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Comparison of three central DXA scans of postmenopausal women and its relation to anthropometric and chronological factors

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ABSTRACT

INTRODUCTION: Dual-energy X-ray absorptiometry is the standard tool for assessing bone mineral density and risk fracture. However, several studies have shown discrepancies in its scans at different body regions and in serial measurements of the same individual.

OBJECTIVE:To compare the sensitivity of central DXA scores taken from lumbar spine, femoral neck and total hip in detection of osteoporosis in comparison the standard total body scan and to find the correlation of patients' anthropometric and chronological factors on BMD in osteoporotic patients.

METHODS: A cross sectional study was conducted on 190 postmenopausal women (45-74 years) attending Al-Yarmouk Teaching Hospital (Baghdad, Iraq) for bone scans were included. Of these, 146 were recorded or newly diagnosed cases of osteoporosis. The rest were normal controls. The sensitivity and specificity of the three central scans (lumbar spine, femoral neck and total hip) were measured and the osteoporotic cases whose results were consistent in the two most sensitive regions were selected for correlation study with four parameters: age, duration of menopause, body mass index and waist/hip ratio.

RESULTS: Frequency distribution of true positive and true negative cases and controls showed that lumbar scans had the highest sensitivity and specificity for bone mineral density measurement (sensitivity 97.5 % and specificity 83.3 %), followed by total hip scans (sensitivity 91.1 % and specificity 62.1 %). Osteoporotic cases in both lumbar ad total hip regions showed a negative correlation between bone mineral density and both increasing age and duration of menopause. According to body mass index characterization, most osteoporotic cases were average-weighed and to lesser extent obese. Overweighed women had the least risk for bone loss. Waist/hip ratio did not differ significantly between osteoporotic, osteopenic and normal individuals.

CONCLUSION: In post-menopausal women, Measurement of BMD by DXA scan taken from lumbar and total hip is more sensitive and more specific than using femoral head in comparison to the standard total body scan.

Key words: DXA, Osteoporosis, Lumbar spine, Femoral neck, total hip, Body mass index, Waist/hip ratio, Menopause.

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INTRODUCTION

Osteoporosis is a silent but preventable disorder characterized by loss of bone density that becomes apparent and complicated by fractures following minor trauma.[1] Dual-energy X-ray absorptiometry (DXA) is the standard test used for measuring bone mineral density (BMD) at primary health centres and general hospitals.[2] The problem with DXA is that it is not an exact measure of BMD and has a number of physical deficiencies that should be corrected with different anthropometric and chronological measures e.g. age, duration of menopause, bone mass and body mass.[3] Moreover, different types of scanners and different scanned regions produce different BMD readings.[4] Newer techniques of the measurement of BMD have been introduced including quantitative computed tomography, radiographic absorptiometry and quantitative ultrasonometry.[5] However, Central DXA scanning remains the standard technique on which the WHO criteria for osteoprorosis and fracture risk assessment depends.

The objective of this study is to compare the sensitivity of central DXA scores taken from lumbar spine, femoral neck and total hip in de-

tection of osteoporosis and to find the correlation of patients' anthropometric and chronological factors on BMD in osteoporotic patients.

METHODS

Settings and design of the study: A cross sectional study was carried out at the DXA clinic at Al-Yarmouk Teaching Hospital in Baghdad, Iraq from July 2013 to February 2014.

Ethical issue: We get the approval of the hospital research committee to do this research. We explain the purpose of this study to all participants whom have been asked to sign a written informed consent form prior to participation in the study. Participants' Privacy and confidentiality were totally respected throughout the stages of the research.

Definition of cases enrolled in the study, inclusion and exclusion criteria: any postmenopausal women who presented to DEXA department at Al-Yarmook Teaching Hospital during the studied period to perform DEXA scan were enrolled in this study whether this scan is made for the first time or part of follow up process. Those who refused to participate; those who were using any drugs that may interfere with bone metabolism and consequently bone density; and those who had chronic medical illnesses, chronic infections, or endocrine disorders were excluded from this study to avoid the potential risk of interfering with our measurements.

