The Use of Historical and Anthropometric Data as Risk Factors for Screening of Low mBMD & MCI

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Abstract

To evaluate the risk factors which affect bone loss in screening for osteoporosis, interview of anamnestic data (age, marriage status, pregnancies, menopausal age, intake of calcium, vegetables, protein and coffee, excessive use of alcohol and smoking, sedentary habits, family history), medical data, surgical data, followed by measurement of anthropometric variables [weight, height, antero-posterior (AP) thickness at xiphoid level], blood examination (calcium, inorganic phosphorus, alkaline phosphatase), both postero-anterior (PA) hands and lateral thoraco-lumbar radiography were done in 1,182 normal volunteers aged 17-83. From PA hands radiographs, metacarpal bone mineral density (mBMD) and metacarpal index (MCI) were measured by computed X-ray densitometry (CXD) (Bonalyzer, Teijin Ltd., Tokyo). The results showed that the mean of menopausal age in Thai females was 48.86 ± 3.09 years ranging from 39 to 55 years. The average number of children in their family was 2.10. Correlation among anthropometric variables, AP thickness was positive linear correlation to weight/height ratio (r=0.7878, p-value <0.005). Weight, AP thickness and body mass index (BMI) significantly increased with aging (r=0.2456, 0.4489 and 0.3484, p-value<0.005, 0.001 and <0.005), but decreased with height (r=-0.1030, p-value=0.001). Lower mBMD and MCI were associated with increased age, married female, increased pregnancies, increased AP thickness, decreased vegetable intake, increased protein intake and increased years after menopause. From a multiple regression analysis, the significant factors that can predict the MCI were years after menopause, sex, daily vegetable intake and hormonal replacement. The incidence rate of high risk of developing osteoporosis in females, no vegetable intake and no hormonal replacement subjects occurred 7.50, 2.22 and 2.63 times greater than in males, vegetable intake and hormonal replacement subjects, respectively. In postmenopausal women since 1-2, 3-5, 6-10, 11-15 and >15 years, the incidence rate were 5.24, 14.51, 17.01, 20.86 and 29.76 times greater than the rate of premenopausal women. Concerning perimenopausal women, only 2 of all factors influenced the measured mBMD and MCI. The incidence rate of high risk of developing osteoporosis in women who intake protein >30 g/d and intake medicine (corticosteroid) was 2.96 and 6.16 times greater than <30 g/d protein intake and no medicine intake subjects.

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Bone mass loss and osteoporosis are associated with various conditions. Some studies were able to demonstrate the bone loss in some diseases. Bone loss in rheumatoid arthritis is caused by impaired physical activity which may be related to disease activity[1]. Thyrotoxicosis and hyperparathyroidism affect bone loss by excessive bone resorption. Suppression of osteoblasts occurs with excessive use of corticosteroids[2]. Sex, race, hereditary and life style (cigarette smoking, alcohol consumption,[3,4] inadequate exercise, sedentary habit,[1,5,6] inadequate dietary calcium intake and possibly also excess caffeine intake[7] influence the risk of osteoporosis. In childhood and adolescence periods of osteoporotic patients intake lower calcium than the controls[8]. Rapid bone loss at the start of the menopause is also an important contributing factor to developing osteoporosis[9]. In women, lower BMD at the spine is associated with increased age, decreased weight, smoking and delayed menarche[3]. The BMD of women declined significantly after age 40 especially in postmenopausal women[10-14]. However, the BMD of men does not show a downward trend with age[10,11]. Body composition (height and weight) also affects the risk of developing osteoporosis[15,16]. Excessive height loss reflects low bone mass and may predict osteoporosis-related fractures[17]. Weight over 71 kg is associated with a very low risk of being osteopenic compared with women weighing less than 64 kg[15]. There is a high correlation between AP thickness and weight to height ratio [18]. Moreover, surgical procedures that disturb the hormone level such as ovariectomy, thyroidectomy, gastro-duodenal resection, mastectomy can also affect bone mass loss[19].

