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Effect of Symptoms on Physical Performance in COPD

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Structured Abstract

Background—Chronic obstructive pulmonary disease (COPD) patients experience multiple symptoms including dyspnea, anxiety, depression, and fatigue, which are highly correlated with each other. Together, those symptoms may contribute to impaired physical performance.

Objectives—The purpose of this study was to examine interrelationships among dyspnea, anxiety, depressive symptoms, and fatigue as contributing factors to physical performance in COPD.

Methods—This study used baseline data of 282 COPD patients from a longitudinal observational study to explore the relationship between depression, inflammation, and functional status. Data analyses included confirmatory factor analyses and structural equation modeling.

Results—Dyspnea, anxiety and depression had direct effects on fatigue, and both dyspnea and anxiety had direct effects on physical performance. Higher levels of dyspnea were significantly associated with impaired physical performance whereas higher levels of anxiety were significantly associated with enhanced physical performance.

Conclusion—Dyspnea was the strongest predictor of impaired physical performance in patients with COPD.

Keywords

dyspnea; psychological symptoms; fatigue; physical performance; COPD

Introduction

The majority of people with chronic obstructive pulmonary disease (COPD) experience multiple symptoms including dyspnea, anxiety, depression, and fatigue. These common

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symptoms are interrelated.^{1–3} For COPD patients, dyspnea is the most frequent and bothersome symptom, requiring daily management. This experience of breathing discomfort is not only shaped by physiology but is also influenced by psychological, social, and environmental factors.^{4,5} Fatigue is the second most prevalent symptom after dyspnea, and becomes a major complaint of COPD patients as the disease progresses.^{2,6} Although the prevalence of fatigue is 50–71% in people with COPD,^{2,3,7} the clinical relevance of fatigue has received less investigation.⁸ Patients described fatigue as unrelenting tiredness and exhaustion that is always present, and thus limiting their function capacity.^{9,10} Fatigue is common for COPD patients, and contributes to functional impairment in addition to respiratory symptoms.^{3,10} Anxiety and depressive symptoms are also common psychological symptoms in COPD. Psychological distress has negative impacts on fatigue and physical functioning. It also predicts hospitalization due to exacerbation and mortality.^{11,12}

The Theory of Unpleasant Symptoms (TOUS) provides a framework for understanding how multiple concurrent symptoms are interrelated and can impact outcomes.¹³ It has three major components: the symptoms themselves, the factors that can influence the symptom burden (physiologic, psychological, and situational), and the consequences of the symptom experience. Reciprocal relationships may exist among three major components. The experience of the interrelated symptoms can affect the patient performance in both functional and cognitive activities.¹⁴

In COPD, the symptoms of dyspnea, anxiety, depression, and fatigue interact with each other. Complex, bi-directional relationships exist among these common symptoms of COPD were founded in recent studies.^{2,15–17} Dyspnea is associated with increased levels of anxiety and depressive symptoms. Although not consistent across all COPD studies, it has been reported that respiratory and psychological symptoms are independent predictors of fatigue in COPD patients.^{1,18,19} Patients with moderate to severe COPD report experiencing notable dyspnea and fatigue with activities of daily living.²⁰ Psychological stress may result from dyspnea, and together with fatigue, may contribute to even worse physical performance.^{1,2,8}

A better understanding of how symptoms contribute to worse physical performance has the potential to enhance symptom management for COPD patients. Structural equation modeling (SEM) is an analytical approach that allows researchers to examine the complex interrelationships among multiple variables.²¹ In previous studies examining symptoms in COPD patients, different modeling approach was used.^{1,22} Among them, multiple indicators for a construct were not included in a path analysis¹ or fatigue and the six minute walk test (6MWT) were treated as a single construct of functional capacity.²² Although similar relationships among several symptoms have been explored by SEM in other studies of chronic illness such as multiple sclerosis²³ and rheumatoid arthritis²⁴, our study may be the first to use a SEM approach to examine the interrelationships between symptoms and physical performance in COPD.

The aim of this paper was to examine a model describing the interrelationships among dyspnea, anxiety, depressive symptoms, fatigue, and physical performance in COPD (Figure 1). The model was developed based on qualitative studies of fatigue in COPD and the

TOUS.^{9,10} Dyspnea, anxiety, and depression were included as influencing factors on fatigue in the proposed model, and that when these symptoms are managed, physical performance as a consequence will be improved. SEM was used to test the direct and indirect effects of four major symptoms on physical performance. The following hypotheses were tested: 1) higher levels of dyspnea are associated with higher levels of anxiety, depression, and fatigue, and higher levels of anxiety and depression are associated with higher level of fatigue; 2) higher levels of dyspnea, anxiety, depression, and fatigue are associated with worse physical performance; and 3) greater dyspnea is indirectly associated with greater fatigue and worse physical performance through greater anxiety and depression, and greater anxiety and depression are indirectly associated with worse physical performance through fatigue.

