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Relationship of BMI with Severity of Chronic Obstructive Pulmonary Disease (COPD)

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ABSTRACT

COPD is linked to significant extra-pulmonary manifestations. However, limited research exists on relationship between BMI and COPD severity. **Objective:** To find frequency of COPD stages and to compare mean BMI in various stages of COPD. **Methods:** This cross-sectional study was conducted at Chest Medicine Department, Mayo hospital, Lahore from August 2022, to February 2023 after approval of synopsis from CPSP. 160 COPD patients were enrolled, and classification as per GOLD guidelines and BMI was calculated. Data were analyzed using SPSS version 26.0, comparison of BMI across COPD stages was done using ANOVA and post Hoc analysis done, p-value ≤ 0.05 considered statistically significant. **Results:** Among 160 individuals, 26.2% had COPD Stage I, 23.8% had stage II, while Stage III and IV observed in 25% each. Mean BMI was 24.30 ± 2.71, 25.86 ± 5.77, 20.29 ± 5.39, and 19.50 ± 6.07 in Stage I-IV, P<0.001. Mean BMI difference was statistically significant when comparing Stage, I vs. III (p = 0.003), Stage I vs. IV (p < 0.001), Stage II vs. III (p < 0.001), and Stage II vs. IV (p < 0.001). However, difference between Stage III and IV was not statistically significant (p = 0.900). **Conclusions:** The distribution of COPD severity was relatively even across all stages, with comparable proportion of patients in each stage. A significant decline in BMI was observed with increasing disease severity. These findings emphasize the importance of regular BMI monitoring in COPD patients, as lower BMI is linked to disease progression and poorer clinical outcomes.

INTRODUCTION

Non-Communicable Diseases (NCDs) represents a major global health challenge of 21st century and leading cause of disease burden and mortality [1]. Among respiratory NCDs, COPD is leading concern, affecting approximately 10% of adult population, with millions of people worldwide experiencing moderate to severe forms of disease [2]. It is primarily characterized by airflow limitation due to airway inflammation and remodeling, often accompanied by emphysema [3]. Beyond its respiratory impact, COPD is associated with various systemic manifestations, including cardiovascular complications, malnutrition, osteoporosis, anemia, GERD, and mental health conditions [4]. These systemic effects contribute to reduced exercise capacity, worsening dyspnea, diminished quality of life, and increased mortality [5]. Research has demonstrated significant relationship between COPD severity and key health indicators such as body mass index [6]. While excess body weight is generally linked to higher mortality rates in general population, research has identified exception known as 'obesity paradox', where obesity appeared to have protective effect [7]. Since then, multiple studies have highlighted potential survival advantage of obesity in

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various chronic conditions, including COPD. Several mechanisms have been proposed to explain this phenomenon. Increased energy reserves in obese individuals may help counteract the catabolic effects of COPD, preventing excessive weight loss and muscle wasting. Additionally, greater muscle mass, particularly in overweight individuals, may contribute to improved respiratory function and better overall physical resilience. Furthermore, adipose tissue is thought to exert a potential anti-inflammatory effect, which may help mitigate the systemic inflammation commonly observed in COPD. It was demonstrated that as COPD severity increases, there is progressive decline in both BMI and low BMI is associated with increased risk of COPD exacerbations and reduced survival rates [8, 9]. Several factors contribute to low BMI, including low socioeconomic status, poor overall health, insufficient physical activity, and recurrent illnesses. Maintaining healthy BMI has been suggested as way to reduce the risk of COPD exacerbations and mortality [10].

Chronic Obstructive Pulmonary Disease (COPD) is a major global and national health burden associated not only with progressive respiratory impairment but also with systemic complications such as malnutrition and weight loss, which can worsen disease outcomes. Although body mass index (BMI) is considered an important prognostic indicator in COPD, limited local evidence exists regarding its relationship with disease severity across different GOLD stages in Pakistani populations. Previous studies have largely focused on pulmonary function while underexploring nutritional status as a marker of progression, particularly in developing countries. Therefore, this study aimed to determine the frequency of COPD severity stages and compare mean BMI across various COPD stages to better understand the association between nutritional status and disease severity. Therefore, the present study aimed to assess the frequency of COPD stages and to compare mean BMI in various stages of COPD.

