Prevalence of Osteoporosis in Thai Men

Chatlert Pongchaiyakul MD*,
Chalermchai Apinyanurag MD**, Supasil Soontrapa MD***,
Sugree Soontrapa MD****, Choowong Pongchaiyakul BSc*****,
Tuan V Nguyen PhD******, Rajata Rajatanavin MD*******

** Departments of Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen*
*** Departments of Radiology, Faculty of Medicine, Khon Kaen University, Khon Kaen*
**** Departments of Orthopaedics, Faculty of Medicine, Khon Kaen University, Khon Kaen*
***** Departments of Obstetric and Gynecology, Hospital, Faculty of Medicine, Khon Kaen University, Khon Kaen*
****** Nursing Division, Srinagarind Hospital, Faculty of Medicine, Khon Kaen University, Khon Kaen*
******* Bone and Mineral Research Program, Garvan Institute of Medical Research, Sydney, Australia*
******** Department of Medicine, Faculty of Medicine, Ramathibodi Hospital, Mahidol University*

Background: *Osteoporosis is a growing health problem not only in women but also in men. However, there is a scarcity of epidemiologic data to study osteoporosis in Thai men.*
Objectives: *To examine the bone mineral density (BMD) and to determine the prevalence of osteoporosis in Thai men.*
Material and Method: *A total of 412 men (159 from Bangkok and 253 from Khon Kaen, respectively) averaging 51 ± 16 years of age, were measured for BMD at the femoral neck and lumbar spine by dual energy X-ray absorptiometry (LUNAR Corporation, WI, USA).*
Results: *The peak BMD was observed in men 20-29 years of age at both the femoral neck (mean ± SD, 1.10 ± 0.15 g/cm^2) and lumbar spine (mean ± SD, 1.17 ± 0.13 g/cm^2). The prevalence of osteoporosis in the entire group of subjects was 12.6, 4.6 and 3.9 per cent at the femoral neck, lumbar spine and both sites, respectively. The prevalence of osteoporosis increased with advancing age and was significantly higher at the femoral neck in urban men than rural men (18.2 vs 9.2 per cent, $p < 0.05$) but comparable at the lumbar spine (5.0 vs 4.3 per cent, $p = 0.81$). The correlation between femoral neck and lumbar spine BMDs was 0.53 ($p < 0.001$). In univariate analysis, increased age, lower weight and lesser height were each associated with lower femoral neck BMD, whereas only lower weight and lesser height were associated with lower lumbar spine BMD. However, when the three factors were entered simultaneously, only increased age and lower weight were significantly associated with lower femoral neck BMD and only lower weight had a significant association with lower lumbar spine BMD.*
Conclusion: *The present study demonstrated descriptive BMD data, normal BMD reference values for diagnosis and reported the prevalence of osteoporosis in Thai men.*

Keywords: *Osteoporosis, Bone mineral density, Men, Thai, Epidemiology*

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Osteoporosis is a metabolic bone disease characterized by relatively low bone mineral density (BMD), microarchitectural deterioration of bone tissue, and increased susceptibility to fracture(1). With an aging global population, osteoporosis is fast becoming a worldwide concern because of its age-associated prevalence, costs, morbidity and mortality(2,3). Although, osteoporosis is generally considered a condition affecting postmenopausal women, up to 20 and 30 per cent of symptomatic vertebral and hip fractures, respectively, occur in men(4-9). As the world's popula-

Correspondence to : Pongchaiyakul C, Division of Endocrinology and Metabolism, Department of Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand. Phone: 0-4336-3664, 0-4336-3746, Fax: 0-4334-7542, E-mail: pchatl@kku.ac.th

tion ages, it is predicted that osteoporotic fractures will increase dramatically by the end of this decade[9].

Important sex-specific differences are already known to occur in bone physiology and geometry, fracture epidemiology, bone gonadal hormone response, and post-hip-fracture mortality. These differences point to the importance of doing separate osteoporosis studies in men as it will lead to more specific and effective prevention-based strategies[10-12].

Although several factors contribute to fracture risk, BMD measurement is still the most important element in diagnosing osteoporosis or in screening people at greater risk of fractures[2]. The WHO has defined osteoporosis in terms of BMD, based on prior studies using dual energy X-ray absorptiometry (DXA)[13]. In order to assure the validity of the results of bone densitometry, those results have to be considered in comparison with the corresponding values that refer to age- and sex-matched, healthy persons from the same population. Although the normal reference data for Thai women has been reported[14-16], there exists no complete set of data regarding the normal range and cut-off values of the hip and spine BMD in Thai men. Therefore, the authors designed a study to examine BMD and to determine the prevalence of osteoporosis in a population-based sample of Thai men.

