# PATIENTS' SELF-REPORTS OF DYSPNEA: AN IMPORTANT AND INDEPENDENT OUTCOME IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE[1]

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## ABSTRACT

*Patients' self-reports of dyspnea are an important clinical outcome in evaluating treatments in chronic obstructive pulmonary disease (COPD). This study evaluated the dimensions underlying self-reported dyspnea ratings, lung function, and respiratory muscle pressures in 143 patients with COPD. The validity of dyspnea ratings and lung function parameters to predict the variance of a common functional measure, the six-minute walk test, was also assessed. Results of a factor analysis confirmed previous work demonstrating the independence of dyspnea ratings from pulmonary function parameters. Dyspnea ratings also explained a greater proportion of the variance in the six-minute walk test than did lung function. Results of this study provide further evidence for the importance and independence of self-reported dyspnea ratings in evaluating outcomes in COPD.*

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## INTRODUCTION

Chronic obstructive pulmonary disease (COPD), which includes emphysema, chronic bronchitis, and non-reversible asthma, is a major cause of death and disability in the United States. COPD is the fourth leading cause of death and accounts for 4% of all deaths (1,2). Dyspnea, the subjective sensation of difficult or labored breathing, is one of the most common and disabling symptoms of people with COPD (3). Dyspnea is a subjective symptom, measured only by self-report, and is often viewed as less important than standardized laboratory tests of pulmonary function (4).

COPD causes significant behavioral dysfunction. As a result of chronic breathlessness, patients often reduce or cease important activities of daily living. For example, shortness of breath is often cited as the reason for reduced exercise, social activity, and sexual activity. It has typically been assumed that shortness of breath is a reflection of underlying physiological damage. However, recent studies have shown that self-reports of dyspnea predict behavioral dysfunction in patients with COPD, independent of laboratory tests of lung function (5–7). While dyspnea is a subjective symptom, it is clearly important in both the diagnosis and treatment of COPD, and it has been shown to be associated with behavioral outcomes including exercise tolerance, quality-of-life, and psychological functioning (8).

Since there is no cure for COPD, a primary goal of most treatments is the reduction and management of breathlessness. However, it has been unclear whether dyspnea is only related to physiologic function or whether it has some important psychological components. A clear understanding of the relationship between physiological and psychological aspects of dyspnea may have important implications for the development of new treatments.

The purpose of this study was to evaluate the dimensions underlying dyspnea ratings, lung function, and respiratory muscle pressures. Mahler and Harver previously reported that dyspnea ratings, lung function, and respiratory muscle pressure are independent of one another (7). To extend this evaluation, we compared the predictive validity of dyspnea ratings and lung function parameters to explain the variance of a common behavioral measure, the six-minute walk test.

## METHODS

### Subjects

One hundred forty-three patients with COPD (74 female, 69 male) were recruited from newspaper advertisements, local hospitals, and physicians to participate in a clinical trial evaluating a program of dyspnea management strategies. Results of the trial have been previously reported (9). Mean age of the subjects was 67.5 years (SD = 9.0, range 40 to 86). Inclusion criteria included diagnosis of COPD and no other medical illness that limited functioning more than COPD. Diagnosis of COPD was determined by clinical history and confirmed with pulmonary function test evidence of expiratory flow obstruction. Pulmonary function tests included spirometric measurements of vital capacity and expiratory flow rates, lung volumes and airway resistance by body plethysmography, and maximal inspiratory and expiratory pressures to assess respiratory muscle strength. All testing and quality control procedures followed standard and recommended methods (10,11).

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### Procedures

During a two-hour clinic visit, measures of dyspnea and exercise tolerance were collected. The study protocol was approved by the Human Subjects Committee of the University of California, San Diego, and all subjects signed a consent form prior to participation.

