

Age-specific Bone Mineral Density Values from Multi-skeletal Sites in Normal Indian Female Population

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Abstract

Background: Data on age-specific normal bone mineral density (BMD) values for the Indian population are scarce. This study aims to find out the normal values of BMD in an all-female urban population. Since BMD and its derivatives are used widely for identifying early osteopenia in the elderly age group, data on normal subjects have both clinical and research utility. We also examined the relationship between body mass index and BMD.

Materials and Methods: We studied the bone mineral densities of 500 asymptomatic Indian females across five age groups (100 in each age group) and analyzed the data for mean values and for percentage decrease every 10 years. The bone mineral densities were measured through a dual energy X-ray absorptiometry (DEXA) on the Hologic QDR densitometer. The patient enrolment was on a voluntary basis. Volunteers with conditions which may affect the BMD value (very low body weight, high-risk medication use, and chronic kidney disease or other conditions associated with bone loss) were excluded from the analysis. The mean values were then compared with western data to assess if the BMD were comparable.

Results: Mean hip BMD for age group 30-39 years was 1.199; for the 40-49 years age group was found to be 0.939; for the 50-59 years age group was 0.848; in the 60-69 years mean BMD was 0.842; and 0.718 was the mean BMD in the 70-79 years age group. An average fall of 11% every 10 years was found with the sharpest dip between ages 30 and 50.

Conclusion: Bone mineral densities decline by an average of 11% every 10 years in females. Normal values for age-matched Indian females were comparable with western data. Our sample size was sufficient enough to extrapolate the mean age-matched values to the entire population.

Key words: Bone mineral density, Dual energy X-ray absorptiometry scan, Osteopenia

INTRODUCTION

The rise in the incidence of osteoporosis in the world prompted various diagnostic procedures to assess bone density.^{1,2} Several noninvasive techniques are available for estimating bone density, such as single energy X-ray absorptiometry, dual energy X-ray absorptiometry (DEXA), quantitative computed tomography, genetic

testing,³ and ultrasound.^{4,5} Of these, DEXA is widely used in modern practice and utilizes two X-ray energies to estimate the area of the mineralized tissue, and the mineral content is divided by the area. The bone mineral density (BMD) values so obtained are compared to that of a normal population (thereby computing the T-score) and with people of the same age, thereby computing the Z score. A Z score of >-1 or T score >-2.5 (i.e., more than 2.5 standard deviations [SDs]) in the hip or femoral neck is the definition of osteoporosis.^{6,7} Each SD increase in T score in adults is associated with 1.5-3-fold increase in fracture risk.^{8,9} These scores are generally calculated in multi-skeletal sites, namely the hip, spine, and radius. The World Health Organization criteria for the diagnosis osteoporosis are summarized in Table 1.

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Table 1: Analysis of variance of hip, spine, and radius BMD

Parameter	Sum of squares	df	Mean square	F	Significant
Hip BMD					
Between groups	12.894	4	3.224	170.875	0.000
Within groups	9.338	495	0.019		
Total	22.333	499			
Spine BMD					
Between groups	5.412	4	1.353	118.022	0.000
Within groups	5.675	495	0.011		
Total	11.087	499			
Radius BMD					
Between groups	0.907	4	0.227	23.336	0.000
Within groups	4.811	495	0.010		
Total	5.718	499			

The DEXA has become the standard for assessing the longitudinal BMD in clinical practice and for pharmaceutical trials after Hologic Inc. introduced it in 1987.^{6,10} After John Cameron proposed the idea of measuring bone mass more than 60 years, the concept, application, technology, and interpretation of DEXA has undergone a revolution, forever cementing its place in modern medicine.^{11,12}

The basic principle behind DEXA is low and high energy photons through the body which assumes that the body is made of two compartments, the bone mineral and soft tissue with varying attenuation coefficients.¹³ The ease of availability of this technology, the drastic reductions in scan times to as less as 3 min and the overall curiosity among the general population to know their “bone strength” has led to widespread and rampant use of “DEXA” in recent times. A lot of data have been generated which the avid clinician must know is dependent on various factors. Gender and age specific variations, equipment manufacturer specific differences, and disease processes can all affect the values obtained after a regular scan.

DEXA is not without its limitations. It provides two-dimensional interpretation for a three-dimensional bone structure.⁵ Therefore, its measurements are expressed in g/cm² rather than a volumetric expression like g/cm³. Bone thickness is not factored into the equation, which may cause some confounding in the values obtained.¹⁴ Many authors recommend BMD be suitably modified to involve body size to achieve a more realistic estimate.^{15,16} Projection artefacts (distance of scanned area from the beam source, changes in surrounding soft tissue causing altered read and thin bones children) can also alter values and their interpretation.

