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Association Between Anthropometric Status, Dietary Intake and Physical Activity with Bone Health Status among Premenopausal Chinese Women in the Klang Valley, Malaysia

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ABSTRACT

Introduction: There is a lack of information on bone health status of premenopausal women in Malaysia. This study investigated the bone health status of premenopausal women and its associations with anthropometric, dietary and physical activity. **Methods:** Bone mineral density (BMD) was measured using dual X-ray absorptiometry (DEXA) at the lumbar spine, femoral neck, total hip and total body. Serum osteocalcin, parathyroid hormone (PTH), beta-crosslaps were also determined. **Results:** A total of 73 Chinese premenopausal women were recruited in the study with a mean age of 39.3 ± 5.0 years. Average BMI, body fat percentage and lean body mass were 22.2 ± 3.4 kg/m^2, 33.9 ± 4.6% and 34.5 ± 4.4 kg, respectively. Mean BMD at the spine, total hip, femoral neck, and total body were 1.025 ± 0.118 g/cm^2, 0.876 ± 0.109 g/cm^2, 0.739 ± 0.110 g/cm^2, and 1.061 ± 0.755 g/cm^2, respectively. Their serum beta-crosslaps and PTH were within normal range, but serum osteocalcin (8.5 ± 4.2 ng/ml) was low. On average, calorie intake (1506 ± 427 kcal/day) was below the Malaysian Recommended Nutrient Intake (RNI) while their calcium intake achieved only 67% of RNI. Their mean metabolic equivalent score (MET) was 771.4 ± 926.1 min/week. Body weight and related indices (BMI, lean mass, fat mass) were significantly positively correlated with BMD at all skeletal sites. **Conclusion:** The study revealed that Chinese premenopausal women in the Klang Valley have low calcium intake and low level of physical activity.

Key words: Bone mineral density, Chinese, dietary intake, Malaysia, premenopausal women

INTRODUCTION

The declaration of years 2002-2011 as the Decade of the Bone and Joint is timely as musculoskeletal conditions continue to affect hundreds of millions of people worldwide (US Department of Health and Human Service, 2004). The total incidence of osteoporosis is estimated at about 75 million for Europe, United States and Japan (EFFO & NOF, 1997). Not only is it a disease of the western countries, but Asia is also projected to account for more than 50% of all osteoporosis-related hip fractures by the year 2050 (Gullberg, Johnell & Kanis, 1997). Over a decade, hip fracture rates in Malaysia have increased from 0.73 to 0.9 per 1, 000 persons over 50 years old (Lim *et al.*, 2005). Among

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women of all ethnic groups in Malaysia, Chinese women had the highest incidence of hip fractures (220 per 100 000) (Lee & Khir, 2007).

Bone loss in women usually occurs after the attainment of peak bone mass, which usually occurs around 35 years of age, well before menopause (Arlot *et al.*, 1997). There is evidence that two-thirds of the risk for fracture can be predicted based on premenopausal bone mineral density (BMD), and only about one-third is attributable to accelerated and/or prolonged postmenopausal loss (Sowers, 2000). Prolonged life expectancy allows women in Malaysia to live up to an average of 76.6 years (Department of Statistics, 2010), which also indicates that these women are likely to spend one-third of their lifetime menopausal, hence predisposing themselves to greater likelihood of fractures.

Studies on bone health status of premenopausal women are rather scanty, particularly in Malaysia. Thus, our study aimed to determine the bone health status of premenopausal Chinese women living in the Klang Valley and its associations with anthropometric measurements, dietary factors and physical activity. Identification of factors influencing bone mass in premenopausal women is of utmost importance as there is still a window of opportunity to enhance their bone status prior to menopause.

