American Journal of Oral Medicine and Radiology

ISSN - 2394-7721

www.mcmed.us/journal/ajomr

Research Article

BONE MINERAL DENSITY PATTERNS AT LUMBAR SPINE AND HIP USING DUAL ENERGY X–RAY ABSORPTIOMETRY: A DESCRIPTIVE STUDY

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ABSTRACT

In recent years, the widespread availability of bone densitometry techniques has given way to working definitions of osteoporosis based on measurements of bone mineral density (BMD). A WHO study group composed of 16 internationally known experts in the field of osteoporosis proposed a criteria for the diagnosis of osteoporosis based on a specific level of bone density. The participants were recruited in the study upon informed consent. The patient underwent bone mineral density at lumbar spine (L1 to L4) and total hip. The study included 269 subjects referred by clinicians for DEXA scan. Of 269 subjects, 35.32% (n=95) were diagnosed osteoporotic at lumbar spine. 36.8% (n=99) were in the osteopenic range and 27.88% (n=75) were in the normal range. When T score classification of study population at spine & hip are compared, it is observed that 41 participants were diagnosed in osteoporotic range at hip and 95 participants were diagnosed in osteoporotic range at lumbar spine. Thus determination of BMD at lumbar spine was more sensitive for diagnosis of osteoporosis in this study.

Key words:- DEXA scan, BMD, lumbar spine.

Access this article online	
Home page: http://www.mcmed.us/journal/ajomr DOI: http://dx.doi.org/10.21276/ajomr.2017.4.1.4	**Quick Response code**

Received:09.03.17	**Revised**:18.03.17	**Accepted**:21.03.17

INTRODUCTION

The term osteoporosis was coined from Greek words, “osteon” meaning bone and “poros” meaning small pores or passages. Thus the term osteoporosis is descriptive of bony changes that occur in osteoporosis.

The modern definition of osteoporosis is much debated. A working definition for osteoporosis was given at the 1993 Consensus Development Conference and it was defined as: “A systemic skeletal disorder characterized by a low bone mass and microarchitectural deterioration of bone tissue, with subsequent increase in bone fragility and susceptibility to fracture” [1].

This definition does not necessitate that an individual should sustain a fragility fracture before the diagnosis of osteoporosis is made, but introduces the concept of low bone mass and its association with higher fracture risk. The loss of bone occurs "silently" and progressively. Often there are no symptoms until the first fracture occurs. The definition also emphasized that both bone mass and microarchitecture accounts to bone strength.

But, the Consensus Conferences’ definition was difficult to implement clinically into practice since the precise objective measurements for low bone mass, architectural deterioration, or increased risk of fracture that was necessary for a diagnosis of osteoporosis was

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absent from the definition. Though the definition includes terms like low bone mass, microarchitectural deterioration, increased bone fragility, only bone mineral density (BMD) can be objectively measured till date. Low bone mass has proved to be the single most important objective predictor of fracture risk [2]. Lower the bone mass, weaker the bone and lesser the force required to cause a fracture. Bone densitometry is a technique for assessing bone mass noninvasively and Dual energy X-Ray Absorptiometry (DEXA) has been established as the "gold standard" method for assessing BMD [3].

In recent years, the widespread availability of bone densitometry techniques has given way to working definitions of osteoporosis based on measurements of bone mineral density (BMD). A WHO study group composed of 16 internationally known experts in the field of osteoporosis proposed a criteria for the diagnosis of osteoporosis based on a specific level of bone density [4]. An approach similar to current definitions of hypertension or hypercholesterolemia was utilized. The definition of hypertension reflects a blood pressure value, where it has reached a level that places the individual at risk for the undesirable outcomes. Similar concept is applied to definition of osteoporosis when it is defined based on objective measurements of bone mineral density.

Osteoporosis is defined in terms of bone density measurement and based on a comparison of the patients´ measurement to the standard peak adult bone mass (PABM). WHO study group noted that a cut-off value of 2.5 SD or more below the average value for healthy young women for bone density at the PA spine or proximal femur or for bone mineral content at the mid-radius would result in 30% of all postmenopausal women being labelled as osteoporotic. And 50% or more of these women will have sustained a fracture of the spine, femur, forearm, humerus or pelvis. Thus a cut off point of 2.5 SD below peak adult bone mass (PABM) for diagnosis of osteoporosis is based on epidemiological data derived from a population of postmenopausal Caucasian women where 50% of whom had already suffered a fragility fracture.

