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# The Body Mass Index, Airflow Obstruction, Dyspnea and Exercise Capacity (BODE) Index in Chronic Obstructive Pulmonary Disease for Saudi Population

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## Abstract

**Study objective:** The objective of this study is to determine whether the BODE (body mass index, airflow obstruction, dyspnea and exercise capacity) index correlates with frequency of exacerbation and smoking (pack/year) in patients with COPD Saudi Arabia.

**Methods:** Forty COPD patients were recruited from King Fahad University Hospital and two sets of outcome were measured: the BODE index parameters and the correlation between BODE index with the frequency of exacerbation events as well as the number of packs of cigarettes that a patient consumes in a year. All the statistical analyses were carried out using Statistical Package for the Social Sciences (SPSS) software, version 21.0.

**Results:** There was a positive correlation found between the BODE index and exacerbation events ($r=0.389$, $n=23$, $p<0.05$). However, for smoking frequency, the result of the correlation analysis showed that its correlation with the BODE index was not statistically significant ($r=0.021$, $n=23$, $p=0.461$). Those involved in the study were 23 participants after the application of the inclusion and exclusion criteria, all are male with a mean age of 67.70 years. The results show that while a correlation was observed for exacerbation, the correlation with smoking frequency was not significant. The analysis also identified age as a factor that has significant correlation with the BODE index which is may be due to the lack of control and uniformity in the age range of the participants.

**Conclusion:** This study results suggest that the BODE index could potentially be used in Saudi patients with COPD to assess disease progression. However, variable controls be emphasized and better gender representation be achieved in future study.

**Keywords:** $FEV_1$; 6MWT; Exacerbations; Smoking; Pack/year; BODE index

## Introduction

COPD is a slowly progressive disorder defined by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) as "A common preventable and treatable disease characterized by persistent airflow limitation that is usually progressive and associated with an enhanced chronic inflammatory response in the airway and the lungs to noxious particles or gases. Exacerbation and comorbidities contribute to the severity in individual patients" [1].

Globally, COPD burden is projected to increase in the coming decades, WHO [2] estimated that 65 million people have moderate to severe COPD and more than 3 million people die of COPD. Recently, COPD become third top worldwide cause of death from fourth place in 1990 [3]. In the Middle East, COPD become a major public health problem but not received adequate attention and remains under-diagnosed and under-recognized [4]. Particularly, the prevalence of COPD in Saudi Arabia is unknown because of the absence of population-based epidemiological studies [5]. However, the Saudi Initiative for Chronic Airway Disease (SICAD) panel believes that COPD prevalence is rising in Saudi Arabia due to rising tobacco smoking among men and women [6]. Hence, grading the severity of COPD by the force expiratory volume in one second ($FEV_1$) is often used [7]. However, COPD is a complex chronic inflammatory disease, the $FEV_1$ is not a better classification of the illness and predicts the disease outcome [7]. In 2004, Celli [8] develpoed a multidimensional index that combines these principal prognostic determinants: the BODE index (body mass index (B), airflow obstruction (O), dyspnoea (D) and exercise capacity (E) that provide useful prognostic information among patient with COPD than $FEV_1$ alone.

The chronic progressive course of the disease is frequently worsened by disease exacerbation period, which negatively affect lung function [9]. Therefore, preventing exacerbation is an essential goal to manage the disease. The multidimensional body mass index, airflow obstruction, dyspnea, exercise capacity (BODE) index has measuring the impact of COPD exacerbations which shows to be a better predictor of the number [10].

The main objective of the present study was to determine whether the BODE index correlates with frequency of exacerbation and smoking status (pack/year), among COPD patients in Saudi population. Both exacerbation frequency and smoking is the most important major cause of both the development and poor outcomes in these patients [11]. There are various observed and published articles, which confirm the association of smoking status with disease severity, progression and mortality [12,13]. However, the prevalence of smoking in the Saudi Arabia increased considerably and no studies was assessed the correlation between smoking (pack/year) and BODE index among

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COPD patient in Saudi population. We hypothesized that the BODE index have a correlation with smoking in COPD patients.

