Evaluation of Forearm Bone Mineral Density : Comparison of Dominant and Non-Dominant Forearms

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Abstract

For evaluation of forearm bone mineral density (BMD), (1) BMD of corresponding sites of dominant and non-dominant forearms were compared and (2) characteristics of each of the 4 regions of interest (ROIs) including supradistal, distal 1/10, distal 1/6 and distal 1/3 along the long bone of both forearms were analyzed. One hundred and forty one women (79 normal and 62 osteoporotic) were recruited by randomized selection from the department of Nuclear Medicine of Phramongkutklao Hospital. Both dominant and non-dominant forearms of each subject were scanned by Panasonic (DXA-70) dual energy X-ray absorptiometry (DEXA) on the same day. Lumbar spine BMD was also measured by Hologic DEXA (QDR-4500) and WHO criteria for diagnosis of osteoporosis was applied for identifying osteoporosis and normal groups. The results showed that none of the corresponding sites of BMD of both forearms were significantly different ($p>0.05$ for all). The BMD from distal to proximal of each long bone (radius and ulna) of both forearms was gradually increased in osteoporosis and normal groups. Further distal sites of the forearms and lower BMD were found. Comparison between mean BMD at corresponding sites in normal and osteoporotic groups, had significantly different BMD at both radii for all ROIs ($p<0.05$). While BMD at corresponding sites of both ulna in the 2 groups was not significantly different ($p>0.05$). A great percentage change of mean BMD in the osteoporotic group was seen at supradistal and distal 1/10 of both forearms when using BMD in the normal group as control. We suggest that both distal radii especially at supradistal and distal 1/10 sites should be scanned in routine practice. The distal location of the forearms had a relatively smaller amount of surrounding soft tissue than the proximal.

Key word : Forearms, Bone Density

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Osteoporosis is a common metabolic disease in which low bone mass and micro-architectural deterioration of bone tissue lead to increased bone fragility and a consequent increase in fracture risk[1]. Accurate assessment of individual fracture risk requires measurement of bone mass (density)[2]. A single BMD measurement at the forearm has a predictive ability for fragility fractures including spine, hip and other fractures [3,4]. The peripheral location of the human forearm, with its relatively small amount of surrounding soft tissue, improves the accuracy and precision of bone mass measurement and has made this site an early choice for the assessment of a subject's bone mineral status[3,5]. However, it is still unknown whether : (1) BMD of the dominant forearm is similar to the non-dominant forearm and (2) each of the 4 ROIs along the long bone of both forearms are identical. The aim of this study was to answer these questions using Panasonic (DXA-70) DEXA in healthy subjects.

MATERIAL AND METHOD

One hundred and forty one women (aged 40-76 years, mean 56.82 years, SD = 7.25) were recruited by randomized selection from the department of Nuclear Medicine of Phramongkutklao Hospital. In 95.74 per cent of them, the right forearm was used as the dominant one. Both dominant and non dominant forearms of each subject were scanned by Panasonic DEXA on the same day. The 4 ROIs including supra-distal, distal 1/10, distal 1/6 and distal 1/3 of each long bone (radius and ulna) of the forearms were measured. Bone mineral content (g), area (cm^2) and bone mineral density (g/cm^2) were computed at each of the ROIs. None of the study subjects had suffered from severe osteoarthritis or bone related diseases or were on drugs known to interfere with bone mass. Women with surgical menopause were excluded. Lumbar spine BMD was also measured by Hologic DEXA (QDR-4500) and WHO criteria for diagnosis of osteoporosis was applied for identifying osteoporotic and normal groups.

Statistics

Statistical analysis was performed using the software SPSS/PC+ Version 7.5. Mean ± SD of base line characteristics and 4 ROIs of both

Table 1. Baseline characteristics of the subjects in osteoporotic and normal groups.

	osteoporotic	normal	p
n	62	79	
age (years)	59.82 ± 8.71	52.64 ± 7.89	0.552
weight (kg)	55.02 ± 6.93	60.07 ± 8.78	0.191
height (cm)	154.51 ± 5.32	156.33 ± 5.31	0.976
recall menarche age (years)	14.10 ± 1.34	13.87 ± 1.91	0.056
menopausal age (years)	48.19 ± 3.45	48.63 ± 3.14	0.693

Table 2. Mean BMD (g/cm^2) ± SD of 4 ROIs of dominant and non-dominant forearms (radius and ulna).

