years after menopause (r= -0.18, p= 0.01), number of pregnancies (r= -0.16, p=<0.05), total breastfeeding time (r= -0.16, p< 0.05), and history of injectable-contraception usage (r= -0.18, p<0.01), and no correlation was found between BMD and coffee consumption, family size, r age at menopause (Table 1).

Table 1. Characteristics of studied postmenopausal women and their correlation with bone mineral density

Variables	BUA[a] Mean(SD)	R
Age	53.6 (3.6)	-0.219**
Education	3 (1)	0.322***
Per-capita income	626.6 (370.4)	0.255***
Family size	5.6 (1.6)	0.069
Osteoporosis history (%)	51 (25.4)	-0.411***
Body mass index	24.8 (3.6)	0.434***
Age at menarche	13.4 (1.4)	-0.221**
Age at menopause	49.5 (2.3)	-0.007
Years since menopause	4.1 (3.2)	-0.176**
Parity	5 (2)	-0.162*
Total lactation period (months)	41.6 (22.3)	-0.159*
Injectable contraceptive history (%)	133(66.2)	-0.177**
Coffee consumption (%)	118 (58.7)	0.066
Physical activity	5.5 (1.4)	0.40***
Calcium intake	451 (182)	0.58***

[a] Broadband ultrasonography attenuation
* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
*** Correlation is significant at the 0.001 level (2-tailed).

Table 2 indicates the risk factors influencing bone mass density. Women with normal bone density were statistically different from osteoporotic women in their age (p< 0.001), educational level (p< 0.001), family income (p<0.05), family history of osteoporosis (p< 0.001), age at menarche (p< 0.05), years since menopause (p< 0.05), BMI (p< 0.001), physical activity level (p< 0.001), and calcium intake (p< 0.001) (Table 2).

Women with osteoporotic bones were older and experienced their first period later, compared to women with normal bones. Educational level and per-capita income were higher and duration after menopause was shorter in normal subjects. The mean score of activity was significantly lower in osteoporotic women. Further, mean calcium intake and mean body mass index were higher in normal women. Women with a positive family history of osteoporosis were more susceptible to develop osteoporosis compared to women without history of osteoporosis (Table 2).

Table 2. Prevalence of osteoporosis by socio-demographic factors, reproductive history, and lifestyle habits

Characteristics	Normal	Osteoporosis	p-value
Age	53.1	54.9	0.001
Education (%)			0.000
No formal education	3	9	
Primary school	28	19	
Secondary school	74	22	
Diploma/ graduate	39	7	
Per-capita income	662.3	536.6	0.030
Family history of osteoporosis (%)			0.000
Yes	19	32	
No	125	25	
Body Mass Index	25.6	22.8	0.000
Menarche	13.2	13.8	0.019
Years since menopause	3.7	4.9	0.018
Physical activity	5.8	4.7	0.000
Calcium intake	502	321.8	0.000

Values are the mean±SD except osteoporosis history and education which are percentages. P-value for continuous variables was obtained by student t-test and for categorical variables by chi-square test.

From lifestyle components in this study, risk factors such as alcohol intake and tobacco usage were not counted in the analysis because of their very small numbers (only 1 current and one ex-smoker and six alcohol ex-users and five current users).

We stratified three remaining lifestyle variables coffee consumption, physical activity, and calcium intake - and assessed their relationships with BMD through chi-square tests to obtain more precise results about the impact of lifestyle traits on BMD. Data from Table 3 confirmed that no relationships exist between coffee consumption and BMD, while respondents with normal bone density have more activity and more calcium intake. Table 4 illustrates a two-step hierarchical regression analysis that examines the effects of physical activity and calcium intake on BMD. Results revealed a significant model

(ΔF (2, 185)=27.70, P<0.001) suggesting that both variables were significantly associated with BUA over and beyond socio-demographic and reproductive factors. Further results from coefficient indicate that, in addition to the amount of calcium intake and physical activity index, the age of respondents, the presence of a family history of osteoporosis, body mass index, and total breastfeeding time, significantly influenced calcaneal BMD while controlling confounding variables (Table 4).