## Methods

### Ethical considerations

The study was designed to make sure that the patients would be subjected to as minimal strain as possible. In the case of potentially strenuous tests, particularly for the $FEV_1$ and the 6MWT, they were done under the careful observation of an experienced medical team. Moreover, all participants provided full consent to the study and they were completely aware of all the tests that would be asked of them. Lastly, all the data that was gathered from the patients was strictly and exclusively used for the purposes of the study and have not/will not be disclosed for any other matter beyond this.

To provide an external audit of the procedure and to assure that it meets all ethical requirements, before the study was carried out, the study protocol underwent a rigorous approval process that was led by the Institutional Review Board and the Director of the General Research in the KFHU and university of Dammam prior to the commencement of the study. (REF: KFHU/EXEM 066 (Appendix 1)).

### Participants

The study recruited 40 patients who have been diagnosed with chronic obstructive pulmonary disease (COPD) from the King Fahad Hospital of the University (KFUH) outpatient pulmonary clinic in Alkhobar, Saudi Arabia. In an effort to provide a diverse set of participants, recruitment did not have any bias towards disease severity. Both inclusion and exclusion criteria were determined to ascertain that only valid participants are included in the study. In terms of the inclusion criteria, the patient had to either be a smoker or a non-smoker and they should be successfully diagnosed with COPD in accordance to the standards set by the Global Initiative for Chronic Obstructive Lung Disease [14]. The patients, therefore, underwent a pulmonary function test and the assigned pulmonologist also assessed the current symptoms manifested along with their medical history. When a positive diagnosis is made, the patient is then briefed on the study and is asked for their full consent for participation. The consent forms given to the patients were written in both English and Arabic (Appendix 2).

With regard to the exclusion criteria, the first was that individuals who have been diagnosed with bronchial asthma, bronchiolitis, cystic fibrosis, neuromuscular disease, as well as infectious COPD were not included in the recruitment pool.

Among the 40 participants recruited for this study, 23 (57.5%) were eligible for participation. From an initial pool of 31 males and 9 females, the final 23 participants were especially composed of males. This immediately underscores limitations in terms of generalizability across genders.

In addition to this, the patients who were unable to carry out both the lung function test and the six-minute walk tests were not included in the study. These exclusion criteria were set to make sure that only relatively stable patients were included; that is, patients who run the risk of becoming aggravated by the tests and data collection requirements of the study were not included.

### Study design

The primary goal of the study is to be able to determine whether the body mass index, airway obstruction, dyspnoea, and exercise capacity (BODE) Index correlates with common indicators of COPD, which are smoking frequency and exacerbation frequency, in the case of Saudi Arabia. Since the association between these variables is the crux of the analysis, therefore, that the study follows a correlational study design. It is hypothesized that a positive and significant correlation exists between the BODE index and smoking frequency and exacerbation frequency, respectively.

There are two sets of outcome measures for the study. The first set is composed of the constituent measures that are needed for the computation of the BODE index and these are: the body mass index (BMI), the forced expiratory volume in one second ($FEV_1$), the Modified Medical Research Council (MMRC) Dyspnoea Scale score, and the six-minute walk test (6WMT) result. The second set of outcome measures represent the factors that have been found to be indicative or generally correlated to COPD and these are: the frequency of exacerbation events experienced by the patient and the number of packs of cigarettes that a patient consumes in a year [15,16].

## BODE Index and its Constituent Measures

The BODE index is an aggregate of several measures commonly used to assess the state of the pulmonary condition of a patient [17].

Each of the measures constituting the BODE index are scored using the metric shown in Table 1. The BODE index for a patient is the sum of the individual scores of each constituent measure.

### Body mass index

The BMI of an individual is calculated by dividing the recorded mass in kilograms by the square of the height in meters [18]. The BMI of an individual has long been considered to be an objective standard for determining a person's weight classification; however recent advances have focused on the computation of a person's body fat rather than the BMI [19]. In this study, both the height and weight measurements were recorded using a Seca 700 mechanical column scale with eye-level beam and it was made sure that there were very few variables that could affect the data collected. In order to do this, patients were asked to wear light clothing while standing barefoot, with both ankles together and in the most vertically erect position possible.

### Airway obstruction

For the airway obstruction component of the BODE index, the $FEV_1$ is the measure used. The $FEV_1$ refers to the maximum amount of air that a person can exhale in one second and it is automatically processed using a spirometer and reported as a percentage, with higher percentages representing lower levels of obstruction [20]. In the study, the Jaeger® Carefusion Spirometer was used to compute the $FEV_1$ of each participant.

