Original Article

Anthropometry and BODE Index in Stable Chronic Obstructive Pulmonary Disease Patients and its Correlation with Disease Severity and Health-Related Quality of Life

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Abstract

Introduction: Patients with chronic obstructive pulmonary disease (COPD) are often malnourished with resultant poor health-related quality of life (HRQoL). This study aimed to determine various anthropometric indices and the BODE index in stable COPD patients and correlate them with HRQoL using the St. George's Respiratory Questionnaire (SGRQ). **Materials and Methods:** A cross-sectional, observational study was done between August 2019 and September 2021 at a tertiary care hospital in 100 stable COPD patients. **Results:** Fifty-four males and 46 females with a mean age of 53 ± 11 years. Average body mass index (BMI) was 21.27 ± 2.62 kg/m^2. The mean BODE index of the study participants was 4.37 ± 1.78. The anthropometric indices – triceps/scapular skin fold thickness, waist-to-hip ratio, and mid-upper-arm circumference did not correlate significantly with worsening Global Initiative for COPD (GOLD) stages (one-way analysis of variance [ANOVA] $P > 0.05$). There was a correlation between decreasing BMI and the worsening GOLD stage (one-way ANOVA $P < 0.05$). The anthropometric indices did not correlate with the BODE Index (Pearson Correlation coefficient $P > 0.05$). On linear regression analysis, higher GOLD stage, higher Modified Medical Research Council grade, and lower BMI correlated with higher SGRQ score. **Conclusion:** Stable COPD patients with low BMI and poor BODE index had poor HRQoL. Other anthropometric indices did not correlate with HRQoL.

Keywords: Anthropometry, body mass index, chronic obstructive, pulmonary disease, quality of life

Introduction

Chronic obstructive pulmonary disease (COPD) is a common respiratory condition punctuated by periods of acute exacerbations, characterized by persistent symptoms such as cough and breathlessness due to chronic exposure to noxious particles, gases, and smoking. On spirometry, postbronchodilator forced expiratory volume in 1 s/forced vital capacity (FEV1/FVC <0.70 confirms COPD diagnosis).[1]

Malnutrition and weight loss are prevalent in COPD.[2] These individuals have higher nutritional requirements due to systemic inflammation and increased work of breathing. Furthermore, recurrent superadded infections and COPD exacerbations lead to a persistent catabolic state.[3] Anthropometric indices are used to evaluate the nutritional status. The evaluation is inexpensive and can be repeated over a period.

In developing countries, including India, studies assessing the relationship of nutritional status with COPD with the stages of the disease are scarce. The current study aims to fill this lacuna in the literature of Indian COPD patients and evaluates the anthropometric indices in COPD patients, calculates the BODE index, and correlates them with the questionnaire-based evaluation of health-related quality of life (HRQoL).

Materials and Methods

An observational, cross-sectional study was done between August 2019 and September 2021 at a tertiary care hospital in

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Maharashtra, India. Approval was taken from the Institutional Scientific and Ethics Committee before the commencement of the study (IEC Ref No: I.E.S.C./143/2019).

Patients aged ≥18 years with chronic respiratory complaints (breathlessness, dry or productive cough with chest discomfort), fulfilling spirometry criteria of "ratio of postbronchodilator FEV1 to the FVC <0.70" were selected for the study.

The following were excluded from the study – patients with acute exacerbation of COPD during admission or in the preceding 4 weeks, having comorbidities such as chronic kidney, liver, thyroid disease or malignancy, suffering from known cardiovascular disorders such as congenital, valvular or ischemic heart disease, suffering from any chronic disease induced cachexia, those with relative contraindications to spirometry and with physical and cognitive impairment making them incapable of completing the walk test or questionnaire.

A total of 465 patients diagnosed with COPD were admitted to the hospital during the study duration. Figure 1 shows the algorithm for the selection of the study participants.