Table 3. Relationship between lifestyle risk factors and osteoporosis

Risk factors	Osteoporosis(n, %)	Normal (n, %)	*P* value
Activity			
1-4	20 (35.1)	22 (15.3)	0.000
5-7	36 (63.2)	106 (73.6)	
8-10	1 (1.8)	16 (11.1)	
Calcium			
<300 (mg)	28 (49.1)	10 (6.9)	0.000
300- 500	21 (36.8)	64 (44.4)	
501- 700	7 (12.3)	50 (34.7)	
≥ 700	1 (1.8)	20 (13.9)	
Coffee			
Users	34 (56.6)	87 (60.4)	0.920
Non users	23 (40.4)	57 (39.6)	

Table 4. Hierarchical regression analysis for variables predicting BUA (N=201)

	Step 1			Step 2		
	B	SE	β	B	SE	β
Constant	53.863	26.156		31.446	23.814	
Age	-2.066	.753	-.473**	-1.871	.672	-.429**
Education	.598	1.203	.036	-.707	1.087	-.043
Family size	1.174	.825	.119	.644	.739	.065
Menarche	-1.004	.711	-.088	-.198	.643	-.017
Menopause	1.515	.834	.225	1.437	.743	.213
Parity	-.004	.607	.000	-.152	.540	-.020
Lactation	-.082	.050	-.116	-.111	.045	-.158*
BMI	1.065	.286	.244***	.760	.258	.174**
YSM	1.116	.735	.227	.935	.654	.190
Per-capita	.007	.004	.168*	-.001	.003	-.035
Injectable contraception	-1.707	2.273	-.052	-1.569	2.056	-.047
Osteoporosis history	-10.377	2.182	-.288***	-7.538	2.009	-.209***
Coffee				.035	.006	.407
Activity				1.816	.626	.162**
Calcium				.223	.193	.062***

BMI = body mass index. YSM = years since menopause
First step: ΔF(12, 188)=10.28 , p<.001 , ΔR Square =0.40
Second step: ΔF(3, 185)= 17.84 , p<.001 , ΔR Square=0.14

Significant inverse and positive relationships were found between BMD and some socio-demographic and reproductive factors. However results obtained from a two step hierarchical multiple regression analysis revealed that the factors that remained significant after adjustment were age, BMI, osteoporosis history, and lactation. Among lifestyle traits in this study, calcium intake and physical activity were striking independent predictors of BUA

4. Discussions

The present study was designed to determine how lifestyle habits correlate with BMD. The main result of the study was that, among investigated lifestyle variables, calcium derived from food and the level of physical activity and the age of the participant, BMI, family history of osteoporosis, and total duration of breastfeeding were predictive variables of osteoporosis in postmenopausal women. A great deal of the previous work on the impact of calcium intake and activity corroborate our findings. Also agreeing with our findings, a positive correlation between calcium intake (an essential mineral for bone formation) and BMD was underlined by several studies (Wenya, 2008; Chee, 2003; Lau, 2001; Hejazee, 2009; Nakamura, 2009; Islam, 2003; Zaitun, 2003; and Shea, 2002). In contrast to our findings and contrary to expectations, in a study of French women, no association was found between calcium intake and osteoporosis or the presence of fractures (Fardellone, 2010). Also, Loyd et al., in a 10-year longitudinal study of young women found no association of bone gain or bone strength with calcium intake. The only determinant of BMD in their study was exercise (Loyd, 2004). Further, other authors reported insignificant influence of dietary calcium intake on BMD (Yahata, 2002; Runyan, 2003; Anaforoglu, 2009; and Bauer, 1993).

One possible explanation for these inconsistencies might be differences in the amount of calcium in different communities. Generally, in developing countries, people consume smaller amounts of calcium than people in western countries, which is very much less than recommended amount. So, bone loss due to lower calcium consumption is common in poorer communities while bone loss in developed countries might stem from other risk factors affecting bone mineral density (Islam, 2003; Chailurkit, 2010).

