Original Article/นิพนธ์ต้นฉบับ

Forearm Bone Mineral Density: A Comparison Study of Positioning and Side

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Abstract

Background: The scanning position for measure forearm bone mineral density (BMD) is recommended by the International Society for Clinical Densitometry (ISCD) to scan at the non-dominant forearm in the sitting position. However, this position may be uncomfortable for the patients. Especially for those who are elder or cannot easily move. Pragmatically, the supine position is more comfortable than the sitting position for patients to measure forearm BMD.

Objective: The purpose of this study was to estimate the difference of forearm BMD between the standard sitting and supine position as well as between the non-dominant and the dominant side.

Methods: One hundred and fifty two female patients who gave written informed consent underwent 3 acquisitions of dual X-ray absorptiometry (DXA) altogether: 2 on the non-dominant forearm--one in the sitting and the other in the supine position; 1 on the dominant forearm in the sitting position.

Results: All patients were right forearm dominant. The 33% radius BMD difference between the sitting and supine position was -0.005 g/cm^2 (95% CI, -0.03 to 0.02) while that between the dominant and non-dominant side was -0.011 g/cm^2 (95% CI, -0.06 to 0.04). When classified by World Health Organization (WHO) classification into 3 groups as normal, low bone mass, and osteoporosis, the agreement between the sitting and supine position of the non-dominant at this site was perfect (Kappa = 0.85) while that between the dominant and non-dominant side in the sitting position was moderate (Kappa = 0.64).

Conclusions: Measurement of BMD by DXA at non-dominant forearm in the sitting position can be scanned in the supine position without a change in diagnosis. Then the dominant forearm can be used instead the non-dominant if the non-dominant forearm is not properly done due to the presence of historical fracture or congenital deformities.

Keywords: DXA, Forearm, Positioning, Supine, Sit

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Introduction

The osteoporosis is a major public health problem that affects more than 200 million people worldwide. The Bone Mineral Density (BMD) was used for diagnosis and follow up in this disease. The common skeletal sites for assessed BMD values measured by dual X-ray absorptiometry (DXA) are lumbar spine, proximal femur and forearm.[1]

The forearm site is used for diagnosis of osteoporosis, fracture prediction, and serial therapy monitoring instead of the spine and femur when the spine and femur cannot be measured, parathyroidism patient and obese patient.

The scanning position for measure forearm BMD is recommended by the International Society for Clinical Densitometry (ISCD) to scan at the non-dominant forearm in the sitting position.[2] However, the dominant forearm will be using instead when the non-dominant forearm is not suitable for scanning due to the presence of deformities or artifacts in the region of interest.[3] The sitting position may be uncomfortable for the patients especial who are elder or cannot easily move. Pragmatically, the supine position is more comfortable than the sitting position for patients to measure forearm BMD.

This study consisted of 2 parts aiming at comparing the forearm BMD at various sites. The first part of the study was to compare the BMD between the standard sitting and the supine position in the non-dominant forearm. The second part was to compare the BMD between the non-dominant and the dominant side in the standard sitting position.

Materials and Methods

Subjects

Consecutive female patients referred for BMD determination were invited 155 patients to take part in this study. Those who agreed and gave written informed consent were included in the study. The 3 patients were excluded (2 presence of structural abnormality and 1 artifact in the forearms).

Sample Size Calculation

Minimum detectable BMD difference of 0.005 g/cm^2 was used for sample size calculation the standard. We used the SD values for the different positioning (0.010 g/cm^2) and for the different forearm side (0.019 g/cm^2) from our pilot study. This study needed 122 patients for the positioning comparison and 152 patients for the side comparison.

DXA Measurements

All patients underwent three DXA scans of the forearms: two on the non-dominant forearm--one in the sitting and the other in the supine position; the last one on the dominant forearm in the sitting position.