METHODS

This study was part of a 12-month randomised trial that examined the effects of soy isoflavones on bone mineral density in Chinese premenopausal women. A total of 73 healthy, free living Chinese premenopausal women aged 30 to 45 years old from the Klang Valley were recruited from the community through advertisements (flyers sent to organisations), health screening, health talks and through referral. Women could not be enrolled if they had any detectable diseases or on medications, including exogenous estrogens, corticosteroids, thiazine and others which are known to affect bone metabolism; on hormone replacement therapy (HRT) for the previous 12 months; or if they are pregnant or lactating. Potential subjects were screened on completion of the screening questionnaire and those who were eligible were invited to participate in the study. The study was explained and written informed consent was obtained from all the subjects prior to data collection. The study was approved by the Medical Research Ethics Committee of Universiti Putra Malaysia.

The subjects were interviewed face-to-face, employing the validated questionnaire (Chee *et al.*, 2003) which consisted of 36 questions on socio-demographic data, current and past medical history, reproductive history, history of bone fracture (self & family members), patterns of physical activity, smoking and alcohol habits, consumption patterns of milk and dairy products as well as soy products. Physical activity level was measured using the short form of International Physical Activity Questionnaire (IPAQ, 2005). The total energy expenditure (MET-min/week) was computed by the multiplication of the duration (in minutes) and frequency (days) of walking by a factor of 3.3, moderate-intensity by a factor of 4 and vigorous-intensity activities by a factor of 8. The total energy expenditure was categorised into insufficiently active, sufficiently active or highly active.

Body weight and height were measured without shoes, to the nearest 0.1 kg and 0.5 cm, respectively with SECA (USA). Body mass index (BMI) was calculated by dividing body weight (kg) by the square of body height (m^2). The classification of BMI was based on World Health Organisation (WHO, 1995). Lean body mass and fat mass were assessed by total body dual energy X-ray absorptiometry (DEXA) scans (Hologic Discovery, USA).

Bone densitometry

Bone mineral density of the total body, lumbar spine (L1-L4) and femoral neck and total hip was measured using DEXA (Hologic Discovery, USA) by a trained technician. Bone mineral density (g/cm^2) was classified according to the World Health Organisation criteria (1994) for T-score: normal (> -1), osteopenia (≤ -1 to > -2.5), osteoporosis (≤ -2.5).

Biochemical measurements

Fasting venous blood (10 ml) was drawn from each subject by a qualified physician for the analysis of bone markers - parathyroid hormone (PTH), osteocalcin and beta-crosslaps. These markers were measured by electrochemiluminescence immunoassay using the Elecsys 2010 analyzer (Roche Diagnostics, Germany).

Dietary assessment

Dietary data were collected and analysed using a 24-hour diet recall. Subjects were asked to recall foods taken over the past 24 hours using local household measurements (bowls, cups, glasses, teaspoons, and tablespoons) on a weekday. Based on diet recall, the average energy and nutrients intakes (calcium, iron, phosphorus, magnesium, vitamin A, vitamin C, thiamine, riboflavin, niacin, folate) were estimated using Nutritionist Pro software (First DataBank USA, 2005) and compared with the Malaysian Recommended Nutrient Intake (RNI).

Statistical analyses

Data analysis was performed with Statistical Package for Social Sciences (SPSS) software version 16.0 (SPSS Inc. Chicago, USA). The socio-demographic, anthropometric, bone density, bone turnover markers and lifestyle variables are presented descriptively as mean, standard deviation, and range. Pearson's correlation coefficient was used to test for correlations between continuous variables. The level of significance was set at $p<0.05$ for all analyses (two-tailed).

RESULTS

The subjects' socio-demographic characteristics are shown in Table 1. The mean age of the subjects was 39.3 ± 5.0 years.

Table 1. Descriptive characteristics of the subjects (n=73)

Characteristics	Mean ± SD
Age (years)	39.3 ± 5.0
Age of menarche (years)	12.8 ± 1.5
Anthropometry	
Weight (kg)	55.9 ± 9.6
Height (m)	1.58 ± 0.05
Body mass index (kg/m^2)	22.2 ± 3.4
Percent body fat (%)	33.9 ± 4.6
Lean body mass (kg)	34.5 ± 4.4
Bone Mineral Density (g/cm^2)	
Total body	1.061 ± 0.755
Spine L1-L4	1.025 ± 0.118
Total hip	0.876 ± 0.109
Femoral neck	0.739 ± 0.110
Bone markers	
Serum osteocalcin (ng/ml)	8.2 ± 4.2
Serum beta-crosslaps (ng/ml)	0.20 ± 0.11

