WALAILAK JOURNAL

http://wjst.wu.ac.th Article

Bone Mass, Body Mass Index, and Lifestyle Factors: A Case Study of Walailak University Staff

Rapheeporn KHWANCHUEA, Sasithorn THANAPOP, Suchittra SAMUHASANEETO, Suree CHARTWAINGAM and Sirirak MUKEM

School of Medicine, Walailak University, Nakhon Si Thammarat 80161, Thailand

(Corresponding author; e-mail: krapheep@wu.ac.th)

Received: 23 January 2012, Revised: 17 May 2012, Accepted: 16 August 2012

Abstract

To assess bone mineral density (BMD) and explore lifestyle factors affecting BMD in 310 staff of Walailak University aged 25 - 45 years (men = 23.23 % and women 76.77 %). BMD was evaluated by Quantitative ultrasound (QUS) analysis at the left distal-third radius. Anthropometric data including body mass index (BMI) and waist circumferences (WC) were measured, and lifestyle behaviors were also explored using the questionnaire. BMD status of both men and women showed similar results, 14.84 and 0.97 % of both genders were determined to have osteopenia and osteoporosis, respectively. Important data demonstrated the highest numbers of younger women aged 25 - 30 with osteopenia (30.61 %). Anthropometric results showed that 44.83 % of all subjects represented abnormal BMI (BMI < 18.5 and BMI ≥ 23), and percentages of the men who had BMI more than 23 (51.39 %) were larger than those of the women (30.67 %). In contrast, only 26.45 % of both genders demonstrated abnormal WC, and the numbers for women were higher. Descriptive data of beverage consumption showed that most of men and women subjects had caffeine and carbonated beverage intakes less than 7 cups per week (73.61 and 87.82 %) and less than 3 cups per week (95.83 and 97.06 %) respectively, whereas only 9.72 and 26.89 % of men and women consumed more than 3 packs of milk per week. Results of lifestyle behaviors showed that almost all subjects preferred exercise, but only 47.22 and 31.09 % of men and women exercises 3 or more times per week. The multivariate analysis showed that BMD status is significantly associated with age group and BMI (OR = 3.30, CI, 1.086 – 6.3747 and OR = 0.43, CI, 0.2697 – 0.9805, respectively) after adjusting for age and gender. Normal BMI and older age group are the potential determinants, and other risk factors such as caffeine and carbonated beverages are sufficient concerns in adults.

Keywords: Body mass index, bone mineral density, lifestyle behaviors, osteoporosis

Introduction

Osteoporosis is a major public health concern. It is a systematic skeletal disease characterized by a reduced bone mass and a microarchitectural deterioration of bone tissue. Both characteristics lead to bone fragility which increases risk of bone fractures, especially fractures of the hip, spine and wrist. Osteoporosis occurs in both men and women with advancing age affecting up to 1 in 2 women and 1 in 5 men over the age of 50 years [1]. In Thailand, prevalence of osteoporosis was reported among women and men; they were 19.8 % at the lumbar spine of women [2], and 12.6 % at the femoral neck of men [3]. In young healthy Thai adults (20 - 40 years), the prevalence of osteopenia and osteoporosis in both sexes were 12.56 - 17.74 % and 0.62 - 1.04 %, respectively [4]. Osteoporosis is of increasing social and economic importance as the size of the aging population continues to grow. It is therefore projected that the magnitude of the problem may be even larger in developing countries, including in Thailand [5].

Bone mass is the weight of bone substance per unit of external volume. It is directly dependent upon both its volume or size and the density of the mineralized tissue contained within the bone. Approximately 50 - 70 % of bone content is minerals (mostly hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$]), therefore bone mass is also called bone density or bone mineral density (BMD). Bone mass represents the strength of bones that is usually determined by the amount of calcium and phosphorus that a specific bone contains. The World Health Organization's (WHO) definition of osteoporosis references the mean peak bone mass (PBM) observed in women aged 20 - 45. Osteoporosis is defined by the "T-score," which is the number of standard deviations (SDs) from the mean BMD in young adult women. When T-score at any site is less than −2.5 or lower Osteoporosis is present, whereas Osteopenia is defined as a T-score less than -1 and more than −2.5 [6]. As explained, the physiology of bone, bone formation is predominant during the first ten years of human growth. During the second to approximately the fourth decade of life, the processes of formation and resorption are in balance and PBM is reached. PBM is attained between the age of 20 - 25 and levels remain relatively static until the age of 45 when bone density starts to fall [7]. Then, resorption slightly exceeds formation at about the beginning of the fifth decade of life, resulting in a net negative balance, consequently accelerating bone loss.

It is widely known that several factors are related to variation in bone mass. Most of them that affect accumulation and maintenance of bone mass are genetic factors, PBM, balanced nutrition, physical activity, and lifestyle risk factors (such as caffeine and carbonated beverage intakes, smoking, and alcohol consumption) [1]. Moreover, anthropometric data (body weight and body mass index or BMI) are related factors that contribute to the variability in total bone mass. Two studies have reported that high BMD is closely associated with elevated BMI in women [8], and obesity significantly decreases the risk for osteoporosis but did not decrease the risk for osteopenia [9]. Whilst another study concluded that increased central body fat had a negative association with BMD [10]. In addition, increased physical activity is associated with an increase in BMD and a concomitant decrease in BMI [11].