Osteoporosis is a significant and growing problem among the elderly. Although therapies exist to treat established disease, preventive measures that maintain bone mass throughout life are preferable[20]. There is a great need for a simple means of identifying persons at low risk of developing osteoporosis, in order to exclude them from screening with bone mineral measurements by dual energy X-ray absorptiometry (DEXA), since this procedure is relatively more expensive and time consuming for general use in the unselected population[15]. The use of questionaires has been proposed as a valuable low cost screening tool in the younger groups[21]. Practically, risk factors are most generally assessed by history of significant concerns about the accuracy of assessment[22] and doubt regarding the ability of this approach to improve the yield from scanning of subjects with low bone density[23,24].

This study addressed the relationship of 18 risk factors, as assessed by questionares and body composition measurements, to mBMD and MCI. The incidence rate of high risk of developing osteoporosis and the relative risk of exposure to these factors were calculated.

MATERIAL AND METHOD

The volunteer group consisted of 1,023 females (18-82 yrs) and 159 males (17-83 yrs), interview of anamnestic data (age, marriage status, pregnancies, menopausal age, intake of calcium, vegetables, protein and cafeine, excessive use of alcohol and smoking, sedentary habits, family history), medical data (medication intake and disease affected bone loss), surgical data, followed by measurement of anthropometric variables (weight, height, AP thickness), blood examination (calcium, inorganic phosphorus, alkaline phosphatase), both PA hands and lateral thoraco-lumbar radiography were done on all subjects. Exclusions included vertebral compression and deformities seen on radiographs. Also subjects who had a history of symptomatic fractures of the hip or vertebra were excluded.

Calcium intake was evaluated by a dietary questionaire of 10 calcium rich foods and subjects were asked to evaluate their average weekly intake of various foods over the last month.

Vegetable intake was assessed by a frequency of daily intake at least 3 table-spoons (45 cc) for 1-2 days, 3-5 days and 6-7 days in a week and scored 0, 1 and 2.

The assessment of protein intake using daily intake >30 g for 1-2, 3-5 days and 6-7 days in a week and scored 0, 1 and 2. In practice, protein intake 30 g equivalent to 10 pieces of thin sliced pork sized 1x1 inch.

Excessive alcohol intake defined as daily consumption, for at least three years, of more than 20 ml of ethanol for women and more than 60 ml of ethanol for men[25].

Smoking was defined using the New Zealand National Heart foundation definition of a smoker as a subject who at any stage had smoked at least one cigarette per day for a period over six months. Current and ex-smokers were defined by pack years[3].

Family history was assessed by the following questions: Does the subject have any blood relative over 45 years of age who has had a fractured wrist, hip or shoulder? A positive response was scored as 1.

The measured mBMD and MCI has been described[11,12]. mBMD was expressed as the thickness of an aluminium equivalent (mm Al) corresponding X-ray absorption. MCI was expressed as the degree of cortical thickness.

The results were analyzed by the statistical package SPSS-PC. Descriptive statistics (mean, standard deviation and range) of variables of 1,182 volunteers were described and student's *t*-test was used to compare the mean of those variables in both sexes. Correlation between mBMD (ΣGS/D), MCI and anthropometric variables, anamnestic data, medical data, surgical data were performed. Differences in means were considered statistically significant if the p-values were <0.05. To evaluate the influence of risk factors on MCI, a multiple regression analysis was used under stepwise regression. For testing the assumption of this multiple regression equation, lack of fit for linearity test, Durbin-watson test for independence of residuals, normality test of residuals by histogram and normal probability plot were done.

