Original Article

# Prevalence of Metabolic Syndrome in Chronic Obstructive Pulmonary Disease and its Correlation with Body Mass Index, Airflow Obstruction, Dyspnea, and Exercise Index and C-Reactive Protein

**D. Suresh Kumar, Richard Samuel[1], Viola Savy DSouza[2], Madhu Keshava Bangera[3]**

Department of Respiratory Medicine, Meenakshi Medical College Hospital and Research Institute, Kanchipuram, [1]Department of Tamil Nadu Accident and Emergency Care Initiative and Health Technology Assessment, State Consultant, National Health Mission, Government of Tamil Nadu, Chennai, Tamil Nadu, [2]Department of Health Policy, Prasanna School of Public Health, Manipal Academy of Higher Education, Manipal, [3]Department of Dental Materials, Manipal College of Dental Sciences, Manipal Academy of Higher Education, Mangalore, Karnataka, India

## Abstract

**Context:** Chronic obstructive pulmonary disease (COPD) is a widespread reason of disease and death in developing countries like India, although it is preventable, controllable, and treatable. **Objectives:** We studied the occurrence of metabolic syndrome (MetS) among cases of stable COPD and determined the correlation between stable COPD with MetS and body mass index, airflow obstruction, dyspnea, and exercise (BODE index) and C-reactive protein (CRP) titer. **Methods:** The study was a case–control analysis conducted on 90 patients from November 2019 to August 2020. **Results:** Seventy percentage of our case population belonged to Global Initiative for Chronic Obstructive Lung Disease (GOLD) Grade 1 and 2. A significant correlation between forced expiratory volume 1 s ($FEV_1$) with body mass index (BMI), triglycerides (TGs), high-density lipoproteins (HDL), systolic blood pressure (SBP), and fasting blood sugar (FBS) was found. The higher the GOLD grade (lower $FEV_1$), the higher the values of BMI, TG, HDL, SBP, and FBS. A negative association with MetS is related to small study population. **Conclusion:** Patients with MetS had significantly lower $FEV_1$, higher mean SI, higher mean waist circumference, higher mean BMI, higher mean SBP and diastolic blood pressure, higher FBS, and higher HDL and TG. Patients with MetS showed higher BODE index and CRP titer compared to ones without it. Apart from routine vaccination, assessment of systemic comorbidities for early detection of MetS plays a pivotal role to provide best possible quality of life and utmost care to COPD patients and helps reduce mortality and morbidities of COPD.

**Keywords:** Body mass index, airflow obstruction, dyspnea, and Exercise index, chronic obstructive pulmonary disease, C-reactive protein, Global Initiative for Chronic Obstructive Lung Disease grade, metabolic syndrome

## Introduction

Chronic obstructive pulmonary disease (COPD) is a familiar, avertible, and curable illness categorized by lasting respiratory signs and airflow restriction because of the airway and alveolar anomalies. It is produced by a substantial introduction to harmful elements or smokes and affected by host components resulting in abnormal lung growth.[1] COPD signifies a task critical public health challenge.[1] India reports the leading cause of approximately 55.3 million COPD cases, leading in the world and second leading cause of deaths as per disability-adjusted life year. Globally, COPD numbers are expected to grow in the future due to continual contact with the risk factors and population maturing.[2] The prevalence rate by 2060 may account for 5.4 million deaths per annum.

Access this article online

Quick Response Code:

Website: www.ijrc.in

DOI: 10.4103/ijrc.ijrc_44_22

**Address for correspondence:** Dr. Madhu Keshava Bangera, Manipal College of Dental Sciences, Manipal Academy of Higher Education, Manipal - 575 001, Karnataka, India.
E-mail: madhu.bangera@learner.manipal.edu



**How to cite this article:** Kumar DS, Samuel R, DSouza VS, Bangera MK. Prevalence of metabolic syndrome in chronic obstructive pulmonary disease and its correlation with body mass index, airflow obstruction, dyspnea, and exercise index and C-reactive protein. Indian J Respir Care 2022;11:314-20.

**Received:** 03-03-2022 **Revised:** 29-05-2022
**Accepted:** 27-06-2022 **Published:** 12-11-2022

Due to the pouring of battery of inflammatory markers in the blood, COPD has multiple systemic complications such as systemic hypertension, heart failure, arrhythmias, obstructive sleep apnea, skeletal muscle dysfunction, metabolic syndrome (MetS), and depression.[1] Although tobacco smoke has remained the main risk component of COPD, chronic inflammation including systemic inflammation is deemed an essential cause engaged in the pathogenesis of COPD. MetS is a part of systemic inflammation with a cluster of metabolic dysregulations such as central obesity, high blood pressure, dyslipidemia, and high blood sugar, predisposing to cardiac disease.[3] COPD patients with MetS show raised levels of inflammation. Hence, identifying the incidence of MetS in COPD allows early diagnosis along with prevention of mortality as well as morbidity.