METHODOLOGY

The participants were recruited in the study upon informed consent. The patient underwent bone mineral density at lumbar spine (L1 to L4) and total hip. The study included 269 subjects referred by clinicians for DEXA scan.

Exclusion criteria:

- Non-consenting patients.
- Patients who underwent bone density study at only one skeletal site.

Informed consent

Individuals fulfilling the selection criteria were informed in detail about the purpose of the study and a written informed consent was obtained from them prior to their enrolment into the study.

Data collection

Upon obtaining the informed consent the patients' relevant clinical history was obtained through personal interviews, use of case records, files and documents. The details were noted on a predesigned proforma.

Diagnostic criteria for osteoporosis

T-score of -2.5 or lower at any of the skeletal site measured is diagnosed as osteoporosis.

Diagnostic criteria for Osteopenia

T score between -1 & -2.5 is diagnosed as osteopenia.

Diagnostic criteria for normal study

T- score not less than -1 was considered normal.

RESULTS

During one year period, a total of 269 subjects were recruited in the study after having met the inclusion criteria. The results of this study are presented below.

Of 269 subjects, there were 205 females and 64 males.

Age of the study population ranged from 24 years to 87 years. Mean age of the study population was 58.4 yrs with a standard deviation of 12.1 yrs. Majority of the patients were in the age range of 61-70 yrs (n=88, 32.71%). 71 subjects (26.39%) were in the age group 51 to 60 years. There were 47 patients (17.47 %) in the age group of 41 to 50 years, 39 patients (14.5%) were aged >70 years and 24 patients (8.92 %) were aged less than 40 years.

On classifying the patients according to BMI, most of the patients were classified as normal or overweight. Of 269 subjects, 91 (33.8%) subjects had normal BMI and 90 (33.5%) subjects were overweight. 76 (28.2%) were obese and 12 (4.5%) were underweight. The average BMI of the study population was 26.9 kg/m2 with BMI ranging from as less as 11.5 kg/m2 to maximum of 42.1 kg/m2.

Increasing age negatively correlated with T scores at spine as well as hip. With increasing age, T scores were more negative.ie farther from the normal young adult values.

Increasing BMI positively correlated with T scores at spine with statistically significant P value. Similarly, increasing BMI positively correlated with T scores at hip with statistical significance.

T scores at spine had positive correlation with T scores at hip. Those who had higher bone mineral density at spine also had higher values at hip. The correlation was statistically significant.

Of 269 subjects, 35.32% (n=95) were diagnosed osteoporotic at lumbar spine. 36.8% (n=99) were in the osteopenic range and 27.88% (n=75) were in the normal range.

Of 269 subjects, 15.24% (n=41) were diagnosed osteoporotic at hip. 37.17% (n=100) were in the osteopenic range and 47.58% (n=128) were in the normal range.

When T score classification of study population at spine & hip are compared, it is observed that 41 participants were diagnosed in osteoporotic range at hip and 95 participants were diagnosed in osteoporotic range at lumbar spine. Thus determination of BMD at lumbar spine was more sensitive for diagnosis of osteoporosis in this study.

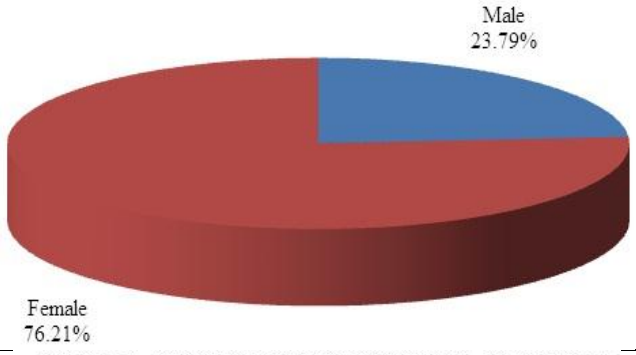
A total of 105 patients were diagnosed to have osteoporosis defined by T score less than -2.5 at any of the two skeletal sites measured. Out of 105 subjects, 64 patients were osteoporotic exclusively at spine and 10 patients were osteoporotic only at hip. 31 patients had osteoporosis at both spine and hip skeletal sites.

