Bone Mineral Density: Correlation between the Lumbar Spine, Proximal Femur and Radius in Northern Thai Women

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Objective: *To determine the correlation of bone mineral density (BMD) in lumbar spine, proximal femur and 1/3 radius in northern Thai women.*
Materials and Method: *The data of this study was collected from the medical records and the BMD results of 885 perimenopausal and postmenopausal women who had the BMD measurement in Division of Nuclear Medicine, Department of Radiology, Faculty of Medicine, Chiang Mai University between January and December 2007. BMD was measured using dual-energy X-ray absorptiometry (Hologic, QDR-4500C).*
Results: *Mean age (± SD) was 58.7 ± 9.9 year. The lowest T-score was found 51.6% at lumbar spine (LS), 29.2% at 1/3 radius, 13.8% at femoral neck (FN), 2.9% at total femur (TF) and 2.5% at trochanter region (TR). We found a significant correlation between age, BMI, duration of menopause, and BMD at the LS, TF, FN, TR and 1/3 radius ($p < 0.01$). The correlation between the BMD measures at LS and TF, FN, TR and1/3 radius were 0.708, 0.667, 0.721 and 0.633, respectively ($p < 0.01$). Women with perimenopausal status had higher height and BMD values at all five observed sites than postmenopausal women ($p < 0.01$).*
Conclusion: *The present found a good correlation of the BMD from various skeletal sites. Interestingly, the correlation was found highest between the LS vs. TR and TF vs. TR region. Clearly, estrogen-deficient plays important role on the low BMD values in all skeletal sites.*

Keywords: *Bone mineral density, Correlation, Perimenopausal, Postmenopausal*

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Osteoporosis is a major health problem that is becoming more prevalent in Thailand. It is the most common metabolic disease of bone that is characterized by deficit in bone mineral density (BMD), microarchitectural deterioration, compromised bone strength, and an increase in the risk of bone fracture(1-4). The importance of measurement of BMD is, to early diagnosis and treatment of osteoporosis and prevention of bone fractures and its consequent disease complication and disability(2,3), assessment of fracture risk, and monitor patients by performing serial BMD assessments(5). BMD depends on age, disease, genetic of osteoporosis, mechanical factors, nutrition, vitamin D status, calcium intake, and the body hormones effects(6).

The diagnosis of osteoporosis is established by standard measurement of BMD, which has been shown to correlate with bone strength and is an excellent predictor of fracture risk. Dual-energy x-ray absorptiometry (DXA) is currently the most widely used method for BMD measurement of the axial skeleton with high precision. Areal BMD is expressed in absolute terms of grams of mineral per square centimeter scanned (g/cm^2) and as a relationship to two norms: compared to the expected BMD for the patient's age and sex (Z-score), or compared to "young normal" adults of the same sex (T-score). The difference between the patient's score and the norm is expressed in standard deviations (SD) above or below the mean. Usually, 1 SD equals 10 to 15% of the bone density value in g/cm^2. Depending on the skeletal site, a decline in BMD begins during young adulthood, accelerates

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in women at menopause, and continues to progress in men and in women after age 50. According to the World Health Organization (WHO) diagnostic classification, osteoporosis is defined by BMD at the spine or hip that is less than or equal to 2.5 SD below the young normal mean reference population.

In postmenopausal women and men aged 50 years and over, the WHO diagnostic T-score criteria (normal, osteopenia, and osteoporosis) are applied to BMD measurement by central DXA at the lumbar spine, total hip, and femoral neck. BMD measured by DXA at the 1/3 radius site can be used for diagnosing osteoporosis when the hip and spine cannot be measured. The International Society for Clinical Densitometry (ISCD) recommended that premenopausal women, men less than 50 years of age, and children, the WHO BMD diagnostic classification should not be applied. In these groups, the diagnosis of osteoporosis should not be made on the basis of densitometric criteria alone[7].

The correlation between BMD measurements at various skeletal sites has been questioned[8-13]. This controversy is supported by the fact that the proportion of cortical to trabecular bone varies throughout the skeleton[14] and by the different rates of turnover of cortical and trabecular bone with ages, menopause status, and disease-related bone changes[15-18]. The aim of the present study was to determine the correlation of BMD in various skeletal sites including lumbar spine, non-dominant proximal femur, and 1/3 radius (non-dominant side), and to determine the prevalence of low bone mass and osteoporosis in perimenopausal and postmenopausal women in Northern Thailand.

