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Original Article

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Metabolic Syndrome Among Patients with Chronic Obstructive Pulmonary Disease: A Cross-Sectional Study from a Tertiary Care Hospital

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Abstract

Objective: To determine the prevalence of metabolic syndrome and its individual components among patients with chronic obstructive pulmonary disease and to assess their association with disease severity and symptom burden. ***Design:*** Prospective cross-sectional study. ***Subjects/Patients:*** A total of 105 patients diagnosed with chronic obstructive pulmonary disease based on clinical, radiological, and spirometric criteria at a tertiary care hospital over a period of 18 months. ***Methods:*** Anthropometric measurements, clinical parameters, and laboratory investigations were recorded for all participants. Metabolic syndrome was diagnosed using the National Cholesterol Education Program Adult Treatment Panel Three criteria. Disease severity was assessed using the Chronic Obstructive Pulmonary Disease Assessment Test and categorized according to Global Initiative for Chronic Obstructive Lung Disease grouping. Statistical analysis was performed using Statistical Package for the Social Sciences version twenty-two, with a p value less than 0.05 considered statistically significant. ***Results:*** Metabolic syndrome was present in 33.3 percent of patients. Impaired fasting blood glucose, elevated blood pressure, and increased waist circumference were the most frequent abnormalities. Metabolic syndrome was more common in elderly patients and males. Most affected patients belonged to the most severe disease group. ***Conclusion:*** Metabolic syndrome is common in chronic obstructive pulmonary disease and is strongly associated with advanced disease severity, highlighting the need for routine metabolic screening and integrated management strategies.

Keywords: ***Chronic Obstructive Pulmonary Disease, Metabolic Syndrome, Systemic Inflammation, Global Initiative for Chronic Obstructive Lung Disease Classification, Cardiovascular Risk.***

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disorder characterized by persistent airflow limitation that is not fully reversible, usually resulting from chronic bronchitis, emphysema, or both. It is primarily caused by long-term exposure to noxious particles or gases, particularly tobacco smoke; however, environmental pollution, occupational exposures, and genetic factors such as alpha-1 antitrypsin deficiency also contribute significantly. Over the past two decades, COPD has increasingly been recognized not merely as an isolated pulmonary condition but as a systemic inflammatory disease associated with numerous extrapulmonary manifestations and comorbidities. Among these, metabolic syndrome has emerged as one of the most clinically significant conditions because it substantially increases the risk of cardiovascular disease, type 2 diabetes mellitus, and overall mortality [1,2].

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Metabolic syndrome represents a cluster of metabolic abnormalities including central obesity, insulin resistance, dyslipidemia characterized by elevated triglycerides and reduced high-density lipoprotein cholesterol, hypertension, and impaired glucose metabolism. Its pathogenesis is multifactorial and involves genetic predisposition, sedentary lifestyle, unhealthy dietary patterns, and chronic low-grade systemic inflammation. According to the National Cholesterol Education Program Adult Treatment Panel III criteria, metabolic syndrome is diagnosed when three or more of the following are present: waist circumference greater than 102 cm in men or greater than 88 cm in women, triglycerides ≥150 mg/dL, HDL cholesterol <40 mg/dL in men or <50 mg/dL in women, blood pressure ≥130/85 mmHg, and fasting plasma glucose ≥100 mg/dL. These metabolic abnormalities contribute to atherosclerosis, diabetes, and cardiovascular morbidity and may interact bidirectionally with pulmonary pathophysiology in COPD [2,3].

Growing evidence suggests that systemic inflammation is an important link between COPD and metabolic syndrome. COPD is characterized by chronic inflammation within the airways, lung parenchyma, and pulmonary vasculature, but this inflammatory process frequently extends beyond the lungs. Elevated systemic inflammatory markers such as C-reactive protein, tumor necrosis factor-alpha, interleukin-6, and fibrinogen have been demonstrated in COPD patients irrespective of smoking status or disease severity. Persistent low-grade inflammation may contribute to insulin resistance, endothelial dysfunction, and adipose tissue dysregulation, which are key components of metabolic syndrome [3,4].