Therefore, our study aimed to primarily assess bone mineral density (BMD) using Quantitative Ultrasound (QUS) analysis, and to explore lifestyle behaviors that may relate to bone mass. Furthermore, the results obtained will be applied to determine and promote bone health in adult staff of the university, and importantly to prevent osteoporosis in later life.

Materials and methods

Subjects

This is a cross-sectional survey study. The population of the study is 620 university staff. Staff with postmenopausal, pregnancy and chronic diseases was excluded from this study. We recruited only 310 men and women staff (50.00 %) who were 25 - 45 years old, and volunteers. The subjects were grouped by age 25 - 30 years (n = 75; 26 men and 49 women), and 31 - 45 years (n = 235; 46 men and 189 women). We collected the personal information using a self-administered questionnaire. Anthropometric data and BMD were assessed by the researcher. The study protocol was approved by the Ethics Committee in Human Experimentation of Walailak University, and all the participants gave their written informed consent.

Measurement of bone mineral density (BMD)

Bone mineral density was evaluated using a new Quantitative Ultrasound (QUS) prototype, the Omnisense developed by Sunlight (multi-sites bone sonometer, Sunlight Omnisense® 7000S). The speed of sound (SOS) was recorded at the left distal-third radius. The average value of SOS was calculated and then automatically compared to a selectable built-in Asian reference database. The Omnisense results are expressed as T-scores that are compatible with World Health Organization criteria for osteoporosis diagnosis [12]. "T-score" is the number of the standard deviations (SDs) from the mean BMD in young adult women. The T-score values were used in this study to determine the BMD status of the subjects; normal BMD, osteopenia, and osteoporosis. A normal BMD is indicated when the T-score value is equal to or more than −1.00. Osteopenia is defined as a T-score less than −1 and more than −2.5, whereas osteoporosis is defined as a T-score less than −2.5. However, if the value of T-score at the left distal-third radius indicated osteoporosis, it would be confirmed by re-measurement at another site of the medial tibia.

Anthropometric measurement and lifestyle assessment

Anthropometric data, body weight (kg) and height (m) were measured with a balance-beam scale and a stationary vertical height board. Body mass index or BMI (kg/m^2) was calculated as weight (kg) divided by height squared (m^2). Each was classified into five groups according to their BMI based on WHO Asian BMI classifications which are (1) < 18.5 kg/m^2: underweight; (2) 18.5 to < 23 kg/m^2: normal-weight; (3) 23 to < 27.5 kg/m^2: pre-obese; and (4) ≥ 27.5 kg/m^2: obese [13]. Waist circumference or WC (cm) was measured at the minimum circumference between the iliac crest and the rib cage. Using Asian reference [14,15], WC ≤ 90 cm in men and WC ≤ 80 cm in women are categorized as a normal WC.

The questionnaire assessed for five components of lifestyle behaviors: exercise, beverage consumption, diary food intake, smoking and genetic bone diseases. Each component was asked for yes or no, if yes data would be future collected for details, type and frequency (regularity or irregularity by indicating times per week or per month). Data for exercise, beverage consumption and diary food intake were assessed over the six month collection periods. For beverage consumption, it was subdivided into the topics of (1) tea or coffee (caffeine contained beverages), (2) alcohol beverages (alcohol, beer or wine), (3) carbonated sugary beverages (such as cola beverages) or other soft drinks, and (4) milk intake. In addition, data for other supplements (such as high calcium diets or drugs) were also collected. Quantity of the beverage intake was categorized according to an average unit of consumption; cups or packs per week or per month. For milk intake, two groups of the subjects were assigned as low (less than average) and normal (equal or more than average). The subjects with coffee/tea or soft drink intake were divided into the groups of normal (less than average) and high (equal or more than average).

Statistical analysis

The normal distribution of data was explored before using the parametric statistics calculation. Firstly, descriptive statistics was indicated by mean, standard deviation (SD) and frequency of the sample characteristics and behaviors. Then Pearson's Chi-square and Fisher's Exact test were calculated in order to explore the association of BMD status and potential risk factors (anthropometric and life style characteristics) in crude analysis. Finally, simple logistic regression analysis was employed to estimate the odds ratio and 95 % confidence interval among BMD status and all potential risk factors with *p-value* less than 0.1 in crude analysis which was stratified by gender and age group. Statistical analyses were performed using R program version 2.11.0 and Package Epicalc [16].

Results

Bone mineral density

Table 1 shows the BMD status of 310 subjects who were categorized by gender and age [men (25 - 30 years = 26 and 31 - 45 years = 46) and women (25 - 30 years = 49 and 31 - 45 years = 189)]. BMD was assessed by the new Quantitative Ultrasound (QUS) prototype (the Omnisense) at the left distal-third radius. The average value of SOS was compared to the Asian reference database, and its result was expressed as a "T-score" value to indicate BMD status of the subject. After measurement of BMD, the subjects were divided into 3 groups according to their BMD status: normal BMD (T-score ≥ −1.00) and low BMD, osteopenia (−1.00 > T-score ≥ −2.5) and osteoporosis (T-score < −2.5). Data in **Table 1** show similar results in both genders. More than 80 % of both men and women subjects have a normal BMD, 14.84 and 0.97 % of all subjects were found to have osteopenia and osteoporosis, respectively. However, the data concerned in the women aged 25 - 30 years indicated the highest proportion of osteopenia (30.61 %).