ROIs	dominant	non-dominant	t	p
radius				
supradistal	0.409 ± 0.053	0.409 ± 0.060	0.05	0.961
distal 1/10	0.484 ± 0.059	0.489 ± 0.059	-1.14	0.119
distal 1/6	0.536 ± 0.060	0.538 ± 0.061	-0.74	0.460
distal 1/3	0.610 ± 0.062	0.599 ± 0.069	1.25	0.192
ulna				
supradistal	0.352 ± 0.05	0.365 ± 0.055	-1.34	0.106
distal 1/10	0.443 ± 0.067	0.451 ± 0.074	-1.52	0.132
distal 1/6	0.495 ± 0.066	0.493 ± 0.064	0.32	0.747
distal 1/3	0.611 ± 0.064	0.603 ± 0.054	1.73	0.087

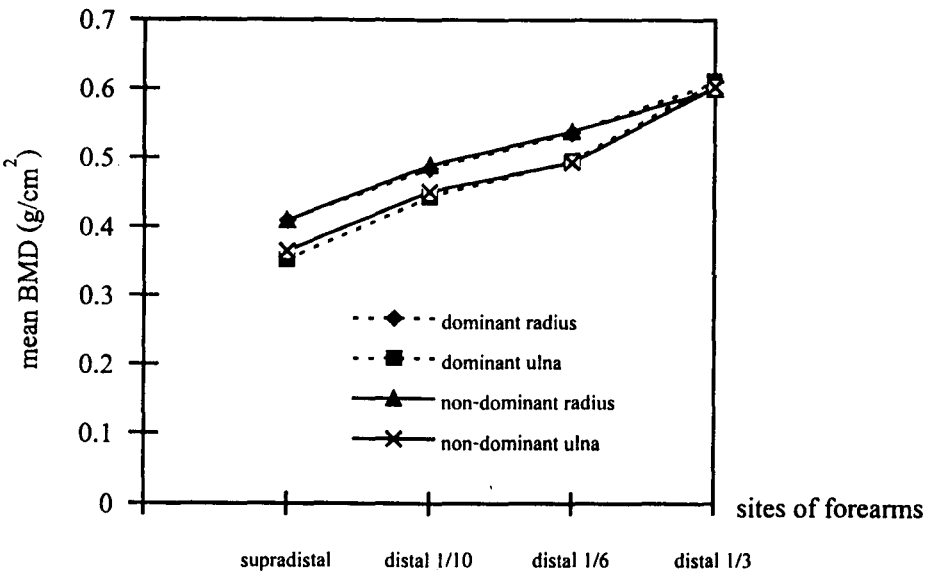

Fig. 1. Mean BMD (g/cm^2) at various sites of dominant and non-dominant forearms.

Table 3. Comparison of mean BMD (g/cm^2) of 4 ROIs along the long bone of both forearms in osteoporotic and normal groups.

ROIs	osteoporotic		normal	
	t	P	t	P
Dominant radius				
supradistal & distal 1/10	5.57	< 0.001*	9.50	< 0.001*
supradistal & distal 1/6	9.63	< 0.001*	15.16	< 0.001*
supradistal & distal 1/3	15.20	< 0.001*	21.54	< 0.001*
distal 1/10 & distal 1/6	8.61	< 0.001*	11.22	< 0.001*
distal 1/10 & distal 1/3	10.54	< 0.001*	19.28	< 0.001*
distal 1/6 & distal 1/3	6.21	< 0.001*	14.03	< 0.001*
Dominant ulna				
supradistal & distal 1/10	8.45	< 0.001*	12.97	< 0.001*
supradistal &distal 1/6	12.64	< 0.001*	18.34	< 0.001*
supradistal & distal 1/3	30.86	< 0.001*	22.18	< 0.001*
distal 1/10 & distal 1/6	5.40	< 0.001*	11.21	< 0.001*
distal 1/10 & distal 1/3	18.28	< 0.001*	13.58	< 0.001*
distal 1/6 & distal 1/3	13.67	< 0.001*	8.69	< 0.001*
Non-dominant radius				
supradistal & distal 1/10	10.06	< 0.001*	12.50	< 0.001*
supradistal & distal 1/6	14.18	< 0.001*	16.66	< 0.001*
supradistal & distal 1/3	14.55	< 0.001*	17.90	< 0.001*
distal 1/10 & distal 1/6	10.28	< 0.001*	9.86	< 0.001*
distal 1/10 & distal 1/3	11.36	< 0.001*	13.34	< 0.001*
distal 1/6 & distal 1/3	7.14	< 0.001*	6.91	< 0.001*
Non-dominant ulna				
supradistal & distal 1/10	7.85	<0.001*	7.92	< 0.001*
supradistal & distal 1/6	13.32	<0.001*	19.77	< 0.001*
supradistal & distal 1/3	28.19	<0.001*	31.75	< 0.001*
distal 1/10 & distal 1/6	12.04	<0.001*	3.16	< 0.001*
distal 1/10 & distal 1/3	21.18	<0.001*	10.46	< 0.001*
distal 1/6 & distal 1/3	15.37	<0.001*	14.87	< 0.001*

* significant at $p < 0.05$

forearms of the patients were calculated. Paired *t*-test was used to compare the BMD of corresponding ROIs of dominant and non dominant forearms and to evaluate the BMD of each ROI along long bone. Characteristics of BMD from supradistal to distal 1/3 of each long bone was plotted by using the software EXCEL. Student's *t*-test was used to compare BMD of corresponding ROIs in normal and osteoporotic groups. Percentage change of mean BMD in the osteoporotic group was calculated using the mean BMD of the corresponding sites in the normal group as control.

