Bone Mineral Density in Rural Thai Adults Living in Khon Kaen Province

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Abstract

Objectives : To define the bone status and pattern of bone loss in a normal adult population living in a rural area of Khon Kaen province.

Study design : A descriptive study.

Settings : Department of Medicine, Faculty of Medicine, Khon Kaen University, Thailand.

Subjects : 436 subjects (181 men and 255 women), aged 20-80 years.

Main Outcome Measures : Bone parameter including total bone mineral density (BMD), the bone mineral density at different sites such as forearm, lumbar spine and hip, bone mineral content (BMC) were measured by dual energy X-ray absorptiometry (DEXA).

Results : The result revealed that women had lower bone mass at various bone sites than men. The peak bone mass in women was observed between 30-39 years of age except at the distal radius which occurred between 20-29 years of age while the peak bone mass in men was observed between 20-29 years of age. It was also shown that bone loss occurred in both men and women with advancing age. The rate of decline at all sites in women was greater than men especially when they were over 60 years old. When comparisons were made between pre and post-menopausal women, the mean of bone mineral density in pre-menopausal women was 1.18 ± 0.08, 0.69 ± 0.06, 0.69 ± 0.06, 1.0 ± 0.13, 1.15 ± 0.13 g/cm^2 at total body, mid-shaft radius, ultra distal radius, femoral neck and lumbar spine, respectively while the mean of bone mineral density in post-menopausal women was 1.02 ± 0.12, 0.54 ± 0.11, 0.54 ± 0.11, 0.75 ± 0.16, 0.88 ± 0.2 g/cm^2 at total body, mid-shaft radius, ultra distal radius, femoral neck and lumbar spine, respectively which were lower than BMD in pre-menopausal women (p<0.05). The mean bone mineral content (BMC) in pre-menopausal women was 2401 ± 318.3 g while in post-menopausal women it was 1915.4 ± 421.7 g (p<0.05). The rate of bone loss correlated with the duration after menopause. In this study, using World Health Organization criteria for diagnosis of osteopenia and osteoporosis and a reference value obtained from Khon Kaen young adults, the prevalence of osteopenia in Khon Kaen women subjects was 37.4 per cent at femoral neck, 30.2 per cent at lumbar spine, 44.5 per cent at ultra distal radius,

31.5 per cent at mid-shaft radius and the prevalence of was osteoporosis 19.3 per cent at femoral neck, 24.7 per cent at lumbar spine, 18.5 per cent at ultra distal radius and 26.4 per cent at mid-shaft radius.

Conclusion : The result of this study demonstrated the bone parameters in rural Thai adults living in Khon Kaen province, the pattern of bone loss, the difference between men and women and finally the prevalence of osteopenia and osteoporosis.

Key word : Bone Mineral Density, Khon Kaen

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Osteoporosis is a disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in fracture risk. Osteoporosis is considered a major public health problem in Western countries, however, it has become an increasing problem in Asian countries as well[1-6]. The burden of osteoporosis fracture is increasing worldwide because of longevity of the population. The proportion of people over 60 years in Thailand was 7.2 per cent in 1990 and is projected to be 9.1 per cent and 15.2 per cent in the year 2000 and 2020, respectively. In some regions, increased age specific rates of fracture have also been reported[7]. An epidemiological study reported that age-specific hip fracture increased exponentially in Thai people after the age of sixty[8].

In 1994, the World Health Organization (WHO) proposed diagnostic guidelines for osteoporosis based on the measurement of bone mineral density (BMD) by dual energy X-ray absorptiometry (DXA) and the T-score. Osteoporosis is defined as a BMD value that is 2.5 standard deviations or more below the average value for young healthy women [9]. In Thailand, an earlier study, showed that the peak bone mass in women living in Bangkok was observed between 20-29 years of age at the femoral

neck and lumbar spines while peak bone mass in men was observed between 20-29 years of age at the femoral neck and 30-39 years of age at the lumbar spine[10]. It was shown that bone loss occurred in both men and women with advancing age. For Thailand, people residing in different regions may have different BMD due to multiple factors. However, data concerning BMD in rural Thai adults are lacking, for this reason the authors evaluated the bone mineral density pattern of bone loss with ageing at all bony sites in normal rural Thai adults, in Khon Kaen province.