Table 1 Assessment of BMD status at the left distal-third radius using the Omnisense Sunlight Omnisense® 7000S in 310 subjects in Walailak University.

BMD Status (T-score)		Number of subjects (%)				
		Men (n = 72)		Women (n = 238)		Total
		25 - 30 years	31 - 45 years	25 - 30 years	31 - 45 years	
Normal BMD	Normal to high (T-score ≥ −1.0)	20(76.92)	38(82.61)	33(67.35)	170(89.95)	**261(84.19)**
		58(80.56)		203(85.29)		
Low BMD	Osteopenia (−1.0 > T-score ≥ −2.5)	6(23.08)	7(15.22)	15(30.61)	18(9.52)	**46(14.84)**
		13(18.06)		33(13.87)		
	Osteoporosis (T-score < −2.5)	0(0.00)	1(2.17)	1(2.04)	1(0.53)	**3(0.97)**
		1(1.39)		2(0.84)		
Total		**26(100)**	**46(100)**	**49(100)**	**189(100)**	**310(100)**
		72(100)		**238(100)**		

Anthropometric data (Body mass index and Waist circumference)

The anthropometric data was demonstrated by BMI and WC (**Table 2**). Comparing the BMI status, the ratio of the women subjects who represented a normal weight (59.24 % of all women) was more than that of the men (41.67 % of all men). The numbers of men with BMI more than 23 (pre-obese and obese) were 2 times larger than those of the women. The numbers of two women aged groups in each BMI status were similar, except numbers of the younger women in the underweight group was twice as high. Data for the men were not different from those of the women. However, the proportion of the older men with obesity (13.04 %) was higher than that of younger men (7.69 %) and those of the two age groups among the women (4.88 and 6.88 %).

Table 2 Anthropometric data: body mass index (BMI, kg/m^2) and waist circumference (WC, cm) of 310 subjects in Walailak University.

Anthropometric characteristics	Number of subjects (%)				
	Men (n = 72)		Women (n = 238)		Total
	Group 1 25 - 30 years	Group 2 31 - 45 years	Group 1 25 - 30 years	Group 2 31 - 45 years	
1. Body mass index: BMI (kg/m^2)					
< 18.5 (underweight)	4(15.38)	1(2.17)	8(16.33)	16(8.47)	**29(9.35)**
18.5 – < 23 (normal weight)	11(42.31)	19(41.30)	27(55.10)	114(60.32)	**171(55.16)**
23 – < 27.5 (pre-obese)	9(34.62)	20(43.48)	12(24.49)	46(24.34)	**87(28.06)**
≥ 27.5 (obese)	2(7.69)	6(13.04)	2(4.08)	13(6.88)	**23(7.42)**
Total	**26(100)**	**46(100)**	**49(100)**	**189(100)**	**310(100)**
2. Waist circumference; WC (cm)					
Normal:					
- WC ≤ 90 cm	22(84.62)	38(82.61)			
- WC ≤ 80 cm			33(67.35)	135(71.43)	
Total					**228(73.54)**
Abnormal					
- WC > 90 cm	4(15.38)	8(17.39)			
- WC > 80 cm			16(32.65)	54(28.57)	
Total					**82(26.45)**
Total	**26(100)**	**46(100)**	**49(100)**	**189(100)**	**310(100)**

Waist circumference (WC) was also recorded. The numbers of the subjects with normal and abnormal WC of both aged groups in men and women were not different. Although most of staff represented a normal WC, the proportion of men (more than 80 %) was higher than those of women (67 - 71 %) in both age groups. Numbers of the men with a WC over normal were less than those of the women. This result does not parallel the data of BMI that numbers of the men with higher BMI were greater.

We regrouped five BMI groups into two groups, normal BMI and the rest of abnormal BMI to explore association of the anthropometric factors and the BMD status (**Table 3**). The number of subjects in a group of normal BMI that represented a normal BMD (94.64 %) was more than that in the group of abnormal BMI (88.03 %). Data of WC show that numbers of the subjects in the groups of normal WC and abnormal WC that represented low and normal BMD were not different. The crude association analysis of two anthropometric factors (BMI and WC), and BMD status demonstrated weak association of abnormal BMI (low weight and overweight) and normal BMD status (OR = 1.08, *p-value* = 0.04). However, there was no association among waist circumference and BMD status (*p-value* = 0.6).

Table 3 Crude association analysis of anthropometric factors (BMI and WC) and BMD status of 310 subjects in Walailak University.

Anthropometric factors	BMD status		*p-value*
	Staff number (%) of low BMD	**Staff number (%) of normal BMD**	
1. Body mass index (BMI)			
Normal	9(5.36)	159(94.64)	0.04
Abnormal	17(11.97)	125(88.03)	
2. Waist circumference (WC)			
Normal	18(7.89)	210(92.11)	0.60
Abnormal	8(9.76)	74(90.24)	

Lifestyle characteristics

Data from **Table 4** shows that most of the men and women had a milk intake less than 3 packs per week, at the same time 30.56 % of men and 40.76 % of women preferred consumption of a hi-calcium supplementary. Most subjects did not consume coffee or tea more than a cup daily (73.61 % of men and 87.82 % of women). Carbonated-contained beverages were not popular soft drinks in these subjects because approximately 95 - 97 % consumed them only less than 3 cups per week. Drinking alcohol and smoking was not defined in both genders, although 43.06 and 18.06 % of men drinking alcohol and smoking respectively accepted a little intake. However, although most subjects favored exercise, the number of women subjects in the low exercise group (< 3 times per week) was large (68.91 %). The parallel percentage of men did exercises with low and normal intensity (52.78 and 47.22 %).

