Original Article

Patterns of Age- and Sex-Related Variations in Bone Mineral Density of Lumbar Spine and Total Femur: A Retrospective Diagnostic Laboratory-Based Study

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Abstract

Background: Osteoporosis is a major public health problem and should be a priority for healthcare providers and policymakers as it is an important reason of morbidity, mortality, and high-cost incurred in the management of its complications such as hip fractures. This study is designed to assess the bone mineral density (BMD) variation with age, site, and sex. Study is based on diagnostic laboratory data of BMD. **Methods:** A retrospective analysis was conducted on a sample population of 935 persons (73.5% women, 26.4% men), who underwent dual-energy X-ray absorptiometry scan between 2015 and 2017 in a National Accreditation Board for Testing and Calibration Laboratories accredited Mumbai (Maharashtra, India) based diagnostic laboratory. Lumbar spine, right and left total femur, BMD were analyzed across age, sex, and sites. The prevalence of low BMD and osteoporosis at these sites has been estimated as per the World Health Organization criteria of osteoporosis diagnosis using T scores. **Results:** Overall the prevalence of osteoporosis was found to be 6.4%, 5.5%, and 16.4%, while the prevalence of low BMD was 32.6%, 32.8%, and 31.2% at right total femur, left total femur, and lumbar spine, respectively. The decline in BMD at lumbar spine is more among women and it was a consistent decline with age, while among men' decline rate was less at all three sites. **Conclusion:** Our study highlighted the variation of BMD at different sites of body and higher vulnerability of spine for fragility fractures. Our study has shown a sharp decline in BMD among women during transition from 5th to 6th decade which signifies association of menopause with osteoporosis. Major limitation of the study is unavailability of clinical profiles of the subjects because of which it is difficult to ascertain whether BMD estimation was a diagnostic or screening procedure. In addition, study is conducted in diagnostic lab settings, due to which it is possible to overestimate prevalence of low BMD and osteoporosis by extrapolating these findings to the community.

Keywords: *Bone mineral density, femur, fractures, lumbar spine, osteopenia, osteoporosis*

Introduction

Osteoporosis is a major public health problem worldwide because of associated morbidity, considerable mortality and high cost incurred in the management of complications associated with it.

Osteoporosis is characterized by low bone mass and micro-architectural deterioration of the bone tissue, leading to enhanced bone fragility and an increased risk of fractures.[1] Osteoporosis is a silent, painless disease until the fragility fracture occurs. As per the World Health Organization (WHO), clinical criteria

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for the diagnosis of osteoporosis is based on bone mineral density (BMD) measurements and presence of fractures.[2] BMD is measured by using dual energy X-ray absorptiometry (DEXA) scan. For the diagnostic purposes, BMD is converted into T scores. T score is a number of standard deviations (SDs) above or below the mean in healthy young adults.

Although, any osteoporotic bone is prone to fragility fractures, most common fractures associated with osteoporosis includes hip fractures, vertebral compression fractures, and wrist fractures. The highest rate of mortality has been seen due to hip fractures which leads to serious complications such as disability, urinary tract infections, and bed sores.[3] According to a research study,[4] only 50% of those with fracture recover functionally and about 25% of patients reside in long-term care facilities for a year or more. Hip fractures have sequelae in the form of decreased bone and muscle mass. Lumbar spine fractures are quite predominant which can lead to complications such as immobility, pneumonia, pressure sores, pulmonary embolism, and neurologic impairment.[5] These fractures require surgical interventions and long-term rehabilitation, which incurred great costs for the family and healthcare system.[6] Wrist fractures have been known to cause complications such as carpal instability, tendon rupture, or malunion.[7]

Hip fractures are especially important implication of osteoporosis regarding morbidity, mortality, and financial burden. In 2005, hip fractures in the USA were estimated to account for 14% of total fractures but 72% of total fracture related healthcare cost.[8]

According to a prospective study[9] which highlights a small decline in BMD at hip and spine among women before menopause, while this rate of loss tripled during the early postmenopausal period (<10 years after menopause) and decreased thereafter to a premenopausal rate for the hip and zero for spine. A small bone loss among men was reported across age throughout life.

