

Correlation of Body Mass Index and Oxygen Saturation in Chronic Obstructive Pulmonary Disease Patients at a Tertiary Care Center in Nepal: A Cross-Sectional Study

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Purpose: Chronic obstructive pulmonary disease (COPD) is a major cause of mortality and morbidity worldwide. COPD is associated with clinically relevant pulmonary and extrapulmonary manifestations, including hypoxemia and weight loss. The correlation of body mass index (BMI) and oxygen saturation (SpO₂) with COPD grades may provide a useful additional marker for understanding and managing the disease. The aim of the study was to study the correlation of BMI and oxygen saturation with COPD in patients presenting to a tertiary care center in Nepal.

Patients and Methods: A descriptive cross-sectional study was conducted among 145 COPD patients visiting the Department of Medicine in Shree Birendra Hospital between 1 March 2019 and 28 February 2020. A non-probability purposive sampling method was used and data were analyzed using SPSS version 21. A *p*-value of <0.05 was considered significant.

Results: Out of 145 COPD patients, 58 (40%) were underweight, 53 (36.55%) were of normal weight, 20 (13.79%) were overweight, and 14 (9.6%) were obese. The number of underweight patients was highest in COPD grade 4 and lowest in COPD grade 1. The proportion of subjects with underweight BMI and hypoxia increased with COPD severity, and both were statistically significant (*p*-values <0.01).

Conclusion: Our study shows that BMI and oxygen saturation have an inverse association with COPD severity. The correlation of BMI and oxygen saturation with COPD grade could provide a supplementary marker of disease severity, which could be useful in the understanding of the disease process and subsequent management of COPD.

Keywords: body mass index, chronic obstructive pulmonary disease, oxygen saturation, chronic obstructive airway disease

Introduction

In the twenty-first century, chronic obstructive pulmonary disease (COPD) is recognized as a disease of global public health concern. From 1990 to 2015, mortality due to COPD increased by almost 11% and the prevalence of the disease increased by 44%.¹ Airflow limitation due to loss of lung elastic recoil and/or airway narrowing is characteristic of COPD.² COPD affects the lungs and also has significant systemic consequences.³ COPD patients with low oxygen saturation (SpO₂) have a greater chance of having the worst degree of breathlessness, with poor quality of life, reduced exercise tolerance, increased risk of cardiovascular morbidity, and greater risk of death.^{4,5} Low body weight in COPD patients is associated with increased mortality, independently of lung function.⁶

This study was carried out to identify the association of the severity of COPD with SpO₂ and body mass index (BMI) in the Nepalese population. The correlation of BMI and oxygen saturation with COPD grades could provide a supplementary marker of disease severity which could be useful in the understanding and management of COPD.

Materials and Methods

A descriptive cross-sectional study was conducted among COPD patients visiting the Department of Medicine in Shree Birendra Hospital between 1 March 2019 and 28 February 2020. Ethical approval for the study was granted by the Institutional Review Committee, Nepalese Army Institute of Health Sciences (NAIHS-IRC). This study was conducted in compliance with the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all the participants and the confidentiality of the information was ensured. All adult patients of age 18 years and above with COPD, using inhaled bronchodilators or steroids, and giving written consent, were enrolled in the study. Patients with acute exacerbation of COPD within the last 2 weeks before enrollment, taking oral steroid treatment, or receiving domiciliary oxygen therapy, and patients with active pulmonary tuberculosis, heart failure, or malignancies, were excluded from the study. A non-probability purposive method of sampling was used for the collection of data. The sample size was calculated on the basis of the prevalence of COPD globally, 8.4–15%, as reported by Adeloye et al.⁷ Taking a prevalence of 10%, with a confidence interval of 95% and allowable error of 5%, the minimum sample size was calculated as 144.

Data were collected on a self-designed semi-structured pro forma, which included questions related to demographic variables and relevant clinical history. Following an interview by the researcher, participants underwent anthropometric measurements and spirometry. Each patient's weight was taken using a platform weighing scale. Standing height was measured with the participants barefoot, eyes looking ahead, and standing straight with the heels, buttocks, and occiput touching the wall. The BMI was computed by dividing body weight (kilograms) by the square of the height in meters (m²). The BMI was categorized according to the new classification for Asians (Table 1).⁸

Spirometry was performed using the Medical International Research Spirolab 4 Portable, Desktop, and PC-Based Spirometer. Prior to performing spirometry, patients were instructed not to take any inhalational bronchodilators on the day of spirometry. Post-bronchodilator spirometry was used to diagnose and grade COPD patients according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines (Table 2).⁹ Oxygen saturation was measured using a pulse oximeter.

