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ORIGINAL RESEARCH

Obesity Prevalence and Association with Spirometry Profiles, ICU Admission, and Comorbidities Among Patients with COPD: Retrospective Study in Two Tertiary Centres in Saudi Arabia

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Background: Obesity is common among chronic obstructive pulmonary disease (COPD) patients and is associated with an increase in acute exacerbation episodes. However, data on obesity's impact on and association with clinical outcomes among patients with COPD are limited. This study aimed to determine overweight and obesity prevalence and associations with spirometry profiles, intensive care unit (ICU) admission, and comorbidities in patients with COPD.

Methods: In this retrospective cohort study, we reviewed the electronic health records of adult individuals diagnosed with COPD who visited the studied pulmonary clinics between 1 January 2018 and 31 December 2022 and then collected key demographic variables and relevant clinical outcomes and comorbidities.

Results: A total of 474 patients with COPD were included in the final analysis, of whom 60% were male. The occurrences of overweight and obesity were 32.7% and 38.2%, respectively. The presence of comorbidities was high in obese patients (78.4%), followed by overweight patients (63.8%) with COPD. Obese and overweight patients had the highest ward admission rates (38.3% and 34.2%, respectively). ICU admissions were higher in obese and overweight patients (16% and 12%, respectively) compared with normal-weight patients (9%). Although no significant correlation was found between body mass index and spirometry parameters, comorbidities and ICU admission were linked to overweight and obesity in COPD patients (AOR: 1.82 95% CI: 1.15 to 2.86 and AOR: 3.34 95% CI 1.35 to 8.22, respectively).

Conclusion: Our findings imply that obesity in COPD is prevalent and is associated with adverse clinical outcomes including a greater number of comorbidities and higher rates of hospitalization and admission to ICUs although no associations were found between body weight and spirometry parameters. Further studies are needed to assess whether implementing and optimising obesity screening and management at an early stage in COPD can prevent further deterioration.

Keywords: COPD, obesity, ICU admission, spirometry parameters, comorbidities

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Introduction

Chronic obstructive pulmonary disease (COPD), defined as a preventable and treatable disease characterised by expiratory airflow limitation that is irreversible,[1] is one of the top three causes of death, with 90% of the death rate happening in low- and middle-income countries.[2,3] More than three million patients with COPD died in 2012, accounting for 6% of worldwide deaths.[4] Additionally, it has been projected that COPD will be responsible for 7.8% of global deaths in 2030.[4] The characteristics of respiratory symptoms of COPD are both chronic and progressive dyspnoea, cough and sputum production.[1] An acute deterioration in these respiratory symptoms, known as an acute exacerbation of COPD, is associated with higher use of medications, healthcare use, low levels of physical activity, and poor health, related to quality of life.[1] This association is also found more significantly in obese COPD patients compared with normal-weight COPD patients.[5–8]

Obesity is one of the several factors associated with worsening COPD symptoms.[9] Obesity is defined as an abnormal or excessive accumulation of fat or adipose tissue in the body that may impair health conditions.[10] Body mass index (BMI), which is weight in kilograms (kg) divided by the square of height in meters (m^2), is a common screening tool used to classify overweight and obesity.[11] For adults, the World Health Organization (WHO) defines overweight as a BMI of 25 to 29.9 kg/m^2 and obesity as a BMI of 30 kg/m^2 or greater.[12] The Centers for Disease Control and Prevention (CDC) further divide obesity into three classes: class I, or mild (30–34.9 kg/m^2), class II, or moderate (35–39.9 kg/m^2), and class III, or morbid (40 kg/m^2 or higher).[13]

Although weight loss is common in people with COPD, several studies have reported that around 65% of the COPD population is classified as overweight or obese.[5,6,14–16] More importantly, COPD patients who are overweight or obese have a higher prevalence rate of comorbid diseases, including hypertension, diabetes, osteoarthritis, and heart failure compared to normal-weight COPD patients.[6,8,14,15,17] Obesity in COPD is correlated with impaired health-related outcomes including worsening dyspnoea, quality of life, and exercise capacity compared with non-obese COPD patients.[17] Obesity is not only associated with subjective outcomes but also with a high risk of acute exacerbation of COPD, resulting in increasing hospital stays[17] and higher numbers of prescribed medications.[6–8]

Although a decline in forced expiratory volume (FEV_1) is considered to be an important prognostic marker in COPD, studies have demonstrated that force vital capacity (FVC) can provide valuable information for the diagnosis and monitoring of COPD.[18,19] Reduction in lung function has long been reported to be associated with the presence of several factors, including an increase in the frequency of acute exacerbations. Decreased FVC is associated with several comorbidities, one of which is obesity.[20,21] In people with COPD, obesity could restrict FVC by the accumulation of adiposity in the abdominal and thoracic parts, which may directly decrease vital capacity by reducing lung expansion room during inspiration.[22] Given the vast burden of COPD in Saudi Arabia[23] and the lack of data on the effects of obesity on lung function, particularly spirometry measures and other clinical profiles in Saudi COPD patients, this study sought to report on the prevalence of overweight and obesity and their effects on spirometry parameters and other clinical outcomes in people living with COPD.

