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Study of Bone Mineral Density in Patients with Chronic Obstructive Pulmonary Disease

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KEYWORDS

COPD, bone mineral density, osteoporosis, osteopenia, GOLD staging, BMI, smoking.

ABSTRACT:

Background/Objectives: Chronic Obstructive Pulmonary Disease (COPD) is increasingly recognized for its systemic complications, including significant effects on bone metabolism. Osteopenia and osteoporosis are prevalent yet underdiagnosed comorbidities in COPD patients. The objective of this study was to assess the prevalence of osteopenia and osteoporosis in patients with COPD and to evaluate the relationship between bone mineral density (BMD) and key clinical parameters.

Methodology: This prospective observational study was conducted at the National Institute of Medical Sciences and Research (NIMS), Jaipur, between May 2023 and November 2024. A total of 122 clinically stable COPD patients, diagnosed according to GOLD guidelines, were enrolled. Data were collected through structured clinical history, physical examination, spirometry and ultrasound-based BMD measurements. Statistical analysis included descriptive statistics, chi-square tests and Pearson correlation using SPSS version 20.

Results: The mean age of participants was 61.38 ± 11.97 years with a nearly equal male-to-female ratio. Most subjects were either current or former smokers (63.1%) and more than half (58.2%) were classified as obese. BMD assessment revealed that 68.8% of COPD patients had low BMD—34.4% had osteopenia and 34.4% had osteoporosis. However, statistical analysis showed no significant association between BMD status and COPD severity based on GOLD stages ($p = 0.993$), BMI ($p = 0.845$), or smoking status ($p = 0.646$).

Conclusion: This study demonstrates a high prevalence of reduced bone mineral density among COPD patients, independent of traditionally recognized risk factors such as BMI, smoking and disease severity. Given the high burden of bone demineralization in COPD, routine BMD screening should be incorporated into clinical practice.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) represents a major global health burden, ranking among the leading causes of mortality worldwide.[1] While COPD is primarily characterized by progressive airflow limitation and respiratory symptoms, there is growing recognition of its significant systemic manifestations that extend far beyond the lungs. Among these extra-pulmonary complications, osteoporosis has emerged as a particularly important and frequently underdiagnosed comorbidity that substantially impacts patient morbidity and mortality.[1,2] The relationship between COPD and bone health represents a complex interplay of multiple pathophysiological mechanisms. Patients with COPD demonstrate a markedly increased prevalence of osteoporosis and osteopenia compared to age-matched controls, with studies revealing prevalence rates as high as 48% among COPD patients.[3] This association is particularly pronounced in male patients, where significant differences in bone mineral density (BMD) have been documented, especially at the hip region.[1] The clinical significance of reduced bone density in COPD extends beyond the immediate concern of fracture risk, with recent research demonstrating that lower thoracic vertebral bone density serves as an independent predictor of all-cause mortality in COPD patients.[4]

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The development of osteoporosis in COPD patients results from a constellation of interconnected factors including chronic systemic inflammation, prolonged corticosteroid therapy, smoking history, physical deconditioning, vitamin D deficiency, and hypogonadism.[5,6] Recent evidence suggests the presence of bone-muscle crosstalk mechanisms that may compound both osteoporosis and sarcopenia risk in COPD patients, indicating that bone and muscle health should be considered as interconnected rather than isolated comorbidities.[7] Despite the high prevalence and clinical significance of osteoporosis in COPD, this comorbidity remains frequently underdiagnosed and overlooked in routine pulmonary care. The widespread use of chest computed tomography in COPD monitoring presents a unique opportunity for concurrent bone health assessment, as CT-derived bone measurements can serve as valuable surrogates for osteoporosis screening.[2] Understanding the prevalence, risk factors, and clinical implications of reduced bone mineral density in COPD patients is essential for developing comprehensive care approaches that address both respiratory and skeletal health, ultimately improving quality of life and clinical outcomes for this vulnerable patient population.[8]

METHODOLOGY

Study Design and Setting: This is an observational prospective study conducted at the National Institute of Medical Sciences and Research (NIMS), Jaipur, Rajasthan, spanning from May 1, 2023, to November 1, 2024. The study was conducted on patients presenting to the inpatient department (IPD), outpatient department (OPD) and intensive care unit (ICU). The calculated sample size was 122 patients. Purposive sampling was used targeting patients who met the inclusion criteria. Inclusion criteria included age ≥ 18 years, patients presenting to IPD, OPD, or ICU at NIMS, confirmed diagnosis of COPD as per GOLD guidelines and clinically stable patients (not in acute exacerbation). Exclusion criteria included pregnant or lactating females, patients with known risk factors affecting BMD such as chronic corticosteroid use, kidney disease, hyperthyroidism, patients with recent acute myocardial infarction or stroke and those with malignant tumors.