Material and Method

Setting and Subjects

The authors designed a cross-sectional study of the Thai population. The Khon Kaen University and Mahidol University Ethics Committees examined and approved the study protocols. Informed written consent was obtained from each participant. The present study was conducted in accordance with the 1975 Helsinski Declaration (revised 1983).

The data was collected in Khon Kaen (Northeast-rural) and Bangkok (Central-urban), Thailand. The method of recruitment was previously described in detail[17]. Briefly, in Khon Kaen, subjects were recruited from 2 villages in the Muang district. There were 14 hamlets in the two villages. In each hamlet, a full list of subjects was obtained, from which 40 subjects were randomly selected by the village's administrator. The selected subjects were then sent a letter of invitation to participate in the present study. The response rate was 80.3%. In Bangkok, subjects were recruited via a media campaign, and the sampling technique was similar to the scheme used in Khon Kaen, where subjects were randomly selected from 5 districts within the city of Bangkok. In the present study, the subjects were selected from the databases (159 and 253 from Bangkok and Khon Kaen, respectively), ranging between 20 and 87 years of age.

The authors excluded patients with: bone disorders, chronic diseases or history of taking medications affecting calcium and bone metabolism such as steroids, thyroid hormone, fluoride, bisphosphonates, calcium, antiepileptics, thiazides, calcitonin, alcohol abuse and a previous history of hypogonadism.

Measurements

Body weight (while wearing light indoor clothing) was measured using an electronic balance (accuracy 0.1 kg) and standing height (without shoes) with a stadiometer (nearest 0.1 cm). Body mass index (BMI) was calculated as the ratio of weight (kg) over height (m^2).

In Khon Kaen, BMD (g/cm^2) at the femoral neck and lumbar spine (L2-L4) was measured by DXA using a LUNAR DPX-IQ densitometer (LUNAR Corporation, Madison, WI, USA), while BMDs were measured using a LUNAR DPX-L densitometer (LUNAR Corporation, Madison, WI, USA) in Bangkok. Both study sites used the same protocol. The BMD measurements (from the DXA machines) were corrected using software from the manufacturer.

The coefficient of variation of BMD for normal subjects was 1.5 and 1.3 per cent for the lumbar spine and proximal femur, respectively. The prevalence of osteoporosis was determined by age group. Osteoporosis was defined by a T-score within 2.5 SD or below that of a young adult male designated as the normal reference.

Statistical analyses

Statistical analyses were performed using SPSS 9.0 (SPSS Inc., Chicago, Illinois). Descriptive results were expressed as the mean, standard deviation (SD) and per cent. Bone mineral density values were analyzed in 10-year intervals by calculating the mean and SD. Normality was confirmed in all age groups. The difference in BMD and prevalence of osteoporosis between urban and rural populations was tested by the unpaired *t*-test and Chi-Square test, respectively. The correlation between BMD, age, body weight and height was obtained using the Pearson correlation coefficient (r). Simple linear regression analysis was used to estimate the strength of association between age, weight, height and BMD. The statistical significance was defined at p value < 0.05.

Results

The authors recruited 412 men for the present study. The ratio of subjects from the urban and rural was 2:3. Age averaged 51 ± 16 years (range, 20-87). Other characteristics are shown in Table 1. Body weight was positively associated with BMD at the femoral neck ($r = 0.14$, $p = 0.006$) and at the lumbar spine ($r = 0.36$, $p < 0.001$), whereas age was negatively correlated with femoral neck BMD ($r = 0.51$, $p < 0.001$) but not with lumbar spine BMD ($r = 0.09$, $p = 0.07$). Height was associated with the femoral neck ($r = 0.19$, $p < 0.001$) and lumbar spine BMD ($r = 0.23$, $p < 0.001$). The correlation between femoral neck and lumbar spine BMDs was 0.53 ($p < 0.001$).

The peak BMD was observed in the men between 20 and 29 years of age. Bone mineral density decreased with increasing age; however, the decrease was more pronounced at the femoral neck (Table 2; Fig. 1, 2).