Material and Method

This was a cross-sectional study. The data of the subjects was collected from the medical records and the BMD results of perimenopausal and postmenopausal women who had the standard BMD measurement in the Division of Nuclear Medicine, Department of Radiology, Faculty of Medicine, Chiang Mai University between January 2007 and December 2007. The present study was reviewed and approved by the Ethics Committee of Faculty of Medicine, Chiang Mai University, Thailand.

Inclusion criteria

1. Women with perimenopausal and menopausal status who had BMD measurement at lumbar, non-dominant hip and non-dominant forearm
2. No prior history of medical treatment for low bone mass or osteoporosis
3. No history of underlying disease that might affect the bone density such as tumor, thyrotoxicosis, autoimmune disease, and renal tubular acidosis

Exclusion criteria

1. Women who had prior BMD testing that consequence to medical treatment
2. Evidence of degenerative disease, scoliosis, compression fractures, and artifact demonstrated on BMD imaging report or other imaging modalities
3. History of fractures of lumbar spine, non-dominant femur, or non-dominant forearm
4. History of surgery of lumbar spine, non-dominant femur, or non-dominant forearm

BMD was measured using DXA (Hologic, QDR 4500C). The DXA device was calibrated daily and weekly by using appropriated phantoms methods. To assess BMD, second to fourth lumbar spine, the non-dominant femur, and 1/3 region of non-dominant radius, bone density was calculated based on gm/cm^2. Measurements over the femur included regions of interest drawn over the femoral neck (FN), trochanter region (TR), and total proximal femur (TF).

The parameters in the present study were as the following; age, menopause age, duration after menopause, weight, height, body mass index (BMI), BMD (g/cm^2), T-score, and Z-score of the L1-L4 spine, TF, FN, and TR of non-dominant femur, and 1/3 radius of non-dominant forearm. The results of BMD measurements will be categorized to three categories, normal, low bone mass, and osteoporosis according to the World Health Organization 1994 criteria using Japanese reference database provided by Hologic manufacture. Then, the prevalence of low bone mass and osteoporosis were calculated as correlated to duration after menopause.

All data were analyzed using the Statistical Package for Social Sciences version 16.0 (SPSS Inc, Chicago, IL, USA). The results of the statistical analysis were expressed as mean values ($\pm$ standard deviation [SD]). To compare the mean between two groups, the Student t test was used. The correlation between continuous variables was evaluated by Spearman's correlation. A p-value of less than or equal to 0.05 was considered to be statistically significant.

Results

Eight hundred eighty five subjects between 35 to 91 years (mean $\pm$ SD = 58.7 $\pm$ 9.9 year) were

Table1. Clinical characteristics and BMD of the study groups (n = 885)

Variables	Perimenopause (n = 149)	Postmenopause (n = 736)	EMG (n = 220)	LMG (n = 516)
Age	48.20 ± 4.20	60.90 ± 9.30	53.10 ± 3.60	64.20 ± 6.05
Weight (kg)	55.20 ± 7.90	60.90 ± 9.30	57.00 ± 8.50	5.40 ± 10.00
Height (m)	1.53 ± 0.04	1.51 ± 0.06	1.53 ± 0.06	1.50 ± 0.06
BMI (kg/m^2)	36.10 ± 5.20	37.00 ± 5.90	37.20 ± 5.40	36.90 ± 6.10
BMD of LS	0.938 ± 0.122	0.800 ± 0.148	0.849 ± 0.132	0.779 ± 0.150
BMD of TF	0.836 ± 0.108	0.748 ± 0.131	0.802 ± 0.105	0.724 ± 0.134
BMD of FN	0.759 ± 0.095	0.677 ± 0.113	0.727 ± 0.097	0.656 ± 0.112
BMD of TR	0.638 ± 0.092	0.554 ± 0.112	0.601 ± 0.088	0.534 ± 0.116
BMD of 1/3 radius	0.663 ± 0.051	0.600 ± 0.086	0.647 ± 0.601	0.579 ± 0.088

Values are mean ± SD unless indicated otherwise
BMI = body mass index; BMD = bone mineral density; LS = lumbar spine; TF = total femur; FN = femoral neck; TR = trochanter region; EMG = early menopause group; LMG = late menopause group

enrolled in the study. There were 149 women with perimenopausal status and 736 women with post-menopausal status. Basic clinical characteristics of the subjects and BMD of the present study groups are shown in Table 1. The BMD of LS showed the highest values.