The main shortcoming of such a modality, which is being used with increasing frequency in the Indian urban setting, is a lack of normative data for the Indian population.

The definition for “normal” has far reaching implications on diagnosis, treatment, and prognosis in a variety of disorders. A falsely low BMD might subject the Indian patient to unnecessary tests and interventions. Conversely, a “normal” BMD may deprive the patient of medications which may benefit his disease process. Recently, body mass index is being taken into cognizance for greater accuracy of required results. DEXA is being routinely used for assessing fracture risk in patients with both primary and secondary osteoporosis.^{17,18} For fracture risk, specifically, newer scores have been developed, such as the FRAX, Garvan score, and the Q fracture score.^{4,19,20} Furthermore, DEXA is finding application structural analysis of joints and visceral fat analysis as well.¹⁰

Aims and Objectives

To study of the age-specific BMD values from multi-skeletal sites in normal asymptomatic Indian female population.

MATERIALS AND METHODS

We conducted a single center, observational study where patients were recruited from the out-patient department to undergo DEXA on a volunteer basis. We tried to ensure adequate representativeness from the participants, i.e., diverse weight, height, and ethnic backgrounds. Written consent was obtained. Detailed medical, surgical, and drug history were obtained. Participants meeting any exclusion criteria (see below) were excluded from the study. A total of 500 participants entered the study. The participants underwent a multi-skeletal site (total hip, lumbar spine, and left radius, both 33% and ultradistal) DEXA scan using a Hologic QDR densitometer after a detailed anthropometric analysis. The operator for all scan was the same to ensure uniformity in the protocol. The data were collected over a period of 15-month March 2015 to June 2016.

Inclusion Criteria

The study included asymptomatic female patients who were selected after a baseline evaluation which included complete hemogram, liver and renal function tests, sugars, and thyroid profile.

Exclusion Criteria

Our endeavor was to exclude participants with conditions predisposing to early bone loss. These include (1) Diabetes, both Type 1 and Type 2,²¹ (2) early menopause, (3) steroid use (>7.5 mg of prednisolone or equivalent) for >3 months, (4) previous cancer chemotherapy including, but not limited to aromatase inhibitors, (5) low body weight (BMI <17 kg/m²), (6) hyperthyroidism or hypothyroidism, (7) malabsorption disorders, (8) major depression or

antipsychotic medication intake, (9) chronic kidney disease,²² (10) monoclonal gammopathies, (11) organ or marrow transplant, and (12) hypogonadism. The patients were meticulously screened for any conditions which may alter the average for the representative population.

Statistical Analysis

We calculated the T scores (labeled osteopenia as T-score between -1 and -2.5, and osteoporosis >-2.5) for the study population using the peak BMD and SD levels and found a prevalence of osteopenia of 36% ($P < 0.001$) in the 60-69 age group population and 41% ($P < 0.001$) in the 70-79 years age group. However, our study was neither powered nor intended to assess the prevalence of osteopenia. To test whether BMI, hip BMD, spine BMD, and radius BMD differ significantly across the age groups, the statistical tool “one-way ANOVA” is used. All the assumptions of one-way ANOVA are tested and satisfied for normality by the data set collected before applying one-way ANOVA. The statistical analysis is shown in Table 1. The variation of BMD with age is shown in Bar Diagram 1.

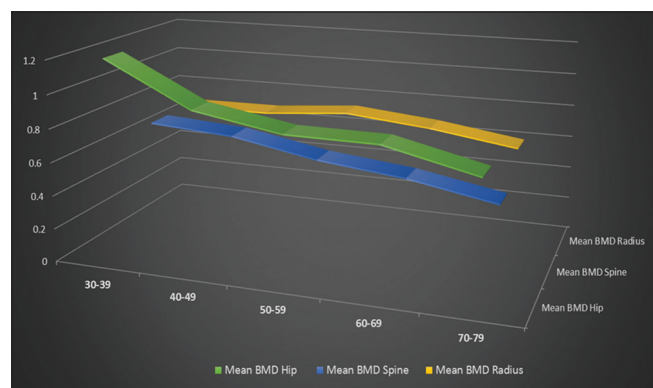
Hip BMD

The *post hoc* tests suggest that the mean hip BMD scores are nearly same for age groups “50-59 years” and “60-69 years.” The hip BMD is decreasing as the age increases.

The age group with the highest hip BMD is “30-39 years;” then it is “40-49 years;” then it is for “50-59 years” and “60-69 years.” It is least for age group “70-79 years.”

Spine BMD

The *post hoc* tests suggest that the mean spine BMD scores are nearly same for age groups “30-39 years” and “40-49 years;” The spine BMD is decreasing as the age increases. The age group with the highest spine BMD is “30-39 years” and “40-49 years;” then it is for “50-59 years;” then “60-69 years.” It is least for age group “70-79 years.”