MATERIAL AND METHOD

A cross-sectional descriptive design was adopted in this study. The subjects consisted of 436 rural Thai adults aged 20-80 years from 2 subdistricts (Nongtoom and Koksri) in Muang District, Khon Kaen province. They were included in the study if they satisfied the following criteria: lived in a rural area for at least 5 years, were ethnic Thais healthy, ambulatory, and willing to participate. Subjects were excluded if they had a bone disorder, chronic disease or history of taking medication affecting calcium and bone metabolism such as steroids and thyroid hormone, or had a previous history of fracture. Female subjects were excluded if they were

pregnant, lactating, had delivered or aborted within 3 months, had a history of oophorectomy, or premature menopause.

Eligible subjects were invited to Srinagarind Hospital where they were interviewed for data pertaining to age, menarche, menopausal age, body weight, height, waist and hip circumference, education level, occupation, annual income, alcohol consumption and cigarette smoking habits. Standardized well-trained technicians measured their bone parameters for total bone mineral density (total BMD),

bone mineral density at different sites e.g. forearm, lumbar spine, femur, as well as bone mineral content (BMC) by dual energy X-ray absorptiometry using DXP-IQ (Lunar, USA).

After the measurements, the subjects were put into three categories according to definition recommended by the European Foundations for Osteoporosis and Bone Disease, the National Osteoporosis Foundation of the United States, and the World Health Organization, 1994[9]. Firstly, a BMD value greater than 1.0 standard deviation below the

Table 1. Demographic characteristics of the study subjects classified by sex.

	Male	%	Female	%
Number of subjects	181		255	
Age (year)	49.08 ± 17.06		50.63 ± 15.89	
Body weight (kg)	58.25 ± 8.76		55.85 ± 10.52	
Height (cm)	161.22 ± 5.86		152.12 ± 5.21	
Body mass index (kg/m^2)	22.38 ± 2.85		24.08 ± 4.03	
Body mass index (kg/m^2)				
< 18.5	12	6.6	17	6.7
18.5-24.9	143	78.9	142	55.7
25.0-26.9	16	8.8	39	15.3
27.0-29.9 8 (4.4) 33 (12.9)				
≥ 30	2	1.1	24	9.4
Waist / Hip ratio :normal	179	98.9	56	22.0
> 0.8 in women, > 1.0 in men	2	1.1	199	78.0
Education levels				
No	5	2.8	25	9.8
Elementary school (gr.1-4)	137	75.7	188	73.7
Elementary school (gr. 5-6)	18	9.9	26	10.2
Junior high school	11	6.1	10	3.9
High school	9	5.0	3	1.2
Bachelor degree or higher	1	0.6	3	1.2
Occupation				
None	12	6.6	19	7.5
House wife	1	0.6	15	5.9
Farmer	150	82.9	212	83.1
Private employee	13	7.2	3	1.2
Own enterprise	-		5	2.0
Government official	2	1.1	-	
Other	3	1.7	1	0.4
Annual income				
< 10,000	8	4.4	15	5.9
10,001-50,000	133	73.5	196	76.9
50,001-100,000	32	17.7	28	11.0
100,001-250,000	7	3.9	16	6.3
> 250,000	1	0.6	-	
Alcohol				
No	75	41.4	253	99.2
Yes	106	58.6	2	0.8
Occasional	36	19.9	1	0.4
Regular	70	38.7	1	0.4
Smoking				
No	45	24.9	254	99.6
Yes	136	75.1	1	0.4

average value of the peak bone of healthy adults was considered normal. Secondly, a BMD value more than 1.0 SD but less than 2.5 SDs below the average value of the peak bone of healthy adults was considered osteopenia. Finally, a BMD value more than 2.5 SDs below the average value of the peak bone of healthy adults was considered osteoporosis.

Statistic analysis

Results are expressed as mean and standard deviation of the mean. Analysis of variance was performed, and the significance of differences was determined by unpaired students' t-test. The SPSS statistical package was used for data analysis.