METHODS

After obtaining synopsis approval from CPSP [CPSP/REU/PUL-2020-062-616], this cross-sectional study was conducted at Institute of Chest Medicine, Mayo Hospital, Lahore. The study duration was six months, from August 2022, to February 2023. A total of 160 patients were included, based on calculated sample size using 95% confidence level, 3.5% margin of error, and expected percentage of stage I COPD as 5.4% [11]. The sampling technique used was non-probability consecutive sampling. Data were collected using pre-designed proforma. Patients of both genders aged between 20-70 years diagnosed with COPD at any stage according to GOLD criteria were included, provided they gave written informed consent. Patients were excluded if they were pregnant, had recent myocardial infarction, active pulmonary TB, malignancy, HIV, or had undergone surgery in preceding four weeks. Written informed consent was obtained before participation. Detailed medical history was recorded, including smoking status. Spirometry was performed using MIR Spirodoc TUKMIR040 (Italy) machine to classify the severity of airflow limitation based on post-bronchodilator FEV_1 as per GOLD guidelines from stage I-IV. Calibration and quality control of the spirometry device were ensured through daily calibration checks using a 3L calibration syringe, adherence to manufacturer-recommended maintenance protocols, and quality control measures as per American Thoracic Society (ATS)/European Respiratory Society (ERS) standards to ensure accuracy and reliability of measurements. BMI was calculated by measuring weight (kg) divided by height (meters squared). To minimize inter-observer variability, height, weight, and spirometry measurements were performed by trained personnel following standardized protocols. Height and weight were measured using calibrated stadiometer and weighing scale, ensuring consistency across measurements. Spirometry was conducted by single trained technician to maintain uniformity. Additionally, periodic cross-checks and quality assurance measures were implemented to ensure reliability and reduce variability in recorded values. All data were entered and analyzed using SPSS version 26.0. Numerical variables, including age, and BMI, were presented as mean ± SD, while categorical variables such as gender and severity of COPD were presented as frequencies and percentages. Comparisons of BMI across different COPD stages were made using ANOVA, and post Hoc analysis was done; p-value ≤ 0.05 considered statistically significant.

RESULTS

As shown in Figure 1 below, among the 160 individuals with COPD, 26.2% were diagnosed with Stage I, 23.8% with Stage II, while Stage III and Stage IV were observed in 25% of patients each.

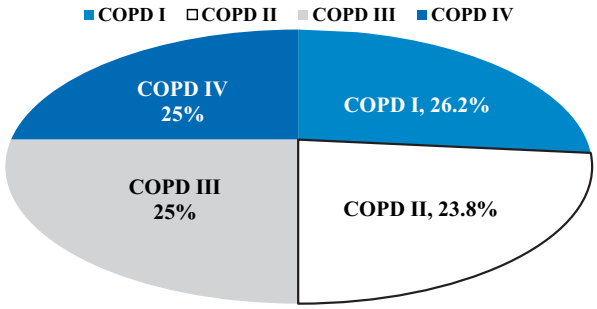

Figure 1: Distribution of Severity of COPD

Stratification of severity of COPD with respect to age, gender and smoking was done. There is significant difference was found between age and severity of COPD. Patient having age >50 years have more severe COPD (stage IV) as compared to age ≤50 years (40% vs 10% p-

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value <0.001). Moreover, COPD was more severe in male as compared to female (40.5% vs 9.9% p-value <0.001). Furthermore, there is no association was found between smoking and severity of COPD.

Table 1: Stratification of Severity of COPD with Respect to Age, Gender and Smoking

Variables		Severity of COPD				p-Value
		I Frequency (%)	II Frequency (%)	III Frequency (%)	IV Frequency (%)	
Age	>50 Years	12 (15.0%)	07 (8.8%)	29 (36.3%)	32 (40.0%)	<0.001
	≤50 Years	30 (37.5%)	31 (38.8%)	11 (13.8%)	08 (10.0%)	
Gender	Male	39 (26.9%)	35 (24.1%)	35 (24.1%)	36 (24.8%)	0.844
	Female	03 (20.0%)	03 (20.0%)	05 (33.3%)	04 (26.7%)	
Smoking	No	03 (20.0%)	03 (20.0%)	06 (40.0%)	03 (20.0%)	0.573
	Yes	39 (26.9%)	35 (24.1%)	34 (23.4%)	37 (25.5%)	

As shown in Table 2, mean BMI significantly varied across different stages of COPD ($p < 0.001$). The BMI was found to be 24.30±2.71 in Stage I, 25.86 ± 5.77 in Stage II, 20.29±5.39 in Stage III, and 19.50 ± 6.07 in Stage IV, respectively. Compared to Stage I, the effect size (Cohen's d) was 0.35 for Stage II (small effect), 0.95 for Stage III (large effect), and 1.03 for Stage IV (large effect), indicating a substantial decline in BMI as COPD severity increased.

Table 2: Comparison of mean Body Mass Index with Severity of COPD

Severity of COPD	N	BMI Mean ± SD	95% CI		Cohen's d Effect	p-Value
			Lower Bound	Upper Bound		
Stage I	42	24.30 ± 2.71	23.45	25.14	Reference	<0.001
Stage II	38	25.86 ± 5.77	23.97	27.76	0.35	
Stage III	40	20.29 ± 5.39	18.57	22.02	0.95	
Stage IV	40	19.50 ± 6.07	17.56	21.44	1.03	
Total	160	22.47 ± 5.73	21.57	23.36	-	

The post hoc analysis of BMI across different COPD severity stages, as shown in Table 3, reveals a significant decline in BMI with increasing disease severity. Patients with Stage III and Stage IV COPD had significantly lower BMI compared to those with Stage I and Stage II. Notably, the mean BMI difference was statistically significant when comparing Stage I vs. Stage III ($p = 0.003$, mean difference = 4.00), Stage I vs. Stage IV ($p < 0.001$, mean difference = 4.79), Stage II vs. Stage III ($p < 0.001$, mean difference = 5.57), and Stage II vs. Stage IV ($p < 0.001$, mean difference = 6.36). However, the difference between Stage III and Stage IV was not statistically significant ($p = 0.900$). These findings indicate a progressive reduction in BMI as COPD severity worsens, with Stage IV patients exhibiting the lowest BMI.