Sample size of 101 was obtained on calculation using WINPEPI software considering the prevalence of COPD as 7% (confidence interval: 95%, margin of error: 5%).[4] It matched with the number of patients who could be considered for the study. An informed and written consent was taken from all the study participants before enrolling in the study. Selected patients underwent spirometry, followed by measurement of anthropometric indices and administration of questionnaires, as described below.

"COSMED Pulmonary Function Equipment– Model Quark PFT 2008," was used for the spirometry. All values of FVC, FEV1, and the ratio of FEV1 to FVC were measured after the three acceptable FVC maneuvers. The largest FVC and FEV1 values were recorded as a result. Furthermore, postbronchodilator FEV1 was recorded for classifying the COPD patients.

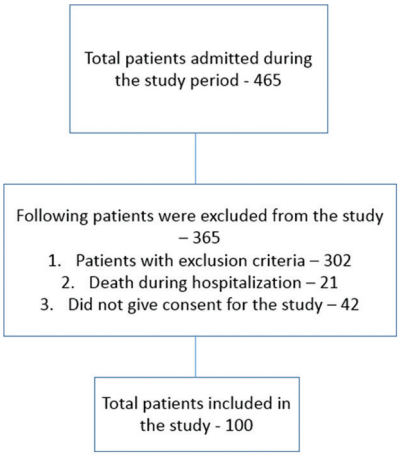

Figure 1: Algorithm for the selection of the study participants

Bronchodilators administered–400 mcg beta-agonist (short-acting); 160 mcg anticholinergic (short-acting) or combined anti-cholinergic with beta-agonist.

All the patients were classified based on the postbronchodilator FEV1 into Global Initiative for COPD (GOLD) stages: Stage 1: Mild: FEV_1 ≥80% predicted; Stage 2: Moderate: 50% ≤FEV_1 <80% predicted; Stage 3: Severe: 30% ≤FEV_1 <50% predicted; Stage 4: Very Severe: FEV_1 <30% predicted.

The same trained investigator performed all anthropometric measurements.

Study participants were appropriately exposed, and measurements were taken in a standing position with feet positioned close together and arms by the side.

Body mass index (BMI) was calculated using the following formula (Quetelet Index): "BMI (kilogram/meter^2) = Weight (kilogram)/(Height [metre])^2." Waist circumference (WC) and hip circumference (HC) were measured using nonstretchable tape to the nearest 1 mm. WC was taken at the end of normal expiration at the midpoint of an imaginary line joining the lower margin of the last palpable rib to the top of the iliac crest. HC was taken at the maximum circumference over the buttocks. Waist-to-hip ratio was taken as the ratio of WC to HC.

Skinfold thickness was measured using a Harpenden caliper (British Indicators Ltd, St Albans UK). Triceps skin fold thickness (TSFT) was measured on the lateral aspect of the right arm, and at the midpoint of the imaginary line between the acromion processes to the inferior margin of the olecranon process, elbow positioned at 90°. Scapular skin fold thickness (SSFT) was measured under the lower angle of the right scapula (10 cm above the left superior iliac crest in the mid-axillary line and along the horizontal plane), along natural skin cleavage, at an angle of 45°. Mid-upper-arm circumference (MUAC) was measured at the same level as the TSFT.

"BODE Index (B for BMI, O for airflow obstruction, D for dyspnea, and E for exercise tolerance)" was calculated using the four variables: body composition (BMI), the intensity of airflow obstruction (FEV1% predicted postbronchodilator), subjective sensation of dyspnea Modified Medical Research Council (mMRC scale), and exercise tolerance.[5]

All patients had to answer the St. George's Respiratory Questionnaire (SGRQ)-C Questionnaire specific for COPD patients.[6] The current study converted SGRQ-C to SGRQ scores as given in the questionnaire protocol. The questionnaire was translated into respective vernacular languages for patients who did not understand English.