Methods

This study was a part of a multi-site prospective observational study of COPD patients to explore the relationship between depression, inflammation, and functional status. The original study was supported by the National Institutes of Health [R01HL093146-01A2]. The data used in this study were collected at baseline. Written informed consent was obtained from all participants and the study was approved by the respective institutional review boards at three clinical sites.

Procedure

Participants were recruited from various sources including outpatient clinics from three medical centers, pulmonary rehabilitation programs, a research database maintained by the investigators, queries of medical records and pulmonary function tests, Better Breaths Club, community pulmonary practices, advertisements, study website, and other referrals. Baseline study assessments were conducted both in person (spirometry, six-minute walk test, activity monitoring, hand grip strength, and completion of questionnaires) and by telephone. Phone visits with a trained mental health professional were scheduled two days after the in-person visit and included assessment of depression and anxiety.

The inclusion criteria of this study were: 1) Diagnosis of COPD confirmed by the following: 1-a) post-bronchodilator Forced Expiratory Volume in one second to Forced Vital Capacity ratio (FEV1/FVC) < 70%; 1-b) moderate to very severe disease by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria²⁵ (FEV1 < 80%), 2) Age ≥ 40 years, 3) A history of current or past cigarette smoking (> 10 pack-years), 4) Stable disease with no acute exacerbations in the past four weeks, and 5) Ability to speak, read and write English. Patients with any of the following conditions were excluded since the primary study was focused on measuring inflammatory processes: other chronic obstructive lung diseases, idiopathic pulmonary fibrosis, uncompensated congestive heart failure, primary pulmonary vascular disease, non-COPD-related chronic inflammatory diseases, infectious disease or auto-immune disease, lung cancer or metastatic cancer, chronic renal failure that requires dialysis, chronic uncompensated liver disease, HIV/AIDS, chronic antibiotic use or ongoing infection, chronic oral prednisone use, bipolar disease, psychotic disorders, and any dementia.

Measures

The latent constructs in the model of this study were dyspnea, anxiety, depression, fatigue, and physical performance. At least two indicator variables that theoretically determined each latent construct were used to measure that construct, as described below and summarized in Figure 1.

Physical performance—Five indicators were considered as measures of the latent construct of physical performance. First, the 6MWT was used, which was performed according to the American Thoracic Society (ATS) guidelines.²⁶ It is a validated measure of functional capacity in COPD patients, which measures the distance patients walk in six minutes. Second, daily total steps measured by an accelerometer (Stepwatch).²⁷ Participants were asked to wear the Stepwatch fastened above the right ankle for one week. The average total steps taken each day was used for the participants who wore the monitor at least three days of the week. Third, hand grip strength was measured by a dynamometer. Testing was repeated three times in the dominant hand while patients were in a sitting position. The handgrip muscle strength was recorded in kilograms and the best value was taken for analysis. The last two indicators were two subscales of the Medical Outcomes Study Short Form-36 (SF-36) questionnaire: Physical Functioning and Role Physical.²⁸ Scores may range from 0 to 100, higher scores indicating higher levels of physical performance.

Dyspnea—Three indicators were used to measure the latent variable of dyspnea. The Chronic Respiratory Questionnaire (CRQ)²⁹ dyspnea subscale measures dyspnea with five common activities using a 7-point Likert scale (1 = extremely short of breath to 7 = not at all short of breath). Scores range from 5 to 35 with higher scores indicating lower levels of dyspnea. Similarly, the University of California, San Diego Shortness of Breath Questionnaire (SOBQ)³⁰ measures dyspnea with 24 common activities using a 6-point Likert scale (0 = not at all to 5 = maximal or unable to do because of breathlessness). Scores range from 0 to 120 with higher scores indicating higher levels of dyspnea. The modified Medical Research Council (mMRC)²⁵ dyspnea score was also included with scores ranging from 0 (I only get breathless with strenuous exercise) to 4 (I am too breathless to leave the house or I am breathless when dressing).