Overall, 222 women (25.1%) had normal bone density, 425 women (48.0%) had osteopenia and 238 women (26.9%) had osteoporosis (Table 3). The lowest T-score was found 51.6% at lumbar spine (LS), 29.2% at1/3 radius, 13.8% at FN, 2.9% at TF, and 2.5% at TR. There was found to be significant correlation between age, BMI, duration of menopause and BMD at the LS, TF, FN, TR, and 1/3 radius ($p < 0.01$) (Table 4). No significant correlation was found between the BMI and the duration after menopause ($p = 0.17$). The correlation between the BMD measured at LS, and TF, FN, TR, and 1/3 radius were 0.708, 0.667, 0.721, and 0.633, respectively ($p < 0.01$). For the different sites of the proximal femur, the present study found statistically significant correlation between TF, FN, and TR regions; $r = 0.935$ (TF vs. TR), $r = 0.893$ (TF vs. FN), and $r = 0.830$ (FN vs. TR) as shown in Table 2.

The prevalence of osteopenia and osteoporosis in different study groups is demonstrated in Table 3. Women with perimenopausal status had higher height and BMD values at all five observed sites than postmenopausal women. The difference was significant for both height and BMD values at all sites ($p < 0.01$). However, there were no statistical significant differences of the weight and BMI between two groups ($p = 0.415$ and 0.071). The present study also classified postmenopausal women into the early group of menopause (EMG, ≤ 5 years; 220 women) and the late group of menopause (LMG, >5 years; 516 women). Similar findings were demonstrated in these two groups (Table 2).

Table 2. Correlation coefficients (r values) of the BMD of the various skeletal sites

Status	Measurement sites			
	TF	FN	TR	1/3 radius
Overall				
LS	0.708	0.667	0.721	0.633
TF	-	0.893	0.935	0.692
FN	-	-	0.830	0.648
Perimenopausal status				
LS	0.686	0.590	0.691	0.246
TF	-	0.870	0.914	0.379
FN	-	-	0.782	0.296
Postmenopausal status				
LS	0.684	0.643	0.695	0.633
TF	-	0.888	0.933	0.696
FN	-	-	0.822	0.656
EMG				
LS	0.619	0.595	0.685	0.548
TF	-	0.855	0.898	0.504
FN	-	-	0.748	0.451
LMG				
LS	0.629	0.680	0.629	0.629
TF	-	0.886	0.935	0.711
FN	-	-	0.824	0.663

All r values are statistically significant ($p < .001$)
BMD = bone mineral density; LS = lumbar spine; TF = total femur; FN = femoral neck; TR = trochanter region; EMG = early menopause group; LMG = late menopause group

Table 3. Prevalence of osteopenia and osteoporosis in different study groups

Group	Number	Normal BMD	Osteopenia	Osteoporosis
Overall	855	222(25.1%)	425(48.0%)	238(26.9%)
Perimenopausal status	149	82(55.0%)	59(39.6%)	8(5.4%)
Postmenopausal status	736	14(19.0%)	366(49.7%)	230(31.3%)
EMG	220	69(31.4%)	116(52.7%)	35(15.9%)
LMG	516	71(13.8%)	250(48.4%)	195(37.8%)

BMD = bone mineral density; EMG = early menopause group; LMG = late menopause group

Table 4. Correlation coefficients (r values) between age, BMI, duration of menopause and the BMD of the various skeletal sites

Parameters	Measurement sites				
	LS	TF	FN	TR	1/3 radius
Age	-0.435	-0.434	-0.468	-0.468	-0.577
BMI	0.315	0.453	0.395	0.397	0.285
Duration of menopause	-0.398	-0.491	-0.501	-0.510	-0.562

All r values are statistically significant (p < 0.001)

Discussion

In Thailand, osteoporosis is a health problem that is becoming more prevalent. It is important to calculate the prevalence of osteoporosis to address the overall magnitude of the problem in the Thai population, particularly women who are considered to be in the risk group. Many research groups had been studied to assess the prevalence of osteoporosis and determine the age-specific and age-adjusted prevalence of osteopenia and osteoporosis in pre- and postmenopausal Thai women(19-23). In a 2000-2001 nation-wide survey, the age-adjusted prevalence of osteoporosis in Thai women aged 40 to 80 years was 13.6% and 19.8% for femoral neck and lumbar spine, respectively(19). The age-specific prevalence of osteoporosis among Thai women below 50 years of age was less than 5% and the prevalence increased with advancing age. In Thailand's over 70 year women, prevalence of disease was 50%(19). In the present study, the authors found that 48.0% and 26.9% of the total subjects had osteopenia and osteoporosis, respectively. When the authors categorized those subjects according to their menopausal status, prevalence of low bone mass and osteoporosis increased from 39.6% and 5.4% in the perimemopausal group to 49.7% and 31.3% in the postmemopausal group. The same paradigm was also demonstrated in EMG and LMG. Therefore, it was clearly demonstrated that estrogen-deficit status had an influence on BMD value.