In routine clinical practice to diagnose osteoporosis, individual BMD values are compared with reference values to calculate T scores. WHO has proposed T scores to diagnose low BMD and osteoporosis. BMD is a marker of bone strength, though other factors are also important. BMD varies with age, ethnicity, sex, and various sites in the body like hip, femur and humerus. Our study highlights the variation of BMD across sites, age, sex, and impact of menopause in women on BMD. This study will help in understanding BMD variations in Indian men and women and to formulate the guidelines focussing on timely intervention to prevent bone decay. It also highlighted important differences in Indian and western population regarding BMD variation.

Objectives

1. Assessing patterns of age and sex-related variations in BMD of lumbar spine and femur
2. Estimation of the proportion of low BMD and osteoporosis.

Methods

This is a diagnostic laboratory-based, observational retrospective study. All subjects (age 20 years or more), who attended a multicenter diagnostic laboratory, based in Mumbai (Maharashtra, India) between June 2015 and March 2017 for screening or diagnosis of osteoporosis by DEXA scan, were considered for analysis.

The diagnostic laboratory is an advanced diagnostic center headquartered in Mumbai with multiple diagnostic centers across wider geographical territory such as New Mumbai, Goa, Satara, Pune, and Thane.

All data variables related to study objectives were obtained from the Laboratory Information System. Following variables were used in the analysis. Demographic profile (age, gender), BMD, T scores, and Z scores at various sites (hip, total body, lumbar spine, total right, and left femur).

Definition of osteoporosis

According to the WHO, clinical diagnosis of osteoporosis is based on BMD values and T scores. T scores ≥−1 is defined as normal, T scores between −1, and −2.5 as low BMD while T score ≤−2.5 indicates osteoporosis.

T and Z scores

T score is the number of SDs of the BMD measurement above or below that of young healthy adults of the same sex. Z score is the number of SDs of the BMD measurement above or below that of adults of the same age and sex.

Descriptive statistics have been described in the form of proportions. Prevalence was calculated by using WHO's diagnostic criteria and proportions were calculated across various categories of age, sex, and site. Excel, 2016 and R were used for the data analysis. Categorical variables were compared using Chi-square test. Significant *P* value is taken as <0.05.

Data confidentiality

For analysis, anonymized data were used as per electronic health record, 2013 standards to maintain the confidentiality of the subjects.

Community participation and benefits

This study will add to fine understanding and highlighting about the patterns of BMD variation in

Indian population and burden of osteoporosis in Indian context. This study will increase fine understanding of researchers about BMD variation.

Dissemination of results

Results will be shared with all collaborating stakeholders. The study will be submitted to peer-reviewed journals and conferences.

Results

Total sample population includes 935 subjects, 688 (73.6%) women and 247 (26.4%) men. Overall mean age was 52.8 years (SD: 15.2), while of women and men were 54.1 years (SD: 13.8) and 49.1 years (SD: 18.1), respectively [Table 1]. The age range was 20–91 years.

The study highlights highest BMD at all sites in 3rd decade of life both among men and women. Among men, mean right total femur BMD is less by 5.9%, 3.1%, and 3.0% in 4th, 5th, and 6th decade in comparison to previous decades, while in 7th decade mean BMD is high by 3.9% than 6th decade, followed by a sharp decline of 9.7% in 8th decade of life [Table 2]. Trends of total left femur BMD are similar, though decline is less during a transition from 7th to 8th decade. Mean lumbar spine BMD, shows a decline of 1.4%, 6.1%, and 1.4% during 4th, 5th, and 6th decade in comparison to the previous decade. Like total femur, a slight increase of 3% in lumbar spine mean BMD is estimated during 7th decade but unlike total femur, afterward decline was very less (0.7%).