The prevalence of osteoporosis was 35.3% (n=95) at the lumbar spine, 15.2% (n=41) at the femoral neck and 39% (n=105) at any site. If BMD was measured only at hip, only 41 subjects would have been diagnosed as osteoporotic instead of 105 subjects diagnosed as osteoporotic in this study population thus missing the diagnosis in rest 64 patients. If BMD was measured only at spine, 95 subjects would have been diagnosed as osteoporotic thus omitting 10 subjects who had osteoporosis only at hip. This translates into conclusion that a significant proportion of subjects would not have been classified as osteoporotic if only one skeletal site was measured.

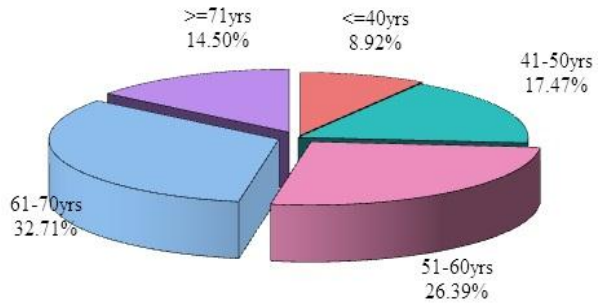
Highest number of osteoporotic individuals were in their 6th & 7th decade. 35.23% osteoporotic patients (n=37 out of 105) fell in the age group of 61-70. 25.71% (n= 27) osteoporotic subjects were in the age range of 51-60 years. There were 27 patients (25.71%) >70 yrs who were osteoporotic. 11 (10.5%) patients had osteoporosis in the age range of 41-50. 3 (2.85%) patients < 40 yrs were osteoporotic. Thus 60.94 % of the patients who were osteoporotic fell in 6th & 7th decade of life.

Highest percentage prevalence of osteoporotic patients were in the underweight category. Out of 12 underweight patients, 10 were osteoporotic with percentage prevalence of 83%. Whereas least prevalence was among the obese patients. Only 20 (26.3%) among 91 obese patients were in osteoporotic range. 43 among 91 subjects who had normal BMI were osteoporotic with percentage prevalence of 47.2% . 32 among 90 overweight patients were osteoporotic (35.5%). Thus the patients with higher body mass index were likely to have higher bone mineral density and thus lesser prevalence of osteoporosis.

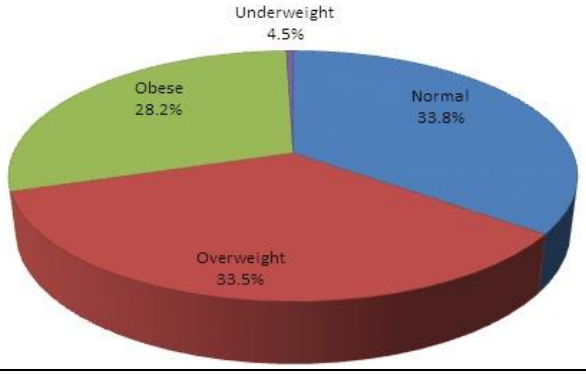
GRAPH 1: DISTRIBUTION OF PATIENTS BY SEX