First, each patient was asked if she was left or right-handed. Then the patient was positioned on a chair with her non-dominant forearm placed parallel to the long axis of the scanning table for the first scan. Secondly, another scan was repeated in the supine position. Similarly, the non-dominant forearm was positioned parallel to the long axis of the scan table. In addition, it was checked if there was a sufficient gap between the arm and the trunk so that the scan field did

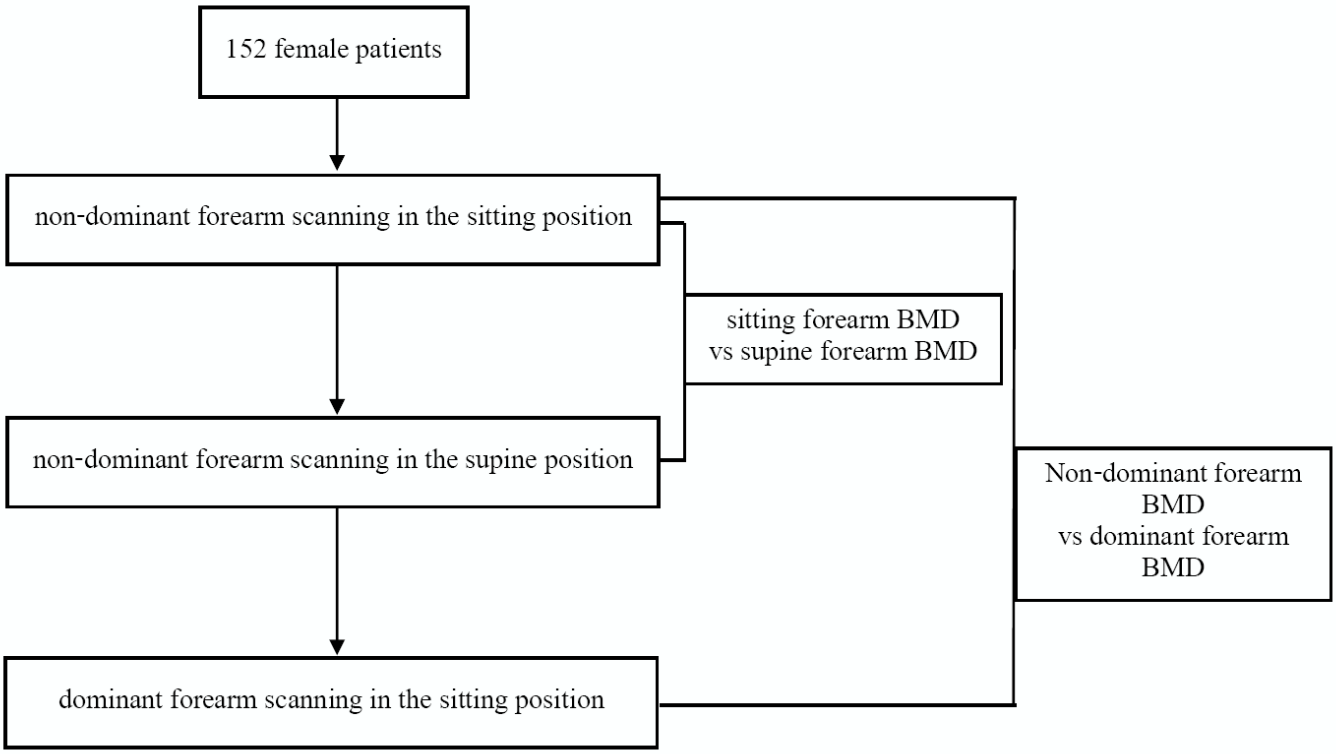

Figure 1 *Protocol Flow Chart*

not include the patient's clothing or any other part of their body. Finally, the last scan was taken at the dominant forearm in the sitting position.