Based on the peak BMD for the entire population, as derived from young adults (mean ± SD: 1.10 ± 0.15 for femoral neck and 1.17 ± 0.13 for lumbar spine), the prevalence of osteoporosis was between 12.6 and 4.6 per cent, at the femoral neck and lumbar spine, respectively. Furthermore, it also increased with advancing age: in individuals over 50, 60 and 70, as the prevalence of osteoporosis at the femoral neck was 19.1 (44/230), 23.8 (35/147) and 32.3 (20/62) per cent, respectively, while at the lumbar spine was 7.4 (17/230), 10.2 (14/147) and 14.5 (4/62) per cent, respectively (Table 3).

The age-specific prevalence of osteoporosis between urban and rural subjects was compared and was significantly higher at the femoral neck in urban men ($p < 0.05$), whereas it was not significantly different at the lumbar spine between regions (Table 3).

In the unadjusted analysis, age, weight and height were each associated with femoral neck BMD, whereas only weight and height were associated with lumbar spine BMD. When the three factors were entered simultaneously, only age and weight were significantly associated with femoral neck BMD and only weight had any significant association with lumbar spine BMD. Each one-year increase in age was associated with a 5.31 mg/cm^2 decrease in femoral neck BMD ($p < 0.001$); and a 0.79 mg/cm^2 decrease in lumbar spine BMD ($p = 0.11$). Furthermore, each 1-kg increase in weight was associated with a 2.20 increase in the femoral neck BMD ($p = 0.007$) and 5.48 mg/cm^2 increase in lumbar spine BMD ($p < 0.001$) (Table 4). However, the three factors collectively accounted for 28 and 14 per cent of the variation in femoral neck and lumbar spine BMD, respectively.

Discussion

Osteoporosis in women has emerged as one of the most common diseases of the elderly and one of the most significant public health issues in the world. This emergence is due in part to the age-related prevalence, and the public appreciation of the seriousness of the consequences vis- -vis morbidity, economic costs and mortality[2,18,19].

Although less common, osteoporosis in men is also prevalent worldwide with equally serious implications. Specific definitions for male osteoporosis are needed and cost-effective guidelines on who should be investigated and treated and how. The role of BMD measurement in diagnosis and treatment decisions needs to be clarified.

This is the first study done in Thai men recruited from both urban and rural regions. They were examined for BMD and the prevalence of osteoporosis.

Table 1. Subject characteristics

	Urban	Rural	Total
Number of subjects	159	253	412
Age (years)	50.0 ± 17.5	51.4 ± 16.0	50.7 ± 16.6
Body weight (kg)	64.2 ± 11.1	60.8 ± 10.6	62.1 ± 10.9
Height (cm)	165.5 ± 6.3	162.3 ± 6.3	163.6 ± 6.5
Body mass index (kg/m^2)	23.4 ± 3.6	23.0 ± 3.1	23.1 ± 3.3
Bone mineral density (g/cm^2)			
Femoral neck	0.87 ± 0.16	0.94 ± 0.17	0.91 ± 0.17
Lumbar spine	1.12 ± 0.17	1.12 ± 0.17	1.12 ± 0.17

All values are means ± SDs

Table 2. Bone mineral density in Thai men by age group

Age group	Femoral neck BMD (g/cm^2)			Lumbar spine BMD (g/cm^2)		
	Urban *(n =159)*	Rural *(n =253)*	Total *(n =412)*	Urban *(n= 159)*	Rural *(n =253)*	Total *(n =412)*
20-29	1.01 0.12 *(n =25)*	1.17 0.14*(n =32)*	1.10 0.15 *(n =57)*	1.13 0.11 *(n =25)*	1.21 0.13*(n =32)*	1.17 0.13 *(n =57)*
30-39	0.94 0.16 *(n =28)*	1.01 0.13 *(n =35)*	0.98 0.14 *(n =63)*	1.16 0.14 *(n =28)*	1.11 0.13 *(n =35)*	1.13 0.14 *(n =63)*
40-49	0.83 0.13 *(n =26)*	0.96 0.11*(n =36)*	0.91 0.13 *(n =62)*	1.07 0.12 *(n =26)*	1.07 0.13 *(n =36)*	1.07 0.13 *(n =62)*
50-59	0.81 0.10 *(n =26)*	0.93 0.15*(n =57)*	0.89 0.15 *(n =83)*	1.08 0.14 *(n =26)*	1.12 0.17 *(n =57)*	1.11 0.16 *(n =83)*
60-69	0.83 0.14 *(n =28)*	0.85 0.11 *(n =57)*	0.85 0.12 *(n =85)*	1.12 0.21 *(n =28)*	1.12 0.17 *(n =57)*	1.12 0.18 *(n =85)*
70+	0.80 0.16 *(n =26)*	0.81 0.16 *(n =36)*	0.81 0.16 *(n =62)*	1.14 0.25 *(n =26)*	1.09 0.22 *(n =36)*	1.11 0.22 *(n =62)*