Materials and Methods

Study Design and Settings

This is a retrospective cohort study that took place in Al-Noor Specialist Hospital, Makkah, Saudi Arabia and King Abdulaziz University Hospital, Jeddah, Saudi Arabia between 1 October 2022 and 1 February 2023.

Study Design and Sample Selection

The study retrospectively reviewed electronic health records (EHR) of 706 adult individuals who visited the studied pulmonary clinics between 1 January 2018 and 31 December 2022 with a documented diagnosis of COPD based on appropriate smoking exposure history and accepted Global Initiative for Chronic Obstructive Lung Disease criteria. The individuals identified were then screened for complete spirometry, acceptable and reproducible spirometry results and BMI data; those with missing or inadequate data were excluded.

Data Collection

Demographic Information

Key demographic variables such as age, gender, smoking status and relevant clinical characteristics were extracted from the EHR.

Spirometry Results

The study included only patients with spirometry tests that adhered to the prevailing guidelines of the American Thoracic Society/European Respiratory Society. These spirometry tests were conducted by trained pulmonary function technologists in pulmonary clinics. While routine validation of the pulmonary function tests was performed by a respiratory consultant, all spirometry tests used in this study underwent additional manual review by two trained senior respiratory therapists (A.A.A. and A.M.A.). Acceptable and reproducible spirometry data, including forced expiratory volume in one second (FEV_1) and FVC, were collected. Only spirometry results meeting established quality standards were included, using a Sensor Medics Vmax 22 machine manufactured by SensorMedics Corporation in Anaheim, California, USA.

BMI

Complete BMI measurements, calculated based on recorded height and weight, were collected to assess patients' weight status. Height and weight measurements were routinely conducted in the clinics, following established protocols, with patients being barefoot and wearing lightweight clothing. A medical scale manufactured by Adam Equipment Inc., Oxford, CT, USA, was used for these measurements. The BMI values were calculated based on the recorded heights and weights obtained before the performance of spirometry tests. To classify the COPD patients, we employed the classifications recommended by the WHO and the CDC,[24,25] where the patients were divided into three groups according to their BMI values: (1) lean or healthy weight (BMI values ranging from 18.5 to 24.9 kg/m^2; (2) overweight: BMI values ranging from 25 to 29.9 kg/m^2; (3) obesity: patients with BMI values of 30 kg/m^2 or above.

Comorbidity Information

Relevant comorbidities such as cardiovascular diseases, diabetes, and hypertension were extracted from the EHR to evaluate their potential influence on the outcomes of interest.

Smoking History

Information on smoking status was collected, as smoking is a significant risk factor for COPD.

Clinical Outcomes

Relevant clinical outcomes, including hospitalisation, ICU admissions, and other COPD-related outcomes, were assessed using available data from the EHR.

Ethical Considerations

This study was carried out in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Unit of Biomedical Ethics Research Committee at Al-Noor Specialist Hospital, Makkah, Saudi Arabia and the Faculty of Medicine at King Abdulaziz University, Saudi Arabia, to ensure patients' privacy, confidentiality, and adherence to ethical guidelines. Given that this is a retrospective study, the need for patient consent was waived by the ethics committee.

Statistical Data Analysis

In this study, data were analysed using IBM SPSS software (version 28). The figures presented were generated using GraphPad Prism (version 9). Descriptive statistics were used to summarise the characteristics of the study population, including demographic variables, spirometry results, BMI data, comorbidities, and clinical outcomes. Pearson correlation test was used to examine correlation between study variables. Potential confounding factors such as age, gender, and smoking history were accounted for through bivariate logistic regression models, adjusting for relevant covariates. For this study, $p<0.05$ was considered statistically significant.

Results

Patient Characteristics

A total of 706 patients visited the studied pulmonary clinics, 230 of whom were excluded as they had missing data or had no acceptable and reproducible spirometry results. Thus, 474 patients with COPD were included in the final analysis (Figure 1).