Depressive Symptoms—Two measures were used for depressive symptoms. The 9-item Patient Health Questionnaire (PHQ)-9 measures the frequency of depressive symptoms³¹ using a 4-point Likert scale (0 = not at all to 3 = nearly every day). Scores that range from 0 to 27. Participants with a score ≥ 10 were considered to have a high likelihood of major depression. The 14-item Hospital Anxiety and Depression Scale (HADS) was also used³² to assess the severity of psychological stress using a 4-point Likert scale (it has a few different descriptions with mostly, 0 = not at all to 3 = most of the time). Half of the 14 questions are about depressive symptoms that were used as the HADS-Depression (HADS-D). A score of 8 or higher on HADS-D indicates borderline or clinically relevant depression.

Anxiety Symptoms—Four measures were used for anxiety. It included the HADS-Anxiety (HADS-A) that is widely used among various population. A score of 7 or lower on HADS-A indicates no anxiety. One item (“Have you been a very nervous person?”) from the

Mental Health subscale of SF-36 questionnaire was used (1 = all of the time to 6 = none of the time). Additionally, two items from the CRQ-emotional function subscales were included, “How much of the time during the last 2 weeks did you feel relaxed and free of tension?” and “In general, how often during the last 2 weeks have you felt restless, tense, or uptight?” Both used a 7-point Likert scale (1 = all of the time to 7 = none of the time).

Fatigue—The CRQ-fatigue and the Vitality subscale of the SF-36 were used to measure the latent variable of fatigue. The 4-item CRQ-fatigue subscale uses a 7-point Likert scale (1 = extremely fatigue to 7 = not at all fatigue) with scores ranging from 7 to 28. The SF-36 Vitality subscale has four-items with two positively worded items (“Did you feel full of pep?” and “Did you have a lot of energy?”) and two negatively worded items (“Did you feel worn out?” and “Did you feel tired?”). Scores range from 0 to 100 with higher scores indicating higher levels of vitality.

Disease severity—Disease severity was categorized using the forced expiratory volume in one second (FEV1). Disease severity was defined according to the GOLD grading system as follows: Moderate COPD (GOLD 2) with moderate airflow limitation FEV1 50% predicted, and Severe COPD (GOLD 3, 4) with severe and very severe airflow limitation FEV1 < 50% predicted.²⁵ Two groups were defined as either moderate (FEV1 50% predicted) or severe (FEV1 < 50% predicted) COPD.

Statistical Analysis

For ease of interpretation, symptom measures were recoded so that higher scores indicate greater symptom burden. Data analyses were conducted in two steps using Stata 14.2 (StataCorp LP, College Station, Texas). First, confirmatory factor analyses (CFA) were performed on the latent variables having more than two indicators (dyspnea, anxiety and physical performance) prior to adding the latent variables into the structural model. All indicators were chosen based on the theoretical framework. Maximum likelihood methods were used to estimate model parameters. Modification indices (Lagrange multiplier tests) were examined to determine whether the model fit improved by removing or replacing specific measurement indicators. The structural model was then estimated to test the hypotheses exploring the proposed relations among dyspnea, anxiety, depression, fatigue, and physical performance. Sensitivity analyses were also performed stratified by the severity of airflow limitation to determine whether the relationships differed by disease severity.

The model was assessed using multiple fit criteria: χ^2 goodness-of-fit statistic, the comparative fit index (CFI), the standardized root mean residual (SRMR), and the root mean square error of approximation (RMSEA). A statistically nonsignificant χ^2 ($p > .05$) is suggestive of a good match between the data and the hypothesized model. However, it has been shown that the chi-square test statistic would be significant for a large sample size. CFI, an incremental fit index measures how much a model being tested is improved compared to a baseline model. A high value of CFI is desirable. RMSEA, a parsimony-corrected index with its 90% confidence interval, measures lack of fit of a model. A value of zero RMSEA means the best fit. SRMR, a statistic related to the correlation residuals, measures the difference between the predicted and observed covariances. A low value of

SRMR is desirable. Cutoff values of 0.95 for CFI, 0.05 for RMSEA, and 0.08 for SRMR were selected to indicate acceptable fit with a maximum likelihood estimation method ²¹.

Results

Participant Characteristics

A total of 302 COPD patients completed the baseline assessments. Among them, 282 patients wore the Stepwatch for at least three days and were included in the analyses (Table 1). The study sample consisted of 80% males, with an average age of 68 years (SD = 9). A majority of the participants was White Non-Hispanic (88%), and had at least a college degree (77%). Furthermore, more than half had an annual income of \$20,000 or more (61%), and were married or partnered (58%). Race/ethnicity and body mass index were significantly different between groups categorized by the severity of airflow limitation (Table 1).