Metabolic syndrome may also adversely influence the course of COPD. Central obesity can mechanically impair lung function by reducing chest wall compliance and diaphragmatic excursion, resulting in ventilatory limitation. Visceral adipose tissue secretes pro-inflammatory adipokines such as leptin and resistin while reducing levels of anti-inflammatory adiponectin, thereby amplifying systemic inflammation. Insulin resistance and hyperglycemia can impair immune responses, increase susceptibility to respiratory infections, and potentially worsen exacerbation severity. Hypertension and atherogenic dyslipidemia further contribute to endothelial dysfunction and impaired pulmonary vascular reactivity, increasing the risk of pulmonary hypertension and right heart dysfunction in COPD patients [4,5].

The coexistence of metabolic syndrome in COPD patients has important clinical implications. Several observational studies have reported a higher prevalence of metabolic syndrome among COPD patients compared with the general population, particularly in those with mild to moderate airflow limitation. Its prevalence appears to decline in advanced COPD, possibly due to cachexia and progressive loss of body fat. However, the presence of metabolic syndrome in COPD is associated with poorer health-related quality of life, increased exacerbation frequency, reduced exercise capacity, and higher cardiovascular morbidity and mortality [5,6].

Oxidative stress represents another important mechanism linking COPD and metabolic syndrome. Both conditions involve an imbalance between reactive oxygen species production and antioxidant defenses. In COPD, oxidative stress arises from inhaled pollutants, inflammatory cell activation, and mitochondrial dysfunction, leading to pulmonary tissue injury and systemic oxidative damage. Similarly, oxidative stress contributes to insulin resistance, dyslipidemia, and hypertension in metabolic syndrome. Mitochondrial dysfunction in skeletal muscle and adipose tissue further perpetuates systemic inflammation and metabolic disturbances, reinforcing the pulmonary and metabolic interaction [7,8].

Hormonal dysregulation also contributes to the relationship between COPD and metabolic syndrome. Elevated cortisol levels, whether endogenous or related to corticosteroid therapy, can promote insulin resistance, central obesity, and protein catabolism. Chronic sympathetic activation in COPD may contribute to hypertension and impaired glucose metabolism. Adipose tissue-derived cytokines such as interleukin-6 and tumor necrosis factor-alpha sustain systemic inflammation and impair insulin signaling, thereby contributing to both metabolic abnormalities and pulmonary dysfunction [9,10].

Skeletal muscle dysfunction is another shared feature. COPD is often associated with muscle atrophy, reduced exercise tolerance, and diminished quality of life due to systemic inflammation, oxidative stress, mitochondrial dysfunction, and nutritional deficits. Similarly, in metabolic syndrome, insulin resistance and chronic inflammation adversely affect skeletal muscle metabolism, reducing oxidative capacity and promoting lipid infiltration, which further contributes to functional decline [10,11].

In view of the increasing recognition of metabolic syndrome as an important comorbidity in COPD and its potential impact on disease progression, cardiovascular risk, and patient outcomes, the present study was undertaken to evaluate the prevalence of metabolic syndrome and its associated complications in patients with chronic obstructive pulmonary disease attending a tertiary care hospital and to assess the correlation between body mass index and the severity of symptoms in these patients.

Materials and Methods

This prospective cross-sectional study was conducted to evaluate the prevalence of metabolic syndrome in patients diagnosed with chronic obstructive pulmonary disease (COPD). The study included patients attending the outpatient department and those admitted to medical wards of a tertiary care hospital. Data were collected through structured interviews, clinical examinations, anthropometric measurements, and laboratory investigations to assess the presence of metabolic syndrome components according to the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) criteria. The study duration was 18 months and commenced after obtaining approval from the Institutional Ethics Committee. The study period included patient screening, informed consent acquisition, clinical assessment, laboratory investigations, and statistical analysis.

