Original Article

Bone Mineral Density Measurements of Lumbar Vertebrae by Quantitative Computed Tomography

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ABSTRACT

Objective: To determine the bone mineral content in cancellous lumbar vertebral bone as a function of age and gender using Quantitative Computed Tomography (QCT) technique.

Methods: This non-interventional descriptive study was carried out at Radiology department of Military Hospital (MH) Rawalpindi from January 2002 to January 2003. The bone mineral densities of cancellous part of first three lumbar vertebrae were calculated by QCT using the bone mineral density phantom provided by the manufacturer. Data was collected from a total of 145 cases, 130 males and 15 females. Patients presenting for CT scan examination having no chronic illness or any disease condition which may affect the bone mineral density (BMD) were selected.

Results: The mean BMD for the males was 166.4±35.8 mg HOA/cm^3 (range 207.4). The mean BMD for the females was 154.6±47.1 mg HOA/cm^3 (range 144.1).The highest mean value in males was seen in 20-29 year age group. For females the highest mean value was seen in 30-39 year age group.

Conclusion: The BMD of lumbar vertebrae was found to gradually increase in the initial years of life reaching a peak in second or third decade. A gradual decline in the values was noted in cases of males. In females there was a sharp decline around the age of menopause. (Rawal Med J 2009;34:4-6).

Key words: Bone mineral density, age, gender, Quantitative computed tomography, lumbar vertebrae.

INTRODUCTION

Despite its seemingly static appearance bone is a remarkably labile tissue throughout life. Remodelling with the daily turnover of up to 1 gm of calcium continues even after the skeleton is fully formed. In normal adult, bone turnover proceeds at a rate of approximately 5%-10% per year. Bone mass is reflected radiologically as bone density, thus providing a means by which metabolic disorders may be detected and monitored. The signs and symptoms of osteoporosis are manifested mainly in the elderly and it has been estimated that the medical consequences of osteoporosis, with regard to illness, disability, lost work days, and mortality, constitute an enormous drain on the resources of the world. Bone mineral measurement has been useful in providing better understanding of the natural history of osteoporosis, the influence of various risk factors that accelerate and retard bone mineral loss with age, the effect of various experimental drugs developed to retard or reverse bone loss, and the association between bone density and fracture risk.[1,2] Various countries have reported normal bone mineral densities (BMD) in persons of varying ages and sex using different methods including QCT. At present, no data is available in local literature regarding mean and range of QCT bone mineral density values in our population. In this study, we calculated the QCT bone mineral density in relation to age and gender in persons Rawalpindi area.

MATERIALS AND METHODS

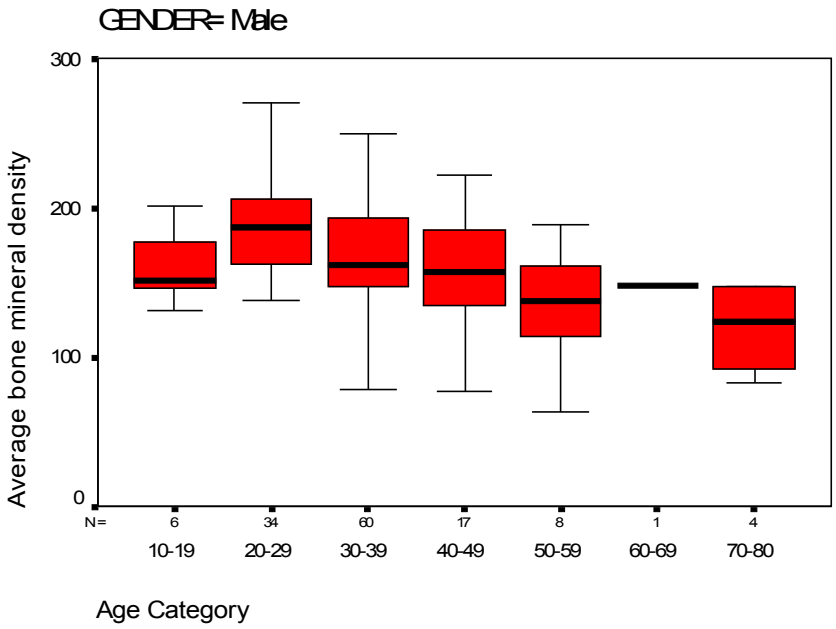
This non-interventional descriptive study was conducted from January 2002 to January 2003 at Department of Radiology, Military hospital, Rawalpindi. A total of 145 cases were selected with