Statistical analysis

Data were analyzed using SPSS Ver. 20 (IBM, Chicago, Illinois, USA) for Windows 10. Variables were identified as categorical or continuous and then expressed as frequency and percentage or mean and standard deviation. Following

statistical tests were applied wherever necessary – One-way analysis of variance (ANOVA) test to find correlation between categorical variables, Pearson Correlation Coefficient, and linear regression analysis to establish the relationship between dependent and independent variables. A $P < 0.05$ was considered statistically significant at a 95% confidence interval.

Results

Out of the total 100 participants, there were 54 males (54%) and 46 female (46%) participants with a mean age of 53 ± 11 years and the age range of 21–78 years.

Table 1 shows the clinical and demographic parameters of the study participants. Average BMI of the cases was 21.27 ± 2.62 kg/m^2 with a range of 15–26 kg/m^2. Thirty-six (36%) out of 100 patients were smokers. All the smokers were males and smoked bidis with an average pack years of 12.5 ± 6.8. A total of 18 (18%) females had a history of exposure to biomass fuel for an average duration of 10.6 ± 4.3 years. The mean duration of COPD was 10.01 ± 3.30 years, and the range of disease duration was 2–15 years. Breathlessness was the most common symptom ($n = 68$; 68%) among the study participants. The mean mMRC grade of the study participants was 2.16 ± 0.77. Eighty-four percent of participants ($n = 84$) had breathlessness more than Grade 2 mMRC and were in GOLD Stage 2/3 of the disease. The mean BODE index of the study participants was 4.37 ± 1.78. All the anthropometric indices fell within the normal range for an adult patient.

The average spirometry readings of the study participants are shown in Table 2. All the spirometry parameters (pre- and postbronchodilator) were statistically significantly different across different stages of GOLD (One-way ANOVA test $P < 0.05$).

Table 3 shows the correlation of anthropometric indices and GOLD stages. The anthropometric indices did not change significantly with the increasing severity of COPD ($P > 0.05$), except BMI ($P < 0.05$). The mean SGRQ total score was 20.64 ± 3.37; Symptom score was 28.17 ± 17.04; Activity score was 20.46 ± 0.77; and Impact score was 20.32 ± 2.73.

Table 4 shows the correlation of HRQoL questionnaire scores with GOLD stages. The scores of all the four domains of SGRQ (Symptom, Activity, Impact, and Total scores) significantly worsened with advancing GOLD stages (ANOVA test $P < 0.05$). On applying "Pearson correlation co-efficient test" to study the correlation between SGRQ and the anthropometric indices with the BODE index, it was found that SGRQ Total and the Symptom scores had a significant correlation with the BODE index ($P < 0.05$). The anthropometric indices (TSFT, SSFT, and MUAC) did not show any significant correlation with BODE Index ($P > 0.05$).

Table 1: Demographic and clinical parameters in the study participants

Parameter	Male	Female	*P**
Age (years)	52.58±12.47	54±10.08	0.27 (NS)
Gender, *n* (%)	54 (54)	46 (46)	-
BMI	21.46±2.60	21±2.66	0.22 (NS)
Risk factors for COPD, *n* (%)			
Smoking	36 (36)	0	-
Biomass fuel exposure	0	18 (18)	
Duration of COPD (years), *n* (%)			
≤5	5 (5)	5 (5)	-
6-10	21 (21)	8 (8)	
>10	28 (28)	33 (33)	
Symptoms, *n* (%)			
Breathlessness	15 (15)	15 (15)	-
Breathlessness with cough			
Dry	13 (13)	6 (6)	
Productive	10 (10)	8 (8)	
Cough			
Dry	11 (11)	8 (8)	
Productive	5 (5)	8 (8)	
mMRC grade	2.29±0.76	2±0.76	0.03
GOLD staging			
Stage 1	7	2	-
Stage 2	21	22	
Stage 3	22	19	
Stage 4	4	3	
BODE index (4-year survival rate)			
0-2 points (80%)	7	7	
3-4 points (67%)	22	18	-
5-6 points (57%)	19	15	
7-10 points (18%)	6	6	
Anthropometric indices			
TSFT (mm)	17.31±3.30	16±3.58	0.08
SSFT (mm)	21.63±3.33	20.03±3.01	0.06
MUAC (cm)	22.70±3.06	21±3.48	0.07
WHR	0.86±0.11	1±0.03	0.07