### Dyspnea Measures

*Mahler's Baseline Dyspnea Index (MDI):* Mahler and colleagues (12) developed an interviewer-administered dyspnea index that rates dyspnea according to three categories: (a) functional impairment, (b) magnitude of task, and (c) magnitude of effort. The functional impairment category addresses whether the patient has reduced or given up activities or a job due to shortness of breath. The magnitude of task category rates the type of task that makes the patient breathless (i.e. light, moderate, or strenuous tasks). The magnitude of effort category assesses how much effort the patient exerts before becoming breathless (e.g. breathless only after extraordinary exertion, or so breathless that s/he has to pause frequently during most tasks). The baseline dyspnea index is used to rate the severity of dyspnea at a single point in time; a transition dyspnea index is used to assess changes from that baseline. At baseline, dyspnea in each of the three categories is rated on a five-point scale from 0 (severe) to 4 (unimpaired). Ratings for each of the three categories can be added to form a baseline total dyspnea score (range, 0 to 12). In another analysis, we evaluated the reliability and validity of the MDI as well as the dyspnea measures described below (13).

*American Thoracic Society Dyspnea Scale (ATS):* This self-report respiratory questionnaire consists of five yes–no questions which correspond to a five-point dyspnea rating scale (14). Based on the response to these questions, dyspnea is rated in terms of one of five grades of severity (Grade 0: Not troubled by breathlessness except on strenuous exertion; Grade 1: Short of breath when hurrying on the level or walking up a slight hill; Grade 2: Patient walks slower than most people his/her age on the level; Grade 3: Patient has to stop for breath after walking about 100 yards on the level; Grade 4: Too breathless to leave the house or breathless after undressing).

*Oxygen Cost Diagram (OCD):* The oxygen cost diagram is a 10 cm line along which activities are written at intervals which correspond to the metabolic equivalents (or oxygen cost) required to perform them (15). Patients are asked to make a mark on the line indicating the point above which their breathlessness would not allow them to go. Examples of activities on the diagram are "brisk walking uphill," "medium walking on the level," "bedmaking," "standing," and "sleeping."

### Exercise Tolerance

*Six-Minute Walk Test (6MW):* The six-minute walk is a standard measure of exercise tolerance used frequently with lung and cardiac disease populations (16). The test was conducted in an area free from distractions with standardized encouragement provided by the staff. Subjects were asked to cover as much ground as they could in six minutes. The timed distance walk test has been shown to be highly reliable (17), with moderate correlations with tests of pulmonary function and maximum exercise capacity (15). Guyatt and colleagues (18) demonstrated a learning across subsequent trials of this test and recommend two practice tests prior to actual test administration.

**TABLE 1**
**Descriptive Statistics ($N$ = 143)**

| Variable | Mean (SD) |
|---|---|
| Gender | 74F/69M |
| Age | 67.5 (9.0) |
| MDI | 4.99 (2.32) |
| ATS | 2.29 (1.50) |
| OCD (cm) | 6.46 (1.66) |
| FVC (L) | 2.54 (0.90) |
| FVC %pred | 77 (21) |
| $FEV_{1.0}$ (L) | 1.22 (0.57) |
| $FEV_{1.0}$ %pred | 53 (24) |
| MIP (cm $H_2O$) | 67.87 (22.41) |
| MEP (cm $H_2O$) | 133.41 (41.89) |

MDI = Mahler's Baseline Dyspnea Index; ATS = American Thoracic Society Dyspnea Scale; OCD = Oxygen Cost Diagram; FVC = forced vital capacity; $FEV_{1.0}$ = forced expiratory volume in one second; MIP = muscle inspiratory pressure; MEP = muscle expiratory pressure.

Because of time constraints in this study protocol, we used one practice test followed by at least ten minutes of rest and then a second test. Data from the longer of the two walks were used.

### Lung Function Measures

*Forced Expiratory Volume in One Second ($FEV_{1.0}$):* A measure of the maximal volume of air that can be expelled from fully inflated lungs in the first second of a forced expiration maneuver. $FEV_{1.0}$ and FVC (below) are commonly used measures of disease severity in COPD.

*Forced Vital Capacity (FVC):* A measure of the maximal volume of air that can be expelled from fully inflated lungs during the entire forced expiration maneuver.

*Muscle Inspiratory Pressure (MIP):* A measure of inspiratory muscle strength used to screen for respiratory muscle weakness.

*Muscle Expiratory Pressure (MEP):* A measure of expiratory muscle strength.

### Statistical Analysis

Data were analyzed using principal components analysis. A matrix of Pearson product moment correlations was created with unit values along the main diagonal. Principal components analysis was used to create linear composites. Components with eigenvalues greater than 1.0 were extracted and rotated to a varimax solution. Hierarchical multiple regression was used to create descriptive equations for estimating walking time from MDI and $FEV_{1.0}$. All analyses were accomplished using the Statistical Package for the Social Sciences X Series (SPSSX) analysis package.