All standard procedures in the positioning and the analysis followed the recommendation of the ISCD. The machine's calibration was performed on a daily basis before each scanning session using the Hologic Discovery A calibration phantom. All acquisitions were performed by an ISCD certified technologist using Hologic Discovery A in the same day. T-score of the 33% radius was derived using the NHANES Caucasian database.[4, 5] Then the patients were classified by World Health Organization (WHO) classification into 3 groups as normal (T-score -1.0), low bone mass (T-score between -2.5 to -1.0), and osteoporosis (T-score $\leq$ -2.5).

The BMD coefficients of variation were 0.82%, 2.52%, and 1.51% for the lumbar spine, femoral neck and total hip, respectively. This study was approved from the Institutional Review Board of Faculty of Medicine, Ramathibodi Hospital.

Statistical Analysis

Continuous variables were described as mean ± standard deviation (SD). Statistical significance was set at the level of $P \leq 0.05$. The BMD data were compared using paired *t* test. The differences in the forearm BMD and their 95% CI were calculated at the ultradistal

radius (UD radius), total radius, and 33% radius for both parts of the study. Linear regression analysis was performed for both comparisons using the non-dominant forearm sitting BMD as the dependent variable. For the comparison of positioning, the non-dominant forearm supine BMD was used as the independent variable. For the comparison of side (dominance), the dominant forearm sitting BMD was used.

The agreements of BMD WHO classification between sitting and supine position and between non-dominant and dominant forearm were assessed using kappa statistics.[6] The statistical analysis was performed using STATA 12 (StataCorp. Version 12. College Station, TX: StataCorp LP; 2012).

Results

This study involved 152 female patients. The subjects ranged in age from 42 to 82 years. All subjects were found to be right handed. All subjects signed an approved informed consent after reading the subjects information sheet about the study were included. Table 1 describes the patient characteristics.

The BMD and BMD difference of the non-dominant forearm at UD, 33%, and total radius in the sitting and supine positions were shown in Table 2.

Bland & Altman plots[7] revealed the differences and the means of the non-dominant forearm BMD in the sitting and the supine position at each ROI shown in Figure 2 - 4.

Table 1 Subject Characteristics

N = 152	Mean ± SD
Age (y)	60.2 ± 7.4
Height (cm)	154.1 ± 5.5
Weight (kg)	59.6 ± 10.2
BMI (g/cm2)	25.1 ± 4.1
Forearm length	24.4 ± 1.1

Comparison between sitting and supine position.

Table 2 BMD and BMD Difference of Non-Dominant Forearm in Sitting and Supine Positions

Region of Interest (ROI)	BMD (g/cm^2)		BMD Difference	
	Sitting ± SD	Supine ± SD	Mean Diff (g/cm^2)	95% CI
UD radius	0.38 ± 0.066	0.38 ± 0.065	0.000	(-0.02) - (0.02)
33% radius	0.61 ± 0.068	0.61 ± 0.072	-0.005	(-0.03) - (0.02)
Total radius	0.51 ± 0.065	0.51 ± 0.065	-0.001	(-0.02) - (0.01)

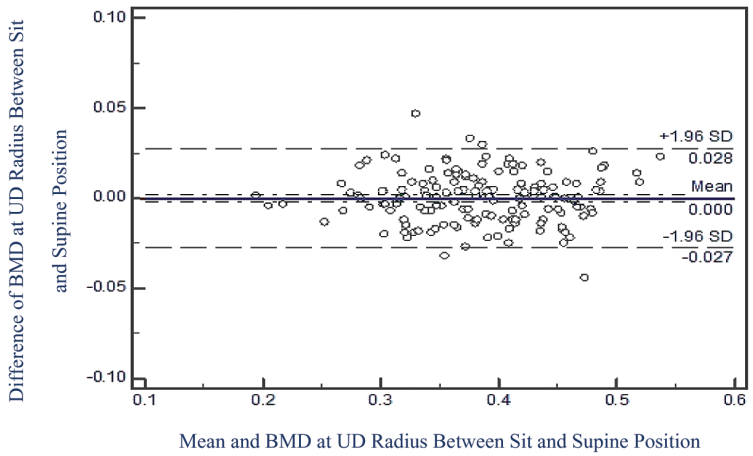

Figure 2 *The Mean and Difference Plots of BMD at UD Between Non-Dominant Forearm in the Sitting Position and the Supine Position*