RESULTS

Following the eligibility criteria, 436 rural Thai adults, 181 men and 255 women were included in this study. Demographic charateristics and anthropometric parameters of the study subjects are shown in Table 1. The majority of subjects were farmers and had less than 4 years of elementary school, the average income was about 10,001-50,000 baht per year. The majority of the male subjects (98.9%) had normal body mass index (78.9%) and waist to hip ratio while 28 per cent and 94 per cent of the females were over weight and obese and 78 per cent had a high waist to hip ratio (> 0.8). The mean and standard deviation of anthropometric parameters by age and sex are shown in Table 2.

Women had lower bone mass at all sites than men. The peak bone mass in women was observed between 30-39 years of age except at the distal radius which occurred between 20-29 years of age while the peak bone mass in men was observed between 20-29 years of age at all sites.

Table 2.   Mean and standard deviation of anthropometric parameter by age and sex.

	Sex	Age group (year)						
		20-29	30-39	40-49	50-59	60-69	>70	Total
Body weight	M	59.4 ± 6.8	59.4 ± 8.0	59.3 ± 9.4	58.9 ± 10.7	57.3 ± 8.1	55.1 ± 8.9	58.2 ± 8.8
	F	53.2 ± 7.2	57.7 ± 12.4	57.2 ± 8.0	59.7 ± 11.0	55.8 ± 9.9	48.3 ± 11.0	55.9 ± 10.5
Height	M	165.1 ± 6.0	162.0 ± 5.8	160.1 ± 5.5	160.7 ± 5.8	159.3 ± 5.2	160.0 ± 5.5	161.2 ± 5.9
	F	152.0 ± 4.5	153.6 ± 4.7	153.1 ± 4.9	152.5 ± 5.4	151.6 ± 5.0	149.2 ± 5.9	152.1 ± 5.2
Waist circumference	M	74.2 ± 5.7	76.9 ± 6.0	79.5 ± 9.1	79.3 ± 8.9	79.5 ± 9.5	77.3 ± 9.5	77.8 ± 8.2
	F	74.0 ± 7.4	77.6 ± 10.2	81.2 ± 8.5	83.1 ± 8.8	84.0 ± 10.5	77.8 ± 12.1	80.3 ± 10.1
Hip circumference	M	91.3 ± 5.0	90.8 ± 5.8	91.3 ± 6.7	90.4 ± 6.4	90.3 ± 9.4	90.4 ± 5.8	90.8 ± 6.6
	F	90.7 ± 6.1	93.3 ± 8.5	95.3 ± 6.9	96.7 ± 7.8	94.4 ± 7.4	90.8 ± 9.1	94.0 ± 7.9
Waist–hip ratio	M	0.81 ± 0.04	0.85 ± 0.04	0.87 ± 0.05	0.88 ± 0.05	0.88 ± 0.05	0.85 ± 0.06	0.86 ± 0.06
	F	0.82 ± 0.06	0.83 ± 0.05	0.85 ± 0.05	0.86 ± 0.07	0.89 ± 0.07	0.85 ± 0.07	0.85 ± 0.06
Body mass index	M	21.8 ± 2.01	22.6 ± 2.31	23.1 ± 3.28	22.7 ± 3.0	22.6 ± 3.1	21.5 ± 3.1	22.4 ± 2.8
	F	23.1 ± 3.2	24.3 ± 4.3	24.4 ± 3.0	25.6 ± 4.2	24.2 ± 4.0	21.6 ± 4.5	24.1 ± 4.0

Table 3.   Mean and standard deviation of BMD and BMC by age and sex.