Means and standard deviations of original values before recoding for all measurements used in the SEM are presented in Table 2. Observed indicators of two constructs, Dyspnea and Physical Performance were significantly different between groups by lung function.

Bivariate correlations among 15 indicators used for five constructs are presented in Table 3.

Confirmatory Factor Analysis Results

A CFA was performed on covariance matrix of each indicator for constructs of dyspnea, anxiety, and physical performance, which had at least three indicators. The initial CFA of dyspnea and anxiety fitted the data well, but the initial CFA of physical performance with five indicators did not. The indicator of handgrip strength had a large residual variance of 89.28 and R-squared of 0.03, and did not have a significant factor loading. The handgrip muscle strength measure was therefore excluded from the SEM analyses, leaving four indicator variables for physical performance.

As a next step, the five-factor standard CFA showed an acceptable fit to the data, $\chi^2 (80) = 287.08$, $p < 0.001$; CFI = 0.92; SRMR = 0.08; RMSEA = 0.10. It means that selected 15 indicators for five constructs were remained in the hypothesized CFA model. Modification indices by Lagrange multiplier tests indicated three sets of indicators having large modification indices: 6MWT and daily total step (41.11), HADS-A and PHQ-9 (22.93), and HADS-A and HADS-D (22.31). Therefore, correlated errors between these sets of indicators were added to the next CFA. The final fit of this model showed a better fit to the data, $\chi^2 (77) = 197.96$, $p < 0.001$; CFI = 0.952; SRMR = 0.075; RMSEA = 0.075 (Table 4).

Structural Equation Modeling Results

The hypothesized structural equation model showed an acceptable fit to the data, $\chi^2 (75) = 197.96$, $p < 0.001$; CFI = 0.951; SRMR = 0.075; RMSEA = 0.076. A correlated error between constructs of Anxiety and Depression was added in the final model after checking modification indices (Table 4). Overall, the specified predictors explained 56% of the variance in anxiety, 56% of the variance in depression, 68% of the variance in fatigue, and 81% of the variance in physical performance. It means that, for example, 81% of the

variance of physical performance is explained by dyspnea, depression, anxiety, and fatigue. The hypotheses about the paths were examined by SEM (Table 5).

Hypothesis 1 states that greater dyspnea is associated with more anxiety, depression, and fatigue, and greater anxiety and depression are associated with more fatigue. SEM results showed that higher levels of dyspnea were associated with higher levels of anxiety ($\beta = .472, p < .001$), depression ($\beta = .456, p < .001$), and fatigue ($\beta = .277, p < .001$). Furthermore, higher levels of anxiety ($\beta = .262, p < .01$) and depression ($\beta = .435, p < .001$) were associated with more fatigue.

Hypothesis 2 states that greater dyspnea, anxiety, depression, and fatigue are associated with worse physical performance. SEM results showed that higher levels of dyspnea ($\beta = -.896, p < .001$) were associated with worse physical performance. On the other hand, higher levels of anxiety were related to better physical performance ($\beta = .266, p < .001$). Depression and fatigue were not significantly related to physical performance.

Hypothesis 3 states that dyspnea is indirectly associated with fatigue and worse physical performance through anxiety and depression, and anxiety and depression are indirectly associated with worse physical performance through fatigue. SEM results showed that higher levels of dyspnea ($\beta = .437, p < .001$) were indirectly related to more fatigue through anxiety and depression. Also, higher levels of anxiety ($\beta = -.244, p < .01$) and depression ($\beta = -.346, p < .001$) were indirectly related to worse physical performance, however not through fatigue.

Subgroup analyses by disease severity

Subgroup analyses based on the severity of airflow limitation are presented in Figure 2 and 3. Different results from the final SEM model were as follows. Among patients with moderate lung impairment (FEV1 50% predicted), greater dyspnea was not related to greater fatigue ($\beta = .161, p = .12$), however, greater fatigue was related to worse physical performance ($\beta = -.277, p < .05$). Among patients with severe or very severe lung impairment (FEV1 < 50% predicted), greater depressive symptoms were related to worse physical performance ($\beta = -.291, p < .05$). Greater dyspnea was related to greater fatigue ($\beta = .319, p < .001$), however, greater fatigue was not related to worse physical performance ($\beta = .013, p = .93$).