In perimenopausal women, the low and high mBMD&MCI groups were identified by using -2 SD of the mean mBMD&MCI in young healthy women (aged 20-40 years) from the previous study as the cutting point[11]. Low mBMD group was defined as women who had mBMD values less than -2SD of the young standards. If the mBMD value was more than -2 SD of the young standards, they were categorized to the high mBMD group. Low and high MCI were defined in the same way but the values of young standards used MCI instead of mBMD. The relative risk of developing osteoporosis was calculated from the ratio of incidence rate of exposing and non-exposing factors.

RESULTS

Table 1 shows the mean, standard deviation and range of various variables of 1,182 volunteers. The average number of children of 730 married samples was 2.10. From exclusion of the surgical menopause conditions, 48.86 years was the mean menopausal age of 258 senile menopause women.

Comparing the means of anthropometric variables between sexes, females had both weight and height less than males (both P-value <0.005). The dietary intake of protein and cafeine was higher in males (p-value=0.008 and <0.005) but calcium intake and vegetable intake were not different in both sexes (p-value=0.202 and 0.417) as shown in Table 2. Weight, AP thickness and BMI significantly increased with aging (r=0.2456, 0.4489 and 0.3484, p-value <0.005, 0.001 and <0.005). However, height decreased with aging (r=-0.1030, p-value=0.001) as shown in Table 3.

Table 1. Descriptive statistics of various variables of 1,182 volunteers and that of variables: children, menopausal age of 730 marriaged, 258 senile menopause samples, respectively.

variable	N	mean	SD	range
age (yrs)	1,182	44.34	12.56	17 - 83
weight (kg)	1,182	57.17	10.24	35.4 - 99.8
height (m)	1,182	1.53	0.14	1.400 - 1.785
AP thickness (cm)	1,182	20.23	2.86	13 - 40
BMI (kg/m^2)	1,182	23.39	4.01	14.08 - 38.21
children	730	2.10	1.48	0 - 8
menopause-age (yrs)	258	48.86	3.09	39 - 55
calcium intake (mg/d)	1,182	398.40	68.02	106 - 895
vegetable intake	1,182	1.64	0.51	0 - 2*
protein intake	1,182	1.58	0.46	0 - 2**
coffee or tea, cafeinated (cup)	1,182	0.64	0.86	0 - 6

* Score 0-2 was described as 0 = average weekly vegetable intake less than 2 days, 1 = average weekly vegetable intake 3-5 days and 2 = average weekly vegetable intake 6-7 days,

** Score 0-2 was described as 0 = no protein intake, 1 = average weekly protein intake less than 30 g/day and 2 = average weekly protein intake more than 30 g/day.

Table 2. Comparison of mean of various variables between female and male.

variable	female (n=1,023) (mean±SD)	male (n=159) (mean±SD)	p-value
age	44.322 ± 12.080	44.465 ± 15.506	< 0.005*
weight	56.051 ± 9.480	64.824 ± 11.926	< 0.005*
height	1.551 ± 0.105	1.674 ± 0.256	< 0.005*
AP thickness	20.021 ± 2.785	21.685 ± 2.972	0.260
BMI	23.375 ± 3.952	23.517 ± 4.393	0.067
calcium intake	402.865 ± 52.619	390.534 ± 78.571	0.202
vegetable intake	1.631 ± 0.493	1.652 ± 0.521	0.417
protein intake	1.566 ± 0.516	1.679 ± 0.495	0.008*
coffee	0.637 ± 0.833	0.691 ± 1.018	< 0.005*

significant at $\alpha = 0.05$

Table 3. Correlation of age to anthropometric variables.

variables	r	p-value
weight	0.2456	<0.005*
height	-0.1030	0.001*
AP thickness	0.4489	0.001*
BMI	0.3484	<0.005*

* significant at $\alpha = 0.05$

The risk factors which had a significant (p-value <0.05) simple rank correlation with mBMD and MCI were age, sex, marriage status, number of pregnancies, AP thickness, daily vegetable intake, daily protein intake and years after menopause as shown in Table 4. Concerning the anamnestic data : age, marriage status, number of pregnancies, daily protein intake and years after menopause had a negative correlation to mBMD and MCI, while daily vegetable intake, hormonal replacement had a positive correlation to both.