BMD (g/cm²)	Sex	Age group (year)						
		20-29	30-39	40-49	50-59	60-69	>70	Total
Total body	M	1.25 ± 0.08	1.2 ± 0.08	1.19 ± 0.07	1.2 ± 0.10	1.14 ± 0.10	1.14 ± 0.12	1.19 ± 0.10
	F	1.16 ± 0.07	1.2 ± 0.08	1.16 ± 0.09	1.11 ± 0.09	1.0 ± 0.10	0.93 ± 0.11	1.10 ± 0.13
Midshaft radius	M	0.78 ± 0.07	0.78 ± 0.07	0.77 ± 0.07	0.78 ± 0.07	0.74 ± 0.1	0.72 ± 0.10	0.76 ± 0.08
	F	0.68 ± 0.05	0.7 ± 0.05	0.68 ± 0.08	0.63 ± 0.10	0.53 ± 0.1	0.45 ± 0.08	0.61 ± 0.11
Distal radius	M	0.46 ± 0.06	0.43 ± 0.05	0.42 ± 0.04	0.40 ± 0.05	0.36 ± 0.06	0.35 ± 0.07	0.41 ± 0.07
	F	0.36 ± 0.04	0.35 ± 0.05	0.34 ± 0.05	0.30 ± 0.05	0.25 ± 0.05	0.21 ± 0.05	0.30 ± 0.07
Femoral neck	M	1.18 ± 0.14	1.02 ± 0.13	0.96 ± 0.11	0.94 ± 0.16	0.84 ± 0.11	0.82 ± 0.14	0.96 ± 0.18
	F	1.01 ± 0.12	1.05 ± 0.14	0.95 ± 0.12	0.87 ± 0.14	0.73 ± 0.15	0.63 ± 0.10	0.87 ± 0.19
Lumbar spine	M	1.24 ± 0.11	1.11 ± 0.14	1.06 ± 0.14	1.09 ± 0.16	1.05 ± 0.12	1.10 ± 0.22	1.11 ± 0.16
	F	1.15 ± 0.09	1.17 ± 0.13	1.11 ± 0.16	1.01 ± 0.21	0.85 ± 0.15	0.76 ± 0.17	1.01 ± 0.22
BMC (g)	M	2,916 ± 316	2,700 ± 330	2,626 ± 296	2,678 ± 440	2,409 ± 420	2,432 ± 390	2,628 ± 401
	F	2,291 ± 278	2,468 ± 370	2,350 ± 310	2,199 ± 401	1,891 ± 361	1,612 ± 394	2,140 ± 448

