# Early Changes of Bone Mineral Density in Symptomatic Women at First Visit to Dual Energy X-Ray Absorptiometry (DXA) Investigation

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**Abstract:**

**Background:** Dual-energy X-ray absorptiometry (DXA) is the most applicable method to assess bone density (BMD). Osteoporosis is diagnosed when finding low BMD compared to a reference population of young healthy women.

**Objective:** This study aimed to categorize the DXA findings in postmenopausal women referred for the first time to DXA investigation.

**Patients & Method:** A total number of 63 women who referred to DXA unit at Al-Yarmouk teaching hospital with a provisional diagnosis of osteoporosis were admitted in the study. Demographic data and medical history obtained from each patient and the anthropometric measurement were determined.

**Results:** The results showed that the BMD is declined non-significantly with advance age and the changes of osteoporosis (as estimated by T score ≤ -2.5) was detected in higher frequency in spine L1, L1-L2 and in Ward's area.

**Conclusion:** It concludes that postmenopausal women of whatever age or demographic characteristics should be subjected to DXA investigation at least of L1 and Ward's area to reach the osteoporosis diagnosis in the first visit to the DXA unit

***Keywords:*** *Dual energy X-ray absorptiometry, postmenopausal women*

## Introduction:

Dual-energy X-ray absorptiometry (DXA) is the most applicable method to assess bone density, and this also allows for the determination of the bone mineral density (BMD) and bone mineral content (BMC). Radiation protection standards have been developed with the advent of bone densitometry, which utilizes ionizing radiation.

Bone mineral density is widely recognized as major predictor for fractures [(1)]. However, case-finding strategy has been shown to be more cost-effective than population-based screening of bone density, and is hence advocated by the World Health Organization (WHO) and in Europe [(2-4)].

Many prospective studies have shown that a decrease in BMD at the spine or hip of one standard deviation (SD) increases fracture risk by a factor of two to three [(5,6)] Methods of measuring BMD are therefore pertinent to the detection of osteopenia, the identification of those individuals at risk of atraumatic fracture, and the assessment of efficacy of either prevention or treatment of associated osteoporosis. Osteoporosis is diagnosed when finding low BMD compared to a reference population of young healthy women. BMD values below T-score -1.0 SD is defined as osteopenia and from T-score -2.5 SD and below as osteoporosis [(7)]. Osteoporosis combined with previous fragility fracture is defined as established osteoporosis [(7)]. The objective of this study is to categorize the DXA findings according to some variables among patients with osteoporosis in women aged 45-70 years old referred for the first time to DXA investigation.

## Materials and methods

This study was carried in the DXA unit at Al-Yarmouk Teaching hospital in Baghdad, Iraq during 2012.The study was approved by the local scientific committee in the College of Medicine, Al-Mustansiriya University. A verbal consent form was obtained from each patient before admission into the study. The patients were referred to the DXA unit as a part of investigation of bone pain with a provisional diagnosis of osteoporosis. The criteria of inclusion are women aged 45-70 years old presented with bone pain, previous fractures and history of frequent falls.

The criteria of exclusion are previous history of radiological investigations e.g. computed tomography scan, radioisotope scan or injected contrast media less than two weeks, renal failure, terminal illness, thyroid disease, history of hysterectomy, hormone replacement therapy, pregnancy and lactate (nursing) mother. A total number of sixty three patients who fulfill the above criteria were admitted in the study. Demographic data, medical history and dietary intake history were obtained from each patient. The following anthropometric measurements were determined: weight (kg), height (m), waist circumference (cm), hip circumference (cm) and arm span (cm). Body mass index was calculated according to the Quetlet's equation: weight/$h^2$ and a BMI $\geq$ 25 kg/$m^2$ categorized as overweight. Waist/hip ratio more than 0.85 referred to the central obesity and the arm span to height ratio exceeding 1.0 in adult considered as normal.