Among women, percentage decline at right and left total femur was comparatively less than men. Total right femur BMD was less by 1.0%, and 0.8% during 4th and 5th decade in comparison to previous decades. During 6th, 7th, and 8th decade decline was 5.8%, 7.6%, and 5.8%, respectively [Table 2]. Lumbar spine BMD was 3.9% and 3.0% less during 4th and 5th decade in comparison to previous decades among women. There was a sharp decline of 10.4% in mean lumbar spine BMD during transition from 5th to 6th decade, which corresponds to menopause, followed by a decline of 5.3%, and 1.1% in 7th and 8th decade.

Among men in 8th decade, mean right, left total femur and lumbar spine BMD was less by 16.9%, 15.9%, and 6.6%, respectively, in comparison to 3rd decade. Women had slightly more decline for the right total femur (19.5%) and left total femur (19.5%) mean BMD but even higher decline in mean lumbar spine BMD (21.9%) in comparison to men. Research has shown a higher rate of osteoporotic spine fractures among women than men.[10] This higher percentage decline in mean BMD at lumbar spine explains it partially.

Table 1: Mean bone mineral density at the lumbar spine and right and left total femur across age and sex categories (original)

Age categories (years)	*n*	Mean BMD (g/cm^2)		
		Right total femur	Left total femur	L1-L4
Men				
20-29	49	1.075	1.088	1.181
30-39	45	1.012	1.022	1.165
40-49	34	0.981	0.970	1.094
50-59	35	0.952	0.942	1.079
60-69	41	0.989	0.982	1.111
>69	43	0.893	0.918	1.103
Women				
20-29	35	0.994	0.996	1.216
30-39	84	0.984	0.979	1.168
40-49	124	0.976	0.982	1.133
50-59	184	0.919	0.923	1.015
60-69	165	0.849	0.855	0.961
>69	96	0.800	0.802	0.950

BMD: Bone mineral density

Table 2: Percentage decline in mean bone mineral density at various sites in men and women with age (original)

Baseline decade	Decade (in comparison to baseline decade)	Percentage decline in Mean BMD in comparison to mean BMD of previous decade		
		Right total femur	Left total femur	Lumbar spine (L1-L4)
Men				
3rd	4th	5.9	6.1	1.4
4th	5th	3.1	5.1	6.1
5th	6th	3.0	2.9	1.4
6th	7th	−3.9*	−4.2*	−3.0
7th	8th	9.7	6.5	0.7
3rd	8th	16.9	15.6	6.6
Women				
3rd	4th	1.0	1.7	3.9
4th	5th	0.8	−0.3*	3.0
5th	6th	5.8	6.0	10.4
6th	7th	7.6	7.4	5.3
7th	8th	5.8	6.2	1.1
3rd	8th	19.5	19.5	21.9

*Negative sign shows an increase in mean BMD. BMD: Bone mineral density

Trends of BMD variation (right and left total femur) among men have shown a consistent decline from the early adult life (during 3rd–4th and 5th decades) with a small increase during 6th–7th decade transition. Women have less decline during early adult life, followed by a consistent high decline after menopause (5th decade onwards).

Mean BMD loss at lumbar spine among men is almost one-third (6.6%) in comparison to women (21.9%).

Mean lumbar spine BMD is 10.4% less in women in 6th decade in comparison to 5th decade, which reflects the impact of menopause on BMD. In comparison men have only a small loss of spinal BMD, 1.4% in spinal BMD from 5th to 6th decade.

As Figure 1 showed a consistent decline among women in spinal BMD, while among men BMD loss in later decades is much less. Right and left total femur BMD in women varies only slightly before menopause, though later it declines consistently [Figure 2]. Among men, the decline is more in early decades and less during later stages of life.