g/cm^2 **BMD of total body**

g/cm^2 **BMD of L2-4 spine**
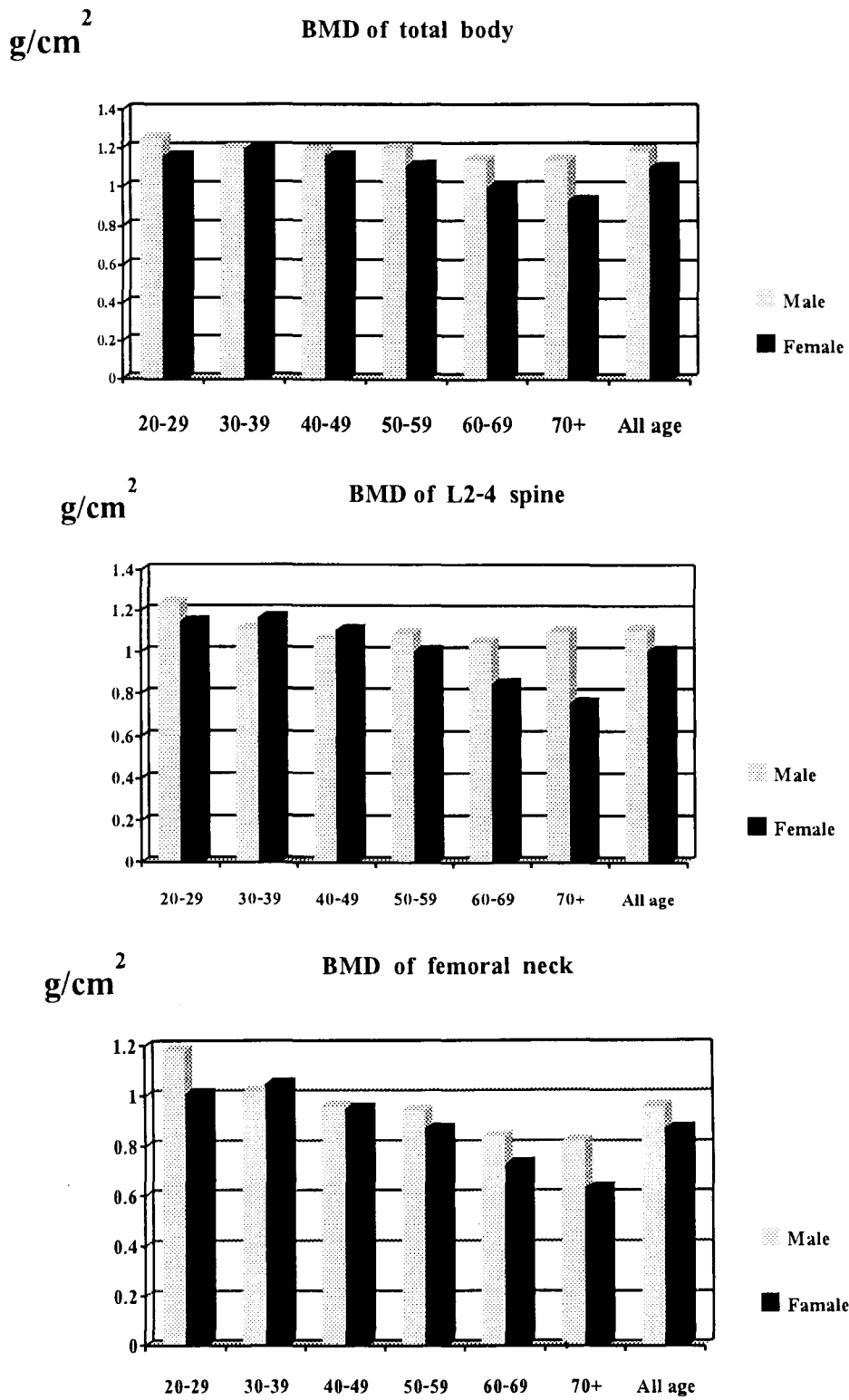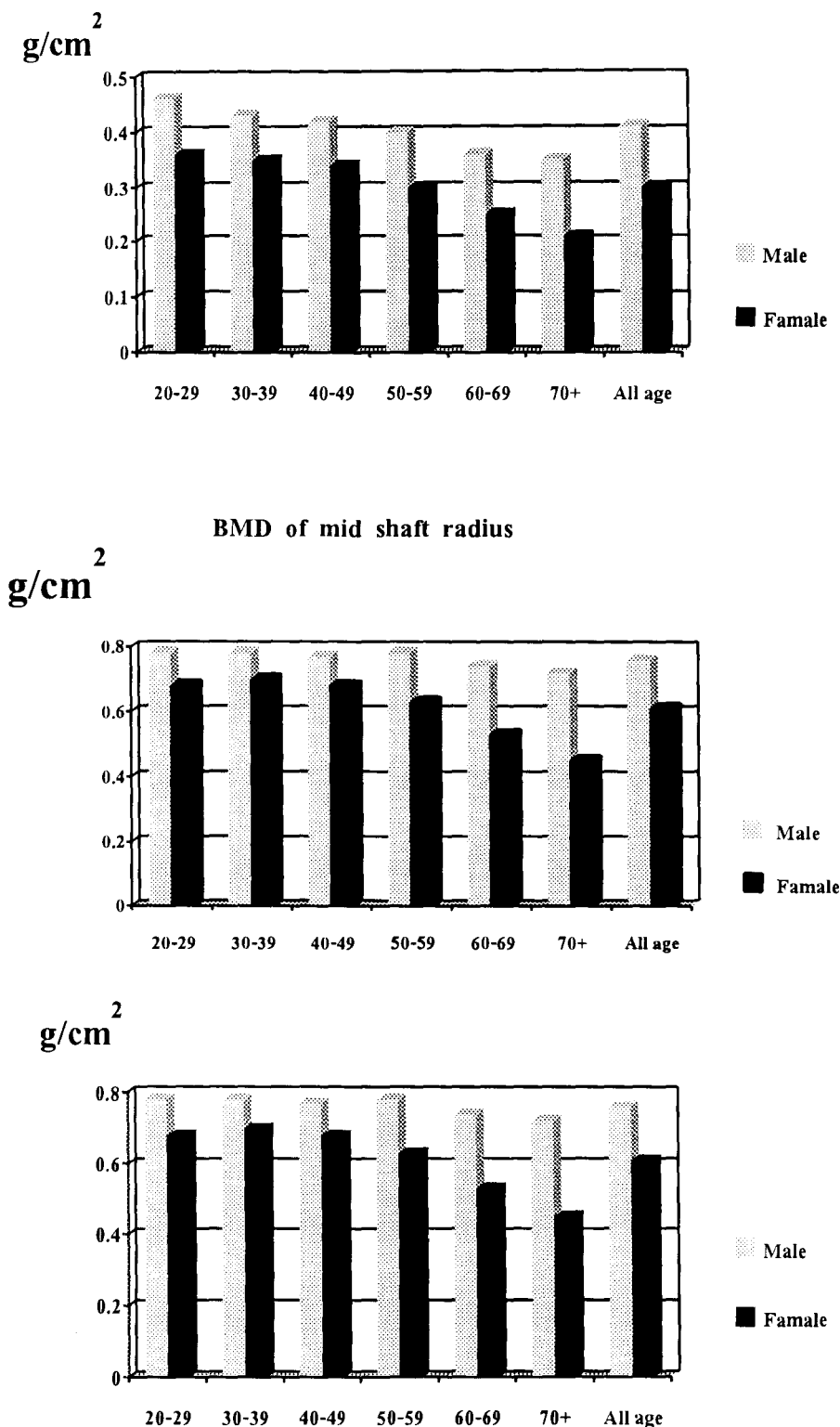