RESULTS

Baseline characteristics (mean ± SD) including age, weight, height, recall menarche age and menopausal age of 62 osteoporotic patients (59.82 ± 8.71 years, 55.02 ± 6.93 kg, 154.51 ± 5.32 cm, 14.10 ± 1.34 years and 48.19 ± 3.45 years) and 79 normal subjects (52.64 ± 7.89 years, 60.07 ± 8.78 kg, 156.33 ± 5.31 cm, 13.87 ± 1.91 years and 48.63 ± 3.14 years) are shown in Table 1. There was no significant difference in age (p= 0.552), weight (p=0.191), height (p=0.976), recall menarche age (p=0.056) and menopausal age (p=0.693) in the osteoporotic and normal groups. The mean BMD of the corresponding sites of dominant and non-dominant forearms were compared. The results show in Table 2 that no corresponding site was significantly different (P>0.05 for all). The characteristics of BMD from distal to proximal of each long bone gradually increased as demonstrated in Fig. 1. This trend was similar among dominant radius, dominant ulna, non-dominant radius and non-dominant ulna. Consideration to mean BMD along each long bone of both dominant and non-dominant forearms, mean BMD among supradistal, distal 1/10, distal 1/6 and distal 1/3 were significantly different (Table 3) in the osteoporotic and normal groups (P<0.001 for all). Comparison between mean BMD at corresponding sites in the normal and osteoporotic groups in Table 4, were significantly different in mean BMD at both radii for all ROIs (p<0.05). While mean BMD at the corresponding sites of both ulna in the 2 groups was not significantly different (p>0.05). Mean BMD of 4 ROIs of dominant and non-dominant radius in the osteoporotic group was significantly lower than that in the normal group with a rate change of 19.95 per cent and 21.30 per cent at supradistal,

Table 4. Comparison of mean BMD at corresponding sites of both forearms in normal and osteoporotic groups.

		dominant				non-dominant			
		normal	osteoporotic	p	percentage change	normal	osteoporotic	p	percentage change
radius									
	supradistal	0.456 ± 0.046	0.365 ± 0.042	0.036*	19.95	0.460 ± 0.044	0.362 ± 0.054	0.029*	21.30
	distal 1/10	0.526 ± 0.002	0.432 ± 0.070	0.017*	17.87	0.560 ± 0.043	0.454 ± 0.071	0.004*	18.92
	distal 1/6	0.569 ± 0.047	0.487 ± 0.073	0.024*	14.41	0.576 ± 0.048	0.500 ± 0.073	0.017*	13.19
	distal 1/3	0.641 ± 0.046	0.555 ± 0.074	0.012*	13.41	0.631 ± 0.054	0.564 ± 0.093	0.002*	10.61
ulna									
	supradistal	0.392 ± 0.045	0.317 ± 0.049	0.698	19.13	0.403 ± 0.041	0.332 ± 0.049	0.298	17.61
	distal 1/10	0.487 ± 0.037	0.392 ± 0.070	0.106	19.50	0.500 ± 0.076	0.400 ± 0.067	0.471	20.00
	distal 1/6	0.536 ± 0.050	0.440 ± 0.067	0.117	17.91	0.536 ± 0.048	0.453 ± 0.068	0.043	15.48
	distal 1/3	0.634 ± 0.392	0.570 ± 0.064	0.455	10.09	0.629 ± 0.039	0.571 ± 0.060	0.016	9.22

* significant at p < 0.05

17.87 per cent and 18.92 per cent at distal 1/10, 14.41 per cent and 13.19 per cent at distal 1/6 and 13.41 per cent and 10.61 per cent at distal 1/3.