Central DXA device that measure bone density in the hip and spine was used in this study. The principle of the DXA machine is to send a thin invisible beam of low-dose X-rays with two distinct energy peaks through the bones being examined. One peak is absorbed mainly by soft tissue and the other by bone. The soft issue amount can be subtracted from the total and what remains is a patient's bone mineral density. DXA machine features special software that computes and display the bone density measurements on a computer monitor. The physical specifications of the DXA machine (DEXXUM3, OsteoSys co. Ltd, Korea, Seoul) which utilized in this study were summarized in Table 1.

**Table 1:** Specifications of DXA machine from the physical point of view

| Mode | Specifications |
|---|---|
| **Scanning method** | Pencil beam |
| **Measurement method** | Non-stop-scan (AP spine, dual femur) |
| **Reference data** | Korean standard data |
| **Reproducibility** | < 1% |
| **Radiation dose** | < 10mRem/dose |
| **X-ray tube voltage** | 83 KV |
| **Amount of leaked radiation** | 0.503µSv/hr – 1.06µSv/hr |

Each patient instructed not to take calcium supplements for at least 24 hours before DXA and t wear loose, comfortable clothing, avoiding garments that have zippers, bets or buttons made of metal. Objects such as wallets that would be in the area being scanned should be removed. Also the patient was asked to remove jewelry, removable dental appliances, eye glasses, and ant metal objects or clothing that might interfere with X-rays images. The patient dose amount in normal position at X-ray voltage 83Kv and it depended on the measuring site (spine or femur), scan speed (fast or normal), scan mode (thin, thick or scattered) and the measured time.

In brief, the measurements of BMD of spine were carried on by placing the light of laser on the navel and implement the measurement. In case of femur the light of laser pointer was placed 15-20 cm below the pelvis bone to leg direction and in the middle of thigh. In this study lumbar (L) vertebrae, intervertebral disc at lumbar region and femur were scanned. The test results were in the form of T score which estimated the risk of developing a fracture:

T score: <-1 is considered normal
-1 to -2.5 is considered osteopenia
< -2.5 are considered osteoporosis

**Statistical analysis**:

The results are expressed as absolute number, percent and whenever possible as mean ± SD. The data were statistically analyzed using student's t test and differences between proportions test taking the $p \leq 0.05$ as the lowest limit of significance

**Results:**

Table 2 shows that the median age of patients was 60 year with a 10 years median duration of menopause. History of smoking was reported in 15.9% and the dietary history revealed high percent of patients consumed diet of high calcium content (Table 2).

History of bone fracture was obtained from 19% of cases and 57.1% of patients had a history of fall (Table 2). Medical history revealed co-existence of chronic diseases; hypertension (28.6%0, diabetes mellitus (15.9%) and rheumatic disorders (30.2%) (Table2). Anthropometric measurements indicated that the patients were obese and the height/arm span ratio within the normal limits (Table 3).

Dual-energy X-ray absorptiometry showed variation in reported osteopenia in term of frequency of cases, site, and the percent of BMD (Table 4). In the lumbar spine, osteopenia was observed in high frequency in L3 while the osteoporotic changes were observed in high frequency in L1. There were no differences in BMD in osteopenic or osteoporotic lumbar vertebrae.

The osteopenic changes were more or less similar in intervertebral discs of lumbar spines while the higher frequencies of osteoporotic changes were observed in L1-L2 intervertebral disc. Once again there were no differences in BMD in osteopenic or osteoporotic intervertebral discs.

In femur, osteopenic and osteoporotic changes were well observed in wards. There were non-significant negative correlation between the total BMD score of femur and age (r=-0.23) or duration of menopause period (r=-0.225) (Figures1 and 2). Also there were non-significant direct correlation between the total BMD score of femur and body mass index (r =0.194), and inverse correlation between the total BMD score of femur and waist/hip ratio (r =-0.167) (Figures 3 and 4).