Data Collection: Detailed clinical history including smoking status, comorbid conditions and history of fracture or bone disease was obtained. All patients underwent routine physical examination and diagnostic investigations including chest X-ray, CT chest and spirometry. Spirometry was used to assess lung function and classify COPD severity according to GOLD guidelines: Mild COPD (GOLD I) with FEV1 > 80% of predicted, Moderate COPD (GOLD II) with FEV1 50% to 80% of predicted, Severe COPD (GOLD III) with FEV1 30% to 50% of predicted and Very Severe COPD (GOLD IV) with FEV1 < 30% of predicted.

Bone Mineral Density Measurement: BMD was measured using ultrasound densitometry at the femur, pelvis and calcaneum. WHO classification was used: Normal (T-score ≥ -1), Osteopenia (T-score between -1 and -2.5) and Osteoporosis (T-score ≤ -2.5).

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 20.0. Descriptive statistics included frequencies, percentages and mean ± standard deviation. Chi-square tests were used for categorical variables and Pearson correlation for continuous variables. A p-value < 0.05 was considered statistically significant.

RESULTS

This section presents the comprehensive findings from our prospective observational study of 122 clinically stable COPD patients. All participants underwent thorough clinical evaluation, spirometry assessment and ultrasound-based bone mineral density measurement. The results systematically examine demographic characteristics, clinical parameters, bone health status and statistical associations between BMD classification and key variables including COPD severity (GOLD staging), BMI categories and smoking status.

Table 1: Demographic and Clinical Profile of the Study Participants (N = 122)

Variables	**Result**
Age (in years) (mean ± SD)	61.38 ± 11.97
Gender n (%)	
Male	57 (46.7)
Female	65 (53.3)
Smoking Status n (%)	
Current Smoker	37 (30.3)
Ex-Smoker	40 (32.8)
Non-Smoker	45 (36.9)
BMI Category n (%)	
Normal Weight	34 (28.1)

Overweight	17 (13.9)
Obese	71 (58.2)
Chief Complaints n (%)	
Chest Pain	29 (23.8)
Cough	29 (23.8)
Fatigue	29 (23.8)
Shortness of Breath	35 (28.7)
COPD Severity (GOLD Stage) n (%)	
Mild (Stage I)	30 (24.6)
Moderate (Stage II)	31 (25.4)
Severe (Stage III)	27 (22.1)
Very Severe (Stage IV)	34 (27.9)
History of Present Illness n (%)	
COPD Stage 1	30 (24.6)
COPD Stage 2	21 (17.2)
COPD Stage 3	32 (26.2)
COPD Stage 4	39 (32.0)
Past Medical History n (%)	
Diabetes	27 (22.1)
Hypertension	35 (28.7)
Osteoporosis	29 (23.8)
No History	31 (25.4)
Family History of COPD n (%)	
Present	71 (58.2)
Absent	51 (41.8)
General Physical Examination n (%)	
Clubbing	29 (23.8)
Cyanosis	21 (17.2)
Icterus	27 (22.1)
Pallor	25 (20.5)
Normal	20 (16.4)
Pulse Rate (mean ± SD)	78.69 ± 11.04
Respiratory Rate (mean ± SD)	17.98 ± 3.87
Systolic BP (mean ± SD)	115.31 ± 13.91
Diastolic BP (mean ± SD)	75.39 ± 8.65
Smoking Index (mean ± SD)	241.97 ± 145.61

This table summarizes the demographic and clinical characteristics of 122 COPD patients. The mean age was 61.38 ± 11.97 years, reflecting a middle-aged to elderly population typically affected by COPD. Interestingly, there were more females (53.3%) than males (46.7%), which may suggest increasing COPD incidence among women—potentially due to rising smoking rates or exposure to indoor pollutants. The smoking status data revealed that 63.1% were either current or former smokers, reaffirming tobacco use as a major etiological factor in COPD. Obesity was notably prevalent with 58.2% of participants classified as obese, which may contribute to both respiratory burden and metabolic complications. The most common presenting complaint was shortness of breath (28.7%), followed by cough, fatigue and chest pain (each 23.8%). Regarding COPD severity, the distribution was relatively even with the largest proportion in Stage IV (27.9%). Additionally, 23.8% had a prior history of osteoporosis, reinforcing the relevance of BMD evaluation in this population. The mean smoking index was 241.97 ± 145.61, indicating substantial lifetime tobacco exposure. Basic vitals like pulse, respiratory rate and blood pressure remained within acceptable ranges, supporting that the study targeted clinically stable patients.