Table 4. Correlation of mBMD and MCI to various variables.

variables	mBMD		MCI	
	r	p-value	r	p-value
age	- 0.2768	< 0.005*	- 0.1670	< 0.005*
sex	0.0764	0.011*	- 0.0889	0.003*
marriaged status	- 0.0755	0.012*	- 0.0856	0.004*
pregnancies	- 0.0730	0.015*	- 0.0881	0.003*
weight	0.0153	0.611	- 0.0310	0.303
height	0.0123	0.500	- 0.0300	0.319
AP thickness	- 0.1312	< 0.005*	- 0.1030	0.001*
calcium intake	- 0.0212	0.481	- 0.0360	0.231
vegetable intake	0.0952	0.046*	0.0882	0.003*
protein intake	- 0.1094	< 0.005*	- 0.0801	0.008*
coffee	0.0571	0.057	0.0528	0.079
years after menopause	- 0.4180	< 0.005*	- 0.2891	< 0.005*
hormonal replacement	0.0055	0.856	0.0329	0.274
family history	- 0.0411	0.172	- 0.0090	0.763
surgical condition	- 0.0587	0.051	- 0.0406	0.176
blood calcium	0.0405	0.177	- 0.0061	0.838
blood phosphorus	0.0429	0.153	0.0023	0.940
blood alk. phosphatase	- 0.0116	0.700	- 0.0226	0.452

* significant at $\alpha = 0.05$

Table 5. Standardized regression coefficient (ß) and p-value from multiple regression analysis of significant variables in the equation.

factor range	ß	p-value
years after menopause (0-32 yrs)	- 0.004	< 0.001
sex (0-1)*	- 0.040	< 0.001
vegetable intake (0-2)	0.013	0.002
hormonal replacement (0-1)**	0.021	0.022

* Score 0 and 1 was described as female and male, respectively.
** Score 0 and 1 was described as no hormonal replacement and hormonal replacement more than 1 year, respectively.

The standardized regression coefficent (ß) and p-value of significant variables from using multiple regression among 18 factors are shown in Table 5. Prediction of MCI using the equation determined by multiple stepwise regression is shown in Table 6 (equation 1). This equation was linear and its residual was independence (Durbin-Watson test = 1.85183), mean of residuals was -0.0001, distribution of residuals was normal as shown in Fig. 1. From these 4 independent variables in equation 1, the incidence rate of high risk of developing osteoporosis and relative risk were calculated. The results showed that the incidence rate in females, no vegetable intake and no hormonal replacement subjects occurred 7.50, 2.22 and 2.63 times greater than in males, vegetable intake and hormonal replacement subjects, respectively. In postmenopausal women since 1-2, 3-5, 6-10, 11-15 and >15 years, the incidence rate was 5.24, 14.51, 17.01, 20.86 and 29.76 times greater than the rate of premenopausal women (Table 7).

AP thickness was not correlated with weight, height and BMI but we found that AP thickness had a positive linear correlation to weight/height ratio (r=0.7878, p-value< 0.005) as shown in Fig. 2 and the prediction of AP thickness is shown in Table 6 (equation 2). The serum calcium, inorganic phosphorus and alkaline phosphatase levels of 960 samples were not correlated to mBMD and MCI as shown in Table 4.

Concerning perimenopausal women, only 2 of all factors influenced the measured mBMD and MCI. The incidence rate of high risk of developing osteoporosis in women who intake protein >30 g/d and intake medicine (corticosteroid) was 2.96 and 6.16 times greater than <30 g/d protein intake and no medicine intake subjects as shown in Table 8.