**Table 2** Characteristics of the study

| **Characteristics** | **(n=63)** |
|---|---|
| Age (year) | |
| Mean ±SD | 59.65±6.01 (60) |
| Marital status | |
| Single | 1(1.6) |
| Nullipara | 5 (7.9) |
| Multipara | 57 (90.5) |
| Smoking | 10 (15.9) |
| Dietary history | |
| Milk | 36 (57.1) |
| Yogurt | 49 (77.8) |
| Cheese | 54 (85.7) |
| Sardines | 53 (84.1) |
| Cooked greens | 62 (98.4) |
| Calcium fortified orange juices | 21 (33.3) |
| Duration of menopause | |
| Mean ±SD | 10.49±6.31(10) |
| History of bone fracture | 12 (19) |
| History of falls | 36 (57.1) |
| History of : | |
| Hypertension | 18 (28.6) |
| Diabetes mellitus | 10 (15.9) |
| Peptic ulcer | 17 (27) |
| Rheumatic joint and bone pain | 19 (30.2) |
| Chronic diarrhea | 8 (12.7) |

The results expressed as number (%) and mean ± SD (median)

**Table 3** Anthropometric measurements

| | |
|---|---|
| Weight (kg) | 76.25±14.25 |
| Height (m) | 1.542±0.059 |
| Body mass index | 31.97±5.956 |
| Waist circumference (cm) | 90.016±12.575 |
| Hip circumference (cm) | 114.762±11.381 |
| Waist/hip ratio | 0.854±0.069 |
| Arm span (cm) | 67.539±3.834 |
| Height/arm span ratio | 2.292±0.102 |

The results are expressed as mean ± SD

**Table 4** Dual-energy X-ray absorptiometry findings

| | Normal | | Osteopenia | | Osteoporosis | |
|---|---|---|---|---|---|---|
| | T score (<-1) | Bone Mineral Density (%) | T score ( -1 to -2.5) | Bone Mineral Density (%) | T score (< -2.5) | Bone Mineral Density (%) |
| Spine | | | | | | |
| L1 | 13 (20.6) | 111.7±25.9 | 22 (34.9) | 78.2±5.3 | 28 (44.4) | 61.5±7.0 |
| L2 | 17 (27.0) | 101.5±11.9 | 28 (44.4) | 80.0±5.4 | 18 (28.6) | 64.1±7.3 |
| L3 | 25 (39.7) | 105.0±17.9 | 32 (50.8) | 79.2±5.1 | 6 (9.5) | 63.8±4.0 |
| L4 | 26 (41.3) | 113.1±20.4 | 27 (42.9) | 80.4±5.1 | 10 (15.9) | 62.2±7.6 |
| L1-L2 | 14 (22.2) | 105.5±17.5 | 28(44.4) | 79.3±5.2 | 21 (33.3) | 63.3±5.0 |
| L1-L3 | 15 (23.8) | 106.7±14.4 | 29 (46.0) | 80.4±5.4 | 19 (30.2) | 67.4±3.6 |
| L1-L4 | 20 (31.7) | 106.0±15.4 | 26 (41.3) | 80.1±5.2 | 17 (27.0) | 67.7±4.2 |
| L2-L3 | 22 (34.9) | 102.1±13.2 | 30 (47.6) | 78.5±5.3 | 11 (17.5) | 67.0±4.3 |
| L3-L4 | 26 (41.3) | 108.5±18.5 | 30 (47.6) | 78.8±4.8 | 7 (11.1) | 64.7±5.8 |
| L2-L4 | 25 (39.7) | 105.0±15.0 | 30 (47.6) | 77.9±4.6 | 8 (12.7) | 65.3±5.2 |
| Femur | | | | | | |
| Neck | 28 (54.9) | 102.3±12.6 | 19 (37.3) | 78.8±6.5 | 4 (7.8) | 63.8±1.3 |
| Wards | 14 (27.5) | 97.1±10.0 | 24 (47.1) | 73.3±6.7 | 13 (25.5) | 50.6±10.1 |
| Trochanter | 35 (68.6) | 103.7±12.4 | 12 (23.5) | 79.5±4.6 | 5 (9.8) | 45.0±18.7 |