Table 2: Frequency Distribution of Bone Mineral Density (BMD) Classification

BMD Classification	Frequency n (%)
Normal	38 (31.1%)
Osteopenia	42 (34.4%)
Osteoporosis	42 (34.4%)
Total	122 (100.0%)

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BMD assessment showed that 68.8% of COPD patients had low BMD: 34.4% had osteopenia and another 34.4% had osteoporosis, while only 31.1% had normal BMD. This indicates a high burden of bone demineralization in this population, even in the absence of advanced COPD symptoms or other classic osteoporosis risk factors. It underscores the silent and underdiagnosed nature of bone loss in COPD and strongly supports the recommendation for routine BMD screening.

Table 3: Association Between BMD Classification and COPD Severity (GOLD Stage)

COPD Severity (GOLD Stage)	Normal n (%)	Osteopenia n (%)	Osteoporosis n (%)	Total n (%)	p-value
Mild	9 (23.7)	11 (26.2)	10 (23.8)	30 (24.6)	0.993
Moderate	11 (28.9)	10 (23.8)	10 (23.8)	31 (25.4)	
Severe	7 (18.4)	10 (23.8)	10 (23.8)	27 (22.1)	
Very Severe	11 (28.9)	11 (26.2)	12 (28.6)	34 (27.9)	
Total	38 (100.0)	42 (100.0)	42 (100.0)	122 (100.0)	

This table investigates whether the severity of Chronic Obstructive Pulmonary Disease (COPD), classified according to GOLD stages, has any association with Bone Mineral Density (BMD) classification. Among patients with mild COPD (Stage I), 23.7% had normal BMD, 26.2% had osteopenia and 23.8% had osteoporosis. In the moderate COPD group (Stage II), 28.9% had normal BMD, while 23.8% had both osteopenia and osteoporosis. Similarly, in severe COPD (Stage III), 18.4% showed normal BMD and 23.8% each had osteopenia and osteoporosis. Among those with very severe COPD (Stage IV), the distribution was fairly consistent with 28.9% having normal BMD, 26.2% with osteopenia and 28.6% with osteoporosis. Despite the progressive nature of COPD, the percentages across all stages were relatively uniform and statistical analysis confirmed that the association between COPD severity and BMD status was not significant ($p = 0.993$). This suggests that reduced bone mineral density in COPD patients is not necessarily linked to the degree of airflow limitation or disease severity. Instead, other systemic factors such as chronic inflammation, corticosteroid use and nutritional deficiencies may play a more decisive role in bone health deterioration in these patients.

Table 4: Association Between BMD Classification and BMI Category

BMI Category	Normal n (%)	Osteopenia n (%)	Osteoporosis n (%)	Total n (%)	p-value
Normal Weight	11 (28.9)	13 (31.0)	10 (23.8)	34 (27.9)	0.845
Overweight	6 (15.8)	4 (9.5)	7 (16.7)	17 (13.9)	
Obese	21 (55.3)	25 (59.5)	25 (59.5)	71 (58.2)	

This table explores the relationship between Body Mass Index (BMI) categories and Bone Mineral Density (BMD) status in patients with COPD. Among those classified as having normal weight, 28.9% had normal BMD, 31.0% had osteopenia and 23.8% had osteoporosis. In the overweight group, 15.8% had normal BMD, 9.5% had osteopenia and 16.7% had osteoporosis. For obese individuals, who formed the majority of the study population (58.2%), 55.3% had normal BMD and identical proportions (59.5%) had both osteopenia and osteoporosis. Despite the large proportion of obese patients across all BMD categories, the association between BMI and BMD classification was not statistically significant ($p = 0.845$). These findings suggest that higher BMI does not necessarily confer protection against bone demineralization in COPD patients. This challenges the traditional notion that higher body weight provides mechanical protection

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for bones and indicates that systemic factors related to COPD—such as chronic inflammation, reduced physical activity, or steroid therapy—may override the protective effects of increased body mass.