Patients aged more than 18 years with a confirmed diagnosis of COPD based on clinical evaluation, radiological findings, and spirometry-confirmed airflow obstruction were included after providing written informed consent. Patients with concurrent respiratory diseases other than COPD and those with occupational lung diseases such as silicosis were excluded. Participants were recruited using a convenience sampling technique from both outpatient services and inpatient medical wards. The calculated sample size for the study was 105 participants.

All enrolled patients constituted a single study group of COPD cases that were further stratified according to disease severity using the COPD Assessment Test (CAT) score and according to the presence or absence of metabolic syndrome. The primary outcome measure was the prevalence of metabolic syndrome among COPD patients. Secondary outcomes included assessment of the correlation between body mass index and COPD symptom severity, evaluation

of individual components of metabolic syndrome, and their association with COPD severity.

Anthropometric measurements included body weight, height, and waist circumference. Clinical assessment included measurement of blood pressure and spirometry evaluation. Laboratory investigations included fasting plasma glucose, serum triglycerides, and high-density lipoprotein cholesterol levels. Metabolic syndrome was diagnosed when three or more of the following criteria were present: abdominal obesity defined as waist circumference greater than 90 cm in men or greater than 80 cm in women, triglycerides ≥150 mg/dL or treatment for hypertriglyceridemia, HDL cholesterol <40 mg/dL in men or <50 mg/dL in women or treatment for low HDL cholesterol, blood pressure ≥130/85 mmHg or current antihypertensive therapy, and fasting plasma glucose ≥110 mg/dL or treatment for diabetes or hyperglycemia.

Severity of COPD symptoms was assessed using the COPD Assessment Test questionnaire, which includes eight items scored from 0 to 5, giving a total score ranging from 0 to 40. Scores less than 10 were categorized as GOLD group A, whereas scores greater than 10 were categorized as GOLD group B or E.

Eligible patients were screened from outpatient clinics and hospital wards. Written informed consent was obtained after explaining the study details in English, Hindi, or Marathi. A structured case record form was used to document demographic details, clinical history, examination findings, and laboratory results. COPD diagnosis was confirmed through spirometry along with clinical and radiological correlation, while metabolic syndrome was diagnosed based on fulfillment of NCEP ATP III criteria. All data were anonymized, recorded in a secured database, and periodically checked for accuracy.

Statistical analysis was performed using SPSS version 22. Continuous variables were expressed as mean with standard deviation or median with interquartile range depending on data distribution. Categorical variables were expressed as percentages and compared using the chi-square test or Fisher exact test as appropriate. Correlations were assessed using Pearson correlation analysis. A p value less than 0.05 was considered statistically significant.

Ethical approval was obtained from the Institutional Ethics Committee before initiation of the study. Written informed consent was obtained from all participants, and confidentiality of patient information was strictly maintained. Participation was voluntary, and patients were allowed to withdraw at any stage without affecting their clinical care. The study did not impose additional financial burden or significant risk beyond routine clinical evaluation.

Results

A total of 105 patients with chronic obstructive pulmonary disease were evaluated for the presence of metabolic syndrome and its associated clinical and biochemical parameters. The age distribution showed that the majority of patients with metabolic syndrome belonged to older age groups. Patients aged above 70 years constituted 30.5% of cases, while those between 50 and 60 years accounted for 42%. This indicates that metabolic abnormalities in COPD are commonly observed both in late middle age and in elderly individuals.

Male patients constituted the majority of the study population, accounting for 70.5%, whereas females represented 29.5%. This male predominance reflects the higher prevalence of smoking, occupational exposures, and environmental risk factors among men in the studied population.