non-probability convenience sampling. Patients presenting for CT scan examination having no chronic illness or any disease condition which may affect the BMD were included. An Informed consent was taken from all participants. Females with pregnancy and lactation were excluded. Detailed clinical history regarding any previous prolonged illness, metabolic and endocrine disease was obtained. Using Helical CT Scanner (Toshiba Express/GX), lateral scanogram of the patient's lumbar spine was obtained including the first three lumbar vertebrae. Three separate slices with thickness of 10 mm were selected. After obtaining the necessary axial slices, selection of region of interest (ROI) was selected inside the cancellous part of the vertebral body taking care not to include any part of the cortical bone. The CT density of this ROI was estimated by the software automatically and plotted onto the regression line. Using the regression line, BMD of the selected ROI was calculated by the software and was shown in units of mg $HACO_3$/ cm^3. The procedure was repeated for each of the three vertebral slices obtained. Bivariate linear regression analysis of the data was carried out using SPSS version 10.0. A P value of < 0.05 was considered significant.

RESULTS

One hundred forty five subjects were enrolled in the study. There were 130 (89.7%) males and 15 (10.3%) females. Age ranged from 10 to 80 years (mean of 34.28±12.21). For the purpose of analysis, cases were divided into 7 groups on the basis of their age (Table 1). Mean BMD for males was 166.4±35.8 mg HOA/cm^3 (range 207.4) and for females, Mean BMD was 154.6±47.1 mg HOA/cm^3 (range 144.1) (table 1 and 2).The data showed that age and average BMD were linearly related. Maximum BMD was observed in 20-29 years age group and as age increased, the average BMD decreased (Fig 1 and 2).

Fig 1. BMD in males, in relation to age (N=130).



Results of the bivariate regression analysis of the data showed Pearson correlation coefficient in males for BMD to be -0.425, which is a moderately high (*P*=.000). For females, Pearson correlation coefficient for BMD was -0.508, which was a moderately high (P= .053).

Fig 2. BMD in females, in relation to age (N=15).

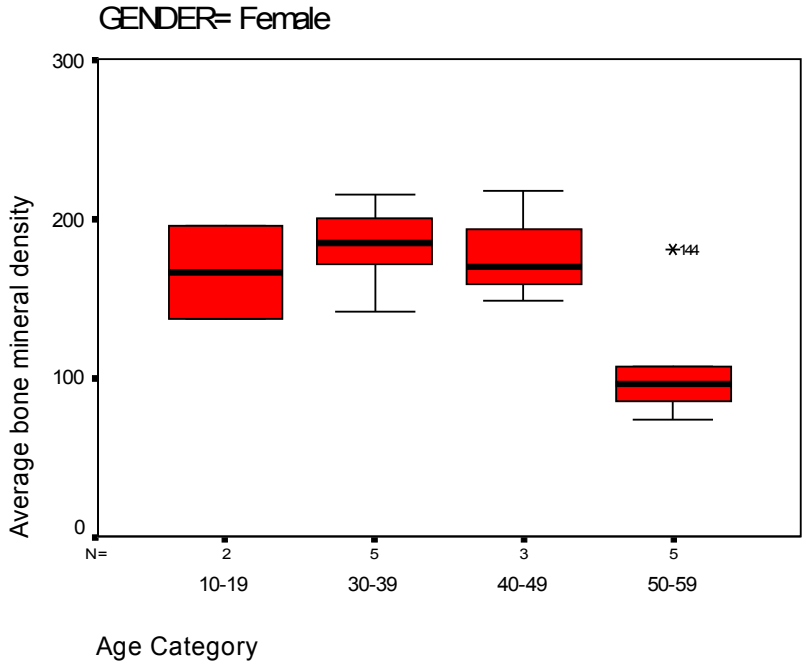


Table 1. Descriptive Data for Male Age groups.

	Age Groups						
Groups	**1**	**2**	**3**	**4**	**5**	**7**	**8**
Age Limit	10-19	20-29	30-39	40-49	50-59	60-69	70-79
Frequency	6	34	60	17	8	1	4
Mean (mg HOA/cm^3)	159.7	185.8	167.5	153.6	124.4	147.3	119.4
Minimum (mg HOA/cm^3)	132.0	138.0	77.7	77.4	63.1	147.3	83.3
Maximum (mg HOA/cm^3)	201.0	271.0	249.0	222.0	189.0	147.3	
Standard Deviation	24.9	28.1	32.9	39.6	40.5	-	32.3

Regression equation for predicting the average BMD from age comes out to be: BMD = -1.858 x Age + 225.805.