DISCUSSION

In this study the mean of menopausal age in Thai females was 48.86 ± 3.09 years ranging from 39 to 55 years. The average number of children in their family was 2.10, this value indicated that the total fertility rate (TFR) fall from about 6.30 during the early 1960's. This decline of TFR was affected by family planning and the increasing rate of contraceptive use in Thailand[26].

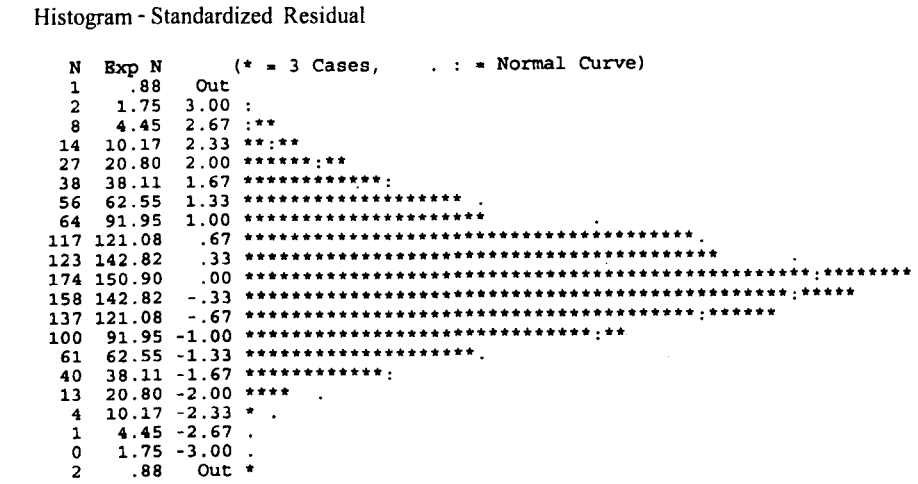
Correlation among anthropometric variables, AP thickness was positive linear correlation to weight/height ratio (r=0.7878, p-value<0.005) as shown in the equation : AP thickness = 6.948 + 0.363 (weight/height). Therefore, the AP thickness can be estimated from the recorded height and weight, as concluded by Hoskins et al[15]. Besides weight[3,15] and height,[27,28] AP thickness is another anthropometric variable which may be used to exclude women from the screening program for postmenopausal osteoporosis. 10.22 per cent of patients with AP thickness less than 17 mm or greater than 23 mm were associated with low mBMD. Weight, AP thickness and BMI significantly increased with aging, indicating that aging people were heavier and more obese than the young. It may be possible to decrease activity and metabolism.

Lower mBMD and MCI was associated with increased age, married females, increased preg-

Table 6. The equations showed dependent variable was predicted by independent variables.

	equations	r	R^2	p-value
1. MCI	= 0.521 - 0.004 (yrs after menopause) + 0.040 (sex) + 0.013 (vegetable intake) + 0.021 (hormonal replacement)	0.4426	0.2329	0.021
2. AP thickness	= 6.948 + 0.363 (weight / height)	0.7878	0.6207	<0.005

nancies, increased AP thickness, decreased vegetable intake, increased protein intake and increased years after menopause. Aging and increased years since menopause showed significantly lower bone mass, the effect possibly mediated through decreased level of oestrogen. From a multiple regression analysis, the significant factors that can predict the MCI were years after menopause, sex, daily vegetable intake