Anthropometric and clinical measurements demonstrated a mixed metabolic profile among COPD patients. The mean body mass index was 24.67 kg/m², suggesting a distribution largely within the normal to overweight range. The mean waist circumference was 80.6 cm, indicating the presence of central adiposity in a significant proportion of patients. Cardiovascular parameters showed a mean systolic blood pressure of 135.8 mmHg and mean diastolic blood pressure of 86 mmHg, suggesting borderline hypertension in many patients. The mean fasting blood glucose level was 112 mg/dL, consistent with impaired glycemic status. Lipid parameters showed a mean triglyceride level of 133 mg/dL and mean high-density lipoprotein cholesterol of 62 mg/dL. Respiratory parameters indicated chronic hypoxemia, with a mean oxygen saturation of 92% and mean arterial pO_2 of 66.6 mmHg.

Waist circumference analysis revealed that 46.6% of participants had measurements between 70 and 80 cm, 39.2% between 80 and 90 cm, and 14.2% greater than 90 cm. Overall, 53.4% of patients had waist circumference above 80 cm, indicating a substantial burden of central obesity among COPD patients.

Fasting blood glucose assessment showed that 39% of participants had normal values below 100 mg/dL, 31.4% had impaired fasting glucose between 100 and 126 mg/dL, and 29.5% had values above 126 mg/dL consistent with diabetes. Thus, more than 60% of patients demonstrated abnormal glycemic status. Hypertension was present in 26.7% of patients, while 73.3% were normotensive. Low HDL cholesterol levels were observed in 33.3% of participants, whereas 66.7% maintained normal HDL levels. Elevated triglycerides above 150 mg/dL were identified in 24.8% of patients, while 75.2% had levels within the normal range.

Based on NCEP ATP III criteria, 66.7% of participants met two criteria for metabolic syndrome but did not fulfill the diagnostic threshold. Among the remaining patients, 10.5% met three criteria, 7.6% met four criteria, and 15.2% satisfied all five criteria. Overall, metabolic syndrome was diagnosed in 33.3% of COPD patients.

Analysis of individual metabolic syndrome components demonstrated that impaired fasting blood glucose was the most frequently observed abnormality, present in 60.9% of patients. Elevated blood pressure was observed in 55.2%, increased waist circumference in 48.6%, low HDL cholesterol in 33.3%, and elevated triglycerides in 24.8%. (Table 1)

Table 1: Distribution of study participants according to individual metabolic syndrome components

Component	Number of participants			
	Yes		No	
Waist circumference (>80cm and >90cm)	31	29.52	74	70.47
Blood pressure (>130/85mmofHg)	58	55.24	47	44.76
Fasting blood sugar (>100mg/dl)	64	60.95	41	39.05
HDL (<50/<40)	35	33.33	70	66.67
Triglycerides (>150)	26	24.76	79	75.24

Assessment of symptom severity using the COPD Assessment Test showed that 83.8% of patients had scores greater than 10, indicating significant symptom burden and reduced quality of life, while only 16.2% had scores below 10. Respiratory system examination revealed wheeze in 46.7% of patients, crepitations in 33.3%, decreased air entry in 14.3%, and normal findings in 5.7%.

According to GOLD grouping based on COPD Assessment Test scores, 83.8% of patients were categorized into group E and

16.2% into group A, indicating that most patients had a high symptom burden and more severe disease classification.

Body mass index distribution showed that 38.1% of patients had BMI between 18.6 and 22.9 kg/m², representing the normal weight category. Overweight individuals with BMI between 25 and 29.9 kg/m² accounted for 27.6% of the study population. Obesity with BMI between 30 and 34.9 kg/m² was observed in 12.4% of patients. Another 21% had BMI between 23 and 24.9 kg/m², while only 1% were underweight. (Table 2)

Table 2: Distribution of study participants according to Body Mass Index (BMI)

BMI	Frequency (n)	Percentage (%)
<18.5	1	1.0
18.6-22.9	40	38.1
23-24.9	22	21.0
25-29.9	29	27.6
30-34.9	12	11.4
35-39.9	1	1.0
Total	**105**	**100.0**

Evaluation of BMI distribution across GOLD groups demonstrated that normal-weight individuals constituted the largest subgroup in both group A (35.3%) and group E (38.6%). Overweight patients were more frequent in group E (28.4%) compared with group A (23.5%). Obesity was present in approximately 11 to 12% of both groups. Only one patient in group E was underweight. Statistical analysis using the chi-square test showed no significant association between BMI category and GOLD grouping ($p = 0.940$).