In the current study, we reported data from 474 COPD patients; 60% were male. Of those patients, 11 were underweight, 127 were normal-weight, 155 were overweight, and 181 were obese. Among all patients, 118 were non-smokers (25%), 169 were ex-smokers (35.6%), and 149 were current smokers (31.4%). Smoking was greatest among overweight patients (43.8%), whereas 31 obese individuals (35.5%) smoked. The presence of comorbidities (defined as having two or more coexisting disorders other than obesity) was high in obese patients (143, or 79.4%), followed by overweight patients (99, or 63.8%). We also reported the ward admission history due to COPD in the last two years

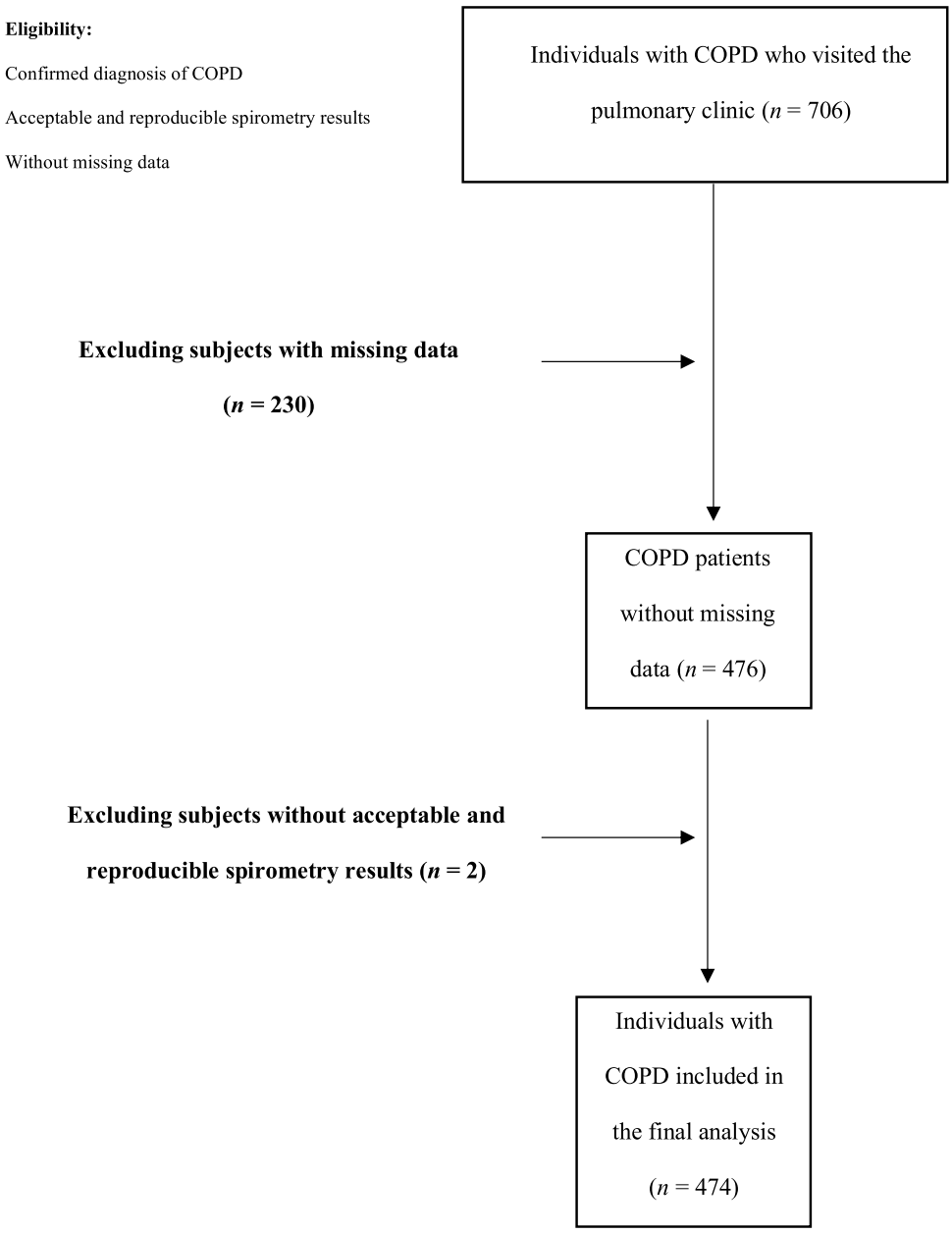

Figure 1 Flow chart of the study.

among all patients. Obese and overweight patients had the highest admission rates (69, or 38.3% and 53, or 34.2%, respectively). More importantly, admission to the ICU was high in obese and overweight patients (12.3% and 16%, respectively) compared with normal-weight patients (5.8%). A detailed description of the clinical characteristics of all patients can be found in Table 1.

Correlation Between BMI and Spirometry Parameters

We found no significant associations of BMI with preFVC L and preFVC % predicted (r = −0.02, p = 0.63 and r = 0.01, p = 0.77, respectively) and FEV_1 L and FEV_1% predicted (r = 0.00, p = 0.99 and r = −0.02, p = 0.66, respectively) (Figure 2A–D). Similarly, FEV_1/FVC % predicted was not associated with BMI (r = 0.03, p = 0.51) among COPD patients (Figure 2E).