Sampling: We selected on a base of every other day persons who have met our inclusion criteria during the studied period. Then, Participants have been classified into two groups. Group one, which included 146 participants who have reduced bone mineral density (BMD) whether they have osteopenia or osteoporosis. The second group included those who were having normal DEXA scan, which was considered as control.

Primary and secondary outcomes: The primary outcome was to measure the sensitivity of DEXA score calculated from femoral neck, total pelvis, and lumbar spine in diagnosis of reduced bone density. The secondary outcome is to find correlation between BMD and some anthropometric and chronological parameters.

Procedure: For sake of our study we calculated T-scores to diagnose BMD as follows. If T-score is > -1 we considered it normal, T score between -1 and -2.5 were considered osteopenic and scores < -2.5 were considered osteoporotic.[6]

In the first part of the study, three postero-anterior (PA) central DXA scans were compared using DEXXUM3 machine (Osteosys Co. Ltd., Korea, Seoul). These are the lumbar spine (L1-L4) score, femoral neck (Hologic) score, and total hip score. The sensitivity of the diagnosis of abnormal BMD calculated from these three sites were compared to the standard total body scan. In the second part, the patients who had osteoporotic results in the two most sensitive scans were revised to examine the effect of four parameters on their bone density. These parameters include age, duration of menopause, body mass index (BMI) and waist/ hip ratio (WHR). BMI was simply calculated by dividing the patients weight in kilograms by the square value of the height in meters, after the weight was recorded using a digital scale and height recorded with the patient standing without shoes. WHR was calculated by dividing the waist circumference in centimetres by the hip circumference in centimetres. Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, using a stretch-resistant tape. Hip circumference was measured around the widest portion of the buttocks, with the tape parallel to the floor.[7]

Data Analysis: Data were analysed by means of SPSS software version 18.0. Variables and scores were normally distributed. Sensitivity and specificity of each central DXA reading were calculated. One-way ANOVA and student t-test were used to compare groups' means. In osteoporotic cases, linear relationships between dependent and independent variables were examined using Pearson's correlation.

RESULTS

Table 1 shows mean ± standard error of mean of age, duration of menopause, BMI, and WHR in women with normal, osteopenic and osteoporotic BMD as measured by T score.

By measuring number of true and false results in comparison to diseased and normal controls, the sensitivity and specificity of the scans were calculated and results are shown in figure 1. Lumbar spine results had the highest sensitivity and specificity, followed by total hip results. Only the femoral neck readings gave error oste-

Table 1: Differences in age (years), menopause duration (years), body mass index (Kg/m2) and waist/hip ratio among recorded cases of postmenopausal women who had consistent bone mineral density in both lumbar spine & total hip DXA scans. (Data expressed as Mean±Standard error of the mean)

Parameter	Patient category		
	Normal	Osteopenic	Osteoporotic
Age (years)	57.06±0.86	56.4±0.88	65.9±1.26*a,b
Menopause duration (years)	6.78±0.84	6.51±0.71	12.74±1.05*a,b
BMI (Kg/m2)	33.12±1.05*b	30.01±0.83	25.99±0.68*a,b
Waist/Hip ratio	0.82±0.01	0.83±0.01	0.85±0.01

* High statistically significant difference (P<0.01) from normal (a) or osteopenic (b).

