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Age, gender, and site-specific variations in bone mineral density: a cross-sectional analysis of osteoporosis risk factors

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ABSTRACT

Background: Osteoporosis is major health issue defined by decreased bone mineral density (BMD) and elevated fracture susceptibility. This study aimed to analyze age, gender, and site-specific variations in BMD and examine osteoporosis risk factors in an Indian population.
Methods: This study was conducted with cross sectional design on 77 participants (54 females, 23 males) aged 20-83 years undergoing 3 Dimensional quantitative computed tomography (QCT) for BMD assessment at a tertiary care hospital in India. BMD measurements of the spine and bilateral hips were analyzed along with demographic and clinical data. Statistical analyses included t-tests, multivariate logistic regression, correlation analysis, and Chi-square tests.
Results: The study revealed a high prevalence of osteoporosis (55.8%) and osteopenia (27.3%). Marked disparities in spine bone mineral density were noted between genders ($p=0.023$) and among age cohorts ($p<0.0001$). Age showed moderate negative relationship with spine BMD ($r=-0.552$, $p<0.0001$) and was recognized as a major predictor of osteoporosis ($p<0.0001$). Gender was not a significant predictor of osteoporosis after adjusting for age in our study.
Conclusions: This study highlights the critical role of age in BMD reduction and osteoporosis risk, with older individuals showing higher rates of osteoporosis. While gender differences in BMD were observed, age emerged as the primary predictor of osteoporosis risk. These findings emphasize the importance of age-related assessments in osteoporosis screening and management strategies.

Keywords: BMD, Osteoporosis, Risk factors, Age and gender distribution

INTRODUCTION

Osteoporosis is global health issue marked by reduced bone mineral density (BMD) and the degradation of bone microarchitecture, resulting in an increased risk of fractures.[1] This metabolic bone disease exhibits notable sexual dimorphism, with distinct differences in epidemiology and pathogenesis between males and females.[2]

The prevalence of osteoporosis is significantly greater in women, particularly postmenopausal women, compared to men. The National Health and Nutrition Examination (NHANES) survey 2005-2008 reported that the prevalence of osteoporosis at the hip or lumbar spine was 16% in women and 4% in men aged 50 years and older.[3] This disparity is largely attributed to the rapid bone loss experienced by women during the menopausal transition due to estrogen deficiency.[4]

Despite the lower prevalence, osteoporosis in men is associated with significant morbidity and mortality. Men tend to experience fractures at a higher BMD compared to women, and they are more prone to disability or death

following osteoporotic fractures.[2,5] Additionally, men are often underdiagnosed and undertreated for osteoporosis, with studies showing that only 12% of men undergo BMD testing or receive osteoporosis treatment while on oral glucocorticoid therapy, compared to 23% of women.[6]

Given these gender disparities in osteoporosis prevalence, fracture risk, and management, there is a critical need for comprehensive studies examining the sex-specific differences in BMD, fracture incidence, and associated risk factors specifically cantering the Indian population. Such research can inform tailored screening and treatment strategies for both men and women, potentially improving outcomes and reducing the burden of osteoporosis-related complications.[7]

The primary objective of this study was to analyze age, gender, and site-specific variations in BMD and examine osteoporosis risk factors in an Indian population. By conducting a cross-sectional analysis of BMD measurements obtained through 3D quantitative computed tomography (QCT), this research aimed to provide insights into the prevalence of osteoporosis and osteopenia, assess the impact of age and gender on BMD, and identify significant predictors of osteoporosis risk.

The findings of this study are intended to inform tailored screening and treatment strategies for both men and women, potentially improving outcomes and reducing the burden of osteoporosis-related complications in the Indian context.

METHODS

Study design

This research utilized a cross-sectional design to analyze age, gender, and site-specific variations in BMD and to examine osteoporosis risk factors and diagnostic discordance. The study was preformed using data collected from a single center's bone densitometry database.

Setting

The study carried out at Lokmanya Tilak Municipal Medical College and hospital, Sion, Mumbai in India. Data were collected from patients who underwent 3 Dimensional-quantitative computed tomography (3D-QCT) for BMD assessment between 07 May 2023, and 01 January 2024.

Participants

Eligibility criteria included all patients aged 20 years and above who underwent 3D QCT-based BMD assessment during the study period. No exclusion criteria were applied to ensure a comprehensive analysis of the population seeking BMD evaluation. The study comprised 77 individuals, consisting of 23 males and 54 females.