Bar Diagram 1: Variation of bone mineral density with age

Radius BMD

The *post hoc* tests suggest that the mean radius BMD scores are nearly same for age groups “30-39 years,” “40-49 years” and “60-69 years.” The age group with the highest radius BMD is “50-59 years;” then it is for “30-39 years” and “40-49 years” and “60-69 years.” It is least for age group “70-79 years.”

RESULTS

Hip

Peak BMD was in the 30-39 years’ ($n = 100$) age group with a mean BMD of 1.199 g/cm². In next group of 40-49 years ($n = 100$), the mean BMD was 0.939 g/cm². For the next two groups of 50-59 years ($n = 100$) and 60-69 years, the mean BMD was 0.848 g/cm² and 0.842 g/cm². Predictably, the lowest BMD was in the 70-79 years’ age group with a mean of 0.718 g/cm². The greatest loss of BMD was between ages of 30 and 50 years. The average loss every 10 years was 11%.

Spine

In the 30-40 years, the mean BMD was 0.692 g/cm². In the next 3 groups of 40-49 years, 50-59 years, 60-69 years the mean BMD was 0.656 g/cm², 0.559 g/cm², and 0.501 g/cm². In the 70-79 years group, the mean BMD was 0.404 g/cm².

Radius

The mean BMD for the various age groups was found to be 0.789, 0.699, 0.699, 0.599, and 0.511, respectively. The average in bone density is reduced by 10% every 10 years. The variance of BMD in hip, spine, and radius is shown in Table 1.

DISCUSSION

Bone densitometry has become the gold standard in the diagnosis and evaluation of osteoporosis. A second DEXA is often to assess therapeutic response. As the obesity, epidemic rages on in the Indian subcontinent, osteoporosis prevalence are sky high, with some estimates ranging from 45% to 50% in elderly patients. DEXA is also being with increasing frequency for patients on long-term corticosteroid therapy, which in itself has a wide range of indications in modern clinical practice today. In 2008, Makker *et al.* established in a landmark study,²³ the normative values for bone density in Indian subjects. They also observed that BMD for Hip in women was lowest in the Ward’s triangle (the inferomedial end of the neck of femur). However, Ward’s triangle is rarely ever selected in clinical practice for evaluation or diagnosis due to stark variations on densitometry. Our results compare well this

study. However, in their study, the established that peak BMD for the radius ultradistal was achieved at the 20-29 years in females, a group which was not part of our study. Hence, our findings still show the age group 30-39 years to have peak values at all skeletal sites, including the radius. Furthermore, a significantly lower fraction (36% in 60-69 years' group and 41% in the 70-79 years' group) of our "normal" participants had osteopenia or osteoporosis. Furthermore, our data suggests a 9-11% reduction in BMD every decade. Our figures are, however, commensurate with the national average prevalence for osteoporosis.

We were unable to demonstrate a change (more specifically, a fall) in BMD in the groups which represent transitions between pre- and post-menopausal women. These groups, namely, ages ranging from 40 to 49 years were expected to depict intra-group variation in BMD, seemingly due to the fraction of participants who were either peri- or post-menopausal. We did not observe any increase in BMD after the age of 70 as reported in some series. Overall, as the graph shows, BMD varied inversely with age. It is unclear whether volumetric BMD in g/cm^3 can be extrapolated or even compared to this data. Further studies with bone mineral apparent density are required.

We set out to investigate normal values of bone density. True to the research question, we eliminated participants aged >80 years. While fully aware that bone density would vary the most in this group, we identified that it would contribute little to our quest for the normal. Our study does not include data from the 20 to 29 age group as well, which was in part due to the paucity of this age group undergoing bone densitometry. The absence of this particular group was acceptable to our investigators since all data presented herein is age specific and not absolute. Our study participants included only women as this was a significant demographic undergoing DEXA scans at our center. The quantum of data available on males would not have been sufficient to draw a statistically significant conclusion. Therefore, the conclusions and averages drawn herein may not be useful for interpretation when considering male patients. Despite these limitations, the data contained herein can forward the cause of accurate and timely interpretation of bone mineral data to diagnose and treat conditions associated with bone loss in a prompt and effective manner.

CONCLUSION

With the ever-increasing use of BMD scan for a plethora of indications (and the ongoing scenario, where many BMD scans are done at the behest of the patient, to know if they have "adequate bone strength") knowing what is

normal is critical to interpretation and implementation of corrective measures. In the Indian scenario, where osteoarthritis is on the rise, the importance of such data cannot be overestimated. Further analyses are required (in the male population, for example) the results of which will help the clinician make meaningful decisions.

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