Discordance among various skeletal sites is common nature. Different hormonal and mechanical influences lead to differential changes in bone mass. After menopause, estrogen deficiency accelerates the age-related loss of bone(20,21). Cancellous bone is more sensitive to changes in bone resorption. Bone loss is going to affect the cancellous skeleton first. The lumbar spine is estimated to contain approximately 66% of cancellous bone. Femoral neck and distal radius contain approximately 25% and 30% of cancellous bone, respectively. Therefore, a central skeletal site will show bone loss first(22). With increasing age, the concordance between peripheral and central sites tends to improve, but in women in their early post-menopausal years, discordance between peripheral and central sites is a source of concern. Correlation of bone mineral density among various measurement sites in Thai women have been reported in two articles. The first one was in 1997, and later in 1998(23,24). Taechakraichana N et al found that BMD of spine and hip was highly correlated in 1,047 women. The present study also showed a significantly high correlation of BMD of total hip and spine (r = 0.7021, p < 0.001). Nevertheless, BMD of the spine was mostly correlated with BMD of trochanteric site ($r = 0.7235$, $p < 0.001$) and least correlated with BMD of intertrochanteric region. ($r = 0.2426$, $p < 0.001$)[23]. Another study conducted by Limpaphayom K et al revealed a significant correlation of BMD of distal and ultra-distal parts of the forearm with various sites of hip ($r = 0.602$, $p < 0.001$). There was also significant correlation of distal and ultra-distal part of forearm with various sites of spines ($r = 0.619$, $p < 0.001$) [24]. They also stated that bone mass measurement of distal forearm might be used to predict the BMD of hip and spine in Thai women. From this present study, the greatest correlation between the LS and various part of proximal femur was found between LS and TR ($r = 0.691$-0.721) and the least correlation was between LS and FN ($r = 0.590$-0.667) in all interesting groups (overall, perimenopausal, postmenopausal, EMG) except LMG. In LMG, interestingly, the authors found the greatest correlation between LS and FN.

After applying the peripheral BMD for correlation, we found poor correlation between LS and 1/3 radius in the perimenopausal group ($r = 0.246$). However, the correlation increased to 0.633 in the postmenopausal group. Correlation coefficients between peripheral and central sites have been found between 0.6–0.70[25]. Therefore, using the peripheral sites will miss a substantial number of individuals with osteopenia or osteoporosis. Significant concordance between sites is not good enough when it is used to predict bone mass from one site to another in particular individual[22,26-28]. Therefore, the diagnosis of low bone density and osteoporosis using peripheral DXA is not considered the practical measurement site in women with perimenopausal or even premenopausal with risk factor. An individual with normal bone mass at a peripheral site could have substantial reductions at central skeletal site and, therefore, need additional testing for these to be discovered. Central DXA measurement is still the best site for screening and diagnosis abnormal bone density.

Conclusion

The present study found rather good correlation of the BMD from various skeletal sites. Interestingly, the correlation was found highest between the LS vs. TR, and TF vs. TR region. Clearly, estrogen-deficient plays an important role on the low BMD values in all skeletal sites. However, the results obtained in the present study might not represent the true magnitude of the problem in Thailand.

Potential conflicts of interest

None.