All values are means SDs.
*Statistical significance at $p < 0.001$ (Using unpaired *t*-test)

Table 3. Prevalence of osteoporosis in urban *vs.* rural Thai men by age group

Age group	FN			LS			FN or LS			FN and LS		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
20-29	-	-	-	-	-	-	-	-	-	-	-	-
30-39	1 (3.6)	-	1 (1.6)	-	1 (2.9)	1 (1.6)	1 (3.6)	1 (2.9)	2 (3.2)	-	-	-
40-49	7 (26.9)**	-	7 (11.3)	-	1 (2.8)	1 (1.6)	7 (26.9)*	1 (2.8)	8 (12.9)	-	-	-
50-59	5 (19.2)	4 (7.0)	9 (10.8)	1 (3.8)	1 (1.8)	2 (2.4)	4 (15.4)	3 (5.3)	7 (8.4)	1 (3.8)	1 (1.8)	2 (2.4)
60-69	7 (25.0)	8 (14.0)	15 (17.6)	3 (10.7)	3 (5.3)	6 (7.1)	4 (14.3)	5 (8.8)	9 (10.6)	3 (10.7)	3 (5.3)	6 (7.1)
70+	9 (34.6)	11 (30.6)	20 (32.3)	4 (15.4)	5 (13.9)	9 (14.5)	5(19.2)	8 (22.2)	13 (21.0)	4 (15.4)	4 (11.1)	8 (12.9)
Total	29 (18.2)*	23 (9.1)	52 (12.6)	8 (5.0)	11 (4.3)	19 (4.6)	21 (13.2)*	18 (7.1)	39 (9.5)	8 (5.0)	8 (3.2)	16 (3.9)

FN; femoral neck, LS; lumbar spine
Statistical significant at $p < 0.05^*$ and $< 0.001^{**}$ (Using Chi-Square test)