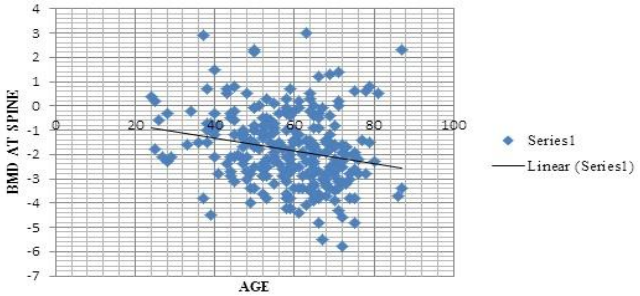
GRAPH 2:DISTRIBUTION OF PATIENTS BY AGE GROUPS



GRAPH 3: DISTRIBUTION OF PATIENTS AS PER BMI

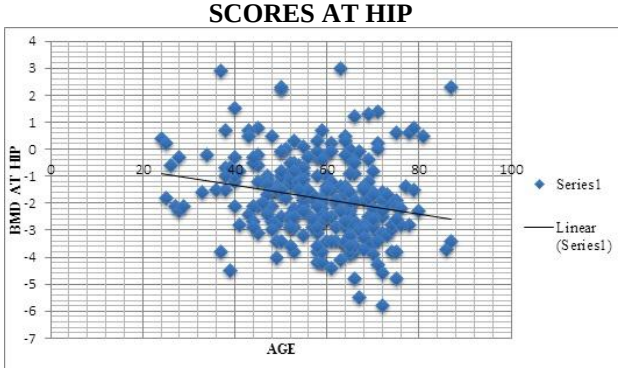


GRAPH 4: CORRELATION BETWEEN AGE & T SCORES AT SPINE



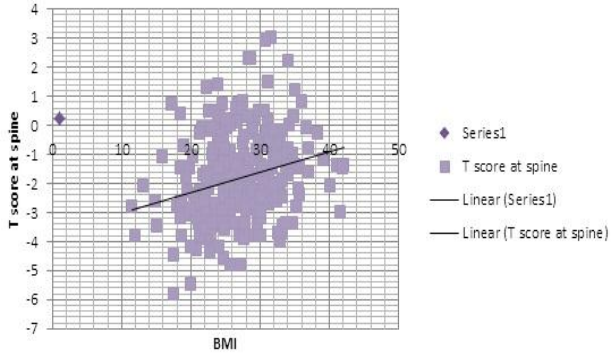
R value -0.219 P value 0.000296

GRAPH 5: CORRELATION BETWEEN AGE & T SCORES AT HIP



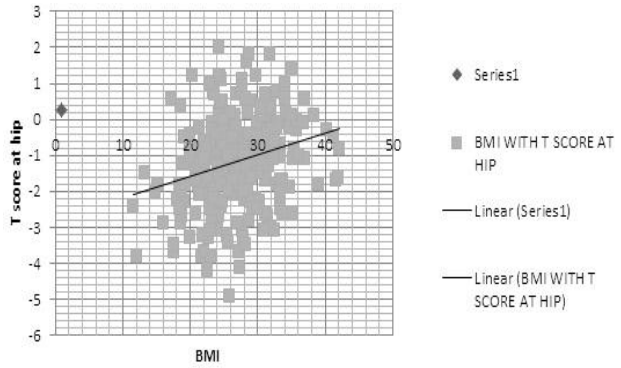
R value: -0.317 p value <0.00001

GRAPH 6: CORRELATION BETWEEN BMI & T SCORES AT SPINE



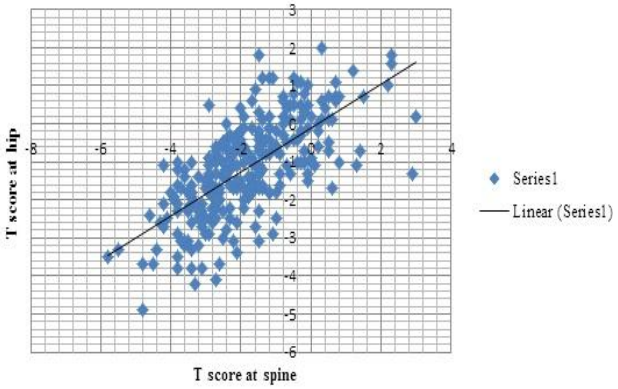
R value : 0.2556 p value <0.00001

GRAPH 7: CORRELATION BETWEEN BMI & T SCORES AT HIP

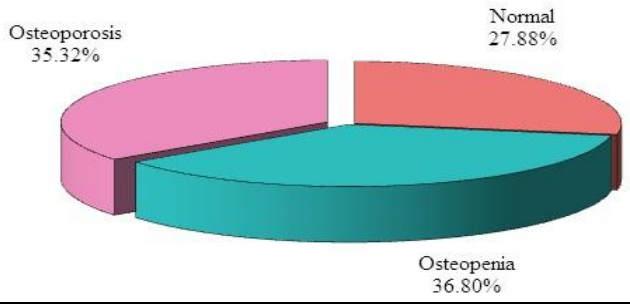


R value: 0.2519 p value <0.00001

GRAPH 8: CORRELATION BETWEEN T SCORES AT SPINE & HIP



GRAPH 9:DISTRIBUTION OF PATIENT T-SCORES AT SPINE



GRAPH 10:DISTRIBUTION OF T-SCORE CLASSIFICATION AT HIP

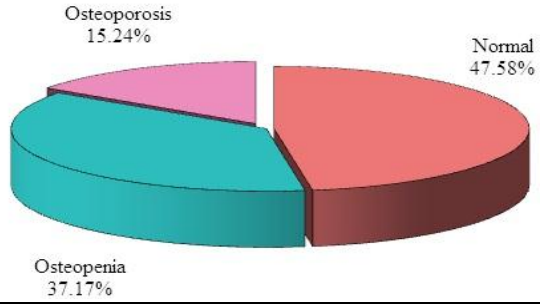


Table 1. Distribution of Patients by Sex

Sex	No of patients	% of patients
Male	64	23.79
Female	205	76.21
Total	269	100.00

Table 2. Distribution of Patients by Age Groups

Age groups	No of patients	% of patients
<=40yrs	24	8.92
41-50yrs	47	17.47
51-60yrs	71	26.39
61-70yrs	88	32.71