g/cm^2 **BMD of femoral neck**

Fig. 1.   BMD of total body, lumber spine, femoral neck, distal radius, midshaft radius and BMC of different age groups in both male and female subjects.

BMD of mid shaft radius

Fig. 1. BMD of total body, lumber spine, femoral neck, distal radius, midshaft radius and BMC of different age groups in both male and female subjects (continue).

The maximum BMC was observed between 30-39 years of age in women and 20-29 years of age in men. (Table 3). It was shown that bone loss occurred in both men and women with advancing age. The rate of decline at all sites in women was greater than men especially when they were over 60 years old as shown in Fig. 1.

The subjects were arranged by menopausal status. When comparisons were made between pre and post-menopausal women, the mean of bone mineral density in pre-menopausal women was 1.18± 0.08, 0.69±0.06, 0.69±0.06, 1.0±0.13, 1.15±0.13 g/cm^2 at total body, mid-shaft radius, ultra distal radius, femoral neck and lumbar spine, respectively while the mean bone mineral density in post-menopausal women was 1.02±0.12, 0.54±0.11, 0.54±0.11, 0.75±0.16, 0.88±0.2 g/cm^2 at total body, mid-shaft radius, ultra distal radius, femoral neck and lumbar spine, respectively which were lower than BMD in pre-menopausal women ($p<0.05$). The mean bone mineral content (BMC) in pre-menopausal women was 2401±318.3 g while in post-menopausal women it was 1915.4±421.7 g ($p<0.05$), which is shown in Table 4. The rate of bone loss correlated with the duration after menopause. (Table 5)

Using the mean -2.5 SD value of BMD at different sites of young adults as a cut-off point of osteoporosis, the cut-off value of BMD for diagnosis of osteoporosis was 0.70, 0.85, 0.23, 0.55 g/cm^2 at femoral neck, L2 - 4 spine, distal radius and midshaft radius, respectively. T- score BMD for diagnosis osteoporosis in pre-menopausal women was 1.35±1.27 at femoral neck and 0.023±1.34 at L2-4 spine, in post-menopausal women was -1.18± 1.64 at femoral neck and -2.69±1.98 at L2-4 spine.

In this study, the recent World Health Organization criteria for diagnosis of osteopenia and osteoporosis using their own referrence value obtained from the mean of young adults, the prevalence of osteopenia in women subjects was 37.4 per cent at femoral neck, 30.2 per cent at lumbar spine, 44.5 per cent at ultra distal radius, 31.5 per cent at mid-shaft radius and the prevalence of osteoporosis was 19.3 per cent at femoral neck, 24.7 per cent at lumbar spine, 18.5 per cent at ultra distal radius and 26.4 per cent at mid-shaft radius.

Table 4. BMD and BMC of the pre- and post-menopausal women.

	Pre-menopausal	Post-menopausal
Number	117	135
BMD (g/cm^2)		
Total body	1.18 ± 0.08	1.02 ± 0.12*
Femoral neck	1.00 ± 0.13	0.75 ± 0.16*
Lumbar spine	1.15 ± 0.13	0.88 ± 0.2*
Ultra distal radius	0.35 ± 0.05	0.26 ± 0.05*
Midshaft radius	0.69 ± 0.05	0.54 ± 0.11*
BMC (g)	2,401.5 ± 318.3	1,915.4 ± 421.7*

* p< 0.05

Table 5. Duration after menopause and bone status.