More than half of them (58.9%) were married and a majority of them (73.3%) had completed at least a diploma or had a tertiary education. Only 9.6% of them were unemployed and 53.4% of them had a high monthly household income above RM5000. The mean age of menarche was 12.8 ± 1.5 years. Only a few of them (13.7%) had ever used oral contraceptives, one person smoked and one person drank alcohol regularly. Those married had approximately 3 children on average and 50.7% of them had breastfed their children.

The subjects had a mean weight of 56.9 ± 9.6 kg and a mean height of 1.58 ± 0.05 m (Table 1). The mean BMI was 22.3 ± 3.4 kg/m^2 while the majority of women (69.9%) had BMI within the normal range (18.50 – 24.99 kg/m^2), 13.7% were overweight (25.0 ≤ BMI ≤ 29.9), 4.1% were obese (BMI>30.0) and 12.3% were underweight (BMI<18.5). The subjects had a mean percentage of body fat of 33.9 ± 4.6 % and a mean lean body mass of 34.5 ± 4.4 kg.

Bone mineral density and bone markers

By T-score classification, osteopenia was present in 11.0% of the subjects at the spine, 5.5% at the hip and 32.9% at the femoral neck (Figure 1). Osteoporosis was seen in 2.7% at the femoral neck. These groups of women may be at increased risk of osteoporosis since they are still well below the age of menopause. The mean (±SD) bone mineral density of total body was 1.061 ± 0.755 g/cm^2, lumbar spine 1.025 ± 0.118g/cm^2, femoral neck 0.739 ± 0.110 g/cm^2, and total hip 0.876 ± 0.109 g/cm^2.

Table 1 shows that serum beta-crosslaps (0.21 ± 0.10 ng/ml) and parathyroid hormone (36.1 ± 18.2 pg/ml) were within normal range (0.01-5.94 ng/ml and 15.0 – 65.0 pg/ml, respectively). However, mean serum osteocalcin (8.5 ± 4.2 ng/ml) was lower than the reference value (Roche Diagnostics, Mannheim, Germany). Serum osteocalcin is lower in premenopausal women than postmenopausal women with