### Dyspnoea

Characterized by a person's awareness of the degree of difficulty of

| Variable | Points on BODE Index | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| $FEV_1$ (% of predicted) | ≥ 65 | 50-64 | 36-49 | ≤ 35 |
| 6MWT (m) | ≥ 350 | 250-349 | 140-249 | ≤ 149 |
| MMRC Dyspnoea Scale | 0-1 | 2 | 3 | 4 |
| BMI ($kg.m^{-2}$) | >21 | ≤ 21 | | |

$FEV_1$% pred: Predicted amount as a percentage of the Forced Expiratory Lung Volume in One Second; 6MWD: Six-Minute Walking Distance; MMRC: Modified Medical Research Council Dyspnoea Scale; BMI: Body Mass Index.

**Table 1:** BODE index calculations constituent scores from outcome measures (p=1007) [8].

his or her breathing, dyspnoea is a common symptom experienced by individuals having pulmonary problems [21].

For the BODE index, in order to quantify the extent of the dyspnoea of the participant, the 5-point MMRC Dyspnoea Scale was used. This self-report instrument in composed of only one item wherein the respondent has to choose among five statements scored from 0 to 4 describing an increasing severity of breathlessness [22]. The inclusion of this scale into the BODE index is due to the fact that it has been found to be associated with COPD and other pulmonary conditions [23]. In this study, the investigator orally instructed the participant to choose among the five possible responses for the MMRC Dyspnoea Scale.

### Exercise capacity

The last outcome measure that composes the BODE index is exercise capacity and this is represented by the 6MWT. This test was first conceived as a means of gauging the effects of a particular treatment for the cardiovascular health of an individual [24]. Moreover, results of the 6MWT have been validated to have a correlation with COPD along with other cardiovascular disease [25]. The test is done by having the patient walk back and forth through a given region for six minutes and the total distance covered by the patient in this time interval is recorded and this total distance is the outcome measure for the test [24].

In the case of the study, an empty corridor was selected in the hospital for the test with markers denoting the region where the patient is allowed to walk. The total forward distance of the corridor was at 30 meters and marked every ten-meter distance on the floor. Throughout the test, oxygen saturation, heart rate and blood pressure were measured to ensure that the patient is clinically stable and the investigator provided standard phrases of encouragement. For safety purposes, a chair and oxygen cylinder placed in the vicinity of the test area so that immediate rest with oxygen can be given if needed.

### Exacerbation and pack/year

Both exacerbation and smoking frequency were chosen to be the factors for COPD and their selection was due to the fact that studies have constantly shown that they are strongly associated with the onset and severity of COPD [26,27].

For the purpose of the study, the definition provided by Soler-Cataluña et al. [28] concerning exacerbation was used and these researchers identified it to be a pulmonary episode wherein bronchodilator medication, corticosteroids, antibiotic treatment, or immediate hospital care and admission was required. The number of exacerbation episodes of the patient was determined through asking direct questions and cross checking relevant medical records.

Smoking frequency was measured with pack/years as the fundamental unit and this is often used for individuals who have had a long history of smoking. The formula for pack/years assumes that each pack contains 20 cigarettes. The number of pack/years, therefore, is the product of the number of years a person has smoked and the number of cigarettes a person consumes per day all divided by 20 cigarettes [29]. By this calculation, a one pack/year is equivalent to smoking a single pack of cigarettes per day for one year or 20 cigarettes per day for an entire year. For the study, data on smoking was acquired by directly asking patients for the relevant information needed for the calculation of pack/years.

### Statistical analysis

The entire goal of the study is to determine whether correlations exist between the relevant variables. In order to do this, the Pearson Coefficients of the correlation between exacerbation and the BODE index and smoking frequency and the BODE index were calculated. The bases for the assessment of the correlation were the sign, magnitude, and statistical relevance of the Pearson Coefficients calculated. All the statistical analyses done in the study were carried out using IBM SPSS 21.