Data were entered into SPSS for Windows version 21 for statistical analysis. Descriptive statistics were calculated using the frequency and percentage for qualitative variables, and the mean and standard deviation for quantitative variables. The chi-squared (χ^2) test was used to compare categorical variables. A 95% confidence interval was used in this study and a *p*-value of <0.05 was considered to be statistically significant.

Results

A total of 145 patients with COPD were enrolled in the study, of whom 81 (55.9%) were male and 64 (44.1%) were female. The mean age of the participants was 62.74±8.04 years. The mean BMI was 20.42±3.50 kg/m². There were 20 (13.79%), 44 (30.34%), 47 (32.41%), and 34 (23.45%) participants with COPD grade 1, grade 2, grade 3, and grade 4, respectively.

Table 1 BMI Classification for Asians

BMI Category	BMI (kg/m ²)
Underweight	<18.5
Normal	18.5–22.9
Overweight	23–24.9
Obese	≥25

Abbreviation: BMI, body mass index.

Table 2 GOLD Criteria for Severity of Airflow Obstruction in COPD

COPD Severity	Characteristics	
	FEV ₁ /FVC	FEV ₁
Grade 1 (Mild)	<70%	≥80% of predicted
Grade 2 (Moderate)	<70%	≥50% to <80% of predicted
Grade 3 (Severe)	<70%	≥30% to <50% of predicted
Grade 4 (Very Severe)	<70%	<30% of predicted

Note: © 2022, 2023, Global Initiative for Chronic Obstructive Lung Disease, available from www.goldcopd.org, published in Deer Park, IL, USA.

Abbreviations: COPD, chronic obstructive pulmonary disease; GOLD, Global Initiative for Chronic Obstructive Lung Disease; FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity.

Among the 145 patients, the mean SpO₂ was found to be 95.85±1.18%, 92.32±1.84%, 88.17±1.48%, and 84.50±1.66% in those with COPD grade 1, grade 2, grade 3, and grade 4, respectively. There was a statistically significant difference in the mean SpO₂ among the different COPD grades ($p<0.01$). Similarly, there was a significant decrease in SpO₂ with the increase in COPD grade (Table 3).

Out of 145 COPD patients, 58 (40%) were underweight, 53 (36.55%) were of normal weight, 20 (13.79%) were overweight, and 14 (9.6%) were obese. The mean BMI of participants with grade 1 COPD was 24.50±3.82 kg/m², grade 2 COPD was 21.69±2.84 kg/m², grade 3 COPD was 19.33±2.76 kg/m², and grade 4 COPD was 17.90±1.86 kg/m². On comparing the mean BMI of the participants with the grade of COPD, a statistically significant difference in the mean BMI was found among the various grades of COPD ($p<0.01$). The mean BMI decreased as the severity of the COPD increased (Table 4).

Table 3 Correlation of COPD Grades and Mean Oxygen Saturation

COPD Grades	Mean SpO ₂ (%)	N	Standard Deviation (%)
Grade 1 (FEV ₁ ≥80%)	95.85	20	1.18
Grade 2 (FEV ₁ 50–79%)	92.32	44	1.84
Grade 3 (FEV ₁ 30–49%)	88.17	47	1.48
Grade 4 (FEV ₁ ≤29%)	84.50	34	1.66
Total	89.63	145	4.13
df=3, $p<0.01$			

Abbreviations: COPD, chronic obstructive pulmonary disease; SpO₂, oxygen saturation; df, degrees of freedom; N, number.

Table 4 Comparison Between COPD Grades and Mean BMI (kg/m²)

COPD Grades	Mean BMI	N	Standard Deviation	Minimum	Maximum
Grade 1 (FEV ₁ ≥80%)	24.50	20	3.82	16.43	34.13
Grade 2 (FEV ₁ 50–79%)	21.69	44	2.84	16.38	26.43
Grade 3 (FEV ₁ 30–49%)	19.33	47	2.76	15.22	25.34
Grade 4 (FEV ₁ ≤29%)	17.90	34	1.86	15.61	24.65
Total	20.42	145	3.50	15.22	34.13
df=3, $p<0.01$					

Abbreviations: COPD, chronic obstructive pulmonary disease; BMI, body mass index; FEV₁, forced expiratory volume in 1 second; df, degrees of freedom; N, number.