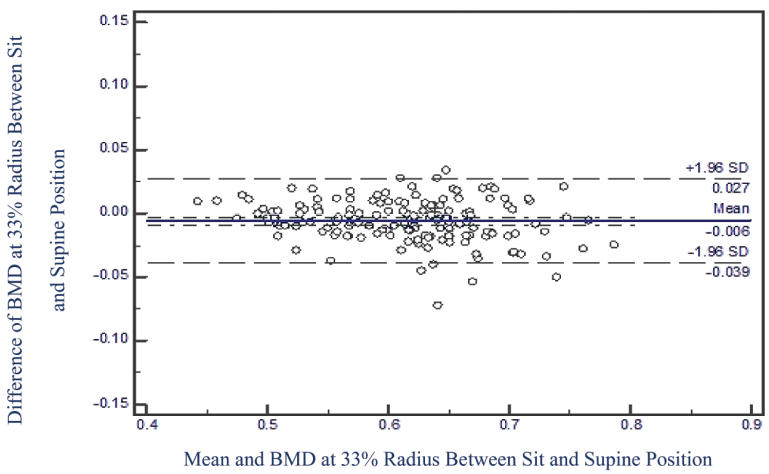

Figure 3 *The Mean and Difference Plots of BMD at 33% Radius Between Non-Dominant Forearm in the Sitting Position and the Supine Position*

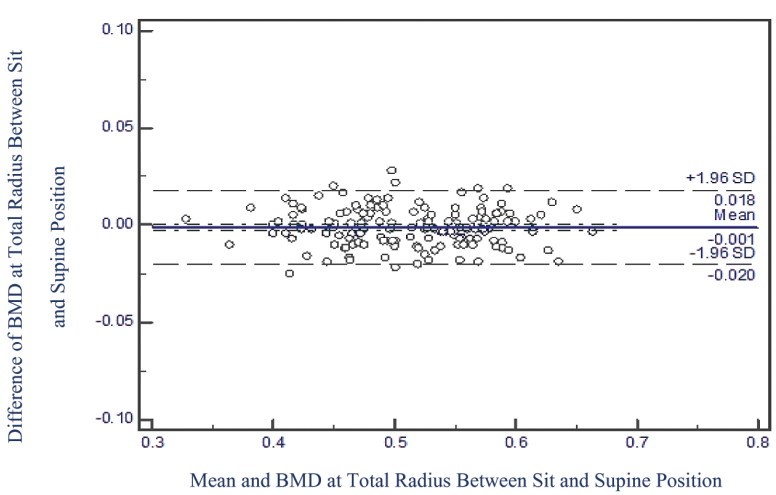

Figure 4 *The Mean and Difference Plots of BMD at Total Between Non-Dominant Forearm in the Sitting Position and the Supine Position*

As shown in Table 3, when classified by WHO classification into 3 groups as normal, low bone mass, and osteoporosis, the agreement between the sitting and supine position of the non-dominant at this site was perfect (Kappa = 0.85)

The BMD and BMD difference of the non-dominant and dominant forearm at UD, 33%, and total radius in the sitting and supine positions were shown in Table 4.

Bland & Altman plots show the differences and the means of the non-dominant and dominant forearm BMD at each ROI shown in Figure 5 - 7.

Table 3 Agreement of Classification of 33% Radius BMD Between Sitting and Supine Position

ROI	Kappa	*P* Value
UD radius	0.81	< 0.001
33% radius	0.85	< 0.001
Total radius	0.88	< 0.001

Comparison between non-dominant and dominant forearm.