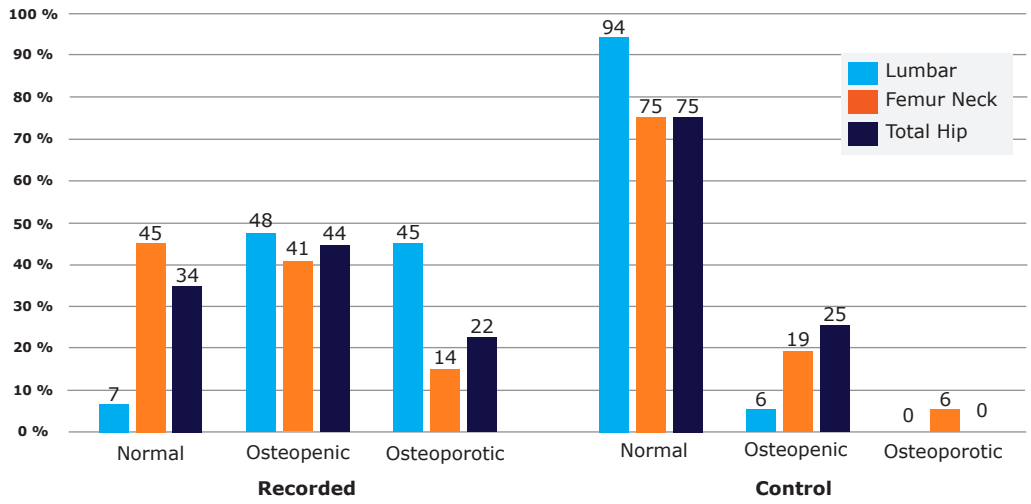

Figure 1: Frequency distribution of bone mineral density results in recorded/diagnosed cases and control normal postmenopausal women using three central DXA scans.

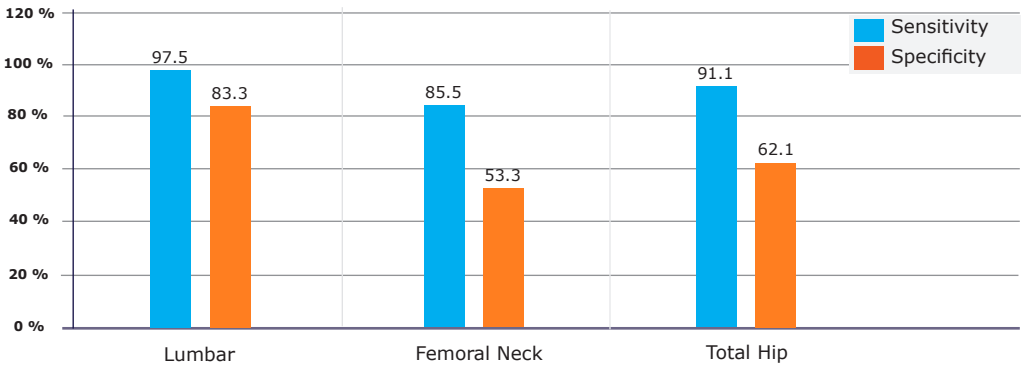

Figure 2: Sensitivity and specificity values of the three central DXA scans used in the study.

openic results in 6% of normal control individuals.

Persons who had T score <-2.5 in both lumbar and total hip scans (N=84), there were significant differences in relation to chronological and anatomical parameters as shown in table 1. Osteoporotic patients had a mean age and a mean duration of menopause that were higher than osteopenic and normal patients with a statistical significance. Osteoporotic patients were generally over 64 years and had menopause for more than of 12-13 years. Osteoporotic patients

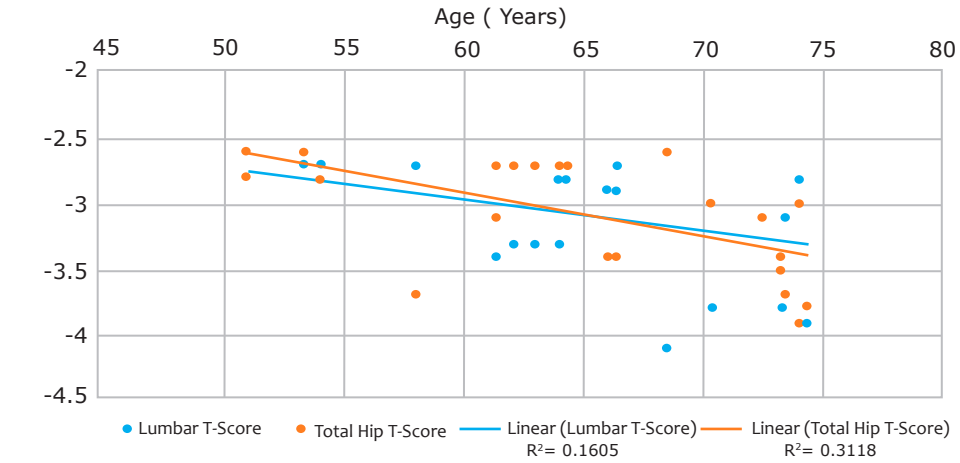

Figure3: Scatter diagram with linear correlation trend between age (years) and bone mineral density in osteoporotic postmenopausal women using lumbar spine and total hipDXA scans.