Potential Factors Associated with Overweight and Obesity in Patients with COPD

Logistic regression analyses were performed to identify potential factors associated with overweight and obesity (BMI of 25 kg/m^2 or above) in patients with COPD; see Table 2. Comorbidities were associated with 86% increased odds of overweight and obesity in COPD patients (OR: 1.86; 95% CI: 1.21 to 2.85; p<0.001). Further, ICU admission within the past two years was associated with overweight and obesity (OR: 2.86; 95% CI: 1.21 to 6.51; p<0.001). Gender, age, and smoking status were not related to overweight and obesity.

In the fully adjusted model (adjusted for age, gender, and smoking status), comorbidities and ICU admission were related to overweight and obesity in COPD patients (OR: 1.82; 95% CI: 1.15 to 2.86; p<0.001 and OR: 3.34; 95% CI 1.35 to 8.22, respectively).

Discussion

To the best of our knowledge, this is the first study to determine the prevalence of overweight and obesity among Saudi patients with COPD and to evaluate their associations with spirometry measures, comorbidities, and ICU and hospital admissions among COPD patients. Our findings demonstrated that 71% of patients with COPD were either obese or

Table 1 Patients Characteristics (n=474)

Variable	All Patients (n = 474)	Underweight (n = 11)	Normal Weight (n = 127)	Overweight (n = 155)	Obesity (n = 181)
Males	285 (60.1%)	5 (45.4%)	82 (64.6%)	103 (66.5%)	95 (52.5%)
Age (mean (SD)	66 (12.0)	68.7 (12.0)	64.9 (11.7)	64.8 (11.3)	67.8 (45.9)
Non-smokers	118 (25%)	4 (30.0%)	23 (18.1%)	34 (21.9%)	57 (31.6%)
Ex-smokers	169 (35.6%)	6 (54.5%)	53 (41.7%)	53 (34.1%)	59 (32.7%)
Smokers	149 (31.4%)	1 (9%)	51 (40.1%)	68 (43.8%)	31 (35.5%)
Comorbidities	324 (67.0%)	8 (72.7%)	74 (58.3%)	99 (63.8%)	143 (79.4%)
Admission history due to COPD in the past 2 years	169 (35.7%)	3 (27.3%)	44 (34.6%)	53 (34.2%)	69 (38.3%)
ICU Admissions in the last 2 years	56 (11.8%)	1 (9%)	7 (5.5%)	19 (12.3%)	29 (16%)
Number of all admissions in the past 2 years					
1	96 (20.2%)	1 (10.0%)	31 (24.4%)	29 (18.7%)	35 (19.3%)
2	46 (9.7%)	0	10 (7.8%)	17 (11.0%)	19 (10.5%)
3 and above	30 (6.3%)	2 (18.2%)	4 (3.2%)	8 (5.2%)	16 (8.8%)

Notes: Data are represented as mean (SD) unless otherwise stated. Underweight, Normal weight, overweight, obesity are classified based on BMI according to the classification of World Health Organization: Underweight below 18.5 kg/m^2, normal weight 18.5–24.9 9 kg/m^2, overweight 25–29.9 kg/m^2, and obesity 30 kg/m^2 and greater.
Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; ICU, intensive care unit.