Discussion

In our study, the increase in COPD severity was found to be associated with the statistically significant decrease in the mean oxygen saturation ($p < 0.01$). This finding was consistent with the results of studies by Gupta et al and Kumar et al, in which the mean SpO₂ progressively decreased with the increase in the severity of COPD.^{8,10} A possible explanation for reduced SpO₂ with increased severity of COPD is the progressive increase in ventilation/perfusion (V/Q) mismatch as the disease progresses.^{5,11} Altered ventilatory control is another important factor responsible for the occurrence of hypoxemia in COPD patients.^{12,13} Similarly, with disease progression there is a deterioration of pulmonary function and this increases the risk of alveolar hypoxia and hypoxemia, leading to a decrease in SpO₂.¹⁴ Hypoxemia and the decrease in SpO₂ with progression of COPD severity are important findings because they lead to poor quality of life, reduced exercise tolerance, poor neurocognitive function, and increased risk of exacerbation and death.^{15,16} Hence, as there is an inverse relationship between COPD stage and oxygen saturation, SpO₂ could be used as a marker of COPD severity, especially in resource-limited settings where pulmonary function tests are not readily available.⁸

In our study, 40% of the total patients were underweight according to the BMI criteria, and the number of underweight patients was highest in COPD grade 4 and lowest in COPD grade 1. A similar result was found in the study conducted by Schols et al,¹⁷ in which approximately 50% of patients with severe COPD suffered from weight loss. Similarly, a study performed in India by Gupta et al⁸ showed that patients with grade 1 COPD were less undernourished (25%) than those with grade 4 COPD (80%), which is consistent with the results of our study. However, in a study by Cochrane and Afolabi¹⁸ on 103 COPD patients in the UK, only 23% of COPD patients were malnourished, unlike in our study where the prevalence of underweight patients was 40%. In our study, the percentage of underweight subjects was high in comparison to the study by Cochrane and Afolabi,¹⁸ probably because of differences in geographical distribution and dietary intake patterns between the two countries, and also because of low socioeconomic status, and late disease identification and treatment in our setting.^{8,10} Hence, there is a need for nutritional counseling in patients with severe COPD, as low BMI is possibly an important and independent risk factor for mortality and morbidity in subjects with severe COPD.¹⁹

Our study also revealed that, with increasing COPD grade, the proportion of subjects with underweight BMI status increased significantly ($p < 0.01$). This finding was similar to that of a study conducted by Steuten et al²⁰ in the Netherlands, in which the prevalence of low body weight was strongly increased in patients with COPD GOLD grade 4. Similarly, Montes de Oca et al²¹ and Yang et al²² found that patients with higher BMI had COPD of lower grade, and predicted that low BMI could be an indicator of mortality among COPD patients.

Malnutrition, reflected as underweight BMI, in COPD patients is related to the imbalance between energy intake and energy expenditure.^{8,10,23,24} COPD patients have symptoms such as postprandial dyspnea, early satiety, fatigue, and loss of appetite, leading to reduced intake of food.^{25–27} Meanwhile, there is increased energy expenditure because of the increased work of breathing, thermogenic effects of bronchodilators, and systemic inflammation.^{24,25} In addition, loss of body muscle mass in COPD can also be due to the adverse effects of corticosteroids on skeletal muscle function.²⁸ At the microscopic level, the increase in severity of COPD is associated with muscle fiber atrophy, muscle fiber alterations, and loss of mitochondrial function.^{28,29} These findings suggest that COPD impairs metabolic function at the cellular level, resulting in weight loss.²⁹ This weight loss, leading to low BMI, correlates with mortality in COPD patients.^{22,30,31}

Our study has some limitations. The study was conducted on a sample of modest size, so the effects of modest sample size should be considered while interpreting the results. In addition, as BMI may not be an ideal tool to measure the lean body mass of COPD patients who have edema due to cor-pulmonale and pulmonary hypertension, the results should be interpreted cautiously in this group of patients. Also, the presence of pulmonary hypertension can hinder the use of SpO₂ as the sole indicator for assessing COPD severity. Moreover, the possibility of selection bias needs to be considered when interpreting the results, as a non-probability purposive sampling method was used in our study.

Conclusion

Our study suggests that BMI and SpO₂ have an inverse association with COPD severity. Hence, BMI and oxygen saturation, in addition to COPD grades, could be used as markers of disease severity, and could add a new dimension in our understanding of the disease process and subsequent management of COPD.

Disclosure

The authors report no conflicts of interest in this work.

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