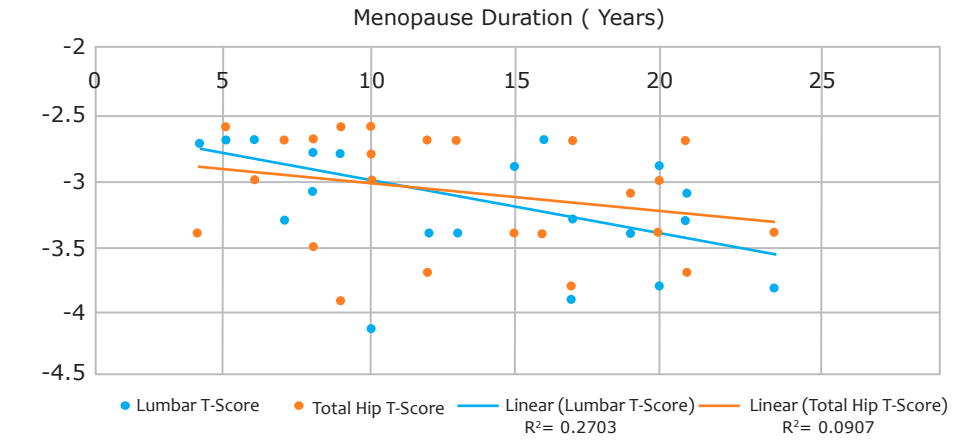

Figure 4: Scatter diagram with linear correlation trend between menopause duration (years) and bone mineral density in osteoporotic postmenopausal women using lumbar spine and total hipDXA scans.

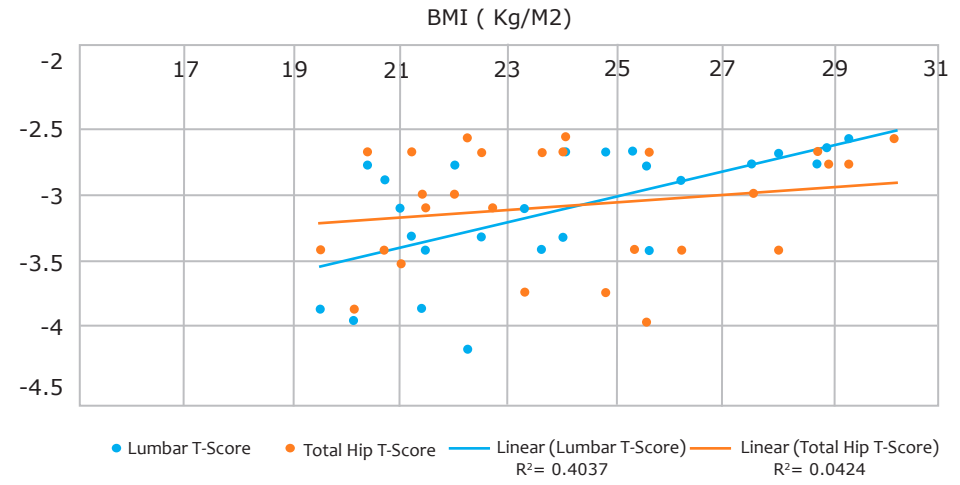

Figure 5: Scatter diagram with linear correlation trend between body mass index (Kg/m2) and bone mineral density in osteoporotic postmenopausal women using lumbar spine and total hipDXA scans.