Table 3: Comparison of Mean Body Mass Index with Severity of COPD (Post Hoc Analysis)

(A) COPD-Severity (I)	(B) COPD-Severity (J)	BMI Mean Difference (I-J)	p-Value	95% CI	
				Lower Bound	Upper Bound
Stage I	Stage II	-1.56	0.524	-4.55	1.41
	Stage III	4.00*	0.003	1.06	6.95
	Stage IV	4.79*	<0.001	1.85	7.74
Stage II	Stage I	1.56	0.524	-1.41	4.55
	Stage III	5.57*	<0.001	2.55	8.59
	Stage IV	6.36*	<0.001	3.34	9.38
Stage III	Stage I	-4.00*	0.003	-6.95	-1.06
	Stage II	-5.57*	<0.001	-8.59	-2.55
	Stage IV	0.79	0.900	-2.18	3.77
Stage IV	Stage I	-4.79*	<0.001	-7.74	-1.85
	Stage II	-6.36*	<0.001	-9.38	-3.34
	Stage III	-0.79	0.900	-3.77	2.18

*p-value significant (<0.05)

DISCUSSION

In current study, 26.3% were diagnosed with COPD Stage I, 23.8% with Stage II, while Stage III and IV were observed in 25% patients each. GOLD classification system for COPD categorizes the disease into four stages based on percentage of predicted forced expiratory volume in one second, which is essential for assessing severity and guiding treatment strategies [12]. The distribution of patients across these stages varies, reflecting clinical

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burden of COPD. Compared to study by Haughney J *et al.*, where Stage II was the most prevalent (52.2%) and Stage IV was least common (5.2%), these findings show more even distribution of COPD severity [13].In current study, there was notable association between age and COPD severity, with younger patients (≤50 years) exhibiting more advanced disease (stage IV) compared to older individuals. The condition was also more severe in males than females, but no direct correlation was found between smoking history and disease severity.In contrast, Morena D *et al.*, found progressive increase in COPD severity with age, highlighting that older patients were more likely to have advanced stages of the disease [14].Sørheim IC *et al.*, reported that female COPD patients had higher prevalence of severe disease, with more females classified in GOLD Stage III and IV (50.4% vs. 35.6%, p=0.020) compared to males.These findings not aligning with current results, suggests that female patients may experience more rapid decline in lung function and greater disease severity, potentially due to biological differences, exposure patterns, or healthcare disparities [15].According to current study mean BMI has shown decrimental trend from Stage I to stage IV.Mean BMI difference was statistically significant when comparing Stage, I vs. III ($p = 0.003$), Stage I vs. IV ($p < 0.001$), Stage II vs. III ($p < 0.001$), and Stage II vs. IV ($p < 0.001$). However, difference between Stage III and IV was not statistically significant ($p = 0.900$).Studies have consistently supporting current findings, Suleiman, found that patients with more severe COPD (Stages III and IV) tend to have lower mean BMI compared to those with milder disease [16].A prospective cohort study of 1,755 COPD patients found that prevalence of low BMI and fat-free mass index increased with worsening spirometric stage and dyspnea score [17].In contrast, patients with mild or moderate COPD (Stages I and II) often exhibit higher mean BMI. For example, study by Wang H *et al.*, found that overweight and obese individuals were more likely to have mild COPD compared to underweight individuals [18]. Weight loss in COPD is primarily driven by muscle mass depletion, influenced by increased energy expenditure, reduced caloric intake, and metabolic dysfunction. Pro-inflammatory cytokines like TNF-α and tissue hypoxia contribute to muscle degradation and impaired energy production [19].Low BMI is strongly associated with worse COPD outcomes, but some researchers argue that BMI alone may not accurately reflect nutritional status due to factors like increased total body water, which could obscure the effects of malnutrition [20].

This study was limited by its cross-sectional design, which prevents establishing causal relationships between BMI decline and COPD progression, and by single-center non-probability sampling, which may reduce external validity. BMI alone may not fully capture body composition changes such as muscle wasting or fat-free mass depletion, potentially underestimating nutritional impairment. Future research should include multicenter longitudinal studies with larger sample sizes and incorporate comprehensive nutritional assessments, including muscle mass and metabolic markers, to better evaluate the role of nutritional status in COPD progression and patient outcomes.

CONCLUSIONS

The distribution of COPD severity was fairly even across all stages, with comparable proportion of patients in each stage and significant decline in BMI was observed as COPD severity increased. These findings highlight the importance of monitoring BMI in COPD patients, as lower BMI is associated with disease progression and worse clinical outcomes.

Authors' Contribution

Conceptualization: IJ, AJ, HKD
Methodology: IJ, AJ, ZZ, AU, HKD, MR
Formal analysis: MR
Writing and Drafting: ZZ, AU
Review and Editing: ZZ, AU, HKD, MR

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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