MetS is two times more frequent in COPD when equated to the common population.[2,4] Its prevalence is 40% in northern India and swiftly growing in <40 years' age group.[5] The incidence of obese individuals is quickly rising in the country and nearly one-third of the metropolitan inhabitants are affected by MetS.[2] MetS was reported in 44% according to the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), 46% (modified NCEP ATP III), and 31% according to the International Diabetes Federation criteria of COPD patients, alongside non-COPD controls of 31%, 38%, and 32%, respectively.[6] The findings indicate an elevated frequency of MetS in COPD.[4,7,8] Although evidence indicates a significant connection among MetS and lung function damage, the precise description of their association is unidentified. COPD patients die often from comorbidities rather than the disease. Hence, the management of COPD must not only include pharmacological therapy but also assessment of the functional capacity of the patient and comorbidities. Therefore, optimal screening of stable COPD patients with MetS and subsequent treatment upon diagnosis of both can significantly reduce the long-term complications of COPD.

C-reactive protein (CRP) raises up to 1000 times at zones of infection or inflammation and acts as a sensitive marker.[9] Being an acute-phase protein, human CRP can potently activate the classical complement pathway and participate in the inflammatory process of COPD. Through the disease process, CRP concentrations grow quickly in the initial 6 to 8 h and soar up to 350–400 mg/L beyond 48 h. CRP levels fall once inflammation subsides, designating it a valuable marker for scrutinizing the disease progression.[10] CRP levels indicate the overall systemic load of inflammation and are enhanced in steady COPD subjects and through its aggravations. It is a predictive factor for the course of COPD as well as for hospitalizations and death due to chronic respiratory failure.[9]

The body mass index (BMI), airflow obstruction, dyspnea, and exercise (BODE index) capacity by a 6-min walk distance predicts mortality in COPD.[11] It suggests adverse consequences of exacerbations and hospitalizations and serves as unrelated interpreters of survival in COPD.[12] Hence, an experiment was designed to evaluate the predominance of MetS in stable COPD individuals with central obesity, dyslipidemia, fasting blood sugar (FBS), and elevated blood pressure. The study further assessed the correlation between MetS among cases of COPD with BODE index and CRP titer.

## Methods

The study was undertaken after acquiring ethics committee authorization from the institution and informed consent from subjects. A case–control study comprising 50 stable COPD and 40 controls attending respiratory medicine outpatients department (OPD) from November 2019 to August 2020 was designed. The inclusion criteria were no acute exacerbation, no history of exacerbation for at least 1 year before the study, not on oral steroids for >6 months, no other systemic inflammatory disease, and no known ischemic heart disease. Two out of 40 controls by screening were found to be asymptomatic COPD and were excluded. Relevant history was obtained regarding smoking (in terms of the smoking index) and occupation. Dyspnea acuteness was evaluated by the Modified Medical Research Council Scale. A chest X-ray ruled out active infection as well as other pleuroparenchymal diseases.

Patients with a history of hospitalization for severe aggravation of COPD in the last year, COPD with bronchiectasis, interstitial lung disease another pulmonary disease, known systemic inflammatory disease, patients on antihypertensive, antidiabetic, immunosuppressants, statin, known ischemic

**Table 1: Chronic obstructive pulmonary disease assessment test score in case group and global initiative for chronic obstructive lung disease grade values postbronchodilator forced expiratory volume 1 s**

| Parameters | Frequency | Percent | Valid percent | Cumulative percent |
|---|---|---|---|---|
| CAT score (10-20) | 33 | 66.0 | 66.0 | 66.0 |
| CAT score (21-30) | 16 | 32.0 | 32.0 | 98.0 |
| CAT score (>30) | 1 | 2.0 | 2.0 | 100.0 |
| CAT score (total) | 50 | 100.0 | 100.0 | |
| GOLD 1 (post-BD FEV1: ≥80) | 8.0 | 16.0 | 16.0 | 16.0 |
| GOLD 2 (post-BD FEV1: 50-79) | 27 | 54.0 | 54.0 | 70.0 |
| GOLD 1 (post-BD FEV1: 30-49) | 15 | 30.0 | 30.0 | 100.0 |
| GOLD 1 (post-BD FEV1: Total) | 50 | 100.0 | 100.0 | |

COPD: Chronic obstructive pulmonary disease, CAT: COPD assessment test, GOLD: Global initiative for chronic obstructive lung disease, BD: Bronchodilator, $FEV_1$: Forced expiratory volume 1 s

heart disease, lack of informed consent, known systemic comorbidities other than MetS, or on long-term medication like immune suppression or anti-arrhythmias were excluded.