Table 4 BMD and BMD Difference of Non-Dominant and Dominant Forearm

ROI	BMD (g/cm^2)		Difference	
	Non-Dominant	Dominant	Mean	95% CI
UD radius	0.38	0.39	-0.006	(-0.05) - (0.04)
33% radius	0.61	0.62	-0.011	(-0.06) - (0.04)
Total radius	0.51	0.52	-0.008	(-0.04) - (0.02)

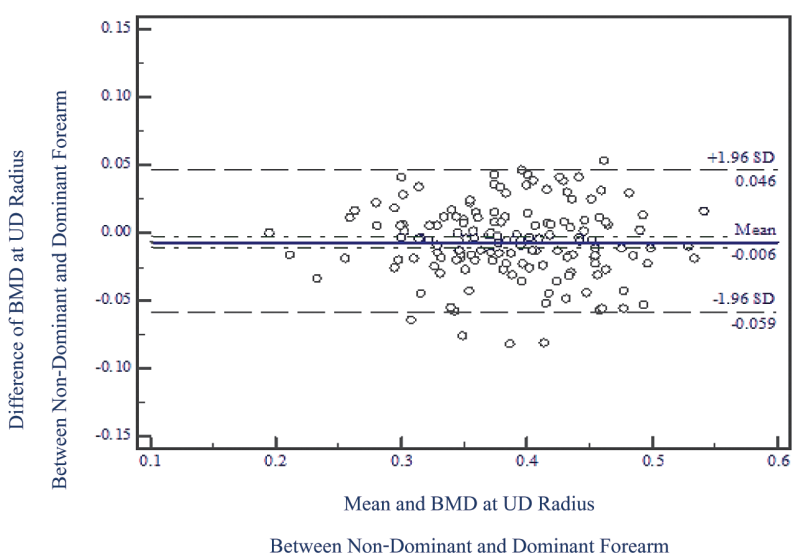

Figure 5 *The Mean and Difference Plots of BMD at UD Between Non-Dominant and Dominant Forearm*

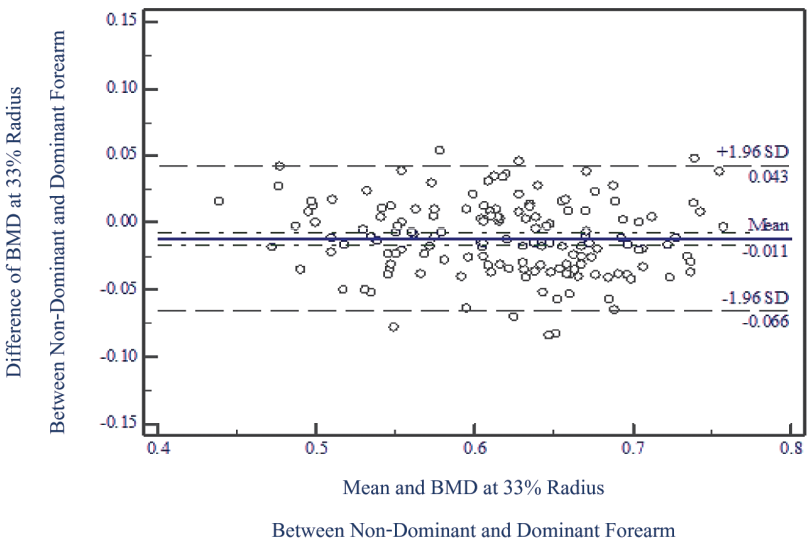

Figure 6 *The Mean and Difference Plots of BMD at 33% Radius Between Non-Dominant and Dominant Forearm*