Based on the WHO criteria for osteoporosis diagnosis, the prevalence of low BMD and osteoporosis was estimated. Out of total subjects, 16.4% had osteoporosis of lumbar spine, while 31.2% were with low BMD. Prevalence of osteoporosis based on T score of total right and left femur was 6.4% and 5.5%, while low BMD prevalence was 32.6 and 32.8%, respectively.

Osteoporosis of lumbar spine is more common among women (17.7%) than men (12.6%), though it is not significant statistically (P = 0.06). While at right and left total femur, the proportion of osteoporosis and low BMD is similar among men and women [Table 3]. The proportion of low BMD at lumbar spine is slightly high among women (32.6%) than men (27.9%).

Like BMD, the proportion of osteoporotic subjects at spine varies with age among men and women. Among

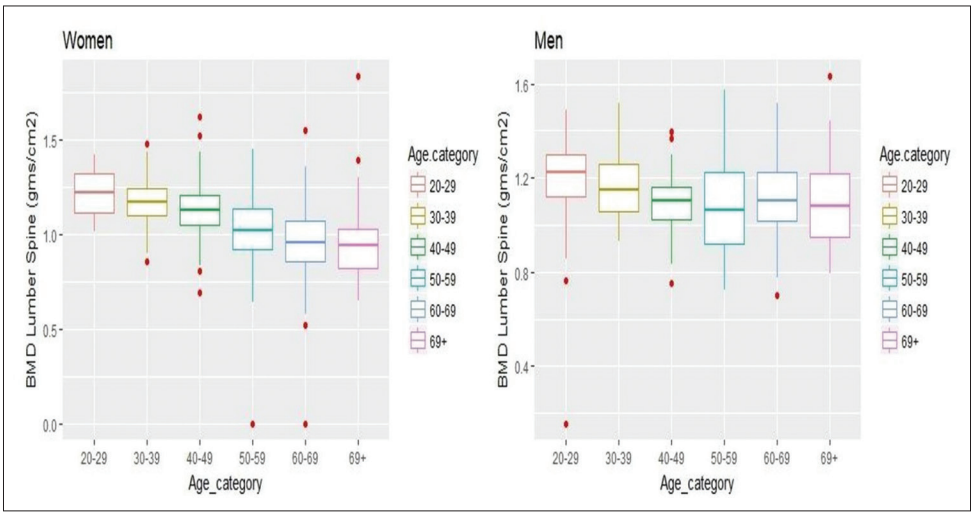

Figure 1: Box and whisker plots showing trends of lumbar spine bone mineral density among women and men

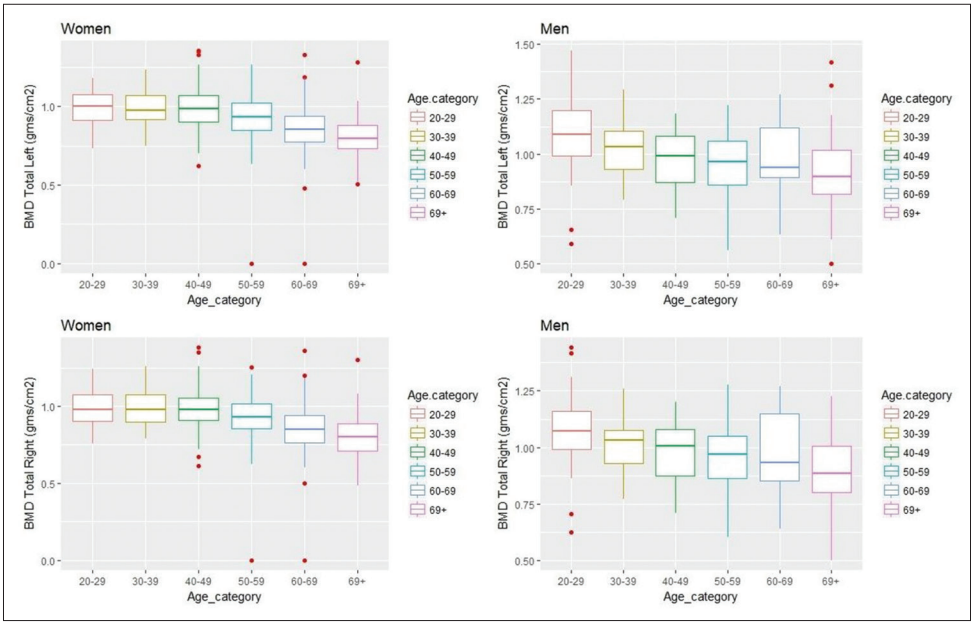

Figure 2: Box and whisker plots showing trends of the right and left total femur bone mineral density among women and men