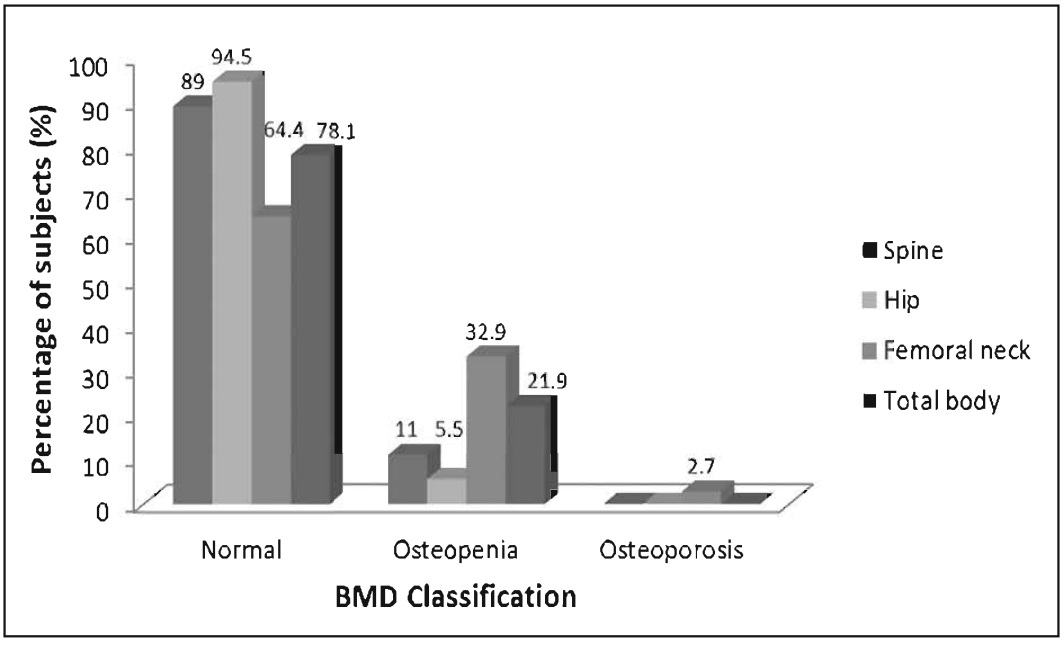

Figure 1. Bone mineral density classification of subjects

a high bone turnover (Nabipour *et al.*, 2008). It was observed that serum osteocalcin decreased significantly from 20 – 29 years to 30 – 49 years, followed by progressive increases after 50. Conversely, the bone resorption marker, serum beta-crosslaps increased gradually after 30 years of age (Nabipour et al., 2008).

Dietary intake

Dietary assessment revealed that the subjects had a mean (±SD) energy intake of 1506 ± 427 kcal/day (Table 2). The mean energy percentage from carbohydrate, protein, and fat were 46%, 18%, and 36%, respectively. Energy intake in these women reached 69% of the Malaysian Recommended Nutrient Intakes (RNI, Female 30-50 years old) (NCCFN, 2005). The mean calcium intake was low, with a mean of 534 ± 347 mg/day, achieving only 67% of RNI. Mean intake of other potential bone protective nutrients - phosphorus and magnesium were 700 ± 391 mg and 138 ± 99 mg, respectively. Iron intake was only 45% of RNI which is in line with a lower iron intake among premenopausal women in Malaysia (Pon *et al.*, 2006).

Physical activity

Only 39.7% of the subjects reported exercising regularly, implying the majority practised a relatively sedentary lifestyle. They spent an average of 6 hours sitting during weekdays. The mean MET score for physical activity was 771.4 ± 926.1. About 18% of the subjects did not participate in any type of physical activity at all, including walking. More than half of the women in this study (61.6%) were inactive, whereas 37% were sufficiently active and 1.4% of the subjects were highly active.

Table 2. Nutrient intake and physical activity level of subjects (n=73)

Nutrients	RNI	Mean ± SD	Range
Macronutrients			
Energy (kcal/day)	2180	1506 ± 427	455 - 2938
Carbohydrate (g/d)		173 ± 57	43 - 323
% Energy	55-70	46	
Protein (g/d)	55	69 ± 30	15 - 175
% Energy	10-15	18	
Fat (g/d)		61 ± 23	20 - 157
% Energy	20-30	36	
Micronutrients			
Calcium (mg/d)	800	534 ± 347	
Iron (mg/d)	29	13 ± 6	
Thiamin (mg/d)	1.1	1.7 ± 4.6	
Riboflavin (mg/d)	1.1	1.9 ± 4.7	
Niacin (mg NE/d)	14	12.9 ± 20.2	
Folate (µg/d)	400	127.8 ± 134.0	
Vitamin C (mg/d)	70	107 ± 224	
Vitamin A (µg/d)	500	706 ± 709	
Magnesium (mg/d)	–	138 ± 99	
Phosphorus (mg/d)	–	700 ± 391	
Physical activity			
Total MET-min/week		771.44 ± 926.084	

Reference: Malaysia Recommended Nutrients Intake (RNI) (2005), Female 30-50 years old.

Table 3. Correlation for bone related variables with lumbar spine, hip and total body BMD

Variables	*r-value*			
	Spine BMD	*Hip BMD*	*Neck BMD*	*Total body*
Weight	0.532**	0.440**	0.441**	0.293*
BMI	0.470**	0.475**	0.441**	0.267*
Age of menstruation	-0.224	-0.202	-0.243*	-0.144
Fat mass	0.490**	0.428**	0.429**	0.268*
Lean mass	0.477**	0.440**	0.448**	0.274*
Calcium intake	0.008	-0.089	-0.102	-0.011
Total MET	0.084	0.165	0.170	0.147
Serum osteocalcin	-0.024	0.065	0.115	-0.019
Serum beta-crosslaps	-0.067	-0.149	-0.013	-0.059

* Correlation significant at $p< 0.05$.
** Correlation significant at $p< 0.01$.