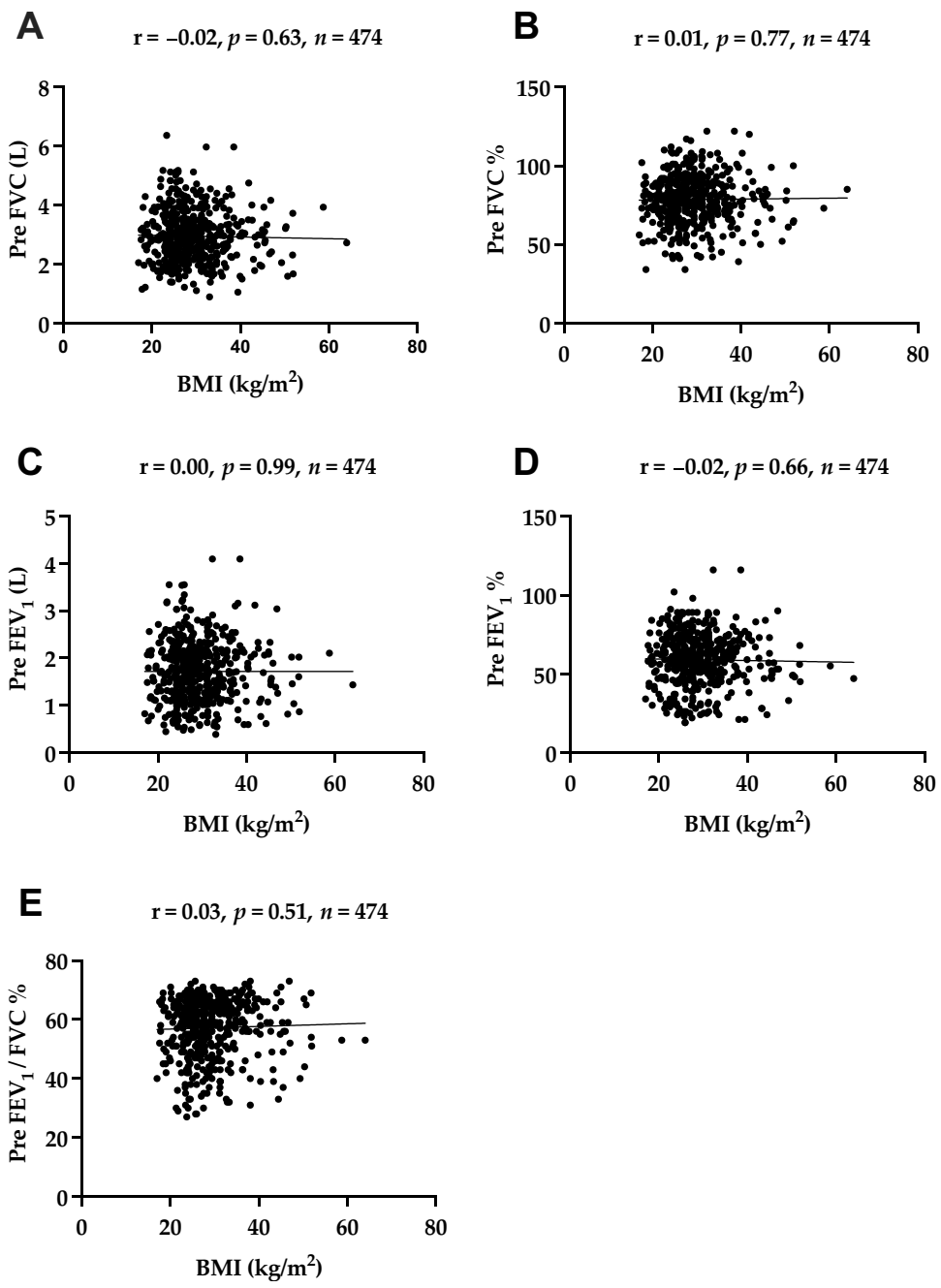

Figure 2 Correlation between BMI kg/m^2 with prebronchodilator forced vital capacity (preFVC) L (**A**), preFVC % (**B**), prebronchodilator forced expiratory volume in one second (preFEV$_1$) L (**C**), preFEV$_1$% (**D**), and prebronchodilator FEV$_1$/FVC % (**E**), among patients with COPD.

overweight. Although no associations were observed between BMI and spirometry profiles, obese patients with COPD had higher numbers of comorbidities and higher ICU admission rates compared with normal-weight patients with COPD. These observations provide alarming evidence of the high prevalence of overweight and obesity among patients with COPD in Saudi Arabia and suggest that obesity in COPD can lead to negative clinical outcomes. This points to the need for the implementation of obesity screening and treatment plans at an early stage in COPD to prevent further deterioration.

The incidence of obesity has increased globally, leading to an increase in the prevalence, morbidity, and clinical manifestations of several respiratory disorders.[26] Our findings demonstrated that overweight and obesity are prevalent

Table 2 Bivariate Logistic Regression Models of the Factors Associated with Overweight and Obesity in Patients with COPD

Descriptor	OR (95% CI)	Adjusted OR (95% CI)
Gender		
Female	1	
Male	0.78 (0.51–1.20)*	
Age		
Below 66 years	1	
> 66 years	0.98 (0.65–1.48)	
Smoking Status		
Non-smokers	1	
Ex-smokers	0.53 (0.30–0.93)	
Current smokers	0.65 (0.37–1.14)	
Comorbidities		
No	1	1
Yes	1.86 (1.21–2.85)**	1.82 (1.15–2.86)***
ICU Admission		
No	1	
Yes	2.86 (1.26–6.51)*	3.34 (1.35–8.22)*
Admission history due to COPD in the past 2 years		
No	1	1
Yes	1.08 (0.70–1.65)	0.74 (0.45–1.19)

Notes: Adjusted model include age, gender and smoking. *p < 0.05, **p < 0.01, ***p < 0.001.
Abbreviations: COPD, chronic obstructive pulmonary disease; ICU, intensive care unit.