## RESULTS

Descriptive statistics for measures of dyspnea, lung function, and exercise tolerance are listed in Table 1. Correlation coefficients for dyspnea ratings, spirometry, and maximal respiratory pressures are shown in Table 2.

### Factor Analysis

Data on the MDI, ATS, OCD, $FEV_{1.0}$, FVC, MIP, and MEP for 143 subjects were subjected to principal components analysis. The solution yielded two factors that explained 66.1% of the variance. As seen in Table 3, the lung function and maximal

TABLE 2
**Correlations Among Dyspnea Ratings, Spirometry, and Maximal Respiratory Pressure**

| | MDI | ATS | OCD | $FEV_{1.0}$ | FVC | MIP | MEP |
|---|---|---|---|---|---|---|---|
| MDI | 1.00 | | | | | | |
| ATS | −0.57 | 1.00 | | | | | |
| OCD | 0.47 | −0.52 | 1.00 | | | | |
| $FEV_{1.0}$ | 0.35 | −0.33 | 0.39 | 1.00 | | | |
| FVC | 0.24 | −0.27 | 0.28 | 0.80 | 1.00 | | |
| MIP | 0.19 | −0.30 | 0.26 | 0.44 | 0.51 | 1.00 | |
| MEP | 0.16 | −0.17 | 0.14 | 0.32 | 0.40 | 0.54 | 1.00 |

respiratory muscle pressures loaded on Factor I; the three dyspnea measures loaded on Factor II. It should be noted that while $FEV_{1.0}$ loaded strongly on Factor I, it also had a modest loading on Factor II.

### Multiple Regression Analysis

Two hierarchical multiple regression analyses were conducted to compare the predictive validity of the MDI and $FEV_{1.0}$ in explaining the variance in the six-minute walk test, which served as the dependent variable in both analyses. The MDI was chosen from the three dyspnea measures because a previous analysis indicated that it is the most reliable and valid of the three (13). $FEV_{1.0}$ was chosen from the spirometry and respiratory muscle pressure variables because they all loaded on a single factor and because previous work supported the use of $FEV_{1.0}$ as the best single indicator of disease severity in patients with COPD (19).

In the first analysis, the MDI was entered first, followed by $FEV_{1.0}$. As seen in Table 4, when entered first, the MDI explained 40% of the variance with $FEV_{1.0}$ explaining an additional 6% (F = 55.6, df = 2,129, $p < .0001$). In the second analysis, $FEV_{1.0}$ was entered first and explained 24% of the variance; the MDI explained an additional 22% of the variance. The beta coefficients for the MDI and $FEV_{1.0}$ were statistically significant (all $p < .001$).

One concern with these findings is whether dyspnea is equally related to walking performance and lung function parameters in patients with moderate versus severe COPD. In order to investigate this issue, we divided patients by median $FEV_{1.0}$ score (median = 1.05L) to form a severe group (mean $FEV_{1.0}$ = 0.78, SD = 0.18, $N$ = 67) and a moderate group ($FEV_{1.0}$ = 1.66, SD = 0.49, $N$ = 66). For the severe group, the dyspnea measures remained significantly correlated with $FEV_{1.0}$: r = 0.56 for the MDI, r = −0.33 for the ATS, and r = 0.33 for the OCD (all $p < .01$). However, the dyspnea measures were uncorrelated with the pressure measures (MIP and MEP) for patients with severe COPD. For the patients with moderate disease, the dyspnea measures were not significantly correlated with $FEV_{1.0}$ or the inspiratory and expiratory pressure measures. It is important to note that these correlations may be attenuated by the median split of $FEV_{1.0}$ restricting the range of variability. Correlations between 6MW scores and the dyspnea measures for patients with severe COPD were r = 0.65 for the MDI, r = −0.46 for the ATS, and r = 0.49 for the OCD (all $p < .01$). For patients with moderate disease, correlations between 6MW scores and the dyspnea measures were r = 0.47 for the MDI, r = −0.34 for the ATS, and r = 0.34 for the OCD (all $p < .01$).