Discussion

The aim of this study was to examine the direct effects of dyspnea, anxiety, depressive symptom, and fatigue on physical performance, as well as the indirect effects of these symptoms on physical performance by an SEM approach. The hypothesized model was guided by the TOUS which includes (1) physiological and psychological factors of fatigue symptoms as dyspnea, anxiety, and depressive symptoms, (2) fatigue as the main symptom experience, and (3) physical performance as the consequence of these interrelated symptoms. Worse dyspnea was significantly associated with worse anxiety, depression, fatigue and physical performance. Higher levels of anxiety were associated with greater physical performance, while fatigue was not associated with physical performance. Dyspnea

was indirectly associated with fatigue through anxiety and depressive symptoms, and anxiety and depressive symptoms were indirectly associated with worse physical performance.

Consistent with previous studies, dyspnea was associated with anxiety, depression^{11,33} and fatigue^{1,34} and was a strong determinant of physical performance in the current study.^{7,35,36} Increased levels of anxiety were positively associated with improved physical performance, consistent with the findings in a previous study of a subset of 148 COPD patients who participated in the present study³⁷. However, it is known that anxiety is one of the major comorbidities in COPD. The current analyses differed from the prior study in that it included both objective and subjective measurements for physical performance as opposed to objectively measured daily step counts alone. It was suggested that increased daily steps may be a behavioral manifestation of the restlessness, or as non-goal directed activities from high levels of anxious symptoms.³⁷ An anxious mind may result in not sitting or resting still, however it should not be interpreted as an improvement in physical performance due to higher levels of anxiety. Future longitudinal studies are needed to better understand this relationship.

The association between depressive symptoms and physical performance has been mixed with some null studies^{38,39} and others reporting an association.^{34,40} These inconsistent findings may be due to different measures used to capture depressive symptoms and physical performance. Depression was measured by using subjective survey instruments; however, the measurements of physical performance included both subjective and objective measures. Bivariate analyses between depressive symptoms and objective physical performance did not show any significant association, whereas depression was correlated with subjective measures of physical function. To get the latent construct of physical activity, we included both objective measures of physical performance and exercise capacity and self-report to capture patient perception of physical function, however this may have attenuated the relationship between depression and physical activity. We recognize that step counts represent actual physical performance, distance covered during a walk test reflects exercise capacity, and self-report captures patients' perception⁴¹ and thus, our decision to combine these seemingly disparate measures into one latent construct of "physical performance" could have obfuscated any relationship that might exist. In subgroup analyses stratified by moderate or severe airflow limitation, this direct relationship between depression and physical performance was significant among severe COPD patients. Moderate COPD patients showed the indirect relationship between depression and physical performance through fatigue. One possible interpretation for these findings is that severe COPD status may make patients have difficulty to differentiate their co-occurring symptom experiences.

Fatigue was significantly associated with all other symptoms, as found in previous studies.^{1,34,42} The strong association between dyspnea and fatigue has been supported by several studies, implying shared underlying mechanisms are plausible.^{42,43} Patients are often not able to differentiate between the two symptoms and report both with more advanced disease.¹⁰ Our sensitivity analyses show that the association between dyspnea and fatigue is stronger in patients with more severe disease. Between the two groups stratified by disease severity, it was observed that severe COPD group had more ethnically diverse patients.

Anxiety and depressive symptoms are closely related with fatigue, as in previous studies.^{12,34} However, while it shows at least the same relational direction, the finding of the insignificant relationship between fatigue and physical performance is inconsistent with previous studies.^{1,22,42} Prior studies showing significant associations used multi-dimensional measures of fatigue^{43,44} or measured fatigue in relation to functioning.⁴⁵ Thus, one of the possible reasons for the lack of association in our study is that the SF36-V and CRQ-F instruments do not directly ask patients about the impact of fatigue on their physical performance, but simply captures a single-dimensional level of tiredness. The TOUS also suggests multidimensional measurements for the symptom experience.¹⁴

Interestingly, in the innovative subgroup analyses restricting the analysis to either moderate or severe airflow limitation, this relationship between fatigue and physical performance was significant among moderate COPD patients but not the severe COPD patients. Those patients with moderate airflow limitation showed no association between dyspnea and fatigue. In addition, consistent with previous findings,^{46,47} patients with moderate and severe COPD had similar symptom scores of depression, anxiety, and fatigue, but had different dyspnea scores.

SEM was chosen as an analytical approach to examine complex interrelationships among a variety of variables. SEM has the ability to specify latent variable models through providing separate estimation of relationships in the level of measurement and structures. Path analysis has been used to examine the relationships between symptoms and physical performance in previous studies with COPD patients.^{1,22} SEM has less restrictive assumptions considering measurement error compared to the path analysis. On the other hand, SEM often requires a large sample size and at least two indicators for a construct. It is possible that alternative models could fit the data similarly well or better compared to models being tested.