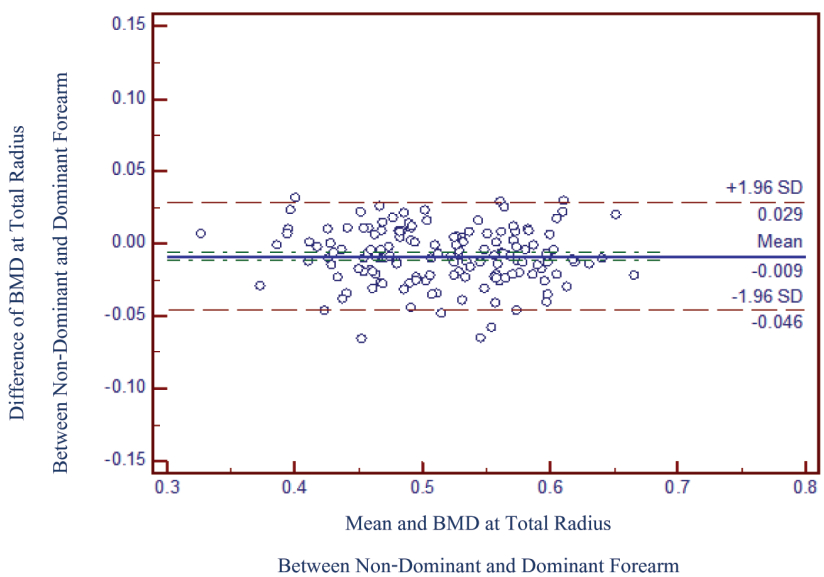

Figure 7 *The Mean and Difference Plots of BMD at Total Between Non-Dominant and Dominant Forearm*

As shown in Table 5, when classified by WHO classification into 3 groups as normal, low bone mass, and osteoporosis, the agreement between the non-dominant and dominant forearm at this site was moderate (Kappa = 0.64)

The precision error expressed as % coefficient of variation (CV) of each ROI was shown in Table 6.

The 33% radius BMD difference between the sitting and supine position was -0.057039 g/cm^2 (95% CI, -0.03 to 0.02) while that between the dominant and non-dominant side was -0.0114145 g/cm^2 (95% CI, -0.06 to 0.04).

Table 5 Agreement of Classification of 33% Radius T-score Between Non-Dominant and Dominant Forearm

ROI	Kappa	*P* Value
UD radius	0.64	< 0.001
33% radius	0.64	< 0.001
Total radius	0.79	< 0.001

Table 6 %CV of Each ROI of Forearm BMD in Sitting and Supine Positions

ROI	Non-Dominant Forearm		Dominant Forearm
	Sitting	Supine	Sitting
UD radius	17.01	17.05	16.96
33% radius	11.19	11.62	11.65
Total radius	12.63	12.66	12.69

Discussion

The reason for using 33% radius BMD in this calculation because it was recommended by the ISCD. Therefore, sample size may not enough for comparing other site.

Because females are more likely to suffer from osteoporosis, we used female BMD values to calculate the sample size. The corresponding difference values in males are likely to be similar to or less due to higher BMD in general. Since we aimed to apply these estimations to patients sent for BMD determination, we chose to invite patients who were the better representative than the healthy volunteers. The latter were likely to be more easily positioned and to have higher BMD; hence, their results may not applicable. With the aim to apply the estimations to cover osteoporotic subjects, the sample size calculation was based on 33% radius BMD as low as 0.500 g/cm^2 (T-score of -3.1 based on Caucasian NHANS database). Subsequently, a minimum detectable difference was set at 1% of this value, which was 0.005 g/cm^2.

The forearm BMD measurement was used in circumstance of the spine and femur could not be measured or interpreted, hyperparathyroidism patient and obese patient. The scanning position for measure forearm BMD is recommended by the ISCD to scan at the non-dominant forearm in the sitting position.[1]

Frequently, with physically and clinical limitation, the patient could not be measured forearm BMD in the sitting position which is recommended by the ISCD. Then the forearm BMD in supine position was selected to compare with sitting position because it is more comfortable for patient, especially for the elderly patient, obese patient and the patient who has difficulty in moving.

The results of this study shown no significant difference in BMD values between the non-dominant forearm in supine position and sitting position with the mean difference of -0.005, 95% CI for mean difference was -0.03 to 0.02, $P < 0.05$, while difference in BMD values between the non-dominant and the dominant forearm has mean difference of -0.011, 95% CI for mean difference was -0.06 to 0.04, $P < 0.05$.