Correlation analysis between BMI and COPD Assessment Test scores showed a Pearson correlation coefficient of −0.007 with a p value of 0.944, indicating no statistically significant correlation between body mass index and symptom severity.

Among patients diagnosed with metabolic syndrome, 94.3% belonged to GOLD group E and 5.7% to group A. In contrast, among patients without metabolic syndrome, 78.6% were classified into group E and 21.4% into group A. This distribution suggests a higher prevalence of metabolic syndrome among patients with more severe COPD (Table 3).

Age-wise distribution of metabolic syndrome showed the highest prevalence in patients above 70 years (31.4%) and those aged 66 to 70 years (22.9%). The lowest prevalence was observed in the 61 to 65 years age group (5.7%). Patients aged 50 to 60 years accounted for approximately 40% of metabolic syndrome cases, indicating that metabolic abnormalities begin to manifest relatively early in the course of COPD.

Gender-wise analysis revealed that metabolic syndrome was more prevalent among males (74.3%) compared to females (25.7%). Among patients without metabolic syndrome, males also predominated (68.6%) compared with females (31.4%).

Overall, these findings demonstrate a substantial prevalence of metabolic syndrome among COPD patients, with significant associations observed with age, gender distribution, glycemic abnormalities, blood pressure, and symptom severity, although body mass index did not show a statistically significant correlation with COPD severity in this cohort.

Discussion

The present study was undertaken to determine the prevalence of metabolic syndrome and its individual components among patients with chronic obstructive pulmonary disease (COPD) and to evaluate their association with disease severity, body mass index, and symptom burden. By integrating clinical examination, anthropometric measurements, biochemical parameters, spirometry findings, GOLD classification, and COPD Assessment Test scoring, the study aimed to provide a comprehensive assessment of the systemic metabolic burden in COPD patients. Increasing evidence indicates that COPD should be considered a multisystem disorder rather than a purely pulmonary disease, and the coexistence of metabolic syndrome significantly contributes to morbidity, impaired quality of life, increased exacerbations, and elevated cardiovascular mortality. Previous studies have highlighted the systemic inflammatory overlap between COPD and metabolic syndrome and their combined effect on outcomes [12-18]. The findings of this study therefore reinforce the importance of early identification and integrated management of metabolic abnormalities in COPD patients.

The age distribution of participants in the present study showed a predominance of elderly individuals, with the largest proportion above 70 years, followed by substantial representation in the 50 to 60 year age group. This reflects the established epidemiological pattern of COPD, where cumulative exposure to smoking, environmental pollutants, occupational hazards, and age-related decline in lung function contribute to disease development. Advancing age also predisposes individuals to metabolic abnormalities such as insulin resistance, hypertension, and dyslipidemia. Park *et al*. demonstrated that frailty, metabolic syndrome, and COPD are interlinked in elderly populations, with higher frailty scores among COPD patients with metabolic syndrome [12]. Kwon *et al*. reported higher metabolic syndrome prevalence in COPD patients older than 60 years based on the Korean National Health and Nutrition Examination Survey [14]. Vanfleteren *et al*. observed metabolic syndrome in 30 to 50 percent of COPD patients, particularly in elderly groups [13]. Park *et al*. further showed that metabolic syndrome accelerates lung function decline in older adults [15]. Chen *et al*. confirmed through systematic review that older COPD patients with metabolic syndrome experience worse symptoms and more frequent exacerbations [17]. These findings support the higher prevalence observed among older individuals in our study.