## Results

Before finally delving into the correlation analysis necessary to confirm or reject the hypothesis of the study, it is important to first provide an overview of the data gathered. As has been mentioned, the 23 participants of this study, after the application of the inclusion and exclusion criteria, are all male. Among them, 9 (39.1%) note that they are smokers while 14 (60.1%) are ex-smokers. The mean age of the participants is 67.70 (SD=11.24). In terms of the two claimed predictor variables for COPD, which are smoking frequency and exacerbation, the participants average 77.80 pack-years (SD=33.45) with a mean of 1.35 (SD=0.94) exacerbation events. In Table 2, the results of the various tests for the computation of the BODE index.

There are several notable results for the quantities shown in Table 2. First, the mean BMI of 27.14 (SD=6.20) indicates that a good majority of the participants are either overweight or obese [30]. Moreover, the $FEV_1$ result shows that all the participants have either an obstruction to their breathing [31].

In the case of the MMRC Dyspnoea Scale score, the interpretation for a mean of 1.65 (SD=0.94) ranges from shortness of breath experienced only under stressful walking conditions to shortness of breath even on otherwise normal conditions [32]. Given all these results, the mean BODE index of the participants is 3.83 (SD=2.53) and this is interpreted to roughly a 67% survival rate in the next four years [33].

### Correlation analysis with the BODE index

The hypothesis of the study was that both the smoking frequency as represented by the pack-years of each patient and the number of exacerbation events experienced would positively and significantly correlate with the BODE index. Given the directional nature of the hypothesis, a One-Tailed Bivariate Correlation Analysis was carried out. For smoking frequency, the result of the correlation analysis showed that its correlation with the BODE index was not statistically significant ($r=0.021$, $N=23$, $p=0.461$). Nevertheless, while the correlation may not be statistically significant, it is important to note that a positive correlation does exist which is in keeping, however partially, with the hypothesis of the study. With regard to the number of exacerbation events, the correlation analysis showed that it has indeed a positive and significant correlation with the BODE index ($r=0.389$, $N=23$, $p<0.05$).

The results indicate that only one of the two hypotheses drawn for the study is to be accepted. As an auxiliary point of analysis, one must also consider the effects of potential confounding variables to the correlation analysis.

In the case of the study, among the information gathered from the participants, age can be considered as a potential confounding variable. In order to test this, a Two-Tailed Bivariate Analysis was carried out with age and the BODE index. The decision to use a two-tailed analysis

| Outcome Measure | N | Mean | Std. Deviation |
|---|---|---|---|
| BMI ($kg.m^{-2}$) | 23 | 27.14 | 6.20 |
| $FEV_1$ (% of predicted) | 23 | 46.73 | 17.14 |
| MMRC Dyspnoea Scale Score | 23 | 1.65 | 0.94 |
| Six Minute Walk Test (m) | 23 | 288.48 | 108.86 |

**Table 2:** Results of tests for the computation of the BODE index.

lies in the fact that there is no concrete hypothesis for the correlation. The result showed that age has a statistically significant and positive correlation with the BODE index ($r=0.459$, $N=23$, $p<0.05$) and it is even stronger than that of the relationship of the BODE index with exacerbation.

## The Impact of BMI on the BODE Index

Several studies have noted that there is an increasing trend of obesity and inactivity in the Saudi population and this could contribute in worsening the COPD condition of the individual [34,35]. As another point of analysis, therefore, the overall effect of the BMI on the BODE index will be investigated into. In order to do this, the participants were divided into two groups, the first group will have those whose BMI is less than 28 (N=12, 52.2%) and the second group will have participants whose BMI is greater than 28 (N=11, 47.8%). The decision to use 28 to demarcate the two groups considered was motivated by the fact that the mean BMI of the participants was at 27.14 (SD=6.20).

To determine if there is a significant difference in the BODE index scores across the two groups, an Independent Samples t-test is carried out. Interestingly, the results show that those with BMI less than 28 have a markedly higher BODE index ($4.08 \pm 2.88$) compared to those who have BMI greater than 28 ($3.55 \pm 2.25$). Nevertheless, the results of the t-test showed that the difference between the two means is not statistically significant ($t21=0.496$, $p=0.625$).

## Discussion

The results of the statistical analysis showed that only one of the two hypotheses of the study was correct. The hypothesis that failed the analysis asserted that the BODE index should be statistically significant with the smoking frequency of an individual, measured in pack/years. This claim is not unfounded because smoking has long been considered to be a detriment in the respiratory health of individuals and, therefore, contributes to the aggravation of COPD [36].