The results are expressed as number (%) and mean ± SD

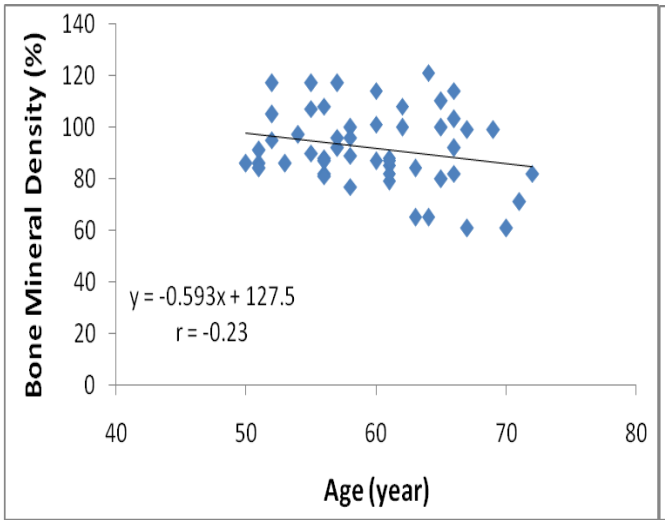


**Figure 1** femur and age Correlation between bone mineral densities.

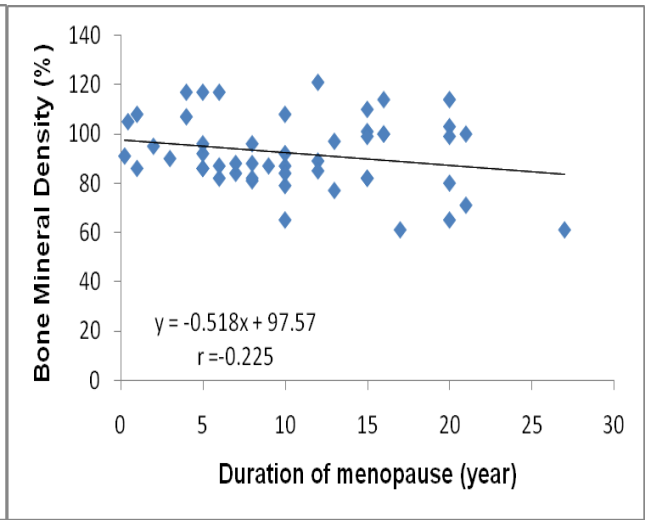


**Figure 2** Correlation between bone mineral density of femur and duration of menopause

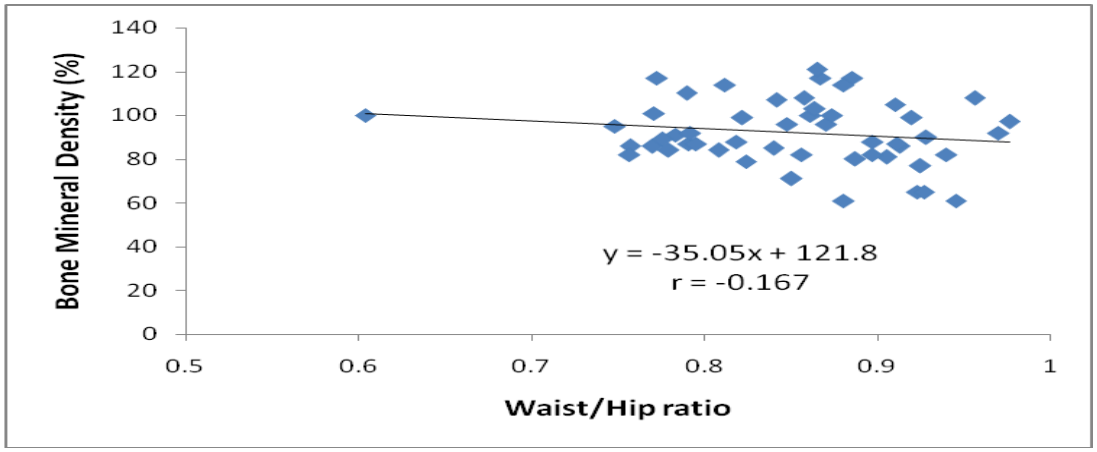


**Figure 3** Correlation between bone mineral density of femur and body mass index

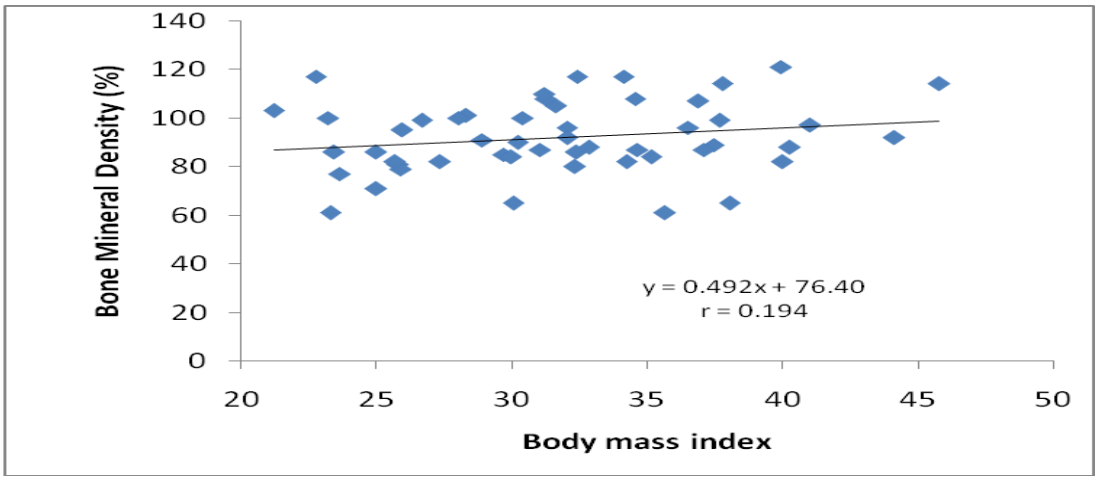


**Figure 4** Correlation between bone mineral density of femur and waist hip ratio

**Discussion:**

The results of this study show that evidence of primary osteoporosis is well observed in patients referred for the first time for DXA investigation. The osteoporotic changes in term of bone mineral density percent followed a hetrogenous pattern in lumbar spine and hip with high frequencies in L1, L1-L2 and Ward's area.

These results are in agreement with [8] who insisted to measure the BMD in L1 and the diagnosis of osteoporosis is achieved when the lowest T-score of the three sites total hip, femoral neck, or trochanter. Moreover, Hamdy et al [8] suggested that Ward's area *per se* should not be used for diagnostic purposes. Hagino [9] advised to measure BMD at posterior-anterior (PA) spine for diagnosis of osteoporosis in all patients and if BMD at PA spine is inappropriate for the evaluation, proximal femur is selected for the measurement site. All the patients allocated in this study were in the postmenopausal period with a mean duration of 10.49 years. There is no doubt that