Table 5: Association Between BMD Classification and Smoking Status

Smoking Status	Normal n (%)	Osteopenia n (%)	Osteoporosis n (%)	Total n (%)	p-value
Current Smoker	8 (21.1)	15 (35.7)	14 (33.3)	37 (30.3)	0.646
Ex-Smoker	15 (39.5)	12 (28.6)	13 (31.0)	40 (32.8)	
Non-Smoker	15 (39.5)	15 (35.7)	15 (35.7)	45 (36.9)	

Table 5 explores whether smoking status—categorized as current smoker, ex-smoker, or non-smoker—has a significant association with bone mineral density (BMD) status in COPD patients. Among current smokers, 21.1% had normal BMD, while 35.7% each had osteopenia and osteoporosis. Among ex-smokers, 39.5% had normal BMD, 28.6% had osteopenia and 31.0% had osteoporosis. For non-smokers, 39.5% had normal BMD and 35.7% each had osteopenia and osteoporosis. While ex-smokers and non-smokers appeared to have slightly better BMD profiles than current smokers, the differences were not statistically significant (p = 0.646). This finding indicates that smoking status alone may not be a strong predictor of bone health in COPD patients. It suggests that systemic inflammation, disease chronicity and other metabolic or pharmacologic influences—like corticosteroid use—may contribute more substantially to bone loss than smoking status alone.

Table 6: Correlation of BMD Measurements with BMI, Smoking Index and COPD Severity

BMD Site	BMI		Smoking Index		COPD Severity	
	(r)	(p)	(r)	(p)	(r)	(p)
Femur BMD	0.074	0.419	0.066	0.472	-0.032	0.723
Pelvic BMD	0.107	0.240	-0.092	0.316	-0.091	0.318
Calcaneum BMD	0.106	0.247	0.145	0.110	-0.144	0.113

Table 6 provides Pearson correlation coefficients (r) for the relationship between BMD at three different anatomical sites - femur, pelvis and calcaneum and three independent variables: BMI, smoking index and COPD severity. Across all sites, the correlations were weak and statistically non-significant. For instance, femur BMD showed a weak positive correlation with BMI (r = 0.074, p = 0.419) and smoking index (r = 0.066, p = 0.472) and a weak negative correlation with COPD severity (r = -0.032, p = 0.723). Similarly, pelvic BMD had negligible correlations: BMI (r = 0.107), smoking index (r = -0.092) and COPD severity (r = -0.091), all with p-values > 0.2. Calcaneum BMD showed a slightly higher positive correlation with smoking index (r = 0.145), but it was still not significant (p = 0.110). These findings strongly reinforce the absence of a linear or direct relationship between bone mineral density and commonly suspected risk indicators like BMI, smoking burden, or even disease severity. It highlights that BMD changes in COPD are likely multifactorial and influenced by systemic inflammation, nutritional deficiencies, steroid exposure and vitamin D metabolism—factors that need independent evaluation.

DISCUSSION

This study evaluated the demographic profile, clinical parameters and bone mineral density (BMD) status in patients with chronic obstructive pulmonary disease (COPD), aiming to explore potential associations between BMD, COPD severity, smoking status and BMI. The findings revealed that a substantial proportion

of patients with COPD also suffered from reduced bone mass, yet there was no statistically significant association between BMD classification and COPD severity, BMI, or smoking history. The study found that 68.8% of the COPD patients had either osteopenia (34.4%) or osteoporosis (34.4%), consistent with previous reports indicating a high prevalence of reduced BMD among individuals with COPD. This is supported by findings from **Graat-Verboom et al. (2009)**[9], who reported that approximately 75% of COPD patients had low BMD with 35% meeting criteria for osteoporosis. Similarly, **Romme et al. (2013)**[10] observed that osteoporosis is highly prevalent in moderate to severe COPD cases, often underdiagnosed and untreated. The systemic inflammation and physical inactivity associated with COPD are believed to contribute significantly to bone demineralization.

Contrary to expectations, no significant association was observed between GOLD stages of COPD and BMD classification (p = 0.993) in the present study. Although a slight increase in osteoporosis cases was noted in the very severe COPD group, the distribution remained statistically similar across stages. These findings align with those of **Bolton et al. (2004)**[11], who noted that while BMD tends to decrease with COPD progression, the relationship is not always linear or statistically significant. Other studies, including one by **Watanabe et al. (2019)**[12], suggest that comorbidities and lifestyle factors often play a more significant role than airflow limitation alone in determining bone health.