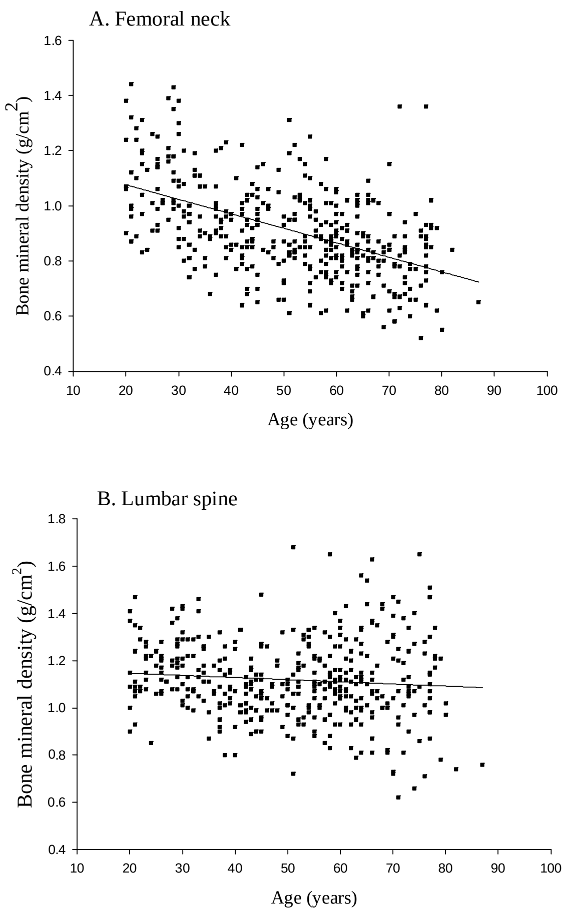

Fig. 1 Scatter plot between age and bone mineral density

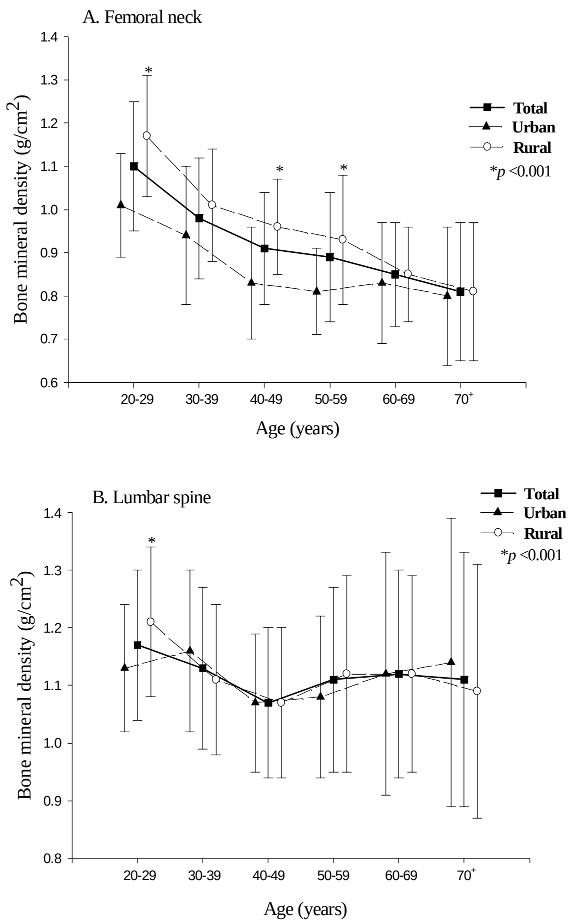

Fig. 2 Bone mineral density in urban and rural Thai men by age group

Table 4. Regression analyses

	Femoral neck BMD (mg/cm²)			Lumbar spine BMD (mg/cm²)		
	Coefficients ± SE[a]	p	$R^{2,b}$	Coefficients ± SE[a]	p	$R^{2,b}$
Univariate						
Age (per 1 yr)	-5.25 ± 0.43	<0.001	0.26	-0.90 ± 0.50	0.072	0.01
Weight (per 1 kg)	2.10 ± 0.76	0.006	0.02	5.54 ± 0.71	<0.001	0.13
Height (per 1 cm)	4.95 ± 1.27	<0.001	0.04	5.93 ± 1.25	<0.001	0.05
Multivariate						
Age (per 1 yr)	-5.31 ± 0.45	<0.001		-0.79 ± 0.49	0.110	
Weight (per 1 kg)	2.20 ± 0.81	0.007	0.28	5.48 ± 0.88	<0.001	0.14
Height (per 1 cm)	-0.96 ± 1.42	0.501		0.09 ± 1.54	0.954	

[a]Values are regression coefficients ± SE describing the change in BMD (mg/cm²) associated with a unit change in the factor
[b]Coefficient of determination: the proportion of variation in BMD is explained by the variation in a factor

Osteoporosis (T-score $\leq$ -2.5 SD) at the femoral neck and lumbar spine was diagnosed when the measured BMD was below 0.80 and 0.91 g/cm^2, respectively. The prevalence of osteoporosis at the femoral neck, lumbar spine and both sites was 12.6, 4.6, and 3.9 per cent, respectively. The prevalence of osteoporosis increased with advancing age. This finding was dif-ferent from previous studies in Thai women among whom osteoporosis at the lumbar spine was more common than at the femoral neck[14-16]. The prevalence of osteoporosis in the present study was consistent with a Taiwanese study[20] but different from studies done in Chinese[21,22], Lebanese[23] and Caucasian men[24-30].

Yeh et al reported that the prevalence of osteoporosis in men aged 70 and over was 32.8 and 15.7 per cent at the femoral neck and lumbar spine, respectively[20], while Chan et al reported the prevalence of osteoporosis in men was 2.0 and 3.4 per cent at the femoral neck and lumbar spine, respectively, while the prevalence increased to 5.1 per cent in men over 70[21]. Malouf et al reported the prevalence of osteoporosis was 9 per cent in both the femoral neck and lumbar spine in Lebanese men[24].Tenenmouse et al reported the prevalence of osteoporosis in Canadian men 50 and over was 6.6 and 2.9 per cent at the femoral neck and lumbar spine, respectively[25]. The study from NHANES III showed the prevalence of low BMD was 33 per cent and osteoporosis in white, Hispanic and African-American men 50 years and over was 7, 3 and 5 per cent, respectively[26], while an Australian study showed the prevalence of osteoporosis higher in elderly white men (11 per cent)[28].