The analysis of crude association of lifestyle characteristics demonstrated that there was no association of all lifestyle characteristics to BMD status. However, we indicate that both caffeine-contained beverage intake and milk intake are potential determinants of BMD (*p-value* $\leq$ 0.2) (**Table 5**).

Table 4 Lifestyle characteristics of 310 subjects in Walailak University.

Lifestyle characteristics		**Number of subjects (%)**		
		Group 1 25 - 30 years	**Group 2 31 - 45 years**	**Total**
Milk intake	**Men**			
	Low (< 3 packs/week)	22(84.62)	43(93.48)	65(90.28)
	Normal (≥ 3 packs/week)	4(15.38)	3(6.52)	7(9.72)
	Total	26(100)	46(100)	72(100)
	Women			
	Low (< 3 packs/week)	39(79.59)	135(71.43)	174(73.11)
	Normal (≥ 3 packs/week)	10(20.41)	54(28.57)	64(26.89)
	Total	49(100)	189(100)	238(100)
Coffee/tea intake	**Men**			
	Normal (≤ 7 cups/week)	22(84.62)	31(67.39)	53(73.61)
	High (> 7 cups/week)	4 (15.38)	15(32.61)	19(26.39)
	Total	26(100)	46(100)	72(100)
	Women			
	Normal (≤ 7 cups/week)	44(89.80)	165(87.30)	209(87.82)
	High (> 7 cups/week)	5(10.20)	24(12.70)	29(12.18)
	Total	49(100)	189(100)	238(100)
Carbonated beverage intake	**Men**			
	Normal (< 3 cups/week)	24(92.31)	45(97.83)	69(95.83)
	High (≥ 3 cups/week)	2(7.69)	1(2.17)	3(4.17)
	Total	26(100)	46(100)	72(100)
	Women			
	Normal (< 3 cups/week)	46(93.88)	185(97.88)	231(97.06)
	High (≥ 3 cups/week)	3(6.12)	4(2.12)	7(2.94)
	Total	49(100)	189(100)	238(100)
Alcohol beverage intake	**Men**			
	No	12(46.15)	29(63.04)	41(56.94)
	Yes	14(53.85)	17(36.96)	31(43.06)
	Total	26(100)	46(100)	72(100)
	Women			
	No	42(85.71)	178(94.18)	220(92.44)
	Yes	7(14.29)	11(5.82)	18(7.56)
	Total	49(100)	189(100)	238(100)
Supplement/ hi-calcium drug intake	**Men**			
	No	20(76.92)	30(65.22)	50(69.44)
	Yes	6(23.08)	16(34.78)	22(30.56)
	Total	26(100)	46(100)	72(100)
	Women			
	No	34(69.39)	107(56.61)	141(59.24)
	Yes	15(30.61)	82(43.39)	97(40.76)
	Total	49(100)	189(100)	238(100)
Exercise	**Men**			
	Low (< 3 times/week)	14(53.85)	24(52.17)	38(52.78)
	Normal (≥ 3 times/week)	12(46.15)	22(47.83)	34(47.22)
	Total	26(100)	46(100)	72(100)

	Women			
	Low (< 3 times/week)	38(77.55)	126(66.67)	164(68.91)
	Normal (≥ 3 times/week)	11(22.45)	63(33.33)	74(31.09)
	Total	49(100)	189(100)	238(100)
Smoking status	**Men**			
	No	21(80.77)	38(82.61)	59(81.94)
	Yes	5(19.23)	8(17.39)	13(18.06)
	Total	25(100)	46(100)	(100)
	Women			
	No	49(100.00)	186(98.41)	235(98.74)
	Yes	0(0.00)	3(1.59)	3(1.26)
	Total	49(100)	189(100)	238(100)

Table 5 Crude analysis of association between BMD status and lifestyle determinants of 310 subjects in Walailak University.

Determinants	BMD status		*p-value*
	Abnormal (%)	Normal to high (%)	
1. Caffeine			
High (> 7 cups/week)	7(14.58)	41(85.42)	0.09
Normal (≤ 7 cups/week)	19(7.25)	243(92.75)	
2. Soft drink			
Normal (≤ 3 cups/week)	26(8.67)	274(91.33)	0.41
High (> 3 cups/week)	0(0)	10(100)	
3. Milk intake			
Low (< 3 packs/week)	10(13.51)	64(86.49)	0.067
Normal to high (≥ 3 packs/week)	16(6.78)	220(93.22)	
4. Exercise			
Low (< 3 times/week)	18(8.91)	184(91.09)	0.649
Normal to high (≥ 3 times/week)	8(7.41)	100(92.59)	

Level of significance is 0.05

Final analysis of potential determinants

The final analysis of the potential determinants (BMI status, milk intake and caffeine-containing beverage intake) and BMD status was examined using Simple Logistic Regression analysis with gender and age group adjustment. The analysis model showed that the age group and BMI status are significantly associated to BMD status (OR = 3.30, CI, 1.086 – 6.3747 and OR = 0.43, CI, 0.2697 – 0.9805, respectively) (**Table 6**).