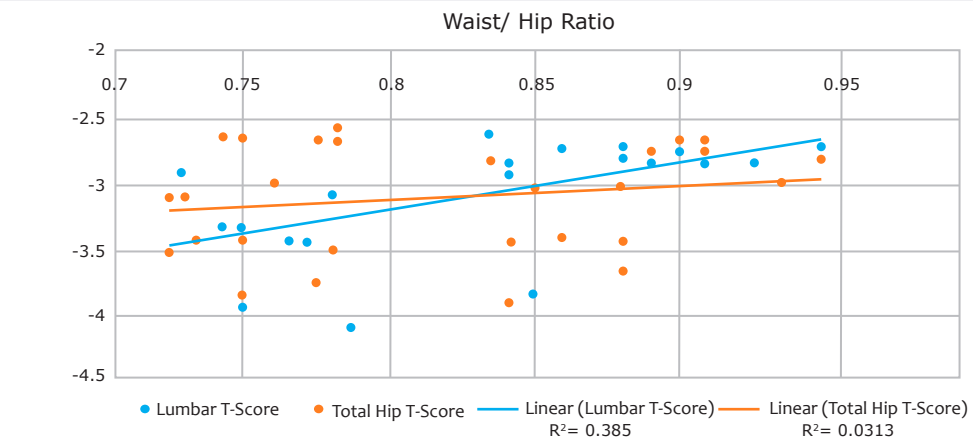

Figure 6: Scatter diagram with linear correlation trend between waist/hip ratio and bone mineral density in osteoporotic postmenopausal women using lumbar spine and total hip DXA scans.

also had a statistically significant low BMI. The highest BMI records were seen in normal scans. There was no statistically significant difference in the WHR among the groups.

In correlation study of osteoporotic women, age had a weak negative correlation with both lumbar spine (r=0.4) and total hip (r=0.55) scans (figure 3). The correlation was also inverse with the duration of menopause with coefficient greater in lumbar (r=0.5) than in total hip (r=0.3) scans (figure 4). BMI had moderate positive correlation with bone mineral density of lumbar scans (r=0.63) but not of total hip scans (r=0.2) as shown in figure 5. The same was true for WHR (r=0.6 for lumbar scans, r=0.18 for total hip scans) as shown in figure 6. The percentage of osteoporotic cases was significantly higher in average-weighed (BMI<25 Kg/m2) and obese (BMI>30 Kg/m2) women and significantly lower in overweighed (BMI= 25-30 Kg/m2) women (figure 7).

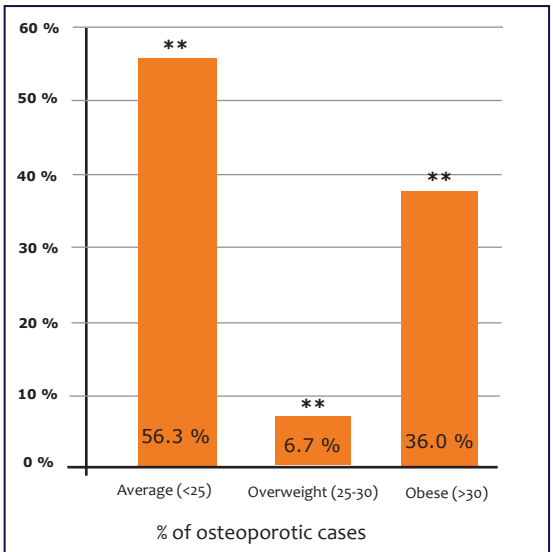

Figure 7: Percentage of osteoporotic cases according to BMI group. (= P value < 0.01 in Chi square test).**