Depending on the skeletal site assessed the prevalence of osteoporosis in men varies between 0 and 36 per cent[12,31]. The discordance using femoral neck and lumbar spine BMD has been explained, however, different conclusions have been reached concerning the relative sensitivity of hip and spine BMD in the diagnosis of osteoporosis based on the criteria from the WHO.

In some reports, measurements of the femoral neck and total hip identified fewer osteoporotic patients than spine BMD[32,33]. While in others, DXA of the hip was a more sensitive indicator for osteoporosis than DXA of the spine[34,35]. In the present study, the prevalence of osteoporosis was nominally higher when determined by DXA at the femoral neck *vs* the lumbar spine. This finding may be explained by the process of osteophytosis, which is a natural aging process and usually more prominent at the lumbar spine than the hip, and plays a role in lowering the sensitivity of DXA in the elderly.

It has been demonstrated that the presence of spinal osteophytes has a major impact on measured BMD in men[36] and is associated with a substantial increase in spinal BMD without necessarily any concomitant decrease in fracture risk[36-39]. Previous studies reported that spinal BMD, measured by DXA in subjects with osteophytosis, are 15 to 30 per cent higher than age-and-sex matched controls without osteophytosis[36,37]. In the present study, the standard deviation was higher in the aging group compared with the younger group (Table 2; Fig. 2).

The incidence of fractures caused by osteoporosis tends to increase with urbanization and the rate of fractures is higher in urban *vs* rural communities[40-46]. While many factors are posited as responsible, BMD is thought as the primary determinant, because it is the most consistent and strongest predictor of fracture risk. Indeed, BMD among rural populations is higher than urban populations[47-49]; however, most studies focus on Caucasian populations so there is a paucity of data on Asians.

In the present Thai population-based study, the authors observed that BMD in urban men was consistently lower than their rural confr res. The peak bone mass in rural men was significantly higher than in urban men and this finding was consistent with a previous study[49]. Secondly, the BMD in rural men was significantly higher than that in an urban population, at the femoral neck (Table 2; Fig. 2) as in previous studies[47,48]. The difference in BMD can perhaps be explained by the difference in physical activity between the two day-to-day environments. Rural populations typically have more strenuous, weight-bearing activity than urban populations[50,51]. Northeast Thais are mainly farmers who spend their days in manual rice culture or at some other vigorous manual activity.

As in the present study, many prior studies found age and weight correlated to BMD of the hip and lumbar spine in both men and women, while any association between height and BMD was less pronounced[52,53]. However, the strength of the association between age, weight and BMD was not strong, particularly at the lumbar spine.

A number of strengths and limitations attend the present study. 1) The data were obtained from large, well-defined rural and urban areas, which made possible reliable delineation of the rural *vs* urban differences. In fact, the subjects in the present study were from two provinces and the authors did not use cluster random sampling for cross-country representation: such an approach could be used in a follow-on study to test whether the present study represents all Thai men. Notwithstanding, the subjects in the present study were randomly selected and well characterized, thus it is a first important step toward recognizing the prevalence of osteoporosis in men in Thailand. 2) Since the present study focused on Thais, the body size, lifestyle, cultural background and environmental living conditions will differ from other populations; therefore, care should be taken when extrapolating these results to other populations. 3) The measurement error for BMD might result in misclassifications of osteoporosis. 4) Body weight was measured only once, which may not reflect the subject's long-term weight. These sources of measurement errors might skew the results; however, such errors are common in this type of study.

In conclusion, the age-specific and -adjusted prevalence of osteoporosis among Thai men was 12.6 and 4.6 per cent for femoral neck and lumbar spine, respectively. The data provided by the present study could serve as normal reference values for Thai men and for a public health policy to promote bone health and the prevention of osteoporosis in Thai men.