Sex-wise analysis revealed a clear male predominance in COPD patients as well as in those with metabolic syndrome. This likely reflects higher rates of smoking and occupational exposure among men. Kwon *et al*. reported similar male predominance in COPD patients with metabolic syndrome, attributing it to smoking and sedentary lifestyle factors [14]. Vanfleteren *et al*. noted sex-related differences in metabolic syndrome components, with males often showing more abdominal obesity and hypertension [13]. Chen *et al*. reported more severe respiratory symptoms among male COPD patients with metabolic syndrome [17]. Li *et al*. highlighted that although COPD remains more common in men, the prevalence among women is increasing due to lifestyle changes [18]. These observations are consistent with the male predominance seen in our cohort.

The anthropometric and biochemical profile of the study population highlighted the systemic nature of COPD. Mean body mass index was in the upper normal to overweight range, while waist circumference suggested central adiposity in many patients. Mean systolic and diastolic blood pressures suggested borderline hypertension, and fasting blood glucose values indicated impaired glycemia. Persistent hypoxemia reflected advanced respiratory involvement. Park *et al*. described multiple metabolic abnormalities in COPD correlating with frailty and functional decline [12]. Kwon *et al*. reported significantly higher fasting glucose and blood pressure

in COPD patients with metabolic syndrome [14]. Vanfleteren *et al*. emphasized systemic inflammation, insulin resistance, and cardiovascular risk in COPD patients with metabolic syndrome [13]. Park *et al*. showed insulin resistance and dyslipidemia accelerate lung function decline [15]. Chen *et al*. confirmed worse symptoms and exacerbation risks among COPD patients with metabolic syndrome [17]. Li *et al*. reported central obesity and insulin resistance as strong predictors of poor quality of life and exacerbations [18].

Central obesity emerged as an important metabolic component in this study. Park *et al*. demonstrated that abdominal obesity correlated with higher frailty indices in COPD patients [12]. Kwon *et al*. identified abdominal obesity as a common metabolic component associated with airflow limitation [14]. Vanfleteren *et al*. reported abdominal obesity in nearly half of COPD patients across cohorts [13]. Park *et al*. found abdominal obesity predicted accelerated lung function decline [15]. Chen *et al*. confirmed abdominal obesity as a prevalent metabolic component linked with poorer outcomes [17]. These findings support the role of central adiposity in COPD-related metabolic risk.

Abnormal glucose metabolism was another prominent finding. Elevated fasting glucose has been identified as a major contributor to frailty in COPD patients with metabolic syndrome [12]. Kwon *et al*. reported impaired fasting glucose and diabetes in nearly one-third of COPD patients [14]. Vanfleteren *et al*. noted glucose abnormalities in approximately 25 to 40 percent of COPD patients with metabolic syndrome [13]. Park *et al*. showed insulin resistance accelerates lung function decline [15]. Chen *et al*. reported higher exacerbation rates among COPD patients with diabetes [17]. Li *et al*. identified insulin resistance as a key driver of COPD progression [18]. These findings align with the high prevalence of glucose abnormalities observed in this study.

Hypertension was present in approximately one-fourth of patients. Park *et al*. identified hypertension as a common metabolic component affecting frailty in COPD [12]. Kwon *et al*. reported hypertension prevalence of around 35 percent in COPD patients with metabolic syndrome [14]. Vanfleteren *et al*. reported 30 to 40 percent prevalence in European COPD cohorts [13]. Chen *et al*. confirmed worse respiratory outcomes among COPD patients with hypertension [17]. Li *et al*. reported hypertension as independently associated with increased exacerbation risk [18]. These findings correspond with the prevalence observed in our cohort.

Regarding lipid abnormalities, one-third of patients had low HDL cholesterol and about one-fourth had elevated triglycerides. Park *et al*. reported reduced HDL associated with frailty in COPD patients [12]. Kwon *et al*. found dyslipidemia, particularly low HDL, common in COPD patients [14]. Vanfleteren *et al*. reported dyslipidemia affecting approximately 30 to 40 percent of COPD patients [13]. Chen *et al*. associated low HDL with higher cardiovascular risk and exacerbations [17]. Li *et al*. identified reduced HDL as a contributor to COPD severity [18]. Elevated triglycerides have similarly been associated with systemic inflammation and COPD morbidity in prior studies [12-18].