There are some limitations of this study. First, the analyses were based on a cross-sectional design. Reciprocal associations between four symptoms and physical performance are plausible. Longitudinal studies are needed to examine the directionality and causality for these complex relationships. Second, only 20% of the participants were female, which makes it difficult to stratify the analyses by gender as it is previously suggested that differing symptom experience across men and women.^{20,48} In the current study, we found that women tended to have higher levels of symptoms including dyspnea measured by CRQ-D and UCSD-SOB, anxiety measured by HADS-A, depression measured by HADS-D and PHQ-9, and fatigue measured by CRQ-F. Third, individual survey questions were used to measure anxiety in order to have at least two indicators to capture the latent construct. Although these single items had significant factor loadings, they may not allow comprehensive evaluations of anxiety as compared to a composite measure. Fourth, other common symptoms, e.g. sleep disorder and pain, were not examined for their effects on physical performance. Recent studies have shown that patients with COPD commonly experience thoracic pain, insomnia and obstructive sleep apnea.^{49,50}

Conclusions

The results of this cross-sectional analyses showed that dyspnea, anxiety and depression had direct effects on fatigue, and that dyspnea and anxiety had direct effects on physical performance for COPD patients. Of the four common symptoms experienced by patients with COPD, dyspnea exerted the strongest effects on physical performance in COPD. The findings presented support the importance of managing multiple COPD symptoms together in order to enhance patients' physical functioning as an outcome of symptom experiences.

Multidimensional assessment of multiple symptoms would help to improve symptom management in COPD patients.

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Figure 1.

Hypothesized Model of the Effect of Symptoms on Physical Performance in COPD

Note. CRQ-D = Chronic Respiratory Questionnaire - Dyspnea subscale; mMRC = the modified Medical Research Council dyspnea score; UCSD-SOB = University of California, San Diego Shortness of Breath Questionnaire; HADS-A = the Hospital Anxiety and Depression Scale - Anxiety; CRQ-EF4 = Chronic Respiratory Questionnaire - Emotional Function subscale question 4; CRQ-EF7 = Chronic Respiratory Questionnaire - Emotional Function subscale question 7; SF36-MH1 = the Medical Outcomes Study Short Form-36 - Mental Health subscale question 1; HADS-D = the Hospital Anxiety and Depression Scale - Depression; PHQ-9 = the Patient Health Questionnaire-9; CRQ-F = Chronic Respiratory Questionnaire - Fatigue subscale; SF36-V = the Medical Outcomes Study Short Form-36 - Vitality subscale; 6MWT = the six minute walk test; SF36-RP = the Medical Outcomes Study Short Form-36 - Role Physical subscale; SF36-PF = the Medical Outcomes Study Short Form-36 - Physical Functioning subscale.

Figure 2.

Effects of Symptoms on Physical Performance among Patients with Moderate COPD

Note. * $p < .05$. ** $p < .01$. *** $p < .001$. The numbers shown in the figure are standardized coefficients.

Figure 3.

Effects of Symptoms on Physical Performance among Patients with Severe COPD

Note. * $p < .05$. ** $p < .01$. *** $p < .001$. The numbers shown in the figure are standardized coefficients.

Table 1

Demographic and Clinical Characteristics

	Total Sample(n = 282)	Severe COPD(n = 170)	Moderate COPD(n = 112)	p-value
Mean ± SD or n (%)				
Socio-Demographics				
Age, years	67.7 ± 8.6	67.2 ± 8.1	68.6 ± 9.3	.18
Gender, women	56 (19.9)	32 (18.8)	24 (21.4)	.59
Race/Ethnicity				
Caucasians	249 (88.3)	143 (84.1)	106 (94.6)	
African-American	18 (6.4)	15 (8.8)	3 (2.7)	
Native Americans/Alaskan Native	8 (2.8)	7 (4.1)	1 (0.9)	.02
Asian	3 (1.1)	2 (1.2)	1 (0.9)	
Other	4 (1.4)	3 (1.8)	1 (0.9)	
Education				
High school or less	64 (22.7)	42 (24.7)	22 (19.6)	.32
Some college or more	218 (77.3)	128 (75.3)	90 (80.4)	
Income (n = 279)				
< 20K/year	108 (38.7)	70 (41.4)	38 (34.5)	.25
20K/year	171 (61.3)	99 (58.6)	72 (65.5)	
Marital status				
Partnered	163 (57.8)	100 (58.8)	63 (56.3)	.67
Un-partnered	119 (42.2)	70 (41.2)	49 (43.7)	
Body Mass Index	28.2 ± 6.2	27.6 ± 6.7	29.1 ± 5.3	.04
Current smoker	76 (27.0)	42 (24.7)	34 (30.4)	.30
Disease Severity				
FEV1, liter	1.36 ± 0.56	1.05 ± 0.36	1.83 ± 0.47	< .001
FEV1 % predicted	44.9 ± 15.8	34.3 ± 9.5	61.1 ± 7.4	< .001

Note. FEV1 = forced expiratory volume in one second.