among Saudi patients with COPD, representing 71% of total patients. In agreement with these findings, a study showed that the majority of COPD subjects in the Middle East and North Africa region were overweight or obese.[15] Furthermore, a study conducted in Spain showed that obesity or overweight was more prevalent in COPD patients than in participants without airway limitations.[6] Several health consequences are linked to obesity in COPD patients, including increased dyspnoea and receiving more inhaled medicine prescriptions compared to normal-weight subjects.[7] Our findings also showed no association between BMI and spirometry parameters. It has been shown that slight obesity is a protective factor for lung function in people at risk of COPD.[27] The protective role of obesity is confirmed by another study, which supports the beneficial role of obesity in lowering mortality and showed that BMI more than 30 kg/m^2 was related to increased spirometry parameters (FEV_1 and FVC) in COPD patients with ischemic heart disease and mild obesity.[28] Another study found that obesity among healthy, non-smoking individuals does not affect the spirometry parameters other than peak expiratory flow rate compared to non-obese subjects.[29] In contrast to our findings and these observations, other reports demonstrated obese patients with COPD had lower spirometry parameters than non-obese COPD patients.[6,30] Possible explanations for the discrepancies between the findings of these studies and those of our study exist. Obese individuals with COPD usually report increased dyspnoea and poorer quality of life than their normal-

weight peers.[7] The presence of these signs and symptoms would encourage individuals to seek medical help sooner, which would enable an earlier intervention. Second, obesity is a marker for less cumulative tobacco exposure and people who stop smoking gain more weight over time than those who continue using tobacco.[24] Therefore, obesity could be protective against the progression of the disease among patients with similar amounts of tobacco exposure. However, the relationship between BMI and spirometry measures in COPD patients in different classes of obesity needs further investigation in well-designed prospective clinical studies.

Being overweight or obese has a harmful influence on a person's physical, emotional, and social well-being and society as a whole through higher healthcare costs. In the current study, comorbidities were associated with increased odds of overweight and obesity in COPD patients, suggesting that obesity can increase the likelihood of developing other comorbidities. Although the association between obesity and comorbidities in COPD has not been assessed before, our finding is similar to previous studies showing an independent association between obesity and other non-pulmonary diseases such as heart failure, cardiac arrhythmia, coronary artery disease and sleep apnoea.[25,31,32] In support of these findings, obese people were reported to be three to four times more likely to have any cardiometabolic risk factor than normal-weight people.[33] These findings, together with our observations showing that obese COPD patients had higher numbers of comorbidities, suggest that obesity in patients with COPD may lead to increased hospitalisations and healthcare costs.

To the best of our knowledge, this is the first study to report higher rates of ICU admissions among obese patients with COPD compared with normal-weight patients. Importantly, ICU admission within the past two years was associated with overweight and obesity. This is, to some extent, justified by the association of obesity and comorbidities, which increases the need for more medications and the chance of hospitalisation. This is supported by a previous study showing that obese COPD patients have longer lengths of stay and higher hospital expenditures, implying that they place a significant burden on the healthcare systems.[34] In addition, obese COPD patients were more likely to require non-invasive and invasive ventilation and had longer hospital stays than those who were not obese.[35] Based on these findings, it is reasonable to encourage researchers and clinicians to develop targeted preventive and therapeutic approaches like weight loss through physical exercise and a healthy diet in the treatment plan for COPD patients to reduce hospital admissions and improve COPD symptoms and overall quality of life.

This study has several strengths. It is the first study to report on the association between obesity and other comorbidities and rates of admission to wards and ICU among Saudi patients with COPD. In addition, although the prevalence and impact of obesity on lung functions and clinical parameters have previously been assessed in patients with asthma,[36] no studies in Saudi Arabia have addressed COPD in the same way, making this study the first of its kind and a vital first step in opening paths for further exploration. Additionally, with adherence to the current American Thoracic Society/European Respiratory Society guidelines, conduct of the spirometry tests and evaluation and validation of the reports were done by trained pulmonary function technologists and respiratory consultants. These spirometry tests underwent additional manual review by trained respiratory therapists to ensure that the tests performed in this study were well-validated and highly accurate. Furthermore, the measurement of patients' height and weight was carried out inside the clinics before the spirometry test was done, with the patients barefoot and wearing light clothes to obtain accurate results, and the BMI was calculated according to the recorded measurements.

Our study is not without limitations. The patient's level of adherence to pharmacological and non-pharmacological therapies was not assessed because the data in the current study were collected retrospectively and information on adherence to therapies was not available. However, it remains important to assess patients' adherence to their medications, pulmonary rehabilitation sessions, and lifestyle changes in future studies. Moreover, this study was conducted on Saudi Arabian patients with COPD. Consequently, the results may not apply to other ethnicities. Finally, this study was conducted in two large medical centres located in the Western Region of Saudi Arabia. Including more hospitals from different regions within Saudi Arabia should be considered for future studies to improve the diversity of study findings.

Our study has practical implications. Given the substantial prevalence of COPD in Saudi Arabia[23] and the limited knowledge and awareness of this condition among the general public in the country,[37] coupled with the notable prevalence of overweight and obesity among Saudi patients diagnosed with COPD in our study, it is imperative that

national public health campaigns should be implemented to effectively address and mitigate these risks. When COPD is diagnosed at an early stage, it is crucial to develop and optimise obesity screening and treatment practices to avoid future worsening of symptoms which lead to hospital and ultimately ICU admission.