Approximately one-third of COPD patients fulfilled diagnostic criteria for metabolic syndrome in this study. Park *et al*. showed higher frailty scores among COPD patients with metabolic syndrome [12]. Kwon *et al*. reported a prevalence of 34.2 percent in COPD populations [14]. Vanfleteren *et al*. reported 30 to 50 percent prevalence across cohorts [13]. Park *et al*. observed accelerated lung function decline in COPD patients with metabolic syndrome [15]. Chen *et al*. linked metabolic syndrome with worse symptoms and higher mortality [17]. Li *et al*. confirmed more severe airflow limitation and poorer quality of life in COPD patients with metabolic syndrome [18]. These findings align closely with the prevalence observed in the present study.

Among individual metabolic syndrome components, impaired fasting blood glucose and elevated blood pressure were the most common abnormalities. Park *et al*. reported fasting glucose and hypertension among the most frequent components [12]. Kwon *et al*. found abdominal obesity, hypertension, and impaired glucose metabolism strongly associated with COPD severity [14]. Vanfleteren *et al*. emphasized hypertension and hyperglycemia as dominant metabolic features [13]. Park *et al*. demonstrated insulin resistance accelerates lung function decline [15]. Chen *et al*. linked impaired glucose control with poor outcomes [17]. Li *et al*. highlighted central obesity and insulin resistance as major contributors to COPD severity [18]. Singh *et al*. also reported higher fasting blood sugar levels in COPD patients compared with controls [19].

Body mass index distribution showed most patients were normal weight or overweight, with relatively few obese or underweight individuals. Kwon *et al*. reported higher BMI values among COPD patients with metabolic syndrome [14]. Vanfleteren *et al*. highlighted obesity as a common systemic manifestation in COPD [13]. Chen *et al*. associated obesity with worse respiratory symptoms and cardiovascular comorbidity [17]. Park *et al*. reported both obesity-related frailty and cachexia in COPD populations [12]. Li *et al*. identified central obesity as a major contributor to COPD severity [18]. These findings suggest a shift toward overweight phenotypes in COPD populations.

No significant association was observed between BMI and GOLD classification in our study. Park *et al*. reported obesity associated with faster lung function decline [15]. Kwon *et al*. noted BMI predicted metabolic syndrome presence but not necessarily COPD severity [14]. Vanfleteren *et al*. described the obesity paradox in COPD [13]. Chen *et al*. reported BMI inconsistently correlated with GOLD staging [17]. Li *et al*. emphasized central obesity rather than BMI as the critical determinant [18]. These findings are consistent with our observation that BMI alone did not influence severity classification.

Similarly, no significant correlation was found between BMI and COPD Assessment Test scores. Park *et al*. found metabolic syndrome components more strongly influenced frailty than BMI [12]. Kwon *et al*. identified central obesity rather than BMI as a predictor of quality of life [14]. Vanfleteren *et al*. emphasized inflammatory and exposure-related determinants of symptoms [13]. Chen *et al*. reported inconsistent associations between BMI and symptoms [17]. Li *et al*. highlighted insulin resistance and central obesity as more important predictors than BMI [18].

A strong association was observed between metabolic syndrome and advanced COPD severity. Park *et al*. reported higher frailty among COPD patients with metabolic syndrome [12]. Naik *et al*. reported metabolic syndrome prevalence ranging from 25.6 to 60.9 percent in COPD populations [20]. Kwon *et al*. observed increasing metabolic syndrome prevalence with COPD severity [14]. Vanfleteren *et al*. highlighted systemic inflammation worsening outcomes [13]. Park *et al*. demonstrated accelerated lung function decline [15]. Chen *et al*. and Li *et al*. confirmed worse symptoms, exacerbations, and mortality associated with metabolic syndrome [17,18].