>=71yrs	39	14.50
Total	269	100.00

Table 3. Distribution of Patients by BMI Groups

BMI groups	No of patients	% of patients
Under weight	12	4.46
Normal	91	33.83
Over weight	90	33.46
Obese	76	28.25
Total	269	100.00

Table 4. Correlation between Age, BMI, Spine and HIP Measurements by Karl Pearson's Correlation Coefficient Method

Variables	Variables	r-value	t-value	p-value
Age	Spine	-0.2196	-3.6783	0.0003*
	Hip	-0.3173	-5.4681	0.00001*
BMI	Spine	0.2556	4.3202	0.00001*
	Hip	0.2519	4.2535	0.00001*
Spine	Hip	0.6788	15.1051	0.00001*

*p<0.05

Table 5. Distribution of Patient T-Scores at Spine

Status of spine	No of patients	% of patients
Normal	75	27.88
Osteopenia	99	36.80
Osteoporosis	95	35.32
Total	269	100.00

Table 6. Distribution of Patient T-score Classification at HIP

Status of HIP	No of patients	% of patients
Normal	128	47.58
Osteopenia	100	37.17
Osteoporosis	41	15.24
Total	269	100.00

Table 7. Comparison of T-Score Classification at Spine & HIP

	Lumbar spine		Total hip	
	Number	Percentage	Number	Percentage
Osteoporosis	95	35.32	41	15.24
Osteopenia	99	36.8	100	37.17
Normal	75	27.88	128	47.58

Table 8. Distribution of Osteoporosis at Spine, HIP & Both

Osteoporosis at Spine Only	Osteoporosis at HIP Only	Osteoporosis at both HIP and Spine	Total
64	10	31	105

Table 9. Age Wise Distribution of Osteoporosis

Age	No. of osteoporotic patients	Percentage
51-60	27	25.71
61-70	37	35.23
>70	27	25.71
41-50	11	10.5
<40	3	2.85

Total = 105 Total = 100%

Table 10. Distribution of Osteoporosis According to BMI

BMI	No. of osteoporotic patients	Total
Normal	43	91
Underweight	10	12
Overweight	32	90
Obese	20	76

TOTAL =105 TOTAL = 269.

DISCUSSION

Several factors have been described as to why such discordance is prevalent in the population. These have been best described by Woodson G in his study on discordance between hip & spine bone mineral densities [5]. The cause of discordance may be physiological where mechanical strain, weight bearing play their key role in remodelling which can lead to discordant measurement between two different skeletal sites. An example of this situation is the difference in bone density observed between the dominant and non dominant appendicular skeleton. Weight bearing can lead to rise in bone mineral density particularly at hip and femoral neck [6]. Spine and hip tend to begin with different T scores. Spine is said to reach its peak bone density atleast 5yrs earlier to hip which can contribute to different bone density readings at a given time [7]. Another physiological factor is that age related bone loss may be more rapid and important physiology in trabecular bone than cortical bone. Sites with different proportions of cortical and trabecular bones may have different T scores leading to discordance.

Other factor for discordance include pathophysiologic causes secondary to pathologic disease processes. Some causes of secondary osteoporosis like corticosteroid use, hyperparathyroidism, malabsorption, liver disease etc preferentially affect spinal column than other skeletal sites [8]. Age related vertebral degenerative osteophytes, facet joint sclerosis, aortic calcifications can affect bone mineral density readings at spine. Any abnormal calcium deposits in the field of DEXA study ROI will falsely elevate the bone mineral density measurements. Further, artefacts like barium sulphate, metals from zipper, coin, clip or other metallic objects in the ROI of the scanner can lead to discordant measurements between two skeletal sites. Finally technical discordance can occur because of technician variability, patients movement, positioning errors like excess internal or external rotations at hip can cause significant variability in BMD measurements which can contribute to T score discordances.