Post-menopausal osteoporosis is one of the classic complications of prolonged estrogen deficiency associated with menopause [10]. Therefore, osteoporotic changes that detected in L1in 44.4% (28 out of 63 patients) were linked to menopause. Also the other factors like diabetes mellitus [11], drugs that used in peptic ulcer [12] and rheumatic pain disorders should be not ignored in the link between osteoporosis and menopause [13].

Most of cases in this study are fairly on dietary regimen that contained considerable calcium level. Therefore, nutritional factor may be not involved directly.

Regarding the age, Rithirangsriroj et al [14] reported that the percentage of osteoporosis seemed to be increasing with age and this finding is documented in this study. The non-significant correlation between age and BMD seems to be related to the small sample size. Also Rithirangsriroj et al [14] found that women of $\geq$ 60 years with body mass index of less than 23 kg/m$^2$ posed a substantial percentage of osteoporosis i.e. the percent of osteoporosis is increased with low body mass index value. Regarding the obesity, the results in this study are not agreed with that of [14] and it can be attributed to the racial factor in which the reference database of T score is belonged to Thailand. It

concludes that postmenopausal women of whatever age or demographic characteristics should be subjected to DXA investigation at least of L1 and Ward's area to reach the osteoporosis diagnosis in the first visit to the DXA unit.

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