Conclusion

Our findings demonstrated that obesity and overweight are prevalent among COPD and are associated with adverse clinical outcomes, including higher numbers of comorbidities and admission rates to ICU but are unlikely to be associated with further impairment in spirometry parameters. These findings suggest obesity is likely to negatively impact the clinical outcomes of COPD patients and point toward a need for early implementation of obesity screening and management programmes for COPD patients in the healthcare system to prevent further deterioration.

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Disclosure

The authors declare no conflict of interest in this work.

References

1. Agusti A, Celli BR, Criner GJ, et al. Global initiative for chronic obstructive lung disease 2023 report: GOLD executive summary. *Respirology*. 2023;28(4):316–338. doi:10.1111/resp.14486
2. Meghji J, Mortimer K, Agusti A, et al. Improving lung health in low-income and middle-income countries: from challenges to solutions. *Lancet*. 2021;397(10277):928–940. doi:10.1016/S0140-6736(21)00458-X
3. Halpin DMG, Celli BR, Criner GJ, et al. The GOLD summit on chronic obstructive pulmonary disease in low- and middle-income countries. *Int J Tuberc Lung Dis*. 2019;23(11):1131–1141. doi:10.5588/ijtld.19.0397
4. Mathers CD, Loncar D, Samet J. Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med*. 2006;3(11):e442. doi:10.1371/journal.pmed.0030442
5. Vozoris NT, O'Donnell DE. Prevalence, risk factors, activity limitation and health care utilization of an obese, population-based sample with chronic obstructive pulmonary disease. *Can Respir J*. 2012;19(3):e18–e24. doi:10.1155/2012/732618
6. Garcia-Rio F, Soriano JB, Miravitlles M, et al. Impact of obesity on the clinical profile of a population-based sample with chronic obstructive pulmonary disease. *PLoS One*. 2014;9(8):e105220. doi:10.1371/journal.pone.0105220
7. Cecere LM, Littman AJ, Slatore CG, et al. Obesity and COPD: associated symptoms, health-related quality of life, and medication use. *COPD*. 2011;8(4):275–284. doi:10.3109/15412555.2011.586660
8. Verberne LDM, Leemrijse CJ, Swinkels ICS, van Dijk CE, de Bakker DH, Nielen MMJ. Overweight in patients with chronic obstructive pulmonary disease needs more attention: a cross-sectional study in general practice. *NPJ Prim Care Respir Med*. 2017;27(1):63. doi:10.1038/s41533-017-0065-3
9. Ma YL, Zhao HJ, Su YH. Association between waist circumference change and incident chronic obstructive pulmonary disease among Chinese adults: a 10-year cohort study. *Sci Rep*. 2022;12(1):18402. doi:10.1038/s41598-022-23248-z
10. Lundequist A, Nallamshetty SN, Xing W, et al. Prostaglandin E(2) exerts homeostatic regulation of pulmonary vascular remodeling in allergic airway inflammation. *J Immunol*. 2010;184(1):433–441. doi:10.4049/jimmunol.0902835
11. Ghesmaty Sangachin M, Cavuoto LA, Wang Y. Use of various obesity measurement and classification methods in occupational safety and health research: a systematic review of the literature. *BMC Obes*. 2018;5:28. doi:10.1186/s40608-018-0205-5
12. Obesity and overweight by World Health Organization. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. Accessed January 13, 2023.
13. Defining adult overweight & obesity by centers for disease control and prevention. Available from: https://www.cdc.gov/obesity/basics/adult-defining.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fobesity%2Fadult%2Findex.html#print. Accessed January 13, 2023.
14. Eriksson B, Backman H, Bossios A, et al. Only severe COPD is associated with being underweight: results from a population survey. *ERJ Open Res*. 2016;2(3). doi:10.1183/23120541.00051-2015
15. Koniski ML, Salhi H, Lahlou A, Rashid N, El Hasnaoui A. Distribution of body mass index among subjects with COPD in the Middle East and North Africa region: data from the BREATHE study. *Int J Chron Obstruct Pulmon Dis*. 2015;10:1685–1694. doi:10.2147/COPD.S87259
16. Montes de Oca M, Talamo C, Perez-Padilla R, et al. Chronic obstructive pulmonary disease and body mass index in five Latin America cities: the PLATINO study. *Respir Med*. 2008;102(5):642–650. doi:10.1016/j.rmed.2007.12.025
17. Lambert AA, Putcha N, Drummond MB, et al. Obesity is associated with increased morbidity in moderate to severe COPD. *Chest*. 2017;151(1):68–77. doi:10.1016/j.chest.2016.08.1432
18. Moon SM, Lim JH, Hong YS, et al. Clinical impact of forced vital capacity on exercise performance in patients with chronic obstructive pulmonary disease. *J Thorac Dis*. 2021;13(2):837–846. doi:10.21037/jtd-20-1098a