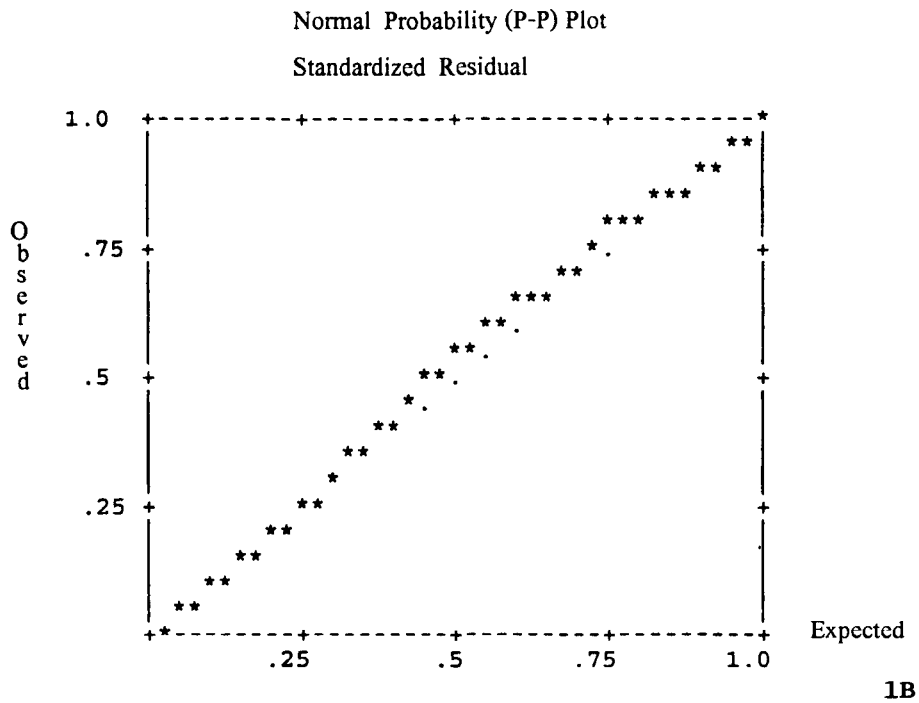


Fig. 1. Histogram (A) and normal probability plot (B) of standardized residuals from multiple regression analysis.

Table 7. The incidence rate of high risk of developing osteoporosis and relative risk by exposing 4 interesting factors that predicted measured mBMD (ΣGS/D) and MCI.

factors	mBMD and MCI		incidence rate	relative risk
	low	high		
1. years since menopause				
1 - 2	14	145	0.0880	5.24
3 - 5	40	124	0.2439	14.51
6 - 10	48	120	0.2857	17.01
11 - 15	34	63	0.3505	20.86
16 - 20	14	14	0.5000	29.76
>20	4	4	0.5000	29.76
premenopause*	13	757	0.0168	
2. sex				
female	96	927	0.0938	7.50
male*	2	157	0.0125	
3. vegetable intake				
no	3	13	0.1875	2.22
everyday*	62	737	0.0841	
4. hormonal replacement				
-	10	108	0.0847	2.63
+*	2	60	0.0322	