Variables

The primary outcome variables were BMD measurements of the spine and bilateral hips, along with their corresponding T-scores and Z-scores. Exposures and predictors included age, sex, comorbidities, history of fragility fractures, and presenting symptoms. Diagnostic criteria for osteoporosis and osteopenia were based on American College of Radiology (ACR) QCT spine BMD classification threshold for the spine and the World Health Organization (WHO) classification criteria for T-scores at the hip joint.

Data sources/measurement

All BMD measurements were performed using a standardized 3D-QCT protocol. Spine BMD and hip BMD was measured in mg/cm^3 and g/cm^2 respectively. T-scores and Z-scores were calculated using UCSF reference databases. Demographic and clinical data were extracted from patient records accompanying the BMD reports.

Bias

To minimize measurement bias, all QCT scans were performed using the same equipment and protocol. To address potential selection bias, consecutive sampling was employed, including all eligible patients during the study period.

Study size

The study size was determined by the number of patients who underwent BMD assessment during the specified time frame, resulting in a sample of 77 participants.

Quantitative variables

BMD values were analyzed as continuous variables. Age was classified into categories (20-39, 40-59, 60-79, and ≥80 years) for subgroup analysis. BMD range at spine were used to classify participants into normal (above 120 mg/cm^3), osteopenia (80 to 120 mg/cm^3) and osteoporosis (below 80 mg/cm^3). T-scores (total hip) were utilized to categorize participants into osteoporosis (T-score ≤-2.5), osteopenia (T-score between -1.0 and -2.5), and normal (T-score > -1.0) classifications.

Statistical methods

Descriptive statistics were employed to encapsulate participant characteristics and BMD measurements. Independent t-tests were utilized to compare BMD results between males and females. One-way analysis of variance (ANOVA) was employed to evaluate BMD variations among age groups. Chi-square tests were used to examine the relationship between categorical factors, including gender and osteoporosis diagnosis. Pearson's correlation coefficient was computed to analyze the association between age and BMD. Multivariate logistic regression

was performed to determine important predictors of osteoporosis, controlling for relevant confounders like age, sex, and comorbidities.

To address diagnostic discordance, kappa statistics were calculated to assess agreement between spine and hip BMD diagnoses. Subgroup analyses were performed to examine BMD patterns in different age groups and between genders. All statistical analyses were conducted using PSPP, with a significance level set at $p<0.05$.

RESULTS

In this study, 77 participants were analyzed to examine the factors associated with BMD and osteoporosis risk. The study population had a mean age of 54.2 years, with an age range of 20 to 83 years, and included 54 females and 23 males (Figure 1). Age groups were distributed as follows: 20–39 (13 participants), 40–59 (32 participants), 60–79 (29 participants), and 80+ (3 participants).

Table 1: Results of our study.

Factors	Our study
Sample size	77
Age (years)	20-83
Gender distribution	70.1% female, 29.9% male
Osteoporosis prevalence	55.8%
Osteopenia prevalence	27.3%
Age-BMD correlation	Negative correlation (r=-0.552)
Gender difference in BMD	Significant (p=0.023)
Age as predictor of osteoporosis	Significant (p<0.0001)

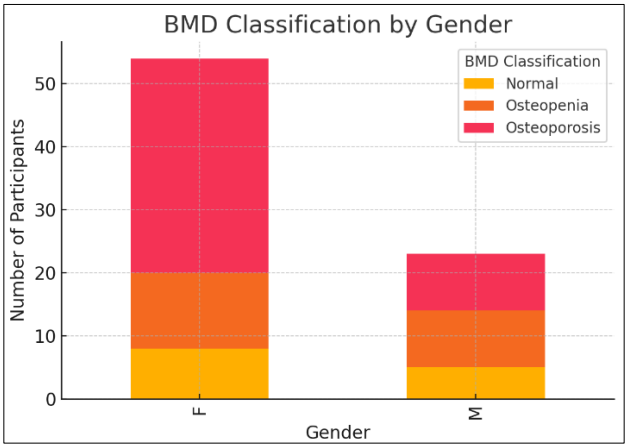

Figure 1: BMD distribution according to gender.