DISCUSSION

With the continuous development of bone densitometry, several differences in techniques, acquisition software and reference database have appeared and such differences may induce some trouble for the physician in decision making for the patient. The current study focuses on discordances in the most commonly used regions of central DXA scans. As shown in the results, femoral neck scans had the lowest sensitivity and specificity when compared to the lumbar and total hip scans in detecting osteoporotic bone. One contributing factor may be the anatomical nature of the region. The amount of fat and soft tissue in the femoral region exceeds that in the lumbar spine and may negatively affect scan results.[8] Femoral neck size and hip dominance also affect results in the femoral region but not the lumbar spine.[9] Another explanation may be related to the different proportions of cancellous and cortical bone. Cancellous bone (which is more prominent in the larger lumbar vertebra) has an accelerated metabolism and a faster and earlier loss than cortical bone.[10] Other causes may be physiological in relation to hip dominance and the more

pronounced response of femoral neck bone to weight bearing and mechanical strain giving it a higher T-score.[11] Technical errors may result from poor positioning. The femoral neck is rarely in the same anatomical position from patient to patient and from scan to scan. Such errors may be overcome by using total hip scans.[12] Total hip scan results were significantly closer to lumbar spine results. This may be related to the inclusion of greater amount of bone than in femoral neck scans. The trabecular arrangement of trochanteric and vertebral bone are similar[13] which shifts total hip results closer to spine results. Despite these discrepancies, femoral neck scans remain vital in hip fracture risk assessment. Hip axis length, femoral neck-shaft angle and femoral neck diameter are important predictors of hip fracture risk.[14] According to evidence-based studies, the international society for clinical densitometry(ISCD) and the international osteoporosis foundation (IOF), now recommend that the femur (neck or total hip) is the optimum site for predicting the risk of hip fracture and the spine is the optimum site for detecting bone loss and monitoring response to treatment.[15] However, the results of the current study suggest that total hip is superior to femoral neck scans. Similar results were shown by previous studies.[16, 17]

In the second part of the study, chronological and anthropometric parameters had a significant influence on BMD in both lumbar and total hip scans. Several studies showed that advancing age, generally after 55 years, is associated with increasing risk of bone loss and subsequent fracture.[18, 19] Estradiol deficiency has been proven to start topological changes in trabecular bone as early as 12 months after menopause has settled and follicular-stimulating hormones have risen.[20] Sioka and colleagues suggested that the cumulative exposure to endogenous estrogens, measured as years of menstruation, seems to be a significant protective factor against the development of postmenopausal osteoporosis and that the age at menopause not menarche that affects the risk of osteoporosis.[21] This coincides with the results in the current study indicating a longer duration of menopause due to an earlier age of onset is another risk factor for osteoporosis development. Similar to the results of the current work, the global longitudinal study of osteoporosis in women concluded that higher BMI was associated with less risk of bone loss and fractures.[22] Other studies are in agreement with ours in that overweight is protective while obesity is predictive of osteoporosis and fracture risk.[23] Moderate weight bearing and light weight-bearing exercise induce a positive balance in the bone multicellular unit towards bone remodeling to resist deformation and make loading possible.[24] Obesity on the other hand is associated with reduced physical activity that can reduce bone tissue organization and reduced alignment of lamellae despite increased cortical thickness (i.e. increased quantity with decreased quality).[25] Our work also showed that BMI is more predictive of osteoporosis risk than WHR. This may be related to the difference in fat distribution among overweight or obese individuals. While subcutaneous fat is beneficial for bone structure and strength, visceral fat has the opposite effect.[26] While WHR measurement depends largely on subcutaneous fat deposits, BMI takes into account visceral fat and lean muscle mass as well; possibly making it a more reprehensive predictor of bone structure and strength.

CONCLUSIONS

In post-menopausal women, Measurement of BMD by DXA scan taken from lumbar and total hip is more sensitive and more specific than using femoral head in comparison to the standard total body scan. Increasing age, duration of menopause, or being average weight or obese have a negative correlation with BMD, while being an overweight has a least risk for bone loss. Waist/hip ratio did not differ significantly between osteoporotic, osteopenic and normal women post-menopause.

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Abbreviation list: Body Mass Index (**BMI**), Bone Mineral Density (**BMD**), Dual-energy X-ray Absorptiometry (**DXA**), International Osteoporosis Foundation (**IOF**), International Society for Clinical Densitometry (**ISCD**), Waist Hip Ratio (**WHR**)

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