A psychometric questionnaire assessment to quantify the symptom burden of COPD (COPD Assessment Test [CAT score]) was performed. CAT scores were classified based on impact level: <10: low; 10–20: medium; 21–30: high; and >30: very high. Blood pressure was measured in seated posture in the right upper limb after 5 min of rest by the auscultatory and palpatory method according to the American Heart Association recommendations. An anthropometric assessment was performed by determining the height and weight of the enrolled patients in light clothes and without shoes. BMI was determined by the division of weight by height with the formula kg/m$^2$. The patients were classified as underweight (<18.5), normal range (18.5–22.9), overweight (23–24.9), obese Class I (25–29.9), obese Class II (≥30.0), or obese Class III (≥40.0), according to the World Health Organization cutoffs for Indian population. Waist circumference (WC) was established with a graduated measure at the center of the lowest rib and the iliac crest. Venous blood was drawn after a 12-h fast for blood analysis. A hexokinase/glucose-6-phosphate dehydrogenase technique reported the glucose level. TG and high-density lipoprotein (HDL) were ascertained by enzymatic and a direct homogeneous assay.

Spirometry was performed using a spirometry machine (Medisoft, Dinant, Belgium) and SpiroWin software in the lung function laboratory. On the day of spirometry, patients were advised not to use bronchodilator (BD) 24 h before the tests. The European Respiratory Society/American Thoracic Society 2019 standards were explained and demonstrated to the patients and followed meticulously. Six-minute walk (6 MWT) test was achieved corresponding to the American Thoracic Society guidelines (2006).[13] Baseline heart rate (HR) and oxygen saturation ($SpO_2$) were documented. Subjects' baseline dyspnea and overall fatigue were noted with a Borg scale (0–10). Post-6 MWT, the postwalk Borg dyspnea, and fatigue were recorded and $SpO_2$ and pulse rate were measured using a pulse oximeter. The number of laps was recorded, and the additional distance covered was recorded. The mean 6 MWT was 380–782 meters and the formula for maximum HR is HRmax = 220-age, which serves as a prognosis indicator.

Based on the BODE index (0–10 points), the patients were grouped into four quartiles of I to IV with values 0–2, 3–4, 5–6, and 7–10, respectively. BODE index score of more than seven was correlated to 30% 2-year mortality, whereas points five to six were linked to 15% 2-year mortality, and <5 points or lower shows 2-year mortality is >10%. CRP titer measurement was performed using the nephelometry method.[9] CRP values <5 mg/dl were considered significant.

The revised NCEP 2005 criteria were used for defining MetS in the study subjects. It necessitates three of the subsequent mechanisms: abdominal obesity (WC ≥90 cm and ≥80 cm for Asian men and women individually), triglycerides (TGs) ≥150 mg/dL, HDL cholesterol ≤ 40 mg/dL 50 mg/dL for men and women separately, systolic blood pressure (SBP), and diastolic blood pressure (DBP): SBP/DBP ≥130/85 mmHg, on drug therapy, and FBS ≥100 mg/dl.

### Statistical analysis

The data were categorized using Microsoft Excel 2010 (Microsoft Corp., Redmond, WA, USA) and analyzed statistically (SPSS for windows, 16.0, SPSS Inc., Chicago, IL, USA). The global significance was $P \leq 0.05$ for a 95% confidence interval and $\alpha = 0.05$.

## Results

Table 1 shows CAT score values and Global Initiative for Chronic Obstructive Lung Disease (GOLD) grade values post BD forced expiratory volume 1 s ($FEV_1$) after the spirometry test. Out of 50 cases, 8 (16%) had MetS according to the NCEP ATP III. Out of 38 controls in the study population, 1 (2.6%) had MetS in accordance with the NCEP ATP III criteria. The mean value of 6 MWT in cases was 335.50 and the minimum

**Table 2: Forced expiratory volume 1 s (Global Initiative for Chronic Obstructive Lung Disease Grading) correlation with various parameters**

| Parameters | GOLD category | Mean±SD |
|---|---|---|
| WC | 1 | 73.38±6.82 |
| | 2 | 80.56±8.72 |
| | 3 | 79.93±9.80 |
| BMI | 1 | 22.75±2.91 |
| | 2 | 23.72±2.61 |
| | 3 | 27.83±3.38 |
| Triglycerides | 1 | 119.88±18.48 |
| | 2 | 123.67±17.23 |
| | 3 | 157.53±42.26 |
| HDL | 1 | 44.75±3.61 |
| | 2 | 39.85±4.61 |
| | 3 | 37.20±5.80 |
| SBP | 1 | 116±9 |
| | 2 | 116±9 |
| | 3 | 127±14 |
| DBP | 1 | 75±8 |
| | 2 | 75±7 |
| | 3 | 81±11 |
| FBS | 1 | 87.38±9.69 |
| | 2 | 95.04±9.49 |
| | 3 | 99.54±9.54 |
| CRP | 1 | 2.40±1.05 |
| | 2 | 2.98±1.19 |
| | 3 | 4.10±1.53 |
| BODE index | 1 | 1.13±0.35 |
| | 2 | 2.26±1.16 |
| | 3 | 4.47±1.59 |