The Least Significant Change (LSC) of non-dominant forearm in the sitting and supine positions were 4.72% and 3.78% and dominant was 4.77%. For follow up purpose, the same position was recommended to use as the base line

Conclusions

Measurement of BMD by DXA at non-dominant in sitting position can be scanned in the supine position without a change in diagnosis. Then the dominant forearm can be used instead of the non-dominant if the non-dominant forearm is not properly due to the presence of historical fracture or congenital deformities.

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Original Article/นิพนธ์ต้นฉบับ

การวัดความหนาแน่นของกระดูกแขน: การศึกษาเปรียบเทียบท่าที่ใช้ในการตรวจและแขนข้างที่ใช้ในการตรวจที่ต่างกัน

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บทคัดย่อ

บทนำ: การตรวจวัดความหนาแน่นกระดูกแขน โดยคำแนะนำของ International Society for Clinical Densitometry (ISCD) กำหนดให้ตรวจแขนข้างที่ไม่ถนัดในท่านั่ง แต่ในทางปฏิบัติการตรวจในท่านั่งนั้น ผู้ป่วยอาจมีข้อจำกัดไม่สามารถตรวจในท่านั่งได้ เช่น ผู้ป่วยสูงอายุที่เคลื่อนไหวลำบาก และถูกเคลื่อนย้ายด้วยรถนั่งหรือรถนอน ดังนั้นจึงเป็นที่มาของการศึกษาเปรียบเทียบระหว่างการตรวจแขนในท่านั่งและท่านอน

วัตถุประสงค์: เพื่อเปรียบเทียบความแตกต่างในการวัดความหนาแน่นของกระดูกแขนระหว่างท่านั่งซึ่งเป็นท่าตรวจปกติกับท่านอน และระหว่างแขนข้างถนัดกับข้างไม่ถนัด

วิธีการศึกษา: ผู้ป่วยหญิงจำนวน 152 ราย เข้ารับการตรวจวัดความหนาแน่นของกระดูกแขนด้วยเครื่องตรวจวัดความหนาแน่นกระดูก ทำการตรวจวัด 3 ครั้ง โดย 2 ครั้ง สำหรับแขนข้างไม่ถนัดในท่านอนและท่านั่ง และ 1 ครั้ง สำหรับแขนข้างไม่ถนัดในท่านั่ง

ผลการศึกษา: มีความแตกต่างของค่าความหนาแน่นที่ 33% radius สำหรับแขนข้างที่ไม่ถนัดระหว่างท่านั่งและท่านอน เท่ากับ -0.005 กรัมต่อตารางเซนติเมตร (95% CI, -0.03 ถึง 0.02) และระหว่างแขนข้างถนัดและแขนข้างไม่ถนัดในท่านั่ง เท่ากับ -0.01 กรัมต่อตารางเซนติเมตร (95% CI, -0.06 ถึง 0.004) เมื่อใช้หลักเกณฑ์ขององค์การอนามัยโลก (WHO) แบ่งผู้ป่วยเป็น 3 กลุ่ม คือ กระดูกปกติ กระดูกบาง และกระดูกพรุน พบว่ามีความสอดคล้องอย่างมากของค่าความหนาแน่นของกระดูก สำหรับข้างไม่ถนัดท่านั่งและท่านอน (Kappa = 0.85) และพบว่าสอดคล้องระดับปานกลาง สำหรับแขนข้างถนัดและไม่ถนัดในท่านั่ง (Kappa = 0.64)

สรุป: ไม่พบความต่างที่ส่งผลต่อการวินิจฉัยในการวัดความหนาแน่นของกระดูกแขนระหว่างท่านั่งกับท่านอน และระหว่างแขนข้างถนัดกับข้างไม่ถนัด ดังนั้นสามารถใช้แทนกันได้

คำสำคัญ: DXA กระดูกแขน ท่านั่ง ท่านอน

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