Associations between bone mineral density and related variables

Table 3 shows that subjects with higher BMI had higher BMD at the spine (r=0.470, $p<0.01$), hip (r=0.475, $p<0.01$), femoral neck (r=0.441, $p<0.01$) and total body (r=0.267, $p<0.05$). Similarly, those with higher lean body mass or higher fat mass had higher BMD at all sites. There was a significant negative correlation between age of menarche and BMD at the femoral neck (r=-0.243, $p<0.05$). Nonetheless, neither calcium intake nor other dietary factors correlated with BMD at all skeletal sites. There was no significant correlation between physical activity and BMD. There were also no significant relationships between serum osteocalcin and serum beta-crosslaps with BMD. Serum PTH, however, showed significant positive correlation with spinal BMD ($p<0.05$).

DISCUSSION

The results showed that osteopenia (-2.5<T-score<-1.0) was prevalent at the femoral neck and spine among the study subjects. This may be due to either to lower peak bone mass attained during adolescence or accelerated bone loss after attainment of peak bone mass (Gourlay & Brown, 2004). Reductions in bone density at different skeletal sites in premenopausal women have been observed in other studies and greater bone loss was found at trabecular bones, i.e. the spine and hip region (Baran, 1999). Citron *et al.* (1995) observed a reduction of vertebral trabecular bone mineral density occurring at a rate of 0.86% per year among 38 - 42 years old premenopausal women while Baran (1999) observed a decline rate of 1.0% per year (age 30 -42 years old). It was also found that 45% of osteoporotic fractures and 53% of hip fractures occurred in those with moderate bone loss (T-scores less than -2.0) (Siris *et al.*, 2004).

Generally, fracture rates are relatively lower among Asians than among Caucasians even though Asians have lower BMD as compared to Caucasians. However, there is no information on bone density status of healthy Malaysian premenopausal women (30-45 years old) available for comparison. One study has reported that 24% of urban midlife women (45 years and above) suffer from osteoporosis (Lim *et al.*, 2005). In their study, Chinese women have the lowest bone mass among different ethnic groups of Malaysia. Young women in the present study had higher bone density, as compared to the Chinese Malaysian post-

menopausal women aged 50-70 years old reported by Chee *et al.* (2010), where 50.0% and 57.9% had osteopenia at the spine and at the femoral neck, respectively. However, in time, this cohort of premenopausal women will reach menopause and the low bone density at a younger age will expose them to greater risk of osteoporosis. Until recently, it was not the norm for premenopausal women to have concerns on their bone health status. Earlier measurement of bone density to identify women with low bone mass is of utmost importance so that appropriate treatment could be advocated to prevent further loss.

According to the National Health and Morbidity Survey III (NHMS III) conducted in Malaysia on adults above 20 years of age, the Chinese had the lowest prevalence of overweight and obesity compared to the Malays and Indians (Institute for Public Health, 2008). Similarly, most of the subjects in the present study (69.9%) had a BMI within the normal range. Nonetheless, the present study showed that 12.3% of the women were underweight, while the NHMS III survey found that the prevalence of underweight was 8.5%. In contrast, Pon *et al.* (2006) observed that premenopausal women had higher BMI than the post-menopausal women in Malaysia.

The present study showed that women with higher body weight had higher BMD at all skeletal sites. Increased body weight is associated with higher bone mass and reduced bone loss through gravitational effect on skeletal loading. Parallel with body weight, subjects with higher BMI also demonstrated higher BMD value. Although higher BMI seems to be protective of bone, this in turn, would be misleading to the public, as higher BMI is also associated with a number of chronic diseases such as cardiovascular disease and diabetes mellitus. Rather, maintaining an adequate body weight for skeletal health should be emphasised; it is noted that the majority of the premenopausal women in the study group had achieved a normal BMI.