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ความชุกของโรคกระดูกพรุนในผู้ชายไทย

ฉัตรเลิศ พงษ์ไชยกุล, เฉลิมชัย อภิญญานุรักษ์, ศุภศิลป์ สุนทราภา, สุกรี สุนทราภา, ชูวงศ์ พงษ์ไชยกุล, ทวน เหงี่ยน, รัชตะ รัชตะนาวิน

***บทนำ**: ปัจจุบันโรคกระดูกพรุนมิได้พบเพียงเฉพาะในเพศหญิงเท่านั้นแต่ยังสามารถพบในเพศชายได้เช่นกัน อย่างไรก็ตามการศึกษาทางระบาดวิทยาในประเทศไทยเกี่ยวกับโรคกระดูกพรุนในผู้ชายยังมีอยู่อย่างจำกัด*

***วัตถุประสงค์**: เพื่อศึกษาความหนาแน่นของกระดูกและความชุกของโรคกระดูกพรุนในผู้ชายไทย*

***วัสดุและวิธีการ**: มีผู้เข้าร่วมการศึกษาทั้งสิ้นจำนวน 412 คน (159 คนจากกรุงเทพมหานครและ 253 คนจากจังหวัดขอนแก่น) อายุเฉลี่ย 51 $\pm$ 16 ปี ทำการวัดความหนาแน่นของกระดูกที่ตำแหน่งกระดูกสะโพกและกระดูกสันหลังระดับเอวที่ 2-4 ด้วยเครื่องวัดความหนาแน่นของกระดูก (LUNAR Corporation, WI, USA)*

***ผลการศึกษา**: พบว่ามวลกระดูกสูงสุดอยู่ระหว่างช่วงอายุ 20-29 ปีทั้งที่ตำแหน่งกระดูกสะโพกและกระดูกสันหลังระดับเอว โดยมีค่าเฉลี่ยและค่าเบี่ยงเบนมาตรฐานที่กระดูกสะโพกและกระดูกสันหลังระดับเอวเท่ากับ 1.10 $\pm$ 0.15 และ 1.17 $\pm$ 0.13 กรัมต่อตารางเซนติเมตร ตามลำดับ พบความชุกของโรคกระดูกพรุนที่ตำแหน่ง กระดูกสะโพกร้อยละ 12.6 ที่กระดูกสันหลังระดับเอวร้อยละ 4.6 และทั้งสองตำแหน่งร้อยละ 3.9 โดยพบ ความชุกของโรคกระดูกพรุนเพิ่มขึ้นตามอายุ นอกจากนั้นพบว่าคนที่อาศัยในกรุงเทพมหานครมีความชุกของโรค กระดูกพรุนที่ตำแหน่งกระดูกสะโพกสูงกว่าคนที่อาศัยในจังหวัดขอนแก่น (ร้อยละ 18.2 เทียบกับ 9.2) โดยพบว่ามีความแตกต่างอย่างมีนัยสำคัญทางสถิติ ในขณะที่ความชุกของโรคกระดูกพรุนที่ตำแหน่งกระดูกสันหลังระดับเอวระหว่างประชากรสองกลุ่มไม่มีความแตกต่างกัน (ร้อยละ 5 เทียบกับ 4.3) พบความสัมพันธ์ระหว่างความหนาแน่นของกระดูกสะโพกและกระดูกสันหลังระดับเอวเท่ากับ 0.53 โดยมีนัยสำคัญทางสถิติ จากการวิเคราะห์สมการถดถอยอย่างง่ายพบว่าอายุที่เพิ่มขึ้น น้ำหนักตัวและความสูงที่ลดลงมีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับการลดลงของความหนาแน่นของกระดูกสะโพก ในขณะที่พบน้ำหนักตัวและความสูงที่ลดลงเพียงสองปัจจัยที่มีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับการลดลงของความหนาแน่นของกระดูกสันหลังระดับเอว เมื่อทำการวิเคราะห์สมการถดถอยเชิงพหุพบว่าอายุที่เพิ่มขึ้นและน้ำหนักตัวที่ลดลงมีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับการลดลงของความหนาแน่นของกระดูกสะโพกในขณะที่พบน้ำหนักตัวที่ลดลงเพียงปัจจัยเดียวที่มีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับการลดลงของความหนาแน่นของกระดูกสันหลังระดับเอว*

***สรุป**: การศึกษานี้ได้นำเสนอข้อมูลเชิงพรรณนาของความหนาแน่นของกระดูก ได้แสดงค่ามาตรฐานของความหนาแน่นของกระดูกจากประชากรอายุน้อยที่ใช้ในการเปรียบเทียบเพื่อการวินิจฉัยโรคกระดูกพรุนรวมทั้งได้ศึกษาความชุกของโรคกระดูกพรุนในผู้ชายไทย*