*Test applied - Student's *t*-test. BODE: BMI, obstruction of airways (FEV_1), dyspnea grading with mMRC, exercise capacity using 6MWD, NS: Not significant, BMI: Body mass index, mMRC: Modified Medical Research council, 6MWD: 6 min walk distance, GOLD: Global Initiative for COPD, FEV_1: Forced expiratory volume in 1 s, TSFT: Triceps skin fold thickness, SSFT: Scapular skin fold thickness, MUAC: Mid upper arm circumference, WHR: Waist-to-hip ratio, COPD: Chronic obstructive pulmonary disease

Table 5 shows the correlation of SGRQ questionnaire with various parameters of COPD using the linear regression analysis. Higher GOLD stage, higher mMRC grade of dyspnea and poorer nutritional status (lower BMI) correlated with higher SGRQ Total Score (or worse HRQoL).

Discussion

In the current study, the age of most of the study participants fell in the fifth and sixth decades of life, with a range of 21–78 years. In a large multicenter study done across Europe

on COPD patients, the mean age was 55.9 ± 6.1 years.[7] Precise data about the age distribution in India are lacking. Few studies have shown that in Indian patients, the mean age of COPD is above 50 years.[8,9] COPD symptoms become more evident as disease progresses, which is when patients seek medical advice. Furthermore, with increasing age, there is a physiological decline in lung function and an increase in cumulative exposure to risk factors.

It has been believed that COPD is more prevalent in males due to their addiction to smoking and occupational exposure. However, there was a female preponderance in a cohort of 17,479 cases from Sweden. The almost comparable prevalence of COPD occurring in recent times in both genders can be attributed to the increasing frequency of smoking and addiction in females, which was previously mostly seen in males. Females are also more prone to develop the harmful effects of passive smoking.[10] Furthermore, household use of biomass/solid fuel, augments the risk of COPD in women by three to four folds, especially in the rural areas of developing countries like India.[11] Around 50% of deaths in developing countries, secondary to COPD, are assumed to be due to biomass exposure, and women comprise about 75% of the affected patients.[12] The prevalence of COPD increased with increasing duration of exposure, and there was a strong relationship between the risk of developing COPD and the age at which the biomass fuel exposure began.[13] Some studies also

Table 2: Average values of the spirometry parameters in the study participants

Parameter	Mean±SD	Range
FVC (L)	2.10±0.96	0.67-4.84
FEV_1 (L)	1.44±0.68	0.45–3.34
FEV_1/FVC	0.67±0.02	0.63–0.69
PB FVC (L)	2.39±1.11	0.73–5.45
PB FEV_1 (L)	1.61±0.76	3.71–0.51
PB FEV_1/FVC	0.67±0.02	0.69–0.64
Obs/Pred PB FEV_1	0.55±0.19	0.25–0.95

PB: Postbronchodilator, Obs: Observed, Pred: Predicted, FVC: Forced vital capacity, FEV_1: Forced expiratory volume in 1 s, SD: Standard deviation

Table 3: Correlation of anthropometric indices with global initiative for chronic obstructive lung disease stages

Anthropometric indices	GOLD stages				*P*-one-way ANOVA test
	1 (*n*=9)	2 (*n*=43)	3 (*n*=41)	4 (*n*=7)	
BMI (kg/m^2)	24.14±1.33	22.70±2.22	20.01±1.03	16.1±0.71	<0.00001
TSFT (mm)	16.66±2	16.58±3.83	17.19±3.1	17±4.76	0.875
SSFT (mm)	17.22±5.67	17.97±5.93	16.97±5.1	16±7.16	0.777
MUAC (cm)	22.22±1.64	21.93±3.61	22.09±3.1	22.86±4.63	0.92
WC (cm)	74.33±5.57	76.27±6.39	76.36±7	78.57±5.09	0.645
WHR	0.89±0.08	0.83±0.12	0.85±0.04	0.87±0.04	0.407