SD: Standard deviation, WC: Waist circumference, BMI: Body mass index, HDL: High density lipoproteins, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBS: Fasting blood sugar, CRP: C-reactive protein, BODE: BMI airflow obstruction, dyspnea, and exercise, GOLD: Global initiative for chronic obstructive lung disease

and maximum value for 6 MWT were 160 and 450. Eighty-two percentage of the cases belonged to the BODE index <5, 12% belonged to the BODE index of 5–6, and 6% to the BODE index of above 7. In controls, the mean value of 6 MWT was 420, and the minimum and maximum values for 6 MWT were 320 and 550, respectively. The minimum CRP value was 1.5 mg/L, maximum was 6.5 mg/L, and mean CRP was 3.78 ± 1.5 mg/L. No significant impression can be derived due to the narrow range of CRP values. Out of 50 cases in the study population, 42 (84%) had CRP titer <5 and 8 (16%) had CRP titer more than 5. Out of 38 controls in the study population, 1 (2.6%) had CRP titer of more than 5. Table 2 summarizes the $FEV_1$ level (GOLD grading) with various parameters of MetS, BODE index, and CRP titer.

Analysis of variance [Table 3] and Bonferroni's *post hoc* test [Table 4] summarize differences between COPD and parameters of MetS. The mean $FEV_1$ in the cases with and without MetS was significant ($P = 0.013$) with 48.24% and 62.08%, respectively. The mean SI in the cases with and without MetS was significant ($P < 0.001$) with 640 and 277.26, respectively. The mean WC was significant ($P = 0.027$) in the cases with and without MetS with scores 85.63 cm and 78 cm, respectively. The BMI in the cases with and without MetS was significant ($P < 0.001$) with values 30.18 and 23.77, respectively. The mean SBP in the cases with and without MetS was significant ($P = 0.002$) with 134.25 mmHg and 117.24 mmHg, respectively. The mean DBP in the cases with and without MetS was significant ($P = 0.002$) with values 86.25 and 75.40 mmHg, respectively. The mean FBS in the cases with and without MetS was significant ($P < 0.001$) with 119.88 and 94.71 mg/dl, respectively. The mean HDL in the cases with and without MetS was significant ($P < 0.001$) at 32.88 and 41.77 mg/dl, respectively. The mean TG levels in the cases with and without MetS were significant ($P < 0.001$) at 189.50 and 122.50 mg/dl, respectively. The mean CRP levels in the cases with and without MetS were significant ($P < 0.001$) with 5.61 and 2.76 mg/dl, respectively.

Based on Karl Pearson's correlation coefficient, a significant correlation of $FEV_1$ with different factors of MetS such as BMI ($P = 0.002$), TG level ($P = 0.036$), HDL ($P = 0.029$), SBP ($P = 0.086$) and FBS levels ($P = 0.001$), CRP level ($P = 0.018$), and BODE index ($P < 0.001$) in cases, was observed. There was no correlation between $FEV_1$ and WC ($P = 0.176$) and DBP ($P = 0.159$). There were no statistically significant variations among MetS in cases and controls. Eight (16%) of the cases and one (2.6%) of the controls showed MetS prevalence. Table 5 shows no correlation between BODE index and CRP titer among cases without MetS.

**Table 3: Analysis of variance statistical analysis**

| Parameters | Groups | Sum of squares | df | Mean square | *F* | Significance |
|---|---|---|---|---|---|---|
| WC (cm) | Between groups | 329.105 | 2 | 164.553 | 2.119 | 0.131 |
| | Within groups | 3649.475 | 47 | 77.648 | | |
| | Total | 3978.580 | 49 | | | |
| BMI | Between groups | 203.000 | 2 | 101.500 | 12.001 | 0.000 |
| | Within groups | 397.500 | 47 | 8.457 | | |
| | Total | 600.500 | 49 | | | |
| Triglyceride level | Between groups | 12755.972 | 2 | 6377.986 | 8.533 | 0.001 |
| | Within groups | 35130.608 | 47 | 747.460 | | |
| | Total | 47886.580 | 49 | | | |
| HDL level | Between groups | 297.413 | 2 | 148.706 | 6.255 | 0.004 |
| | Within groups | 1117.307 | 47 | 23.772 | | |
| | Total | 1414.720 | 49 | | | |
| SBP | Between groups | 1168.124 | 2 | 584.062 | 4.678 | 0.014 |
| | Within groups | 5867.796 | 47 | 124.847 | | |
| | Total | 7035.920 | 49 | | | |
| DBP | Between groups | 401.990 | 2 | 200.995 | 2.461 | 0.096 |
| | Within groups | 3838.030 | 47 | 81.660 | | |
| | Total | 4240.020 | 49 | | | |
| FBS | Between groups | 3833.049 | 2 | 1916.524 | 10.789 | 0.000 |
| | Within groups | 8348.571 | 47 | 177.629 | | |
| | Total | 12181.620 | 49 | | | |
| CRP levels | Between groups | 18.530 | 2 | 9.265 | 5.610 | 0.007 |
| | Within groups | 77.621 | 47 | 1.652 | | |
| | Total | 96.151 | 49 | | | |
| BODE index | Between groups | 71.826 | 2 | 35.913 | 23.511 | 0.000 |
| | Within groups | 71.794 | 47 | 1.528 | | |
| | Total | 143.620 | 49 | | | |