DISCUSSION

There are various radiological methods available for assessing the bone density non-invasively[3]. These include Radiogrammetry, Single Photon Absorption, Dual Photon Absorptiometry, Neutron Activation Analysis, Dual Energy X-ray Absorptiometry, Broad band ultrasound attenuation, Dual energy projection radiography and Quantitative Computed Tomography. Quantitative Computed Tomography (QCT) can determine in three dimensions the true volumetric density (mg/cm^3) of trabecular or cortical bone at any skeletal site. However, because of the high responsiveness of spinal trabecular bone, and its importance for vertebral strength, QCT has been principally employed for determination of trabecular bone density from the vertebral body. The validity of this technique for measurement of vertebral cancellous bone is generally accepted, and it is used at more than 4,000 centres worldwide. The measurement of spinal trabecular bone density by QCT discriminates between osteoporotic women and younger healthy women with more sensitivity than measurements of spinal integral bone by DPA or of appendicular cortical bone by SPA.[6,7] Recent advances in automated software and improved calibration phantoms have resulted in improved precision and accuracy errors and reduced acquisition and analysis time.

Table 2: Descriptive Data for Female Age groups.

	Age Groups						
Groups	**1**	**2**	**3**	**4**	**5**	**7**	**8**
Age Limit	10-19	20-29	30-39	40-49	50-59	60-69	70-79
Frequency	2	0	5	3	5	0	0
Mean (mg HOA/cm^3)	165.8	-	182.3	178.1	108.2	-	-
Minimum (mg HOA/cm^3)	136.0	-	141.0	148	73.2	-	-
Maximum (mg HOA/cm^3)	195.0	-	215.0	217.0	180.0	-	-
Standard Deviation	41.6	-	28.2	35.5	42.2	-	-

In a study from San Francisco,[8] mean BMD for pre-menopausal women aged 41±2 was 155±27, which is slightly lower than mean BMD found in 40-49 years age females in our study, which was 178±35.5. However, early post-menopausal females aged 53±4 in that study showed mean BMD of 117±27, which is higher than mean BMD of 50-59 yrs age group in our study, which comes out to be 108±42.2. This shows a greater loss of BMD after menopause in our study as compared to the above mentioned study which also determines that this decrement in bone density between the two age groups is statistically significant ($P<0.002$). This may signify greater bone mass loss after menopause in our population. However, above mentioned study was purely targeted at females whereas in our study data regarding both genders was collected. Moreover, the number of females included in our study was very small. More local studies specifically targeted at pre and post-menopausal women may shed further light on this observation. Although our subjects may not represent the normal Pakistani population, however, the values obtained by us may be used as baseline for further surveys in the normal population.

In conclusion, our study showed that BMD of lumbar vertebrae gradually increased in the initial years of life reaching a peak in second or third decade. A gradual decline in the values was noted in cases of males. In females, there was a sharp decline in the BMD of lumbar vertebrae around the age of menopause. Further research needs to be carried out to find out BMD values in women particularly after menopause. A general survey of the Pakistani population should be carried out to estimate the normal BMD in our population.

REFERENCES

1. Genant HK, Block JE, Steiger P, Gluer CC. Quantitative computed tomography in the assessment of osteoporosis. In: Genant HK ed. Osteoporosis: Update 1987, p 49. San Francisco. Radiology Research and Education Foundation, 1987.

2. Cann CE, Genant HK, Kolb FO, Ettinger B. Quantitative computed tomography for prediction of vertebral fracture risk. Metab Bone Dis Relat Res 1985;6:1-7.

3. Image DJ. Clinical value of bone densitometry. Am J Roentgenol 1994;163:133-5.

4. Cameron JR, Sorenson J. Measurement of bone mineral in vivo: and improved method. Science 1963;142:230-2.

5. Resch H, Pietschmann P, Bernecker P, Krexner E, Willvonseder R. Broadband ultrasound attenuation: a new diagnostic method in osteoporosis. Am J Roentgenol 1990;155:825-8.

6. Reinbbold WD, Genant HK, Reiser UJ, Harris ST, Ettinger B. Bone mineral content in early-postmenopausal and postmenopausal osteoporotic women: comparison of measurement methods. Radiology 1986;160:469-78.

7. Grampp S, Jergas M, Lang P, Steiner E, Fuerst T, Gluer CC et al. Quantitative CT assessment of the lumbar spine and radius in patients with osteoporosis. Am J Roentgenol 1996;167:133-40.

8. Steiger P, Block Jon E, Steiger S, Heuk A. F, Friedlander A, Ettinger B et al. Spinal Bone Mineral Density Measured with Quantitative CT: Effect of Region of Interest, Vertebral Level, and Technique. Radiology 1990;175:537-43.