Years after menopause	<5	5-10	10-20	>20
Number	27	26	36	46
BMD (g/cm^2) Total body	1.10 ± 0.09	1.06 ± 0.12	1.02 ± 0.10	0.94 ± 0.10
Femoral neck	0.87 ± 0.14	0.80 ± 0.20	0.76 ± 0.12	0.64 ± 0.11
Lumbar spine	1.02 ± 0.16	0.95 ± 0.24	0.88 ± 0.13	0.76 ± 0.16
Ultra distal radius	0.29 ± 0.05	0.28 ± 0.05	0.26 ± 0.05	0.22 ± 0.05
Midshaft radius	0.64 ± 0.09	0.55 ± 0.10	0.56 ± 0.10	0.56 ± 0.11
BMC (g)	2,160 ± 352.4	2,071 ± 438.6	1,937 ± 341.0	1,658 ± 378.6

DISCUSSION

This study revealed that bone mineral density of various sites of normal men peaked earlier than women and men had a higher bone mass than women. The peak bone mass in men was observed between 20-29 years of age while the peak bone mass in women was observed between 30-39 years except at the distal radius which reached its peak in the same decade as men. The peak bone mass in the male subjects occurred in the same age group as Bangkok populations[10], but in the female subjects, bone mass reached its peak at the peak in the younger age group. The average peak bone mass of female subjects for lumbar spine and femoral neck in the present study was higher than earlier reported by Rajatanavin[10]. However, other studies in Thai populations used different software of DXA, and can not be compared[11,12] The rate of decline of bone mass at all sites in women was greater than men especially when they reached the age of menopause. When comparisons were made between pre and post-menopausal women, this study showed the value of BMD at all bone sites and BMC of post-menopausal women were significantly lower than pre-menopausal women. The significant effect of the duration of years after menopause on bone mass was also similar to previous studies[13,14].

When the T-score BMD and the cut-off values for diagnosis of osteoporosis, were calculated, the cut-off values for diagnosis of osteoporosis was not different from that earlier reported[10] at femoral neck (0.85, 0.88 g/cm^2) while the cut off

value at the lumbar spine was lower than an earlier report[10]. By using the WHO criteria for diagnosis of osteopenia and osteoporosis using the reference value obtained from the mean of young adults of BMD, the prevalence of osteopenia and osteoporosis in the studied subjects was high. The prevalence of osteopenia in the women subjects was 37.4 per cent at femoral neck, 30.2 per cent at lumbar spine, 44.5 per cent at ultra distal radius, 31.5 per cent at mid-shaft radius and the prevalence of osteoporosis was 19.3 per cent at femoral neck, 24.7 per cent at lumbar spine, 18.5 per cent at ultra distal radius and 26.4 per cent at mid-shaft radius. Bone mineral density varies widely among different ethnic or geographic groups, dietary calcium intake, life style and other environmental factors[15-19]. The present study was community-based data, covering only a rural area and can be used as a reference for diagnosis of osteoporosis in a rural Thai adult population.

SUMMARY

The result of this study demonstrated the bone parameters in rural Thai adults living in Khon Kaen province, the pattern of bone loss, the difference between men and women, pre-menopausal and post-menopausal women and finally the prevalence of osteopenia and osteoporosis.

ACKNOWLEDGEMENT

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ความหนาแน่นของกระดูกในผู้ใหญ่ไทยที่อาศัยอยู่ในเขตชนบทจังหวัดขอนแก่น

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วัตถุประสงค์ : เพื่อศึกษาปริมาณความหนาแน่นของกระดูกในผู้ใหญ่ไทยที่อาศัยอยู่ในเขตชนบทจังหวัดขอนแก่น

รูปแบบการศึกษา : การวิจัยเชิงพรรณนา แบบตัดขวาง

พื้นที่ศึกษา : ภาควิชาอายุรศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น ประเทศไทย

ประชากรศึกษา : ผู้ใหญ่ไทยที่มีอายุระหว่าง 20–80 ปี จำนวน 436 ราย (เพศชายจำนวน 181 รายและเพศหญิงจำนวน 255 ราย) ซึ่งอาศัยอยู่ในเขตชนบทจังหวัดขอนแก่น