WC: Waist circumference, BMI: Body mass index, HDL: High density lipoproteins, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBS: Fasting blood sugar, CRP: C-reactive protein, BODE: BMI airflow obstruction, dyspnea, and exercise

**Table 4: Bonferroni's *post hoc* test**

| Factors | (I) GOLD (post-BD FEV1) | (J) GOLD (post-BD FEV1) | Mean difference | SE | Significance | 95% CI | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower bound | Upper bound |
| WC (cm) | GOLD 1 (post-BD FEV1 ≥80) | GOLD 2 (post-BD FEV1 50-79) | −7.181 | 3.547 | 0.146 | −15.99 | 1.63 |
| | | GOLD 3 (post-BD FEV1 30-49) | −6.558 | 3.858 | 0.287 | −16.14 | 3.02 |
| | GOLD 2 (post-BD FEV1 50-79) | GOLD 1 (post-BD FEV1 50-79) | 7.181 | 3.547 | 0.146 | −1.63 | 15.99 |
| | | GOLD 3 (post-BD FEV1 30-49) | 0.622 | 2.838 | 1.000 | −6.42 | 7.67 |
| | GOLD 3 (post-BD FEV1 30-49) | GOLD 1 (post-BD FEV1 50-79) | 6.558 | 3.858 | 0.287 | −3.02 | 16.14 |
| | | GOLD 2 (post-BD FEV1 30-49) | −0.622 | 2.838 | 1.000 | −7.67 | 6.42 |
| BMI | GOLD 1 (post-BD FEV1 ≥80) | GOLD 2 (post-BD FEV1 50-79) | −0.9722 | 1.1706 | 1.000 | −3.879 | 1.934 |
| | | GOLD 3 (post-BD FEV1 30-49) | −5.0833* | 1.2732 | 0.001 | −8.244 | −1.922 |
| | GOLD 2 (post-BD FEV1 50-79) | GOLD 1 (post-BD FEV1 50-79) | 0.9722* | 1.1706 | 1.000 | −1.934 | 3.879 |
| | | GOLD 3 (post-BD FEV1 30-49) | −4.1111* | 0.936 | 5.000 | −6.436 | −1.786 |
| | GOLD 3 (post-BD FEV1 30-49) | GOLD 1 (post-BD FEV1 50-79) | 5.0833* | 1.2732 | 0.001 | 1.922 | 8.244 |
| | | GOLD 2 (post-BD FEV1 30-49) | 4.1111* | 0.9365 | 0.000 | 1.786 | 6.436 |
| Triglyceride levels | GOLD 1 (post-BD FEV1 ≥80) | GOLD 2 (post-BD FEV1 50-79) | −3.792 | 11.005 | 1.000 | −31.11 | 23.53 |
| | | GOLD 3 (post-BD FEV1 30-49) | −37.658* | 11.969 | 0.009 | −67.37 | −7.94 |
| | GOLD 2 (post-BD FEV1 50-79) | GOLD 1 (post-BD FEV1 50-79) | 3.792 | 11.005 | 1.000 | −23.53 | 31.11 |
| | | GOLD 2 (post-BD FEV1 50-79) | 33.867 | 8.804 | 0.001 | 12.01 | 55.72 |
| HDL levels | GOLD 1 (post-BD FEV1 ≥80) | GOLD 2 (post-BD FEV1 50-79) | 4.898* | 1.963 | 0.048 | 0.03 | 9.77 |
| | | GOLD 3 (post-BD FEV1 30-49) | 7.550* | 2.135 | 0.003 | 2.25 | 12.85 |
| | GOLD 2 (post-BD FEV1 50-79) | GOLD 1 (post-BD FEV1 50-79) | −4.898* | 1.963 | 0.048 | −9.77 | −0.03 |
| | | GOLD 3 (post-BD FEV1 30-49) | 2.652 | 1.570 | 0.294 | −1.25 | 6.55 |
| | GOLD 3 (post-BD FEV1 30-49) | GOLD 1 (post-BD FEV1 50-79) | −7.550* | 2.135 | 0.003 | −12.85 | −2.25 |
| | | GOLD 2 (post-BD FEV1 30-49) | −2.652 | 1.570 | 0.294 | −6.55 | 1.25 |
| SBP | GOLD 1 (post-BD FEV1 ≥80) | GOLD 2 (post-BD FEV1 50-79) | −0.713 | 4.498 | 1.000 | −11.88 | 10.45 |