Table 6 Association between BMD status and potential risk factors of 310 subjects in Walailak University.

BMD status	ODDs Ratio*	95 % Confidence interval
1. Gender	0.95	0.4892 - 2.1429
2. Age group	3.30	1.086 - 6.3747
3. BMI	0.43	0.2697 - 0.9805
4. Milk intake	1.07	0.3803 - 3.0120
5. Caffeine intake	0.49	0.1886 - 1.2479

* Adjusted for age group, sex
Level of significance is 0.05

Discussion

In this study, we conducted a first assessment for BMD status of 310 staff at Walailak University in both genders aged 25 - 45 years. Staff with postmenopausal, pregnancy or chronic diseases was excluded from the study. Data representing their anthropometric (BMI and WC) and lifestyle characteristics were collected to evaluate correlation between those and BMD status. The subjects were categorized by gender and age. Two age groups (25 - 30 and 31 - 45 years) were divided according to bone physiology. Although, the WHO definition of osteoporosis references the mean PBM observed in women aged 20 - 45 [6], it was revealed that Asian PBM at the total femur, lumbar spine and hip was achieved approximately between 25 - 30 years of age [17-19]. However, in this study, most descriptive data of both age groups are quite similar, but some details are important for consideration in the group of young subjects that will be explained later.

The BMD status of all subjects was assessed using QUS analysis at the site of left distal-third radius. Although, the QUS is not a gold standard instrument for diagnosis of osteoporosis, there is a growing interest in the use of QUS measurements as an alternative to current radiation-based bone densitometry techniques for a non-invasive assessment of fracture risk. QUS was significantly correlated with BMD and has shown r-values between 0.6 and 0.9 in site-specific measurements, and it reflected mainly BMD and assessed bone status at different anatomical sites [20,21]. Speed of sound (SOS) measurements by QUS at the radius could discriminate vertebral fracture patients from controls therefore the SOS measurements in the radius might have a useful diagnostic role [22]. A recent report also accepted that QUS was a simple and effective clinical tool for identifying women at increased risk of fractures and could facilitate the appropriate and more cost-effective use of bone densitometry to prevent osteoporotic fractures [23]. In this study, bone status was classified into 3 groups according to Omnisense Asian reference database [12]; normal BMD (T-score ≥ −1), osteopenia (−1 > T-score ≥ −2.5) and osteoporosis (T-score < −2.5). Our data showed that the numbers of subjects in both age groups of each BMD status were not much different, except numbers for the subjects aged 25 - 30 years who indicated low BMD or osteopenia more than those of the older age groups (23.08 % of men and 30.61 % of women). It is possible that the younger women may have risk factors of BMD more than older women. However, the total numbers of subjects in both younger and older women were different by approximately four times, and thus comparisons may be not analytical. Anthropometric and lifestyle characteristics of both groups would be compared and associated to BMD status to explain these results. When crudely compared, data for BMI and WC of both age groups were not much different, except the number of younger subjects who were underweight which was lower than that of the older subjects. Lifestyle characteristics of both age groups were similar, but some data showed that the younger groups had less milk and calcium supplementary intake, and less exercise when compared to those of the older groups. It is widely known that both lack of exercise and dietary calcium deficiency have been implicated in causation of a reduced bone density. Theoretically, adolescents and young adults whose bones exhibit rapid growth and their bone mass should reach a maximum, but recent evidence revealed that these age groups have an increased sweetened beverage consumption and decreased milk consumption that were associated with low bone density as young adults [24,25]. Articles reviewed that the development of osteoporosis results from an interaction between 1) bone mass accrual via growth, remodeling, and modeling during childhood and adolescence and 2) the maintenance of bone mass (primarily via remodeling) during adulthood [26]. Although, our data about lifestyle behaviors of young adults do not indicate determinants of low bone mass, it is a concern which if remedied may prevent osteoporosis in later life. However, when considering the BMD status of all subjects, we found that 14.84 and 0.97 % had osteopenia and osteoporosis respectively. The BMD status of all groups would be correlated to promoting and risk factors of bone mass later.

Anthropometric measures such as BMI and WC are widely used as convenient indices of adiposity. Both BMI and WC were assessed to indicate the anthropometric factors of BMD. Our results showed numbers of normal BMI subjects and the rest of abnormal BMI (low weight and overweight) were nearly the same. The male group tends to have more weight in advancing years than the female group. The younger groups have more underweight individuals than the older groups, especially younger women. Our data demonstrated that the numbers of normal BMI subjects who represented a normal BMD were larger than those of the abnormal BMI subjects, and crude association analysis showed weak association of abnormal BMI and normal BMD status (**Table 3**). This association indicated BMI was a factor determining BMD; normal BMI represented a positive determinant of BMD, whereas abnormal BMI (low and over BMI) were probably a negative determinant. This prediction relates to previous reports which concluded that body mass was a factor affecting bone accretion, and body weight was considered a strong predictor of BMD [27]. Although it is widely known that high BW or high BMI relates to high bone mass that is not the case in our data, there are prior reports indicated a high percentage body fat and WC were related to low BMD and a vertebral fracture [28], and obesity significantly decreased the risk for osteoporosis but did not decrease the risk for osteopenia [29]. Moreover, a recent study reported that fat mass was not beneficial to bone in adolescents and young adults [30]. In addition, Guney *et al*. [31] showed supportive results that low BMI was associated with low BMD and fractures.