T score discordance can create problems for physicians for interpreting DEXA results and can interfere with their decision making on treatment. These inconsistencies in T score classification support the notion that BMD should be used as one of the factor in making therapeutic decisions.

It was observed in this study that, in both major and minor discordances, lower BMD in lumbar spine was more prevalent. 14 out 15 patients who had major discordance and 100 of 120 patients had lower bone mineral density at lumbar spine. This observation can be due to various reasons. The rate of bone loss can be different in different parts of skeleton. Trabecular composition typical of lumbar vertebrae has been shown to have more rapid deprivation than cortical bone typical of proximal femur [9]. Again secondary causes of osteoporosis previously mentioned can first affect spinal column which can lead to lumbar osteoporosis. Weight bearing can play a role in increasing femoral bone density leading to higher readings of BMD at hip.

Lesser proportion of patients had higher bone density reading at lumbar spine than at hip. One of the reasons for this is that conditions such as minor compression fractures in lumbar vertebrae, facet joint sclerosis, and aortic calcification can elevate the lumbar spine bone density readings. Other reason may be high prevalence of Vitamin D deficiency in Indian population. Various studies have confirmed widespread vitamin D deficiency in Indians. Decrease in serum concentrations of vitamin D can reduce the density of cortical bones due to raising levels of parathyroid hormone (PTH) and may have a supportive role for density of trabecular bones [10].

In accordance with above finding spinal bone density measurement was more sensitive than hip in diagnosing osteoporosis in our study. Out of 105 patients who were osteoporotic, only 41 had osteoporosis at hip. This result is in agreement with previous studies on BMDs using DEXA. Study done by Moyyeri et al showed similar results where, out of 4188 patients, 518 participants were diagnosed in osteoporotic range in hip area and 1036 participants in the lumbar spine. Similarly 536 participants were diagnosed as osteoporotic at hip and 961 at lumbar spine in a study done by El Maghraoui et al. O'Gradaigh et al in their prospective study of discordance in diagnosis of osteoporosis using DEXA had fewer subjects being identified as osteoporotic using total hip & femoral neck BMD than spine BMD [11].

While few studies have reported hip being more sensitive for diagnosis of osteoporosis than spine. For example, in a study by Liu G et al, osteoporosis at hip was present in 33.1% of women & 25.8% of men, whereas, at lumbar spine it was present in only 24.2% of women & 4.2% of men [12]. This study was done in

elderly patients where 75% of men & 61.1% of women had lumbar spine osteophytoses which will have elevated the lumbar spinal BMD. T score discordance was more prevalent in women than men. 51.7% of women had T score discordance while 45.3% of men had discordance between spinal & hip BMD. While 13 women had major discordance, only 2 men had major discordance. Though T score discordance was commonly seen in women, the association of sex with discordance was not significant. Female preponderance in discordance has been observed in study done by Moyyeri et al whereas, it was equally observed in both men & women in study done by A. El Maghraoui et al.

Menopausal status was also significant risk factors for discordance. In 205 female participants, the number of post-menopausal women with diagnostic discordances (75 of 96) was significantly higher than pre-menopausal participants with discordance (56 of 98; $P < 0.001$). Hormone replacement therapy was a significant protector against discordance. Those who had taken hormone replacement therapy were less likely to show discordant BMDs. The above results are similar to studies done on discordance. In study done by Moyyeri et al menopausal status and late menopause were significant risk factors for T score discordance. Meeta Singh et al reported premature menopause and multiple pregnancies to be significantly associated with major discordance. Moyyeri et al reported HRT to be a protective factor against T score discordance.

Osteoporosis at spine showed significant association with discordance. Those who had spinal BMD in the osteoporotic range were more likely to show T score discordance than those who were osteoporotic at hip. The reason for this observation might be that those who had lesser BMD a hip also tend to had low BMD at spine whereas, the converse situation wasn't widely prevalent.

CONCLUSION

Dual Energy X-Ray absorptiometry is a useful diagnostic tool for early detection of osteoporosis and guide therapeutic intervention.

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Cite this article:
Santosh Patil, Pranav Mallya, Arvind Patil. Bone Mineral Density Patterns At Lumbar Spine And Hip Using Dual Energy X–Ray Absorptiometry: A Descriptive Study. *American Journal of Oral Medicine and Radiology*, 4(1), 2017, 18-24. DOI: **http://dx.doi.org/10.21276/ajomr.2017.4.1.4**