* control group

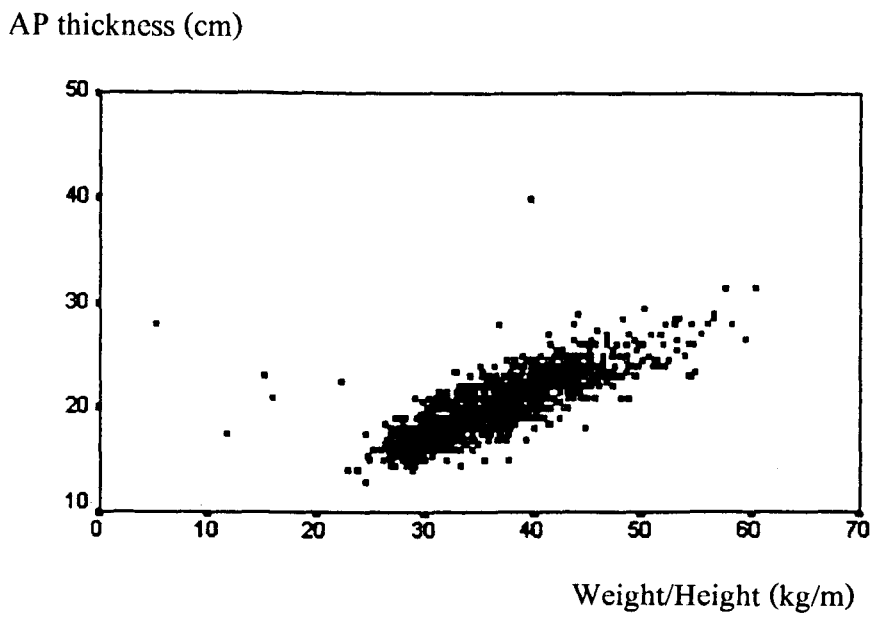


Fig. 2. AP thickness (cm) as a function of the ratio of weight (kg) to height (m) for 1,182 samples.

Table 8. The incidence of high risk of developing osteoporosis and relative risk by exposing 2 interesting factors that predicted measured mBMD (ΣGS/D) and MCI in perimenopausal women.

factors	mBMD and MCI		incidence rate	relative risk
	low	high		
1. protein intake				
>30 g/d	4	213	0.0184	2.96
<30 g/d*	1	160	0.0062	
2. medicine intake				
+	1	14	0.0666	6.16
-*	4	364	0.0108	

* control group

and hormonal replacement. These factors explained 23.29 per cent (R^2=0.2329) of the variance in MCI (Table 6).

Concerning daily dietary intake, males intake more protein and coffee than females but same quantity of calcium and vegetables.

Focusing the incidence rate of high risk of developing osteoporosis from exposing risk factors in perimenopausal women, only 2 of 18 factors influenced the risk of developing osteoporosis. The incidence rate in women who intake protein >30 g/d and intake medicine (corticosteroid) was 2.96 and 6.16 times greater than the <30 g/d protein intake and no medicine intake subjects. Calcium intake has been found to have an effect on bone mineral content in 183 premenopausal women aged 40-50 years[29]. However, in this study calcium intake was not found to have an effect on mBMD& MCI in 215 perimenopausal women. Although with a low dietary calcium intake (398 mg/d) in the Thai population, the fracture risk or risk of developing osteoporosis occurred at the same rate as the Caucasian population[3]. From this study the factors that influenced the risk of developing osteoporosis in all age groups were sex, years after menopause, vegetable intake and hormonal replacement. Only 2 factors: high protein intake and medicine intake, increased the risk of developing osteoporosis in perimenopausal women. The use of historical and anthropometric data as risk factors were valuable for mass screening before DEXA measurement or other radiological diagnosis for osteoporosis. Risk factors were beneficial in reducing scanning by approximately 25-35 per cent[23,24].

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ปัจจัยเสี่ยงที่มีผลต่อ mBMD และ MCI จากการตรวจกรองโรคกระดูกพรุน