WC data showed that the men had a greater number of normal WC than the women. This result does not parallel the BMI data where numbers of the male subjects with over BMI were large. Moreover, crude association analysis also indicated no association among WC and BMD status (*p-value* = 0.6). Although Flegal *et al*. [32] concluded that BMI and WC performed similarly as indicators of body fatness and were more closely related to each other than with percentage body fat, our results do not support this assertion. It may suggest that over BMI in men results from weight of fat mass and lean mass but not the central fat. A previous report showed that bone density is closely related to fat mass in premenopausal women, but less so in men [33]. Even though our study did not measure fat mass, this reason related to fat mass may possibly describe our results.

In addition to the anthropometric factors, lifestyle factors such as caffeine, carbonated and alcohol beverages, diary food intake, and exercise were also assessed in this study. Although most of our subjects preferred less consumption of caffeine and carbonated beverages, and less milk intake, crude association analysis showed that the consumption of caffeine-containing beverages and milk intake were variables to the potential determinants of BMD (*p-value* ≤ 0.2). This analysis relates to previous studies which reported that coffee or caffeine intake was a risk factor for bone fracture depending on the level of milk intake, and this affected only individuals with low calcium intakes [34]. Having large amounts of caffeine about two to three cups' worth of coffee may interfere with the calcium absorption of intestine, and drinking 330 mg of caffeine, or about four cups of coffee every day, increases the risk of broken bones according to the National Osteoporosis Foundation (NOF) [35]. Heaney [36] reviewed the negative effect of caffeine on calcium absorption is small enough to be fully offset by as little as 1 - 2 tablespoons of milk, and NOF [35] recommends that, to maintain bone health, adults under age 50 get 1,000 mg of calcium every day, and adults age 50 and older get 1,200 mg of calcium every day. Furthermore, Conlisk and Galuska [37] revealed that for every 100 mg of caffeine consumed, femoral neck BMD decreased 0.0069 g/cm^2 and lumbar spine BMD decreased 0.0119 g/cm^2 in healthy white women, age 19 - 26 years. However, these findings should be performed to protect low bone mass resulting from excess caffeine intake. Besides caffeine beverages, it has been widely reported that consumption of carbonated beverages has a negative effect on bone mineral accrual with poor calcium intakes. Low calcium intake among children and adolescents increased their risk of osteoporosis in later life [38,39]. Although, most our subjects had less caffeine and carbonated beverages (soft drinks), both factors should be a concern for young adults to maintain and to promote bone health during old age.

As mentioned above, the negative effects of caffeine or carbonated beverages on bone could be replaced by milk intake. Why is that? Milk provides nutrients such as calcium, vitamin A, phosphorus, vitamin C which are important for bone development. Intervention and cross-sectional studies have reported a positive effect of calcium on bone mass in children, adolescents, adults and elderly [40]. Calcium is present in milk in relatively high levels such that 200 mL milk (a typical serving size) would provide about 22 % of the current US daily standard [41]. Among nutritional factors, calcium intake has been found to have a significant positive effect on bone mass in premenopausal women [42,43]. Our current study found that almost more than 90 % of subjects had milk intake less than 3 packs per week whilst nearly a half of the women preferred having some supplement or hi-calcium drugs. The tendency of consumption increased with advancing age. A recent study by Kalkwarf *et al*. [44] suggested that the protective bone mass collection behavior is an important role in premenopausal women if they did not obtain sufficient calcium diet during maximal peak bone mass. In our study, particularly the young subjects should increase their consumption of milk or high calcium diets to promote bone health and to prevent osteoporosis during aging.

The final important factor which was recorded in this study is the type and frequency of exercise. Although our association analysis between exercise and BMD status did not represent a potential correlation, many studies have concluded that regular exercise can improve bone mineral status and neuromuscular competency depending on intensity, frequency and duration of exercise [45].

However, in addition to the potential determinants of BMD status including BMI status, milk intake and caffeine beverage intake that are discussed above, final analysis of this study showed that age group and BMI status were significantly associated to BMD (**Table 6**). The older group tends to have a normal BMD status, whilst the younger group risk to a low BMD. It is possible that the young age group has little concern of the health promotion activities such as consumption and exercise behavior, particularly in women. Most of our volunteer subjects were a group of the women aged 31 - 45 (61 % of all subjects) who have good realization of the factors needed to maintain health. As mentioned above, young women subjects had more risk of lifestyle behaviors, less exercise and less consumption of milk and hi-calcium diets, than those of the older group. Therefore, this age group has a lower BMD than other age groups. However, in men, lifestyle behaviors of young and old ages were not much different.

Conclusions

Our study represented descriptive data of BMD status, anthropometric data and lifestyle characteristics of adults who worked as university officers. Although, most of our subjects represented normal bone health and normal BMI, some of them, particularly the young age group, were still exposed to risk factors of bone loss. BMI was the potential determinants of bone health. Other risk factors such as less milk consumption, more caffeine and carbonated beverages are also a concern. For further reports, we will reveal data of the factors associated with BMD in adolescents of Walailak University in order to find out osteoporosis preventive strategy in elderly life.