both men and women of 3rd and 4th decade, a very small proportion had osteoporosis of lumbar spine, while in 5th decade, men had higher proportion (11.8%) than women (3.2%) and the difference is statistically significant (P = 0.04). An overall proportion of osteoporosis of lumbar spine is high during 6th decade for both men and women, but still, men has higher proportion (25.7%) than women (19%), which is not statistically significant (P = 0.4). Women had much higher proportion during 7th (29.7%) and 8th (34.4%) decade than men, 17% and 20.9%, respectively [Table 4]. Although difference during 7th as well as 8th, decade was not found to be statistically significant (P = 0.1)

The proportion of osteoporotic, considering right and left total femur T scores, is high among men up to 6th decade though in 7th and 8th decade proportion of osteoporosis is greater among women similar to trends at the lumbar spine.

Discussion

A Chinese study[11] illustrates in detail about the significant difference in BMD among age-stratified groups at various body sites. This study has suggested elderly women have greater differences in distribution of BMD than men with aging. Another study[12] reveals that rate of decrease in BMD at femoral neck and intertrochanteric femur is only two-third among men in comparison to women, while only one-fourth of that in woman for lumbar spine. Our study reflects these findings as declines among women for spinal BMD was almost three time more in comparison to men between 3rd and 8th decade of life (21.9% vs. 6.6%). It also highlighted that women have less mean BMD than men of the same age (decade). European prospective osteoporosis study,[13] a multicentric study estimated the influence of age and gender on incidence of vertebral fractures associated with osteoporosis. Incidence increases with age in both men and women, although at all ages, fracture rate was higher among women. Lesser BMD and a greater decline with age among women than men are among major contributory factors for higher rate of fragility fractures in women. Our study has reported much higher rate of bone loss among women in comparison to men at all sites but especially more at lumbar spine.

Lunt *et al*.[14] have attributed greater risk of vertebral deformities among women to higher rate of bone loss. This decline in BMD is steeper among women during their transition from fifth to sixth decade, which reflects the impact of menopause on BMD. According to a

Table 3: Proportion of men and women with low bone mineral density and osteoporosis

Category (*n*)	Low BMD, *n* (%)			Osteoporosis, *n* (%)		
	Right total femur	Left total femur	Lumbar spine (L1-Ll4)	Right total femur	Left total femur	Lumbar spine (L1-Ll4)
Men (247)	82 (33.2)	84 (34)	68 (27.9)	16 (6.5)	19 (7.7)	31 (12.6)
Women (688)	223 (32.4)	223 (32.4)	224 (32.6)	44 (6.4)	32 (4.7)	122 (17.7)
Overall (935)	305 (32.6)	307 (32.8)	292 (31.2)	60 (6.4)	51 (5.5)	153 (16.4)

BMD: Bone mineral density

Table 4: Prevalence of low bone mineral density and osteoporosis across age and sex categories