DISCUSSION

WHO criteria for diagnosis of osteoporosis was used to discriminate the normal and osteoporosis (spine) groups. It is shown in Table 1 that the selected subjects of both groups had similar base line characteristics. Although the decreased BMD in healthy subjects or patients with rheumatoid arthritis seems primarily to be caused by reduction in muscle strength or an impaired physical activity[6-8], BMC of the dominant and non-dominant forearms was also not different in volleyball players[9]. In this study, bone measurements of both forearms in individual subjects revealed similar BMD. It may not be absolutely different for physical activity of dominant and non-dominant forearms. In women who use the right forearm as the dominant one, the left forearm might be used for other activities. Mean BMD from distal to proximal of each long bone of both forearms gradually increased, so the further distal site of the forearms, the lower the BMD. Comparison of mean BMD at corresponding sites in normal and osteoporotic groups, revealed significant difference of BMD at both radii for all ROIs ($p<0.05$). While the BMD at corresponding sites of both ulna in the 2 groups was not significantly different ($p>0.05$). A great percentage change of mean BMD in the osteoporotic group was seen at supradistal and distal 1/10 of both forearms when using the BMD of normal group as control. The correlation of BMD Z-scores of the spine or femur with the ultradistal site of the radius was better than with the mid-distal site. Spine, femur and ultradistal radius have a high proportion of trabecular bone, while the mid-distal site is mainly cortical bone[10]. The distal location of the forearm has a relatively smaller amount of surrounding soft tissue than the proximal. We suggest that both distal radii especially at supradistal and distal 1/10 sites should be routinely scanned.

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การประเมินความหนาแน่นของกระดูกปลายแขน : เปรียบเทียบแขนที่ถนัดและไม่ถนัด

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ได้ทำการประเมินความหนาแน่นของกระดูกปลายแขนโดย (1) เปรียบเทียบความหนาแน่นของกระดูกปลายแขนในตำแหน่งที่ตรงกันของข้างที่ถนัดและไม่ถนัด และ (2) วิเคราะห์ลักษณะการเปลี่ยนแปลงความหนาแน่นตามความยาวของกระดูกปลายแขนจากตำแหน่งปลายสุด ส่วนปลาย 1/10 ส่วนปลาย 1/6 ถึงส่วนปลาย 1/3 ในผู้หญิง 141 คน (ปกติ 79 คนและกระดูกสันหลังพรุน 62 คน) ที่เลือกโดยวิธีสุ่มจากหน่วยเวชศาสตร์นิวเคลียร์ โรงพยาบาลพระมงกุฎเกล้า ทำการวัดความหนาแน่นที่กระดูกปลายแขนทั้ง 2 ข้างด้วย เครื่องวัดความหนาแน่นของกระดูก Panasonic (DXA-70) วัดความหนาแน่นของกระดูกสันหลังส่วนเอวด้วยเครื่องวัดความหนาแน่นของกระดูก Hologic (QDR-4500) แบ่งผู้ป่วยเป็น 2 กลุ่ม คือ กลุ่มที่เป็นโรคกระดูกสันหลังพรุนและกลุ่มปกติตามนิยามขององค์การอนามัยโลก ผลการทดลองพบว่าไม่มีความแตกต่างของความหนาแน่นของกระดูกปลายแขน ในตำแหน่งที่ตรงกันของแขนข้างที่ถนัด และไม่ถนัด (P>0.05 ทุกค่า) ความหนาแน่นตามความยาวของกระดูกปลายแขนอันนอกและอันใน จะค่อยๆ เพิ่มขึ้นจากส่วนปลายไปยังส่วนต้นทั้ง 2 กลุ่ม ตำแหน่งที่ยิ่งอยู่ส่วนปลายมากเท่าใด ความหนาแน่นก็จะยิ่งลดลง เมื่อเปรียบเทียบระหว่างกลุ่มปกติและกระดูกพรุนพบว่าความหนาแน่นในตำแหน่งที่ตรงกันของกระดูกปลายแขนอันนอก แตกต่างกันทุกตำแหน่ง (p<0.05) ในขณะที่ไม่พบความแตกต่างที่กระดูกปลายแขนอันในทุกตำแหน่ง (p>0.05) อัตราการเปลี่ยนแปลงของค่าเฉลี่ยความหนาแน่นของกระดูกปลายแขนทั้ง 2 ข้างในกลุ่มกระดูกพรุนลดลงจากกลุ่มปกติอย่างเด่นชัดที่ตำแหน่งปลายสุด และ ส่วนปลาย 1/10 เนื่องจากส่วนปลายจะมีเนื้อเยื่อห่อหุ้มน้อยกว่าส่วนต้น ดังนั้นในทางปฏิบัติสามารถเลือกทำการวัดความหนาแน่นของกระดูกปลายแขนได้ทั้งข้างที่ถนัดหรือไม่ถนัด โดยเฉพาะอย่างยิ่งตรงตำแหน่งปลายสุด และส่วนปลาย 1/10

คำสำคัญ : กระดูกปลายแขน, ความหนาแน่นของกระดูก

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