Acknowledgements

This research has been financially supported by the Institute of Research and Development, Walailak University under the contract WU 53108. We would like to sincerely thank all participant staff of Walailak University for their cooperation, and also deeply thank the dean and all staff of School of Medicine for their support and encouragement.

References

[1] F Bonura. Prevention, screening and management of osteoporosis: An overview of the current strategies. *Postgrad. Med*. 2009; **121**, 5-17.

[2] KK Limpaphayom, N Taechakraichana, U Jaisamrarn, S Bunyavejchevin, S Chaikittisilpa, M Poshyachinda, C Taechamahachai, P Havanond, Y Onthuam, P Lumbiganon and P Kamolratanakul. Prevalence of osteopenia and osteoporosis in Thai women. *Menopause* 2001; **8**, 65-9.

[3] C Pongchaiyakul, C Apinyanurag, S Soontrapa, S Soontrapa, C Pongchaiyakul, TV Nguyen and R Rajatanavin. Prevalence of osteoporosis in Thai men. *J. Med. Assoc. Thai*. 2006; **89**, 160-9.

[4] W Trivitayaratana and P Trivitayaratana. Peripheral BMD T-scores in the diagnosis of osteoporosis. *J. Med. Assoc. Thai*. 2005; **88**, S8-12.

[5] R Handa, AA Kalla and G Maalouf. Osteoporosis in developing countries. *Best Pract. Res. Cl. Rh.* 2008; **22**, 693-708.

[6] World Health Organization. WHO scientific group on the assessment of osteoporosis at primary health care level. Summary Meeting Report Brussels, Belgium, 5-7 May 2004. Available at http://www.who.int/chp/topics/Osteoporosis.pdf, accessed December 2011.

[7] SH Ralston. *Bone Mass through the Lifespan*. *In*: Women's Health Medicine. Elsevier, 2006, p. 145-8.

[8] S Morin and WD Leslie. High bone mineral density is associated with high body mass index. *Osteoporos. Int*. 2009; **20**, 1267-71.

[9] A Andreoli, A Bazzocchi, M Celi, D Lauro, R Sorge, U Tarantino and G Guglielmi. Relationship between body composition, body mass index and bone mineral density in a large population of normal, osteopenic and osteoporotic women. *Radiol. Med.* 2011; **116**, 1115-23.

[10] X Fu, X Ma, H Lu, W He, Z Wang and S Zhu. Associations of fat mass and fat distribution with bone mineral density in pre- and postmenopausal Chinese women. *Osteoporos. Int*. 2011; **22**, 113-9.

[11] L Langsetmo, CL Hitchcock, EJ Kingwell, KS Davison, C Berger, S Forsmo, W Zhou, N Kreiger, JC Prior and The Canadian Multicentre Osteoporosis Study Research Group. Physical activity, body mass index and bone mineral density-associations in a prospective population-based cohort of women and men: The Canadian Multicentre Osteoporosis Study (CaMos). *Bone* 2012; **50**, 401-8.

[12] OMNISENSE 7000S: with parts & labor warranty plus free add-ons, Available at: http://www.bonedensitometry.com /specials/Omnisense_7000S.htm, accessed May 2012.

[13] HL Wee, YB Cheung, WC Loke, CB Tan, MH Chow, SC Li, KY Fong, D Feeny, D Machin, N Luo and J Thumboo. The association of body mass index with health-related quality of life: An exploratory study in a multiethnic Asian population. *Value in Health* 2008; **11**, S105-14.

[14] A Misra, JS Wasir, and NK Vikram. Review article: Waist circumference criteria for the diagnosis of abdominal obesity are not applicable uniformly to all populations and ethnic groups. *Nutrition* 2005; **21**, 969−76.

[15] W Aekplakorn, V Kosulwat and P Suriyawongpaisal. Obesity indices and cardiovascular risk factors in Thai adults. *Int. J. Obesity*. 2006; **30**, 1782-90.

[16] V Chongsuvivatwong. Analysis of epidemiological data using R and Epicalc. Research Training Special Programme for Research and Training in Tropical Diseases (TDR). World Health Organization, 2007.

[17] VK Shivane, V Sarathi, AR Lila, T Bandgar, SR Joshi, PS Menon and NS Shah. Peak bone mineral density and its determinants in an Asian Indian population. *J. Clin. Densitom*. 2012; **15**, 152-8.

[18] HT Nguyen, B von Schoultz, DM Pham, DB Nguyen, Le QH, DV Nguyen, AL Hirschberg and TV Nguyen. Peak bone mineral density in Vietnamese women. *Arch. Osteoporos*. 2009; **4**, 9-15.