References

1. World Health Organization. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. No. 843 of Technical Reports Series. Geneva: WHO; 1994.
2. Genant HK, Cooper C, Poor G, Reid I, Ehrlich G, Kanis J, et al. Interim report and recommendations of the World Health Organization Task-Force for Osteoporosis. Osteoporos Int 1999; 10: 259-64.
3. Blake GM, Fogelman I. Applications of bone densitometry for osteoporosis. Endocrinol Metab Clin North Am 1998; 27: 267-88.
4. Waine C. Osteoporosis: prevention and management in primary care. BMJ 1997; 314: 1056-9.
5. McGuigan FE, Murray L, Gallagher A, Davey-Smith G, Neville CE, Van't Hof R, et al. Genetic and environmental determinants of peak bone mass in young men and women. J Bone Miner Res 2002; 17: 1273-9.
6. Cooper C, Melton LJ III. Epidemiology of osteoporosis. Trends Endocrinol Metab 1992; 3: 224-9.
7. ISCD Official Positions [homepage on the Internet]. West Hartford, CT: International Society for Clinical Densitometry; 2010 [cited 2007]. Available from: http://www.iscd.org/.
8. Hamdy RC, Petak SM, Lenchik L. Which central dual X-ray absorptiometry skeletal sites and regions of interest should be used to determine the diagnosis of osteoporosis? J Clin Densitom 2002; 5(Suppl): S11-8.
9. Liao EY, Wu XP, Deng XG, Huang G, Zhu XP, Long ZF, et al. Age-related bone mineral density, accumulated bone loss rate and prevalence of osteoporosis at multiple skeletal sites in chinese women. Osteoporos Int 2002; 13: 669-76.
10. Sweeney AT, Malabanan AO, Blake MA, Weinberg J, Turner A, Ray P, et al. Bone mineral density assessment: comparison of dual-energy X-ray absorptiometry measurements at the calcaneus, spine, and hip. J Clin Densitom 2002; 5: 57-62.
11. Blake GM, Knapp KM, Spector TD, Fogelman I. Predicting the risk of fracture at any site in the skeleton: are all bone mineral density measurement sites equally effective? Calcif Tissue Int 2006; 78: 9-17.
12. Hall ML, Heavens J, Ell PJ. Variation between femurs as measured by dual energy X-ray absorptiometry (DEXA). Eur J Nucl Med 1991; 18: 38-40.

13. Lilley J, Walters BG, Heath DA, Drolc Z. Comparison and investigation of bone mineral density in opposing femora by dual-energy X-ray absorptiometry. Osteoporos Int 1992; 2: 274-8.
14. Schlenker RA, VonSeggen WW. The distribution of cortical and trabecular bone mass along the lengths of the radius and ulna and the implications for in vivo bone mass measurements. Calcif Tissue Res 1976; 20: 41-52.
15. Riggs BL, Wahner HW, Dunn WL, Mazess RB, Offord KP, Melton LJ, III. Differential changes in bone mineral density of the appendicular and axial skeleton with aging: relationship to spinal osteoporosis. J Clin Invest 1981; 67: 328-35.
16. Ito M, Nakamura T, Tsurusaki K, Uetani M, Hayashi K. Effects of menopause on age-dependent bone loss in the axial and appendicular skeletons in healthy Japanese women. Osteoporos Int 1999; 10: 377-83.
17. Tsurusaki K, Ito M, Hayashi K. Differential effects of menopause and metabolic disease on trabecular and cortical bone assessed by peripheral quantitative computed tomography (pQCT). Br J Radiol 2000; 73: 14-22.
18. Lochmuller EM, Matsuura M, Bauer J, Hitzl W, Link TM, Muller R, et al. Site-specific deterioration of trabecular bone architecture in men and women with advancing age. J Bone Miner Res 2008; 23: 1964-73.
19. Limpaphayom KK, Taechakraichana N, Jaisamrarn U, Bunyavejchevin S, Chaikittisilpa S, Poshyachinda M, et al. Prevalence of osteopenia and osteoporosis in Thai women. Menopause 2001; 8: 65-9.
20. Ahlborg HG, Johnell O, Nilsson BE, Jeppsson S, Rannevik G, Karlsson MK. Bone loss in relation to menopause: a prospective study during 16 years. Bone 2001; 28: 327-31.
21. Riggs BL, Wahner HW, Melton LJ 3rd, Richelson LS, Judd HL, Offord KP. Rates of bone loss in the appendicular and axial skeletons of women. Evidence of substantial vertebral bone loss before menopause. J Clin Invest 1986; 77: 1487-91.
22. Arlot ME, Sornay-Rendu E, Garnero P, Vey-Marty B, Delmas PD. Apparent pre- and postmenopausal bone loss evaluated by DXA at different skeletal sites in women: the OFELY cohort. J Bone Miner Res 1997; 12: 683-90.
23. Taechakraichana N, Limpaphayom K, Angkawanich P, Poshyachinda M. Correlation of bone mineral density among various measurement sites. J Med Assoc Thai 1997; 80: 293-6.
24. Limpaphayom K, Bunyavejchevin S, Taechakraichana N. Similarity of bone mass measurement among hip, spines and distal forearm. J Med Assoc Thai 1998; 81: 94-7.
25. Blake GM, Patel R, Fogelman I. Peripheral or axial bone density measurements? J Clin Densitom 1998; 1: 55-63.
26. Miller PD, Zapalowski C, Kulak CA, Bilezikian JP. Bone densitometry: the best way to detect osteoporosis and to monitor therapy. J Clin Endocrinol Metab 1999; 84: 1867-71.
27. Melton LJ III, Chrischilles EA, Cooper C, Lane AW, Riggs BL. Perspective. How many women have osteoporosis? J Bone Miner Res 1992; 7: 1005-10.
28. Miller PD, Bonnick SL, Johnston CC, Kleerekoper M, Lindsay RL, Sherwood LM, et al. The challenges of peripheral bone density testing: which patients need additional central density skeletal measurements? J Clin Densitom 1998; 1: 211-7.