GOLD: Global initiative for COPD, BMI: Body mass index, TSFT: Triceps skin fold thickness, SSFT: Scapular skin fold thickness, MUAC: Mid upper arm circumference, WC: Waist circumference, WHR: Waist-to-hip ratio, ANOVA: Analysis of variance, COPD: Chronic obstructive pulmonary disease

Table 4: Correlation of health-related quality of life with global initiative for chronic obstructive lung disease stages

HRQoL questionnaires	GOLD stages				*P*
	I (*n*=9)	II (*n*=43)	III (*n*=41)	IV (*n*=7)	
SGRQ-symptom score	32.29±10.50	21.68±17.49	33.57±16.51	31.03±12.26	0.010
SGRQ-activity score	20.41±0.29	20.22±1.06	20.70±0.33	20.56±0.40	0.036
SGRQ-impact score	18.35±2.98	19.93±1.77	20.74±3.03	22.79±3.57	0.0052
SGRQ total score	20.26±2.65	19.32±2.93	21.8±3.60	22.40±2.31	0.0026

GOLD: Global initiative for COPD, HRQoL: Health-related quality of life, SGRQ: St. George's respiratory questionnaire, COPD: Chronic obstructive pulmonary disease

Table 5: Linear regression analysis of health-related quality of life (St. George's respiratory questionnaire score) with various parameters of chronic obstructive pulmonary disease

Parameter	Regression coefficient of symptom score (*P*)			
	SGRQ SS	SGRQ AS	SGRQ IS	SGRQ TS
GOLD stage	3.953 (0.80)	0.207 (0.041)	1.22 (0.001)	1.33 (0.002)
mMRC	1.96 (0.0001)	0.142 (0.153)	0.297 (0.404)	1.853 (0.0001)
6MWD	3.449 (0.079)	0.157 (0.075)	0.940 (0.002)	1.090 (0.004)
BMI	−1.240 (0.057)	−0.040 (0.169)	−0.290 (0.005)	−0.362 (0.004)

GOLD: Global Initiative for COPD, SGRQ: St. George's respiratory questionnaire, BMI: Body mass index, mMRC: Modified Medical Research Council, 6MWD: 6-min walk distance, COPD: Chronic obstructive pulmonary disease

bring forth the possibility of genetic components that increase females' susceptibility to developing COPD.[14]

Depending on the stage of the disease, COPD patients complain of breathlessness, cough, and sputum production, with varying intensity. In an Austrian study (n = 1195), breathlessness was present in 78.9%, expectoration in 50% and cough in 55% patients.[15] Breathlessness in COPD is attributed to (a) respiratory abnormalities such as expiratory flow limitation and lung hyperinflation; (b) metabolic abnormalities like increased inspiratory neural drive due to abnormalities of gas exchange at the alveolar level and acid-base imbalance.[16] Chronic inflammation of the airways, accumulation of mucus exudates in small airways and associated bronchiectasis, gastroesophageal reflux disease, and laryngopharyngeal reflux were identified as the mechanisms of cough.[17] Neurally mediated mechanisms have also been implicated in causing cough in COPD. Superadded infections change the characteristic of cough from dry to productive.[18]

BODE index is an accepted index for COPD patients to predict their 4-year survival rate. In our study, the mean BODE Index was 4.37 ± 1.78, majority of the patients fell in the second (40%) and third (34%) quartiles, indicating that their 4-year survival rate was 67% and 57%, respectively. In a Spanish study conducted in two cities, the mean BODE index was 2.59 ± 2.08 and 2.42 ± 1.99.[19] In a study conducted in Vienna by Funk *et al*. (n = 122), the mean BODE index was 4.3 ± 2.8, similar to our study.[20]