In terms of osteoporosis outcomes, 43 participants were diagnosed with osteoporosis, while 21 had osteopenia and 13 were classified with normal BMD. Analysis revealed a statistically significant difference in spine BMD between males and females ($t=2.32$, $p=0.023$), indicating that gender plays a role in BMD differences. Furthermore, a significant variation in BMD was observed across age groups ($F=15.99$, $p<0.0001$), suggesting that age substantially impacts BMD levels (Figure 2).

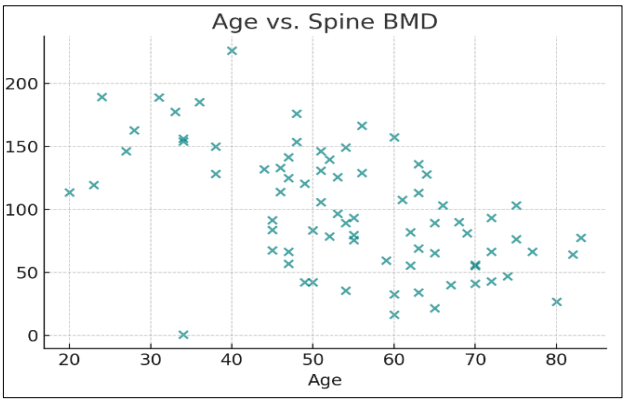

Figure 2: Age versus spine BMD.

Age was found to have a moderate negative correlation with spine BMD ($r=-0.552$, $p<0.0001$), indicating that BMD tends to decline as age increases. Logistic regression analysis identified age as a significant predictor of osteoporosis (coefficient=0.122, $p<0.0001$), with each year of increase in age is linked with a higher incidence of osteoporosis. Gender was not a significant predictor in the logistic model, nor were comorbidities after adjusting for age.

In summary, the analysis demonstrates that age is a key factor influencing BMD and osteoporosis risk, with older individuals showing higher rates of BMD reduction and osteoporosis diagnosis. Gender differences in BMD are present but do not directly correlate with increased osteoporosis risk. These findings highlight the importance of age-related assessments in osteoporosis screening and underscore the limited impact of gender alone on osteoporosis risk when adjusted for age.

DISCUSSION

Our study on BMD measurements in 77 participants revealed a high prevalence of osteoporosis (55.8%) and osteopenia (27.3%). These findings differ significantly from larger studies such as Wang et al and Fan et al, which reported much lower prevalence rates.[8,9] For instance, Fan et al found osteoporosis prevalence of 2.51% in males and 11.72% in females across all ages.[9]

The discrepancy in prevalence rates could be attributed to our smaller sample size and potential selection bias, as our participants were individuals who underwent BMD testing for clinical suspicion of osteoporosis. However, our findings align with these larger studies in demonstrating a significant negative correlation between age and BMD, as well as gender differences in BMD.[2,3,8,9]

The strong association between age and osteoporosis risk observed in our study ($p<0.0001$) is consistent with

previous research.[2-4,8,9] This underscores the importance of age-related bone loss in osteoporosis development, as highlighted by Alswat et al and Chen et al.[2,4]

Gender differences in BMD and osteoporosis risk were observed in our study, with females showing lower BMD values. This is consistent with the findings of larger studies.[2-4,8-10] However, unlike some larger studies, our logistic regression analysis did not find gender to be a significant predictor of osteoporosis after adjusting for age.[8-10] This discrepancy may be due to our smaller sample size or differences in study population characteristics.

The global burden of osteoporosis is significant, as reported by Wang et al, influencing lifestyle, medical conditions of patients.[11] This highlights the growing public health concern of osteoporosis worldwide.

While our study provides valuable insights into the relationships between age, gender, and BMD, the results should be interpreted cautiously due to the study's limitations. The high prevalence of osteoporosis in our study (55.8%) is likely an overestimate compared to larger population-based studies as patient at risk were screened.[8,9] However, the observed relationships between age, gender, and BMD are consistent with larger, more representative studies, suggesting that these trends may be applicable to broader populations.[2-4,8-10] Further research with larger, more representative samples is needed to confirm these findings and explore additional risk factors for osteoporosis.

CONCLUSION

This study enhances the existing knowledge regarding the prevalence and risk factors of osteoporosis, highlighting the significant influence of age and gender on bone health. Future investigations utilizing bigger, more heterogeneous populations are necessary to validate these findings and examine further risk factors for osteoporosis. Longitudinal studies would be especially beneficial in elucidating the development of bone loss over time and in finding early indicators of osteoporosis.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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