The subjects had relatively high mean percentage of body fat (34%) whether they were in the normal weight range or in low weight range. There were 27% of subjects within the age 30-40 years and 15% of subjects aged 40 years and above who had a percentage of body fat exceeding the healthy range (Gallagher *et al.*, 2000). Excessive body fat is associated with obesity which subsequently will lead to other health problems such as cardiovascular disease. Wang *et al.* (1994) found that Asians had a lower mean BMI but a higher percentage of body fat as compared to Caucasians of the same age and sex.

Fat mass has shown a positive correlation with BMD. Douchi *et al.* (2000) have suggested that premenopausal women with android (or upper) body fat distribution have a greater BMD. On the other hand, Young and colleagues (2001) followed a group of female twins and concluded that lean mass had greater association with bone mineral measures during linear growth while changes in fat mass were the predominant predictor during post-linear growth. Nonetheless, both fat mass and lean mass may have a profound effect on bone mass. Lean mass works on mechanical strain and stress on the bone tissues (Bakker *et al.*, 2003) whereas fat mass exerts its profound effect through weight-bearing or humoral factors (Ravn *et al.*, 1999).

None of the dietary factors have shown significant correlation with BMD at all sites. The present study showed that the average daily energy intake of women was lower than the RNI for Malaysian adult women in all age groups (19-29 years: 2,000 kcal/day; 30-59 years: 2,180 kcal/day; ≥60 years: 1,780 kcal/day) (National Coordinating Committee on Food and Nutrition, 2005). This is also slightly lower than the calorie intake reported for Malaysian women by Pon *et al.* (2006). It was noted that the subjects consumed more dietary fat (36%), exceeding the usual advice of 30% of total fat (NCCFN (2005). The calcium intake was relatively low, fulfilling only 67% of the Malaysian RNI

of 800 mg/day for this age-group. The mean calcium intake of 534 mg was slightly higher than other Malaysian adults (397 mg) (Mirnalini *et al.*, 2008). Almost all of them (97%) failed to fulfil daily calcium requirement from food sources. Low calcium intake is a risk factor of hip fractures among Asian women (Lau *et al.*, 2001). The absence of significant correlation between calcium intake and BMD status might probably be due to our small sample size.

Our findings demonstrate that the majority of the subjects were quite sedentary. The prevalence of inactivity among Malaysian adults was 43.7% based on the NHMS III, especially among women, housewives, urban dwellers to name a few (Institute for Public Health, 2008). Low level of physical activity among young Malaysian adults was also underlined by Ismail *et al.* (2002). The low level of physical activity in addition to high dietary fat intake may explain why these women are having a high body fat percentage. It is recognised that physical activity benefits both increasing muscle mass and reducing body fat. However, physical activity is not associated with BMD in the present study. Lifetime exposure to exercise may add more effect to it than looking only at the current physical activity level.

In premenopausal women, early age of menarche is associated with higher bone density (Fujita *et al.*, 1999). The findings of our study showed a beneficial effect of early menarche at femoral neck BMD. A 2-year later mean menarche age has been associated with lower radial area BMD at forearm in healthy young adult women (Chevalley *et al.*, 2008). Women with early age of menarche are bestowed with a longer protective hormonal environment and if protracted long enough to late menopause, they could continue to enjoy the bone-protective effect.

There are a few limitations to the study; the sample size was small and findings are not representative of the general premenopausal women in Malaysia. Nonetheless, the information provided will be useful for future studies on premenopausal women, which are fairly scarce at present. In conclusion, the majority of Chinese premenopausal women had normal bone health status which is appropriate to their age. However, they had low calcium intake and low level of physical activity which are the risk factors for low bone density.

This study provides information on bone health status among younger women in Malaysia. Identification of the potential risk factors may aid in the formulation of public health measures to reduce the occurrence of low bone density and subsequent osteoporosis. It is essential to increase awareness of the younger population of the current and future risk of fractures, so that they can improve on their bone health status throughout their life span by practising a healthy lifestyle which includes the incorporation of diets for healthy bone and physical activity.

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