Severe COPD is a group with FEV1 < 50% predicted and Moderate COPD is with FEV1 $\geq$ 50% predicted.

Table 2

Mean Scores for Measurements of Constructs including Dyspnea, Anxiety, Depression, Fatigue, and Physical Performance

	Total Sample(n = 282)	Severe COPD(n = 170)	Moderate COPD(n = 112)	p-value
Dyspnea				
CRQ-D (5–35↑)	23.83 ± 6.74	21.84 ± 6.46	26.84 ± 6.01	< .001
UCSD-SOB (0–120↓)	42.86 ± 22.34	49.46 ± 21.43	32.85 ± 19.90	< .001
mMRC (0–4↓)	1.94 ± 1.08	2.17 ± 1.07	1.60 ± 1.01	< .001
Anxiety				
HADS-A (0–21↓)	5.05 ± 3.95	4.83 ± 3.74	5.38 ± 4.24	.25
SF36-MHI (1–6↑)	4.71 ± 1.37	4.76 ± 1.33	4.63 ± 1.43	.43
CRQ-EF4 (1–7↑)	4.10 ± 1.71	4.09 ± 1.72	4.11 ± 1.71	.93
CRQ-EF7 (1–7↑)	4.84 ± 1.52	4.84 ± 1.55	4.82 ± 1.48	.89
Depression				
HADS-D (0–21↓)	4.23 ± 4.13	4.28 ± 3.93	4.15 ± 4.43	.81
PHQ-9 (0–27↓)	6.16 ± 4.75	6.09 ± 4.73	6.28 ± 4.81	.75
Fatigue				
SF36-V (0–100↑)	46.6 ± 12.39	46.35 ± 12.51	47.05 ± 12.26	.64
CRQ-F (7–28↑)	15.80 ± 4.88	15.72 ± 4.82	15.92 ± 4.98	.73
Physical Performance				
6MWT (feet)	1091 ± 372	1012 ± 376	1211 ± 334	< .001
Daily Total Steps	6002 ± 3343	5461 ± 3145	6823 ± 3479	< .001
SF36-RP (0–100↑)	29.17 ± 36.93	25.44 ± 35.20	34.82 ± 38.90	.04
SF36-PF (0–100↑)	39.38 ± 22.52	33.76 ± 20.36	47.90 ± 23.05	< .001

Note. ↑ means higher score indicating less symptom or better functioning. ↓ means higher score indicating higher symptom or worse functioning.

CRQ-D = Chronic Respiratory Questionnaire - Dyspnea subscale; UCSD-SOB = University of California, San Diego Shortness of Breath Questionnaire; mMRC = the modified Medical Research Council dyspnea score; HADS-A = the Hospital Anxiety and Depression Scale - Anxiety; SF36-MHI = the Medical Outcomes Study Short Form-36 - Mental Health subscale question 1; CRQ-EF4 = Chronic Respiratory Questionnaire - Emotional Function subscale question 4; CRQ-EF7 = Chronic Respiratory Questionnaire - Emotional Function subscale question 7; HADS-D = the Hospital Anxiety and Depression Scale - Depression; PHQ-9 = the Patient Health Questionnaire-9; SF36-V = the Medical Outcomes Study Short Form-36 - Vitality subscale; CRQ-F = Chronic Respiratory Questionnaire - Fatigue subscale; 6MWT = the six minute walk test; SF36-RP = the Medical Outcomes Study Short Form-36 - Role Physical subscale; SF36-PF = the Medical Outcomes Study Short Form-36 - Physical Functioning subscale.