BMI, skin fold measurements, and body circumference correlate with the nutritional status of a given adult.[21] They have been used in various studies on COPD patients to assess their nutritional status.[22,23] In the current study, only the BMI had a significant inverse relationship with worsening GOLD stages ($P < 0.05$), which was similar to a few other studies.[24,25] None of the other anthropometric parameters differed significantly across four GOLD stages. Poor BMI with GOLD staging can be explained based on the chronic disease process, consisting of increased protein catabolism, inhibition of muscle growth, and oxidative damage to the muscles.[26,27] Assessment of lung functions by spirometry requires the patient's efforts and cooperation. With a fall in the BMI, the patient's physical stamina also reduces and the efforts he can put forth in performing spirometry are affected, leading to abnormal spirometry findings, including the FEV1.

The TSFT and SSFT did not significantly correlate with the GOLD stages. Skin fold thickness is an indirect measure of total body fat-free mass. Few other studies did not find any correlation between the mean skin fold thickness and the GOLD stages.[24,25] Skin fold thickness is highly affected by subcutaneous edema. Furthermore, the COPD patients are on long-term oral and inhaled corticosteroids causing fluid retention and subcutaneous edema, which may confound the measurements. Ideally, "Dual-Energy X-ray Absorptiometry (DEXA)" scan should be done to assess muscle mass. Still, since it is an expensive investigation, it is not done routinely for stable COPD patients. The DEXA scan should be the method of choice as all the other methods underestimated fat-free mass index compared to the DEXA scan.[28]

It is believed that malnutrition in COPD increases pulmonary dysfunction and mortality and lowers exercise capacity. A meta-analysis done to study whether nutritional supplementation improved these outcomes revealed that it did not affect improving the functional capacity or lung functions, among patients with stable COPD.[29] Thus, malnutrition in stable COPD patients may not correlate with pulmonary functions at all like in our study.

The HRQoL, as evidenced by the four domains of SGRQ, worsened with the GOLD stages.

In a Japanese study, there was a significant difference in individual components and total SGRQ scores for different grades of COPD ($P < 0.05$), corroborating our finding.[30]

In our study, the BODE Index showed a weak correlation with BMI, GOLD staging, SGRQ Symptom, and Total score, but not with the other anthropometric indices. In a few other studies, the SGRQ total score strongly correlated with the BODE Index.[30-32] Patients with a higher GOLD stage, higher mMRC grade of dyspnea, and poorer nutritional status (lower BMI) had a worse HRQoL in the current study. Dyspnea was an important predictor of HRQoL in few other studies that concluded that it significantly contributed to the patients' general, physical and mental well-being of the patients.[33,34] Thus, we can infer that more intense and rigorous treatment of COPD might be useful in improving their HRQoL.

BMI correlated negatively with the SGRQ Total, Impact, and Activity scores in the study conducted by Katsura *et al*., in Japan on 83 stable COPD patients.[35] BMI assesses the systemic impact of COPD and thus indicates that although COPD is primarily a respiratory disease, it impacts the overall well-being of an individual.[36]

Our study had a few limitations. These include a relatively small sample size, observer bias in taking anthropometric measurements, and patient selection bias.

Conclusion

With the increasing severity of COPD, the BMI and the HRQoL of the patients significantly worsens. Objective evaluation of the HRQoL of the COPD patients by the SGRQ questionnaire should be done routinely, and management of the disease should be modified if the questionnaire scores are worsening. There is a positive correlation between COPD severity and HRQoL with the BODE Index. Thus, the prognosis of COPD patients and their HRQoL worsens with worsening GOLD stages. However, anthropometric indices cannot be used to assess COPD prognosis. Both the BMI and the questionnaires are simple and noninvasive screening tools to assess the health status of COPD patients.

Data availability

All authors are willing to share data supporting results on request.

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Conflicts of interest

There are no conflicts of interest.

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