Age category (years)	Sex (*n*)	Low BMD, *n* (%)			Osteoporosis, *n* (%)		
		Right total femur	Left total femur	Lumbar spine (L1-L4)	Right total femur	Left total femur	Lumbar spine (L1-L4)
Men							
20-29	49	6 (12.2)	6 (12.2)	9 (18.4)	2 (4.0)	3 (6.1)	2 (4.0)
30-39	45	14 (31.1)	16 (35.5)	15 (33.3)	0	0	0
40-49	34	10 (29.4)	10 (29.4)	12 (35.3)	3 (8.8)	4 (11.8)	4 (11.8)
50-59	35	11 (31.4)	8 (22.9)	9 (25.7)	3 (8.6)	5 (14.3)	9 (25.7)
60-69	41	19 (46.3)	21 (51.2)	11 (26.8)	2 (4.9)	2 (4.9)	7 (17)
>69	43	22 (51.2)	23 (53.5)	13 (30.2)	6 (13.9)	5 (11.6)	9 (20.9)
Women							
20-29	35	5 (14.3)	6 (17.1)	4 (11.-4)	0	0	0
30-39	84	13 (15.5)	10 (11.9)	13 (15.5)	0	0	1 (1.2)
40-49	124	22 (17.7)	22 (17.7)	29 (23.4)	2 (1.6)	1 (0.8)	4 (3.2)
50-59	184	52 (28.3)	49 (26.6)	66 (35.6)	3 (1.6)	3 (1.6)	35 (19)
60-69	165	84 (50.9)	84 (50.9)	69 (41.8)	16 (9.7)	10 (6.0)	49 (29.7)
>69	96	47 (48.9)	52 (54.2)	42 (43.8)	23 (23.9)	18 (18.8)	33 (34.4)
Total	935	305 (32.6)	307 (32.8)	292 (31.2)	60 (6.4)	51 (5.5)	153 (16.4)

BMD: Bone mineral density

survey[15] by the Indian Menopause Society, average age of menopause in Indian women is 46.2 years. Our study has limitation as information regarding menopause is not available but considering fifth decade as the time-period, in which most Indian women, attain menopause and sixth decade as early post-menopausal time-period. Women in sixth decade have mean spine BMD less by 10.4% than women in fifth decade, while difference among men is only 1.4% in between 5th and 6th decade. Till 5th decade, women have lesser proportion of low BMD and comparable proportion of osteoporosis in comparison to men but women have much higher proportion of low BMD from sixth decade and of osteoporosis from seventh decade than men. Various research studies[16-18] have reported the protective effect of oestrogen on bones. Greater loss of BMD and higher proportion of low BMD and osteoporosis in women after menopause are supportive evidence for this theory.

Various studies[19-21] have demonstrated the impact of menopause on loss of BMD, also highlighted higher decay during early postmenopausal period. We find higher decline of spine BMD during 6th decade (10.4%) than later decades (5.5% and 1.1% during 7th and 8th decade).

We estimated the overall proportion of osteoporosis as 16.4% at lumbar spine (men: 12.6% women: 17.7%), 6.4% (men: 6.5% women: 6.4%), and 5.5% (men: 7.7% women: 4.7%) at total right and left femur, respectively. Qureshi *et al*.[22] in a clinic-based study reported prevalence of osteoporosis at lumbar spine as 23% and 15% and at femoral neck as 12% and 7% among women and men (age >40 years), respectively. Our study also has reported higher osteoporosis prevalence at lumbar spine than femur. Various Indian studies[23-30] showed the prevalence of osteoporosis ranging from 8% to 62.0% in different sample populations. A wide range in estimate of osteoporosis prevalence is because these studies had been conducted on populations belonging to different categories (postmenopausal, age > 40 or 50 years) and socioeconomic status.

Conclusion

Our study highlights the impact of age and menopause on BMD loss especially at lumbar spine but also at other sites. Contrary to common belief about osteoporosis as disease of postmenopausal women, our study reveals its significant prevalence among young man and women also. There is a difference between Indian and western populations regarding diet, ethnicity, and various risk factors associated with poor bone health. In Indian context, comprehensive understanding is required about bone health to create country-specific preventive guidelines. Interventions, such as screening, education on diet, and bone strengthening exercises during early life, have the potential of being an effective strategy to prevent osteoporosis and fragility fractures.

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Conflicts of interest

There are no conflicts of interest.

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