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ได้ทำการตรวจกรองโรคกระดูกพรุนในอาสาสมัคร 1,182 ราย ช่วงอายุ 17–83 ปีเพื่อประเมินปัจจัยเสี่ยง ที่มีผลต่อการสูญเสียเนื้อกระดูก โดยการซักประวัติเกี่ยวกับเพศ สถานภาพสมรส การตั้งครรภ์ ปีที่หมดประจำเดือน การรับประทานแคลเซียม ผัก เนื้อสัตว์และกาแฟ การดื่มเหล้า สูบบุหรี่ การทำงานอยู่กับที่ ประวัติครอบครัว การใช้ยา การผ่าตัด หลังจากนั้นจึงทำการวัดส่วนประกอบของร่างกาย (น้ำหนัก ส่วนสูง ความหนาที่ระดับ Xiphoid) ตรวจส่วนประกอบในเลือด (calcium, inorganic phosphorus, alkaline phosphatase) ถ่ายภาพเอกซเรย์มือทั้งสองข้างในท่า Postero-anterior (PA) และถ่ายภาพเอกซเรย์กระดูกสันหลังส่วนอกและเอวท่า Lateral จากนั้นทำการหาค่า Metacarpal bone mineral density (mBMD) และ Metacarpal index (MCI) จากภาพเอกซเรย์มือโดยใช้วิธี Computed X-ray densitometry (CXD) (Bonalyzer, Teijin Ltd., Tokyo) ผลการวิจัยพบว่า อายุเฉลี่ยที่หมดประจำเดือนในผู้หญิงไทยคือ 48.86±3.09 ปี ค่าพิสัย 39 ถึง 55 ปี จำนวนบุตรเฉลี่ยในครอบครัวคือ 2.10 คน จากค่าสหสัมพันธ์เชิงเส้นระหว่างตัวแปรส่วนประกอบของร่างกาย พบว่า ความหนาที่ระดับ Xiphoid มีความสัมพันธ์เชิงบวกกับอัตราส่วนระหว่างน้ำหนักและส่วนสูง (weight/height ratio) (r=0.7878, p-value<0.005), ตัวแปรน้ำหนัก ความหนาที่ระดับ Xiphoid และ Body mass index (BMI) จะเพิ่มขึ้น เมื่ออายุมากขึ้น (r=0.2456, 0.4489 และ 0.3484, p-value <0.005, 0.001 และ <0.005) แต่เมื่ออายุมากขึ้นส่วนสูงจะลดลง (r=–0.1030, p-value=0.001) ส่วนค่า mBMD และ MCI จะมีค่าต่ำเมื่ออายุมากขึ้น, ในผู้หญิงที่แต่งงานแล้วและจำนวนครั้งของการตั้งครรภ์เพิ่มขึ้น, คนที่มีความหนาที่ระดับ Xiphoid เพิ่มขึ้น, รับประทานผักลดลง, รับประทานเนื้อสัตว์มากขึ้น และจำนวนปีหลังจากหมดประจำเดือนมากขึ้น จากการวิเคราะห์สมการถดถอยเชิงเส้นพหุ (multiple regression analysis) ตัวแปรที่สามารถทำนายค่า MCI คือ จำนวนปีหลังจากหมดประจำเดือน เพศ การรับประทานผัก และการได้รับฮอร์โมนทดแทน จากการหาค่าความเสี่ยงสัมพัทธ์ (relative risk) พบว่า เพศหญิงมีอุบัติการของความเสี่ยงสูงต่อการเกิดโรคกระดูกพรุนมากกว่าเพศชาย 7.50 เท่า ในผู้หญิงหลังจากหมดประจำเดือน 1–2, 3–5, 6–10, 11–15 และ มากกว่า 15 ปี มีอัตราเสี่ยงมากกว่าผู้หญิงที่ยังไม่หมดประจำเดือน 5.24, 14.51, 17.01, 20.86 และ 29.76 เท่าตามลำดับ อัตราเสี่ยงในผู้ที่ไม่รับประทานผักและในผู้หญิงที่ไม่ได้รับฮอร์โมนทดแทนเป็น 2.22 และ 2.63 เท่า ของผู้ที่รับประทานผักทุกวันและผู้หญิงที่ได้รับฮอร์โมนทดแทน พิจารณาค่าความเสี่ยงสัมพัทธ์ของตัวแปรต่าง ๆ เฉพาะผู้หญิงวัยใกล้หมดประจำเดือน (perimenopause) พบว่า มีเพียง 2 ตัวแปร ที่ทำนายค่า mBMD และ MCI ได้ โดยผู้ที่รับประทานเนื้อสัตว์มากกว่า 30 กรัมต่อวัน และผู้ที่รับประทานยา (corticosteroid) มีอัตราเสี่ยงต่อการเกิดโรคกระดูกพรุน มากกว่าผู้ที่รับประทานเนื้อสัตว์น้อยกว่า 30 กรัมต่อวัน และผู้ที่ไม่ได้รับประทานยา 2.96 และ 6.16 เท่า

คำสำคัญ : ความหนาแน่นของกระดูก, ปัจจัยเสี่ยง

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