The role of physical activity on bone mineral density in our study aligns with many other studies (Wenya, 2008; Runyan, 2003; Schmitt, 2009; Borer, 2005; Kemper, 2000; Lunt, 2001). Moreover, Robinson et al., in a multiethnic longitudinal study to develop a prediction model, found that physical activity was an important predictor of hip fracture (Robbins, 2007). However, contradictory evidence on the association between activity and BMD also exists (Yahata, 2002; Nakamura, 2009; Anaforoglu, 2009; and Bauer, 1993). There are similarities between our data and several studies that have concluded that dietary calcium intake and physical activity are independent risk factors for bone loss (Pongchaiyakul, 2004; Dionyssiotis, 2010; Yamaguchi, 2000).

Our findings did not show any significant decrease in bone mass correlated with coffee consumption. This result is consistent with data from some studies (Loyd, 2000; Heaney, 2002) while our results are inconsistent with data from studies that support the hypothesis of harmful effect of caffeine on BMD (Bauer, 1993; Ilich, 2002). The negative effects of coffee consumption on BMD have mostly been attributed to a small negative calcium balance because of increased urinary or fecal excretion, so it seems that ingesting enough calcium could offset the harmful effects of caffeine consumption.

We neglected variables of alcohol and tobacco consumption in this analysis because of only very small number of smokers and drinkers were in our study population. Dionyssiotis, et al., didn't find any association between smoking or drinking and BMD in postmenopausal Greek women and they believed that this result, like some previous studies' results, reflected a high prevalence of non-smokers and non-drinkers in their study population (Dionyssiotis, 2010). Although Elgan, et al., reported the inverse effect of smoking on BMD, they also pointed out the small number of smokers in their study (Elgan, 2003). However, the association of smoking (Wallace, 2005; Bauer, 1993; Ilich, 2002) and drinking (Wallace, 2005; Chakkalakal, 2005), with reduced BMD has confirmed by some studies while others have been unable to demonstrate the relationship of alcohol (Wenya, 2008; Yahata, 2002; Bauer, 1993; and Ilich, 2002) and smoking (Wenya, 2008; Yahata, 2002; and Anaforoglu, 2009), with BMD. This discrepancy can be attributed to the amount of alcohol or tobacco use, as even in some references, small or moderate alcohol usage has been reported to be beneficial for bone mass (Ilich, 2002).

Many determinants, such as lifestyle patterns, affect bone metabolism during various phases of life. Thus, some discrepancies and lack of relationships may be due to masking of these factors by greater BMD determinants later in life. For example, age is the most crucial factor influencing BMD. Decreased estrogen levels after menopause intensify the effect of aging. Moreover, lifestyle habits - especially diet and physical activity – are affected by aging and menopause. Also, it is demonstrated that harmful effects of caffeine can be compensated through higher calcium intake. And the inverse effects of aging and estrogen deficiency on BMD can be minimized by physical activity, although the kind of activity should be considered carefully (Melo-Ocarino, 2006). The other explanations for inconsistencies in the results could be variation in the study design, the number of enrolled subjects, the bone sites used in measurement, and statistical tests for analyzing.

Some important limitations must be considered. One limitation was using calcaneous as the site for BMD measurement, meaning that we cannot generalize the result to whole skeleton. On the other hand, dual energy X-ray absorptiometry (DXA) is the gold standard for bone measurement. However, we couldn't use it because it is an expensive method and we didn't have any financial support. Further, the DXA machines are not portable so using it would have entailed some inconveniences for subjects and researchers. More importantly, most people prefer devices without ionizing radiation. However, QUS as a portable, cheap, and non-radiational diagnosis tool might provide a convenient alternative to DXA. Recall bias was the other problem in present study, since most data including data related to calcium intake, physical activity level, and coffee consumption were obtained through self-reports. The most significant finding from this study is that calcium intake and physical activity seem to be major determinants of BMD in post-menopausal Malaysian women. However, as lifestyle behaviors are the most modifiable compared to other risk factors, attention to lifestyle habits (e.g. consuming more calcium-rich foods and doing more exercise) in postmenopausal women can help improve bone health.

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