ตัวชี้วัดหลัก : ความหนาแน่นของกระดูกรวมและความหนาแน่นของกระดูกที่ตำแหน่งกระดูกปลายแขน กระดูกสันหลังส่วนเอว กระดูกสะโพกรวมทั้งปริมาณแร่ธาตุกระดูกโดยทำการวัดด้วยเครื่องวัดความหนาแน่นของกระดูก (dual energy X–ray absorptiometry : DEXA)

ผลการศึกษา : พบว่าเพศหญิงมีมวลกระดูกที่ตำแหน่งต่าง ๆ น้อยกว่าเพศชาย มวลกระดูกสูงสุดของเพศหญิงอยู่ระหว่างช่วงอายุ 30–39 ปี ยกเว้นที่ตำแหน่งกระดูกปลายแขนซึ่งอยู่ระหว่างช่วงอายุ 20–29 ปี ในเพศชายพบว่ามวลกระดูกสูงสุดอยู่ระหว่างช่วงอายุ 20–29 ปีทุกตำแหน่ง พบว่ามวลกระดูกทั้งสองเพศจะลดลงเมื่ออายุเพิ่มขึ้นโดยอัตราการลดลงของกระดูกในเพศหญิงมากกว่าเพศชายเมื่ออายุ 60 ปีขึ้นไป ผลการเปรียบเทียบระหว่างหญิงวัยก่อนหมดประจำเดือนกับวัยหลังหมดประจำเดือนพบว่าค่าเฉลี่ยความหนาแน่นของกระดูกในหญิงวัยหมดประจำเดือนต่ำกว่าในหญิงวัยก่อนหมดประจำเดือน (p<0.05) โดยพบว่าค่าเฉลี่ยความหนาแน่นของกระดูกในหญิงวัยก่อนหมดประจำเดือนเท่ากับ 1.18+0.08, 0.69+0.06, 0.69+0.06, 1.0+0.13, 1.15+0.13 กรัมต่อตารางเซนติเมตรและในหญิงวัยหมดประจำเดือนเท่ากับ 1.02+0.12, 0.54+0.11, 0.54+0.11, 0.75+0.16, 0.88+0.2 กรัมต่อตารางเซนติเมตร ของกระดูกทั่วร่างกาย กระดูกปลายแขนส่วนกลาง กระดูกปลายแขนส่วนปลาย กระดูกสะโพกและกระดูกสันหลังส่วนเอวตามลำดับ ปริมาณแร่ธาตุของกระดูกในหญิงวัยก่อนหมดประจำเดือนเท่ากับ 2401+318.3 กรัม ในขณะที่ในหญิงวัยหมดประจำเดือนมีค่าต่ำกว่าซึ่งเท่ากับ 1915.4+421.7 กรัม (p<0.05) และพบว่าการลดลงของมวลกระดูกสัมพันธ์กับระยะเวลาของการหมดประจำเดือน เมื่อใช้เกณฑ์ขององค์การอนามัยโลกโดยเปรียบเทียบจากค่าเฉลี่ยของผู้ใหญ่อายุน้อยของกลุ่มประชากรที่ศึกษาพบว่าความชุกของภาวะกระดูกบางเท่ากับร้อยละ 37.4, 30.2, 37.4, 30.2, 44.5, 31.5 และความชุกของโรคกระดูกพรุนเท่ากับร้อยละ 19.3, 24.7, 18.5, 26.4 ที่กระดูกสะโพก กระดูกสันหลังส่วนเอว กระดูกแขนส่วนปลายและกระดูกแขนส่วนกลางตามลำดับ

สรุป : ผลการศึกษาวิจัยทำให้ทราบถึงความหนาแน่นของกระดูกในผู้ใหญ่ไทยที่อาศัยในเขตชนบทจังหวัดขอนแก่น รูปแบบของการสูญเสียมวลกระดูก ความแตกต่างของความหนาแน่นของกระดูกระหว่างเพศชายและเพศหญิงและทราบถึงความชุกของภาวะกระดูกบางและกระดูกพรุน

คำสำคัญ : ความหนาแน่นกระดูก, ขอนแก่น

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