| | | GOLD 3 (post-BD FEV1 30-49) | −11.083 | 4.892 | 0.084 | −23.23 | 1.06 |
| | GOLD 2 (post-BD FEV1 50-79) | GOLD 1 (post-BD FEV1 50-79) | 0.713 | 4.498 | 1.000 | −10.45 | 11.88 |
| | | GOLD 3 (post-BD FEV1 30-49) | −10.370* | 3.598 | 0.018 | −19.30 | −1.44 |
| | GOLD 3 (post-BD FEV1 30-49) | GOLD 1 (post-BD FEV1 50-79) | 11.083 | 4.892 | 0.084 | −1.06 | 23.23 |
| | | GOLD 2 (post-BD FEV1 30-49) | 10.370* | 3.598 | 0.018 | 1.44 | 19.30 |
| DBP | GOLD 1 (post-BD FEV1 ≥80) | GOLD 2 (post-BD FEV1 50-79) | −0.370 | 3.638 | 1.000 | −9.40 | 8.66 |
| | | GOLD 3 (post-BD FEV1 30-49) | −6.467 | 3.956 | 0.326 | −16.29 | 3.36 |
| | GOLD 2 (post-BD FEV1 50-79) | GOLD 1 (post-BD FEV1 50-79) | 0.370 | 3.638 | 1.000 | −8.66 | 9.40 |
| | | GOLD 3 (post-BD FEV1 30-49) | −6.096 | 2.910 | 0.125 | −13.32 | 1.13 |
| | GOLD 3 (post-BD FEV1 30-49) | GOLD 1 (post-BD FEV1 50-79) | 6.467 | 3.956 | 0.326 | −3.36 | 16.29 |
| | | GOLD 2 (post-BD FEV1 30-49) | 6.096 | 2.910 | 0.125 | −1.13 | 13.32 |
| FBS | GOLD 1 (post-BD FEV1 ≥80) | GOLD 2 (post-BD FEV1 50-79) | −7.662 | 5.365 | 0.480 | −20.98 | 5.66 |
| | | GOLD 3 (post-BD FEV1 30-49) | −24.092* | 5.835 | 0.000 | −38.58 | −9.61 |
| | GOLD 2 (post-BD FEV1 50-79) | GOLD 1 (post-BD FEV1 50-79) | 7.662 | 5.365 | 0.480 | −5.66 | 20.98 |
| | | GOLD 3 (post-BD FEV1 30-49) | −16.430* | 4.292 | 0.001 | −27.09 | −5.77 |
| | GOLD 3 (post-BD FEV1 30-49) | GOLD 1 (post-BD FEV1 50-79) | 24.092* | 5.835 | 0.000 | 9.61 | 38.58 |
| | | GOLD 2 (post-BD FEV1 30-49) | 16.430* | 4.292 | 0.001 | 5.77 | 27.09 |
| CRP value | GOLD 1 (post-BD FEV1 ≥80) | GOLD 2 (post-BD FEV1 50-79) | −0.5815 | 0.5173 | 0.800 | −1.866 | 0.703 |
| | | GOLD 3 (post-BD FEV1 30-49) | −1.7000* | 0.5626 | 0.012 | −3.097 | −0.303 |
| | GOLD 2 (post-BD FEV1 50-79) | GOLD 1 (post-BD FEV1 50-79) | 0.5815 | 0.5173 | 0.800 | −0.703 | 1.866 |
| | | GOLD 3 (post-BD FEV1 30-49) | −1.1185* | 0.4138 | 0.029 | −2.146 | −0.091 |
| | GOLD 3 (post-BD FEV1 30-49) | GOLD 1 (post-BD FEV1 50-79) | 1.7000* | 0.5626 | 0.012 | 0.303 | 3.097 |
| | | GOLD 2 (post-BD FEV1 30-49) | 1.1185* | 0.4138 | 0.029 | 0.091 | 2.146 |
| BODE index | GOLD 1 (post-BD FEV1 ≥80) | GOLD 2 (post-BD FEV1 50-79) | −1.134 | 0.498 | 0.082 | −2.37 | 0.10 |
| | | GOLD 3 (post-BD FEV1 30-49) | −3.342* | 0.541 | 0.000 | −4.69 | −2.00 |
| | GOLD 2 (post-BD FEV1 50-79) | GOLD 1 (post-BD FEV1 50-79) | 1.134 | 0.498 | 0.082 | −0.10 | 2.37 |
| | | GOLD 3 (post-BD FEV1 30-49) | −2.207* | 0.398 | 0.000 | −3.20 | −1.22 |
| | GOLD 3 (post-BD FEV1 30-49) | GOLD 1 (post-BD FEV1 50-79) | 3.342* | 0.541 | 0.000 | 2.00 | 4.69 |
| | | GOLD 2 (post-BD FEV1 30-49) | 2.207* | 0.398 | 0.000 | 1.22 | 3.20 |