ความหนาแน่นของกระดูก: ความสัมพันธ์ระหว่างกระดูกสันหลังส่วนเอว, กระดูกต้นขาและกระดูกเรเดียส ในกลุ่มสตรีภาคเหนือตอนบน

ศิริอนงค์ นามวงศ์พรหม, มลฤดี เอกมหาชัย, นงลักษณ์ วิลาศเดชานนท์, อลิสา คล้ายเพ็ชร, จันทร์เพ็ญ วงค์บุญตัน, สมบัติ บุญญประภา

วัตถุประสงค์: *เพื่อศึกษาความสัมพันธ์ของความหนาแน่นของกระดูกในกระดูกส่วนต่าง ๆ ได้แก่ กระดูกสันหลังส่วนเอว, กระดูกต้นขาและกระดูกเรเดียสในกลุ่มสตรีภาคเหนือตอนบน*
วัสดุและวิธีการ: *ข้อมูลในการศึกษานี้ได้มาจากการรวบรวมประวัติทางการแพทย์และผลการตรวจความหนาแน่นของกระดูกของสตรีวัยก่อนหมดประจำเดือนและหลังหมดประจำเดือนจำนวน 885 คน ที่ได้รับการตรวจวัดความหนาแน่นของกระดูกที่หน่วยเวชศาสตร์นิวเคลียร์ ภาควิชารังสีวิทยา คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่ระหว่างเดือนมกราคม ถึง ธันวาคม พ.ศ. 2550 ด้วยเครื่อง dual-energy X-ray absorptiometry (Hologic, QDR-4500C)*
ผลการศึกษา: *อายุเฉลี่ยของกลุ่มสตรีที่ศึกษามีค่า 58.7 $\pm$ 9.9 ปี ค่า T-score ต่ำที่สุดอยู่ตำแหน่งกระดูกสันหลังส่วนเอว (LS) 51.6%, 1/3 ของกระดูกเรเดียส (1/3 radius) 29.2 %, ตำแหน่ง femoral neck (FN) 13.8%, ตำแหน่ง total femur (TF) 2.9% และ ตำแหน่ง trochanter (TR) 2.5% พบความสัมพันธ์อย่างมีนัยสำคัญทางสถิติระหว่างอายุ, ดรรชนีมวลกาย, ระยะเวลาหลังหมดประจำเดือน และความหนาแน่นของกระดูกที่ตำแหน่ง LS, TF, FN, TR และ 1/3 radius ($p<0.01$) โดยค่าความสัมพันธ์ระหว่างความหนาแน่นของกระดูกตำแหน่ง LS, and TF, FN, TR และ1/3 radius มีค่า 0.708, 0.667, 0.721 และ 0.633, ตามลำดับ ($p < 0.01$) สตรีวัยก่อนหมดประจำเดือน มีความสูงและความหนาแน่นของกระดูกสูงกว่าสตรีหลังหมดประจำเดือนในทุกตำแหน่งที่ทำการตรวจ ($p < 0.01$)*
สรุป: *การศึกษานี้พบความสัมพันธ์ของความหนาแน่นของกระดูกในกระดูกส่วนต่าง ๆ ในระดับค่อนข้างดี สิ่งที่น่าสนใจคือ ความสัมพันธ์ที่พบมีระดับสูงสุดระหว่างตำแหน่ง LS กับ TR และตำแหน่ง TF กับ TR ภาวะพร่องเอสโตรเจนมีบทบาทสำคัญต่อความหนาแน่นของกระดูกที่ลดลงในทุกตำแหน่งที่ทำการศึกษา*