[19] C Pongchaiyakul, TV Nguyen, C Foocharoen and R Rajatanavin. Estimated volumetric bone mineral density in a rural Thai men and

women: Khon Kaen Osteoporosis Study (KKOS). *J. Med. Assoc. Thai*. 2005; **88**, S46-52.
[20] SH Prins, HL Jørgensen, LV Jørgensen and C Hassager. The role of quantitative ultrasound in the assessment of bone: a review. *Clin. Physiol*. 1998; **18**, 3-7.
[21] CF Njeh, I Saeed, M Grigorian, DL Kendler, B Fan, J Shepherd, M McClung, WM Drake and HK Genant. Assessment of bone status using speed of sound at multiple anatomical sites. *Ultrasound Med. Biol*. 2001; **27**, 1337-45.
[22] KM Knapp, GM Blake, I Fogelman and TD Spector. Multiple site ultrasound measurements predict vertebral fractures in postmenopausal women. *In*: Proceeding of the ASBMR 21st Annual Meeting, St. Louis, USA. 1999.
[23] B Tao, JM Liu, XY Li, JG Wang, WQ Wang and G Ning. An assessment of the use of quantitative ultrasound and the Osteoporosis Self-Assessment Tool for Asians in determining the risk of nonvertebral fracture in postmenopausal Chinese women. *J. Bone Miner. Metab*. 2008; **26**, 60-5.
[24] SJ Whiting, H Vatanparast, A Baxter-Jones, RA Faulkner, R Mirwald and DA Bailey. Factors that affect bone mineral accrual in the adolescent growth spurt. *J. Nutr.* 2004; **134**, 696S-700S.
[25] SJ Nielsen and BM Popkin. Changes in beverage intake between 1977 and 2001. *Am. J. Prev. Med*. 2004; **27**, 205-10.
[26] MK Rizer. Osteoporosis. *Prim. Care. Clin. Office Pract*. 2006; **33**, 943-51.
[27] C Elgan and B Fridlund. Bone mineral density in relation to body mass index among young women: A prospective cohort study. *Int. J. Nurs. Stud*. 2006; **43**, 663-72.
[28] KC Kim, DH Shin, SY Lee, JA Im and DC Lee. Relation between obesity and bone mineral density and vertebral fractures in Korean postmenopausal women. *Yonsei. Med*. 2010; **J51**, 857-63.
[29] A Andreoli, A Bazzocchi, M Celi, D Lauro, R Sorge, U Tarantino and G Guglielmi. Relationship between body composition, body mass index and bone mineral density in a large population of normal, osteopenic and osteoporotic women. *Radiol. Med.* 2011; **116**, 1115-23.
[30] A Janicka, TAL Wren, MM Sanchez, F Dorey, PS Kim, SD Mittelman and V Gilsanz. Fat mass is not beneficial to bone in adolescents and young adults. *J. Clin. Endocrinol. Metab*. 2007; **92**, 143-7.
[31] E Guney, G Kisakol, G Ozgen, C Yilmaz, R Yilmaz and T Kabalak. Effect of weight loss on bone metabolism: comparison of vertical banded gastroplasty and medical intervention. *Obes. Surg*. 2003; **13**, 383-8.
[32] KM Flegal, JA Shepherd, AC Looker, BI Graubard, LG Borrud, CL Ogden, TB Harris, JE Everhart and N Schenker. Comparisons of percentage body fat, body mass index, waist circumference, and waist-stature ratio in adults. *Am. J. Clin. Nutr*. 2009; **89**, 500-8.
[33] IR Reid, LD Plank and MC Evans. Fat mass is an important determinant of whole body bone density in premenopausal women but not in men. *J. Clin. Endocrinol. Metab.* 1992; **75**, 779-82.
[34] E Barrett-Connor, JC Chang and SL Edelstein. Coffee-associated osteoporosis offset by daily milk consumption. *J. Am. Assoc*. 1994; **271**, 280-3.
[35] National Osteoporosis Foundation: Can soft drinks cause a problem for my bones? 2011, Available at: http://www.nof.org, accessed May 2012.
[36] RP Heaney. Effects of caffeine on bone and the calcium economy. *Food Chem. Toxicol.* 2002; **40**, 1263-70.
[37] AJ Conlisk and DA Galuska. Is caffeine associated with bone mineral density in young adult women? *Prev. Med.* 2000; **31**, 562-8.
[38] SA French, BH Lin and JF Guthrie. National trends in soft drink consumption among children and adolescents age 6 to 17 years: Prevalence, amounts, and sources, 1977/1978 to 1994/1998. *J. Am. Diet. Assoc.* 2003; **103**, 1326-31.
[39] SJ Whiting, A Healey, S Psiuk, R Mirwald, K Kowalski and DA Bailey. Relationship between carbonated and other low nutrient dense beverages and bone mineral content of adolescents. *Nutr. Res.* 2001; **21**, 1107-15.
[40] KD Cashman. Review: Milk minerals (including trace elements) and bone health. *Int. Dairy. J.* 2006; **16**, 1389-98.
[41] Institute of Medicine. *Dietary Reference Intakes: Calcium, Magnesium, Phosphorus,*

Vitamin D, *and Fluoride.* National Academy Press, USA, 1997.
[42] RG Cumming. Calcium intake and bone mass: a quantitative review of the evidence. *Calcif. Tissue Int.* 1990; **47**, 194-201.
[43] DC Welten, HC Kemper, GB Post and WA van Staveren. A meta-analysis of the effect of calcium intake on bone mass in young and middle aged females and males. *J. Nutr.* 1995; **125**, 2802-13.
[44] HJ Kalkwarf, JC Khoury and BP Lanphear. Milk intake during childhood and adolescence, adult bone density, and osteoporotic fractures in US women. *Am. J. Clin. Nutr.* 2003; **77**, 257-65.
[45] CM Snow. Exercise and bone mass in young and premenopausal women. *Bone.* 1996; **18**, Supplement, 51S-5.