19. Kang N, Shin SH, Gu S, et al. The impact of low forced vital capacity on behavior restrictions in a population with airflow obstruction. *J Thorac Dis*. 2019;11(4):1316–1324. doi:10.21037/jtd.2019.03.77
20. Godfrey MS, Jankowich MD. The vital capacity is vital: epidemiology and clinical significance of the restrictive spirometry pattern. *Chest*. 2016;149(1):238–251. doi:10.1378/chest.15-1045
21. Lee HM, Le H, Lee BT, Lopez VA, Wong ND. Forced vital capacity paired with Framingham risk score for prediction of all-cause mortality. *Eur Respir J*. 2010;36(5):1002–1006. doi:10.1183/09031936.00042410
22. Salome CM, King GG, Berend N. Physiology of obesity and effects on lung function. *J Appl Physiol*. 2010;108(1):206–211. doi:10.1152/japplphysiol.00694.2009
23. Alqahtani JS, Abdel-Moneim AS. Prevalence, incidence, morbidity and mortality rates of COPD in Saudi Arabia: trends in burden of COPD from 1990 to 2019. *PLoS One*. 2022;17(5):e0268772. doi:10.1371/journal.pone.0268772
24. O'Hara P, Connett JE, Lee WW, Nides M, Murray R, Wise R. Early and late weight gain following smoking cessation in the Lung Health Study. *Am J Epidemiol*. 1998;148(9):821–830. doi:10.1093/oxfordjournals.aje.a009706
25. Fitzgerald AP, Jarrett RJ. Body weight and coronary heart disease mortality: an analysis in relation to age and smoking habit. 15 years follow-up data from the Whitehall Study. *Int J Obes Relat Metab Disord*. 1992;16(2):119–123.
26. Dixon AE, Peters U. The effect of obesity on lung function. *Expert Rev Respir Med*. 2018;12(9):755–767. doi:10.1080/17476348.2018.1506331
27. Tang X, Lei J, Li W, et al. The relationship between BMI and lung function in populations with different characteristics: a cross-sectional study based on the enjoying breathing program in China. *Int J Chron Obstruct Pulmon Dis*. 2022;17:2677–2692. doi:10.2147/COPD.S378247
28. Nemish I, Stupnytska G, Fediv O, Nesterovska O. Correlation between body mass index and spirometry parameters in chronic obstructive pulmonary disease patients with ischemic heart disease and obesity. *Eur Respir J*. 2019;54(suppl 63):1.
29. Al Ghobain M. The effect of obesity on spirometry tests among healthy non-smoking adults. *BMC Pulm Med*. 2012;12(1):10. doi:10.1186/1471-2466-12-10
30. Park JH, Lee JK, Heo EY, Kim DK, Chung HS. The effect of obesity on patients with mild chronic obstructive pulmonary disease: results from KNHANES 2010 to 2012. *Int J Chron Obstruct Pulmon Dis*. 2017;12:757–763. doi:10.2147/COPD.S126192
31. PI-SUNYER FX. Comorbidities of overweight and obesity: current evidence and research issues. *Med Sci Sports Exerc*. 1999;31(11):S602. doi:10.1097/00005768-199911001-00019
32. Vgontzas AN, Tan TL, Bixler EO, Martin LF, Shubert D, Kales A. Sleep apnea and sleep disruption in obese patients. *Arch Intern Med*. 1994;154(15):1705–1711. doi:10.1001/archinte.1994.00420150073007
33. Schienkiewitz A, Mensink GBM, Scheidt-Nave C. Comorbidity of overweight and obesity in a nationally representative sample of German adults aged 18–79 years. *BMC Public Health*. 2012;12(1):658. doi:10.1186/1471-2458-12-658
34. Bhide P, Bapaye J, Mohan G, et al. Impact of obesity on in-hospital morbidity and mortality among patients admitted for acute exacerbations of Chronic Obstructive Pulmonary Disease (COPD). *Cureus*. 2023;15(2):e35138. doi:10.7759/cureus.35138
35. Goto T, Hirayama A, Faridi MK, Camargo CA Jr, Hasegawa K. Obesity and severity of acute exacerbation of chronic obstructive pulmonary disease. *Ann Am Thorac Soc*. 2018;15(2):184–191. doi:10.1513/AnnalsATS.201706-485OC
36. Alqarni AA, Aldhahir AM, Siraj RA, et al. Prevalence of overweight and obesity and their impact on spirometry parameters in patients with asthma: a multicentre, retrospective study. *J Clin Med*. 2023;12(5):1843. doi:10.3390/jcm12051843
37. Alqahtani JS, Aldhahir AM, Siraj RA, et al. A nationwide survey of public COPD knowledge and awareness in Saudi Arabia: a population-based survey of 15,000 adults. *PLoS One*. 2023;18(7):e0287565. doi:10.1371/journal.pone.0287565