GOLD: Global initiative for chronic obstructive lung disease, BD: Bronchodilator, FEV1: Forced expiratory volume 1 s, WC: Waist circumference, BMI: Body mass index, HDL: High density lipoproteins, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBS: Fasting blood sugar, CRP: C-reactive protein, BODE: BMI airflow obstruction, dyspnea, and exercise, SE: Standard error, CI: Confidence interval, *Significance $P < 0.001$

**Table 5: Correlation between BODE index and CRP titer among cases without metabolic syndrome**

| Parameters | Mean | Standard deviation | *n* |
|---|---|---|---|
| BODE index | 2.26 | 1.231 | 42 |
| CRP value | 2.769 | 0.9861 | 42 |

## Discussion

Tobacco smoking is a highly faced risk component for COPD across the world. Our study showed that 80% of the cases were smokers, and among controls, 50% were smokers. A field study in urban and rural population of India indicates that the occurrence of COPD was greater among bidi smoker compared to cigarette smokers (8.2% and 5.9%, respectively).

The mean $FEV_1$ of those with MetS was considerably lower than others. This contrasts with the study result by Díez-Manglano *et al*.,[14] which demonstrated that MetS in COPD was associated with higher $FEV_1$. The occurrence of MetS in our research was lower than that of Reaven,[15] with a frequency of 40.3%. Negative association in the study might be due to small study population. GOLD 3 and 4 underrepresented in our study and a higher percentage of thin built individuals were present. Both HDL and TG showed statistically significant results in groups with and without MetS. However, Jain *et al*.[16] and Rao *et al*.[17] found that the seriousness of COPD had no substantial association to TG, low-density lipoproteins, and HDLs. Our study showed that those with MetS had higher mean WC. Foumani *et al*.,[18] stated that the WC did not have an impact on lung function in contrast to our study; however, it was a prognostic component for COPD acuteness.

Ghatas[19] showed that obesity, elevated BP, and hyperglycemia were considerably high in COPD subjects with MetS like our results. Thirty-two percentage of cases and 23% of controls had FBS >100 mg/dl in our study. In the report of Mahishale *et al*.,[20] occurrence of diabetes mellitus in COPD patients was 25.63% compared to 32% of our results. According to a study by Dharwadkar *et al*.,[21] lung functions were found to be negatively correlated with glycemic status. All the components of the MetS appear to be the strongest contributors in the MetS of COPD cases.

No significant difference in the mean WC in the study population in the GOLD Stages 1–3 was observed. Popović-Grle *et al*.[22] stated WC no significant differences among GOLD 2 and GOLD 3 phases like our observation. HDL level decreased when GOLD grade increased and statistically significant. In our study, population of 50 COPD cases, a substantial positive association was observed among TG level and $FEV_1$ which is against a study by Ameen *et al*.,[23] was a negative correlation of TG level was found with $FEV_1$. The mean SBP did not increase when GOLD grade increased. A report by Logvinenko *et al*.[24] demonstrated a negative link between SBP, DBP, and $FEV_1$. However, our study showed a negative correlation for DBP. There was a significant correlation of $FEV_1$ (GOLD grading) with various components of MetS (BMI, TG level, HDL, SBP, and FBS) and CRP level and BODE index in cases. There was no correlation between $FEV_1$ (GOLD grading) and WC and DBP.

Since assessment of BODE index only requires a spirometer, use of BODE index can prevent wastage of resources in evaluating cases of COPD when providing inflammation with high therapeutic implication. The BODE index in COPD with MetS was more than 5 and it correlates with COPD severity. Cote and Celli[11] observed that the capacity of BODE index to calculate the probability of mortality was greater than $FEV_1$. A study by Yasar *et al*.[25] showed that the mean CRP in COPD with MetS was considerably more than those with COPD alone. Patel *et al*.[26] showed high-sensitivity (hs-CRP) levels correlated positively with BMI and WC in overweight nondiabetic individuals. While the factors of MetS raised, the mean hs-CRP concentrations too raised. Hence, CRP titer among COPD patients should be interpreted in the light of other causes of systemic inflammation like smoking status, recent infection or exacerbation and presence of comorbid disorders like diabetes mellitus or cardiovascular diseases that perpetuates inflammation. All the components of MetS (central obesity, dyslipidemia, systemic hypertension, and increased FBS) appear to be the strongest contributors in MetS of COPD patients.

## Conclusion

The current results shows that the prevalence of MetS in steady COPD patients is 16% in comparison to 2.6% of controls. COPD individuals having MetS compared to ones without it have lower $FEV_1$ with higher smoking index, WC, hypertension, dyslipidemia (high TG, low HDL), and raised blood sugar, which is statistically significant. A substantial association of $FEV_1$ (GOLD grading) with different factors of MetS (BMI, TG, HDL, SBP, and FBS) and CRP level was noted. Cases with MetS showed higher BODE index and CRP titer compared to cases without MetS, which is statistically significant.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

## References

1. Global Initiative for Chronic Obstructive Lung Disease Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease Global Initiative for Chronic Obstructive Lung Disease; 2020. Available from: http://www.goldcopd.org/. [Last assessed on 2020 Dec 01].
2. India State-Level Disease Burden Initiative CRD Collaborators. The burden of chronic respiratory diseases and their heterogeneity across the states of India: The Global Burden of Disease Study 1990-2016. Lancet Glob Health 2018;6:e1363-74.
3. Fahed G, Aoun L, Bou Zerdan M, Allam S, Bou Zerdan M, Bouferraa Y, *et al*. Metabolic syndrome: Updates on pathophysiology and