TABLE 3
**Rotated Factor Loadings**

| | Factor 1 | Factor 2 |
|---|---|---|
| MDI | 0.04 | 0.85 |
| ATS | −0.18 | −0.80 |
| OCD | 0.18 | 0.76 |
| $FEV_{1.0}$ | 0.72 | 0.40 |
| FVC | 0.81 | 0.25 |
| MIP | 0.78 | 0.16 |
| MEP | 0.77 | −0.08 |
| Eigenvalue | 3.19 | 1.43 |

## DISCUSSION

In a sample of 143 patients with COPD, we evaluated the dimensions underlying self-reported dyspnea ratings, lung function parameters, and respiratory muscle pressure as well as the predictive validity of these variables. The results of this study support and extend the work of Mahler and Harver (7) and Wegner and colleagues (20) who demonstrated the independence of self-reported dyspnea ratings from laboratory tests of lung function and respiratory muscle pressure in characterizing the condition of patients with COPD. Our factor analysis of these variables resulted in two factors with lung function and respiratory muscle pressure loading on the first factor and dyspnea ratings loading on the second factor. It should be noted that $FEV_{1.0}$ also showed a modest loading on Factor II. This result is consistent with our results and recent studies indicating that while dyspnea ratings tend to load separately from lung function parameters, there exists an underlying modest correlation between dyspnea and lung function (7,20). The "independence" of dyspnea ratings, as described here and by others, is meaningful, not so much in the statistical sense, but because such results provide empirical support for patients' self-reports of dyspnea as a distinct component in understanding their lung disease.

Given the importance of functional and behavioral outcomes in evaluating treatments for COPD, we used two hierarchical multiple regression analyses to evaluate the ability of the MDI and $FEV_{1.0}$ to predict the variance in the six-minute walk test. When entered into the equation first, the MDI explained a greater proportion of the variance in walking distance than did $FEV_{1.0}$. When entered into the equation following $FEV_{1.0}$, the MDI explained a proportion of the variance in walking distance almost equal to that explained by $FEV_{1.0}$.

These findings confirm several recent observations. Wijkstra and colleagues (21) found that spirometric values and dyspnea (measured using the Borg scale) each significantly corre-

TABLE 4
**Multiple Regression Analysis to Predict Six-Minute Walk Distance**

| Variable | $R^2$ Cumulative | Beta |
|---|---|---|
| | ***1st Analysis:* F(2,129) = 55.59, *p* < .0001** | |
| MDI | 0.40 | 0.52* |
| $FEV_{1.0}$ | 0.46 | 0.28* |
| | ***2nd Analysis:* F(2,129) = 55.59, *p* < .0001** | |
| $FEV_{1.0}$ | 0.24 | 0.28* |
| MDI | 0.46 | 0.52* |

* $p < .001$.

lated with the six-minute walk test. Multivariate analysis gave greater weight to pulmonary function than to dyspnea ratings. The Wegner group (20), using factor analysis methods, found that dyspnea ratings loaded on the same factor as the six-minute walk test, while pulmonary function loaded on a different factor. They suggest that dyspnea and exercise performance are independent and that each of these is independent of exercise capacity. Further, Mahler and Harver (22) found that clinical ratings of breathlessness, obtained using the MDI, along with age and $FEV_{1.0}$ were significant predictors of peak performance on a cycle ergometry test. All of these studies show that self-reported dyspnea ratings are significant predictors of exercise performance.

In summary, our results and those of other investigators demonstrate the importance of dyspnea ratings as an independent factor in characterizing the condition and functional status of patients with COPD. In contrast to Wijkstra (21), our data suggest that dyspnea ratings may be a stronger predictor of functional outcomes than lung function parameters.

Patient self-reports have often been discounted. However, a growing literature suggests that patient self-reports are a meaningful and important component of clinical assessment (4,23–25). This study suggests that the subjective component of dyspnea may vary independently from pulmonary function. Criteria for improvement in COPD must include physiologic, behavioral, and psychological outcomes.

On the basis of these data, it might be argued that intervention should focus on behavioral methods for the management of dyspnea. These is no medical or surgical remedy for the major physiologic abnormalities in COPD. However, if behavioral intervention could train patients to manage dyspnea, patients might experience fewer limitations in important activities of daily living, thus increasing their independent functioning and quality-of-life. Unfortunately, our early investigation of behavioral intervention produced disappointing results (9). However, further study of behavioral intervention is clearly warranted.

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