Nonetheless, compared to exacerbation events, the data gathering for smoking was based on information provided by the individuals rather than actual medical record. This means that the social desirability effect, which is the desire of a patient to not reveal the truth when asked, could have strongly influenced the responses of the participants. This phenomenon pertains to the propensity of individuals to respond to questions or surveys in a manner that they perceive to be congruent to positive societal values [37].

In the case of the study, social desirability could have caused the participants to underestimate or underreport the number of cigarettes that they smoke in a given year or even the length of time they have been smoking, thereby making the computations for the pack/years dubious. Such an underestimation will adversely affect the correlation between smoking and the BODE index and this could explain why the expected statistical significance of the correlation between the two variables was not observed. This adverse effect on the correlation happens because social desirability effects will make the correlation less consistent; that is, the data from those who underreported will obscure the actual correlation that is manifested by those who actually provided more honest approximations.

In the case of exacerbation, however, the data collected was based on medical records and medical history, which is less permeable to social desirability effects. Moreover, the strength of the correlation between exacerbation and the BODE index can be explained by the fact that exacerbation is a more tangible measure of the extent of COPD [38]. While smoking provides an overview of the potential damage that has been brought to the respiratory system of the individual, the number of exacerbation events give an idea of the actual damage that has been caused. The result of the analysis has also been supported by numerous studies, which all confirm that the frequency of exacerbation events have strong correlation with the severity of COPD and, therefore, with the BODE index [17,39].

The results also delved into variables that could potentially affect the BODE index of the participants, therefore, confounding the correlation analysis. The BMI was one of these variables and was highlighted due to the unique Saudi population characteristic that indicates high levels of BMI.

However, the analysis showed that the difference across BMI was not statistically significant. In fact, it is curious to note that those had generally lower BMI levels had a marginally higher BODE index. This could mean that, in the case of the Saudi population, the BMI Index is affected in a greater extent than BODE's other constituent measures.

The other variable that was evaluated was age and it was found to have statistically significant correlation with the BODE index and a correlation that is even stronger compared to that of exacerbation.

The strong relationship of age and the BODE index has been recorded consistently in literature [40,41]. This is not surprising because measures such as exercise capacity and dyspnoea all worsen with age given that aging populations generally decrease their physical activity and are more prone to bouts of fatigue [42]. Compared to exacerbation, therefore, age has a more direct influence on the BODE index and this explains the stronger correlation that it has. What this result emphasises is the need for the study to control for the age variable in order to lessen its influence on the results of the analysis. This was not done successfully in the case of this study, with the age range considered covering 43 to 93 years, and it is a considerable limitation.

Another significant limitation that this study poses is the lack of gender representation. While female participants were considered in the initial pool of 40, the application of inclusion and exclusion criteria ultimately removed them from the final pool of participants. This was primarily due to the fact that all of the females recruited were non-smokers therefore ineligible to participate. However, the Saudi population has a markedly smaller number of female smokers compared to the rest of the world where patterns across gender are more equal [43,44]. In particular, a literature review conducted covering various epidemiological studies found that only roughly 9% of females smoke while 26.5% of males smoke; three times as much as females [44,45]. Nonetheless, gender representation could support the generalizability of the results of the study.

The main recommendation of the study is to improve variable controls so as to reduce the influence of confounding variables, especially that of age. Furthermore, an analysis of gender differences, which could be made possible by better gender representation among the participants, is also recommended.

## Conclusion

The study sought to determine whether there is a significant and positive correlation between the BODE index and smoking and exacerbation, respectively. The results of the study showed that while a significant correlation was observed for exacerbation, the correlation with smoking frequency was not significant. It was noted that the lack of significance between smoking and the BODE index could be attributed to the participants' underreporting of the data needed for the computation of pack-years, the study's measure for smoking frequency,

and this is attributed to social desirability effects.

The analysis also identified BMI and age as potential confounding variables but only age proved to have a significant correlation with the BODE index due to the lack of control and uniformity in the age range of the participants. It is recommended that these variable controls be emphasized and better gender representation be achieved in future iterations of this study.

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