management in 2021. Int J Mol Sci 2022;23:786.
4. Acharyya A, Shahjahan MD, Mesbah FB, Dey SK, Ali L. Association of metabolic syndrome with chronic obstructive pulmonary disease in an Indian population. Lung India 2016;33:385-90.
5. Khan Y, Lalchandani A, Gupta AC, Khadanga S, Kumar S. Prevalence of metabolic syndrome crossing 40% in Northern India: Time to act fast before it runs out of proportions. J Family Med Prim Care 2018;7:118-23.
6. Koul PA. Metabolic syndrome and chronic obstructive pulmonary disease. Lung India 2016;33:359-61.
7. Jindal SK, Aggarwal AN, Chaudhry K, Chhabra SK, D'Souza GA, Gupta D, *et al*. A multicentric study on epidemiology of chronic obstructive pulmonary disease and its relationship with tobacco smoking and environmental tobacco smoke exposure. Indian J Chest Dis Allied Sci 2006;48:23-9.
8. Petty TL. The history of COPD. Int J Chron Obstruct Pulmon Dis 2006;1:3-14.
9. Moayyedkazemi A, Rahimirad MH. Evaluating serum C-reactive protein level in patients with chronic obstructive pulmonary disease and its correlation with disease severity. Biomed Res Ther 2018;5:2784-8.
10. Lam KB, Jordan RE, Jiang CQ, Thomas GN, Miller MR, Zhang WS, *et al*. Airflow obstruction and metabolic syndrome: The Guangzhou Biobank Cohort Study. Eur Respir J 2010;35:317-23.
11. Cote CG, Celli BR. Pulmonary rehabilitation and the BODE index in COPD. Eur Res J 2005;26:630-6.
12. Celli BR, Cote CG, Marin JM, Casanova C, Montes de Oca M, Mendez RA, *et al*. The body-mass index, airflow obstruction, dyspnea, and exercise capacity index in chronic obstructive pulmonary disease. N Engl J Med 2004;350:1005-12.
13. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: Guidelines for the six-minute walk test. Am J Respir Crit Care Med 2002;166:111-7.
14. Díez-Manglano J, Barquero-Romero J, Almagro P, Cabrera FJ, López García F, Montero L, *et al*. COPD patients with and without metabolic syndrome: Clinical and functional differences. Intern Emerg Med 2014;9:419-25.
15. Reaven GM. Banting lecture 1988. Role of insulin resistance in human disease. Diabetes 1988;37:1595-607.
16. Jain KB, Pasari N, Songra A, Bajpai A. The lipid profile parameter in chronic obstructive pulmonary disease patients and correlation with severity of disease. J Cardiothorac Med 2017;5:564-8.
17. Rao MV, Raghu SR, Kiran SP, Rao CH. A study of lipid profile in chronic obstructive pulmonary disease. J Evol Med Dent Sci 2015;4:7287-96.
18. Foumani AA, Neyaragh MM, Ranjbar ZA, Leyli EK, Ildari S, Jafari A. Waist circumference and spirometric measurements in chronic obstructive pulmonary disease. Osong Public Health Res Perspect 2019;10:240-5.
19. Ghatas T. The relationship between metabolic syndrome and chronic obstructive pulmonary disease. Egypt J Bronchol 2017;11:11-5.
20. Mahishale V, Angadi N, Metgudmath V, Eti A, Lolly M, Khan S. Prevalence and impact of diabetes, hypertension, and cardiovascular diseases in chronic obstructive pulmonary diseases: A hospital-based cross-section study. J Transl Int Med 2015;3:155-60.
21. Dharwadkar AR, Dharwadkar AA, Banu G, Bagali S. Reduction in lung functions in type-2 diabetes in Indian population: Correlation with glycemic status. Indian J Physiol Pharmacol 2011;55:170-5.
22. Popović-Grle S, Ladić A, Butorac-Petanjek B, Spicek-Macan J, Cucević B. Waist circumference does not correlate with functional lung capacity in moderate and severe chronic obstructive pulmonary disease. Acta Clin Croat 2013;52:69-77.
23. Ameen NM, El Deen Mohamed RS, Abd El Mageed NI, Abd EL Wahab MH. The metabolic syndrome in patients with chronic obstructive pulmonary disease. Egypt J Chest Dis Tuberc 2016;65:593-6.
24. Logvinenko N, Malyutina S, Denisova D, Voevoda M. Associations of CVD risk factors and airflow obstruction in urban Siberian population: Natalya Kovalkova. Eur J Public Health 2014;24:162-074.
25. Yasar Z, Buyuksirin M, Ucsular FD, Kargı A, Erdem F, Talay F, *et al*. Is an elevated neutrophil-to-lymphocyte ratio a predictor of metabolic syndrome in patients with chronic obstructive pulmonary disease? Eur Rev Med Pharmacol Sci 2015;19:956-62.
26. Patel B, Taviad D, Malapati B, Gokani R, Shaikh N, Shah R. Association of hs-crp levels with obesity & metabolic syndrome in patients with type-2 diabetes mellitus: A link between inflammation, adiposity & insulin resistance. Int J Biol Med Res2015;6:5104-8.