Metabolic syndrome prevalence increased with advancing age in this study. Park *et al*. reported clustering of frailty and metabolic syndrome in elderly COPD patients [12]. Kwon *et al*. reported increasing prevalence after age 60 [14]. Vanfleteren *et al*. noted higher prevalence in elderly cohorts [13]. Park *et al*. demonstrated accelerated lung function decline in older patients [15].

Chen *et al*. and Li *et al*. confirmed age as a major determinant of metabolic syndrome in COPD [17,18].

Metabolic syndrome was more prevalent among male patients. Park *et al*. reported higher frailty among male COPD patients with metabolic syndrome [12]. Kwon *et al*. reported higher prevalence in male COPD patients [14]. Vanfleteren *et al*. described sex differences in metabolic components [13]. Chen *et al*. reported worse symptoms among males [17]. Li *et al*. highlighted narrowing gender differences due to lifestyle changes [18].

Overall, the results of this study emphasize the significant coexistence of metabolic syndrome in patients with chronic obstructive pulmonary disease and its association with age, sex, metabolic abnormalities, and disease severity. The absence of a significant relationship between BMI and COPD severity suggests that metabolic risk assessment should focus more on central obesity, glycemic status, and cardiovascular parameters rather than BMI alone. Early identification and comprehensive management of metabolic syndrome in COPD patients may improve clinical outcomes, reduce exacerbations, and decrease cardiovascular morbidity and mortality [12-18].

Conclusion

The present study demonstrates the substantial coexistence of metabolic syndrome among patients with chronic obstructive pulmonary disease, reinforcing its significance as an important systemic comorbidity. Approximately one-third of COPD patients (33.3%) were diagnosed with metabolic syndrome, with impaired fasting glucose, hypertension, and abdominal obesity emerging as the most prevalent components. Advancing age, male predominance, and central adiposity were strongly associated with metabolic abnormalities in this cohort.

A notable finding was the association between metabolic syndrome and greater COPD severity, as most affected patients were classified within higher GOLD categories, indicating increased symptom burden and exacerbation risk. In contrast, body mass index did not show a significant correlation with COPD severity or symptom scores, suggesting that BMI alone may not adequately reflect metabolic risk or disease impact in COPD patients.

These findings highlight the importance of routine metabolic screening in individuals with COPD and support an integrated approach to patient care that addresses both pulmonary and metabolic health. Early identification and targeted management of metabolic syndrome may help reduce complications, improve quality of life, and optimize long-term outcomes in this high-risk population.

List of Abbreviations

COPD: Chronic Obstructive Pulmonary Disease
CAT: COPD Assessment Test
GOLD: Global Initiative for Chronic Obstructive Lung Disease
NCEP ATP III: National Cholesterol Education Program Adult Treatment Panel III
HDL: High-Density Lipoprotein
BMI: Body Mass Index
SPSS: Statistical Package for the Social Sciences
mmHg: Millimeters of Mercury
mg/dL: Milligrams per Deciliter
pO_2: Partial Pressure of Oxygen
IEC: Institutional Ethics Committee

Declarations

Ethical Approval and Consent to Participate

All procedures performed in this case series were conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki. Ethical approval was obtained from the appropriate institutional review board where required. Written informed consent was obtained from all patients or their legal guardians prior to the procedures.

Consent for Publication

Written informed consent for publication of clinical details and images was obtained from the patients or their legal guardians. All identifying information has been anonymized to protect patient confidentiality.

Availability of Supporting Data

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to institutional and ethical regulations.

Competing Interests

The authors declare that they have no competing interests related to this work.

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Authors' Contributions

All authors contributed substantially to the conception, data acquisition, analysis, drafting, and critical revision of the manuscript. All authors have read and approved the final version of the manuscript.

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