Interestingly, FEV1 (%) values did not show a consistent decreasing trend with increasing GOLD stage and no significant differences in mean FEV1 were found across GOLD categories (p = 0.128). The highest FEV1 was observed in the severe group rather than in the mild or moderate categories. Similar variability was noted by **Sivrikaya et al. (2014)**[13], who highlighted that individual variations in lung function and muscle mass, along with treatment adherence, could explain the inconsistencies in FEV1 among COPD stages.

The study also found no statistically significant association between BMI categories and BMD classification (p = 0.845), although the majority of obese patients were osteopenic or osteoporotic. This challenges the traditional notion that higher BMI provides a protective effect against bone loss. Research by **Lee et al. (2016)**[14] suggested that in COPD, obesity may not confer the same benefit due to altered fat distribution, systemic inflammation and reduced mobility. Furthermore, **Orsitto et al. (2011)**[15] demonstrated that fat mass in COPD may increase inflammatory cytokines that adversely affect bone remodeling.

While current smokers showed a higher tendency toward reduced BMD, the relationship between smoking status and BMD was not statistically significant (p = 0.646). These findings are consistent with earlier studies such as that by **Kanis et al. (2005)**[16], which reported that although smoking is a known risk factor for osteoporosis, its effect may be masked or confounded in populations with multiple comorbidities like COPD. Furthermore, **Chen et al. (2011)**[17] emphasized that smoking-related bone loss may depend on cumulative exposure and other coexisting factors such as vitamin D deficiency and physical inactivity.

None of the clinical parameters like BMI, smoking index or COPD severity showed statistically significant correlations with femur, pelvic or calcaneal BMD values. This suggests a multifactorial etiology for bone loss in COPD rather than a single dominant risk factor. Studies by **van den Borst et al. (2010)**[18] suggesting that reduced physical activity, systemic inflammation, hypoxemia, steroid use and nutritional deficiencies interact to affect bone density in these patients.

Clinical Implications

The high prevalence of bone density abnormalities observed in this study, independent of traditional risk factors, emphasizes the need for routine BMD screening in all COPD patients regardless of disease severity, BMI, or smoking status. The absence of significant associations between BMD and conventional predictors suggests that current risk stratification methods may be inadequate for identifying COPD patients at risk for osteoporosis.

Study Limitations

Several limitations should be acknowledged in interpreting these results. The cross-sectional design limits causal inference and the use of ultrasound densitometry, while practical, may not provide the same precision as dual-energy X-ray absorptiometry (DEXA). Additionally, the study did not account for potential confounding factors such as corticosteroid use history, vitamin D levels, physical activity levels and nutritional status, which could significantly influence bone health outcomes.

Future Research Directions

Future longitudinal studies should investigate the temporal relationship between COPD progression and bone loss, incorporate comprehensive assessment of

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inflammatory biomarkers and evaluate the effectiveness of targeted interventions for maintaining bone health in COPD patients. Research should also focus on identifying novel biomarkers that may better predict osteoporosis risk in this population.

CONCLUSION

This study highlights a notably high prevalence of reduced bone mineral density among individuals diagnosed with COPD, with nearly 69% of participants exhibiting either osteopenia or osteoporosis. This finding aligns closely with a growing body of international literature and underscores that compromised bone health is a prevalent yet often underrecognized comorbidity in patients with COPD. Interestingly, while the study revealed a high burden of low BMD, it found no statistically significant associations between BMD and traditional risk factors such as COPD severity, BMI, or smoking status. This challenges the assumption that more severe airflow limitation or higher cumulative smoking burden directly correlates with more severe bone loss. The lack of association suggests that pathophysiological mechanisms underlying bone demineralization in COPD are multifactorial and may operate independently of the degree of lung function impairment. The absence of significant correlations between BMD values and BMI, smoking index, or COPD severity at three skeletal sites suggests that a unidimensional approach focusing only on lung function, weight, or smoking history may be insufficient in assessing osteoporosis risk in COPD patients.

Given these insights, bone health assessment should become an integral component of routine care in patients with COPD. The high prevalence of low BMD and the lack of significant predictive associations in this study underscore the need for comprehensive patient evaluation and individualized preventive strategies aimed at preserving bone mass and minimizing fracture risk in COPD patients. Future research should aim to clarify the underlying mechanisms and identify novel biomarkers that may more accurately predict osteoporosis risk in this vulnerable group.

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