Table 3

Correlations among Measurements of Constructs including Dyspnea, Anxiety, Depression, Fatigue, and Physical Performance

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Dyspnea															
1 CRQ-D	1.00														
2 UCSD-SOB	.83***	1.00													
3 mMRC	.55***	.60***	1.00												
Anxiety															
4 HADS-A	.37***	.23***	.07	1.00											
5 SF36-MHI	.32***	.25***	.08	.52***	1.00										
6 CRQ-EF4	.44***	.32***	.16**	.55***	.51***	1.00									
7 CRQ-EF7	.45***	.35***	.14*	.64***	.52***	.70***	1.00								
Depression															
8 HADS-D	.35***	.29***	.18**	.63***	.38***	.53***	.50***	1.00							
9 PHQ-9	.43***	.36***	.21**	.63***	.40***	.58***	.63***	.73***	1.00						
Fatigue															
10 SF36-V	.37***	.40***	.26***	.21**	.18**	.41***	.40***	.39***	.40***	1.00					
11 CRQ-F	.53***	.48***	.26***	.41***	.34***	.56***	.60***	.51***	.63***	.60***	1.00				
Physical Performance															
12 6MWT	-.41***	-.44***	-.45***	.03	-.04	-.05	-.02	-.11	-.10	-.15*	-.18**	1.00			
13 Daily Total Steps	-.32***	-.37***	-.42***	.13*	.03	.00	.01	-.09	-.09	-.20**	-.14*	.55***	1.00		
14 SF36-RP	-.54***	-.49***	-.34***	-.24***	-.25***	-.34***	-.33***	-.35***	-.38***	-.34***	-.52***	.26***	.29***	1.00	
15 SF36-PF	-.72***	-.78***	-.61***	-.14*	-.22**	-.28***	-.25***	-.28***	-.31***	-.42***	-.43***	.52***	.48***	.58***	1.00

Note. CRQ-D = Chronic Respiratory Questionnaire - Dyspnea subscale; UCSD-SOB = University of California, San Diego Shortness of Breath Questionnaire; mMRC = the modified Medical Research Council dyspnea score; HADS-A = the Hospital Anxiety and Depression Scale - Anxiety; SF36-MHI = the Medical Outcomes Study Short Form-36 - Mental Health subscale question 1; CRQ-EF4 = Chronic Respiratory Questionnaire - Emotional Function subscale question 4; CRQ-EF7 = Chronic Respiratory Questionnaire - Emotional Function subscale question 7; HADS-D = the Hospital Anxiety and Depression Scale - Depression; PHQ-9 = the Patient Health Questionnaire-9; SF36-V = the Medical Outcomes Study Short Form-36 - Vitality subscale; CRQ-F = Chronic Respiratory Questionnaire - Fatigue subscale; 6MWT = the six minute walk test; SF36-RP = the Medical Outcomes Study Short Form-36 - Role Physical subscale; SF36-PF = the Medical Outcomes Study Short Form-36 - Physical Functioning subscale.

* $p < .05$.

100' > d

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Model Fit Indexes of Structural Equation Modeling Examining Interrelationships between Four Symptoms and Physical Performance

Table 4

	χ^2_M	df _M	RMSEA	CFI	SRMR
Measurement model					
5-factor standard CFA	287.077 ^a	80	.10	.92	.08
5-factor CFA with three correlated errors ^b	197.961 ^a	77	.08	.95	.08
Structural regression model					
Hypothesized model ^c	197.961 ^a	75	.08	.95	.08

^a $p < .001$;

^b allowing three correlated errors between six minute walk test and daily total steps, HADS-A and HADS-D, and HADS-A and PHQ-9;

^c allowing four correlated errors between Anxiety and Depression, six minute walk test and daily total steps, HADS-A and HADS-D, and HADS-A and PHQ-9.

Note. RMSEA, root mean square error of approximation; CFI, comparative fit index; SRMR, standardized root mean residual.

Table 5

Path Coefficients of Direct and Indirect Effects between Four Symptoms and Physical Performance

	Unstandardized	SE	Standardized
Direct effects			
Dyspnea -> Anxiety	0.222 ***	.032	.472 ***
Dyspnea -> Depression	0.251 ***	.035	.456 ***
Dyspnea -> Fatigue	0.376 ***	.082	.277 ***
Anxiety -> Fatigue	0.755 **	.247	.262 **
Depression -> Fatigue	1.073 ***	.210	.435 ***
Dyspnea -> Physical Performance	-3.155 ***	.209	-.896 ***
Anxiety -> Physical Performance	1.994 ***	.543	.266 ***
Depression -> Physical Performance	-.591	.468	-.092
Fatigue -> Physical Performance	-.323	.235	-.124
Indirect effects			
Dyspnea -> Fatigue	0.437 ***	.071	-
Dyspnea -> Physical Performance	0.032	.130	-
Anxiety -> Physical Performance	-0.244 **	.080	-
Depression -> Physical Performance	-0.346 ***	.068	-

Note.

**
 $p < .01$.***
 $p < .001$.