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Additional Evidence for the Affective Dimension of Dyspnea in Patients with COPD

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Abstract

The primary purpose of this secondary analysis was to determine whether 103 participants with chronic obstructive pulmonary disease rated the affective dimension of dyspnea (dyspnea-related anxiety and dyspnea-related distress) separately from the sensory dimension (intensity) during baseline exercise testing conducted as part of a randomized clinical trial. A secondary purpose was to determine if dyspnea-related anxiety and distress were rated distinctly different from other measurements of anxiety. At the end of a 6-minute walk and an incremental treadmill test, participant ratings of the magnitude of dyspnea-related anxiety and distress on the Modified Borg Scale were significantly different from their ratings of the intensity of dyspnea. Dyspnea-related anxiety and distress also appeared to be concepts independent from measures of state anxiety, negative affect, and anxiety before a treadmill test.

Keywords

COPD; dyspnea; anxiety; affective dimension

For people living with chronic cardiopulmonary diseases, dyspnea or breathlessness is a distressing symptom that must be managed daily. Dyspnea is a broad term that encompasses different sensations and subjective experiences. How individuals describe dyspnea depends on the question they are asked, the condition causing the dyspnea, and the magnitude of the work that triggers the symptom (O'Donnell et al., 2007; Schwartzstein, 2005). When medical therapies are ineffective in reducing the intensity of dyspnea, especially in the palliative phase of illness, treatment of affective responses to dyspnea, such as anxiety and distress, may decrease the perceived intensity of the symptom (Carrieri-Kohlman et al., 2001). Valid and reliable measurements of this affective dimension could be used to determine the efficacy of complementary therapies, used with medical treatment, to manage dyspnea.

Dyspnea has been defined by a multidisciplinary committee as a "... subjective experience of breathing discomfort that consists of qualitatively distinct sensations that vary in intensity. The experience derives from interactions among multiple physiological,

psychological, social and environmental factors, and may induce secondary physiological and behavioral responses” (American Thoracic Society [ATS], 1999, p. 322). In this definition, the symptom is acknowledged to be not only a physiological phenomenon, but also, similar to pain, it is multidimensional and influenced by an individual’s experience and the mechanisms. The perceived symptom is ultimately shaped by emotions and psychological, social, and environmental experiences.

Investigators have compared dyspnea with pain and have reported that the sensations are perceived and expressed similarly (Gracely, Udem, & Banzett, 2007; von Leupoldt & Dahme, 2007). The sensory and affective dimensions of pain are independently influenced by psychological factors and are affected by different clinical interventions. The sensory dimension is the intensity of a symptom; the affective dimension is the degree of distress or unpleasantness associated with the symptom (Price, 2000; Wells & Ridner, 2008).

Thus far, most investigators have studied the sensory dimension of dyspnea. The physical sensations of dyspnea induced in the laboratory have been classified as air hunger, effort or work of breathing, and chest tightness. These sensations can be manipulated independently in the laboratory and have been shown to have different mechanical mechanisms and neural pathways (Binks, Moosavi, Banzett, & Schwartzstein, 2002). Other physical sensations are depth and frequency of breathing (Stulbarg & Adams, 2005) and a feeling of *unsatisfied inspiration*, defined as patients not feeling that they can take a deep breath (Mahler & O’Donnell, 2005).

People describe their dyspnea differently. Various clusters of descriptors have been associated with different disease categories (Elliott et al., 1991; Mahler et al., 1996; Simon et al., 1990). Verbal descriptors of dyspnea have also been reported to change with an individual’s health status and to be related to the intensity of perceived dyspnea by individuals with chronic obstructive pulmonary disease (COPD; Parshall, 2002; von Leupoldt, Balewski et al., 2007).

Knowledge about the affective dimension of dyspnea remains limited (Banzett et al., 2000; von Leupoldt, Ambruzsova, Nordmeyer, Jeske, & Dahme, 2006). Observational studies and communication with individuals who experience chronic shortness of breath have indicated that unpleasant emotional feelings are integral components of dyspnea (Brown, Carrieri, Janson-Bjerklie, & Dodd, 1986; Janson-Bjerklie, Kohlman-Carrieri, & Hudes, 1986). Adults who experience chronic shortness of breath have described these affective sensations as anxious feelings, panic, frustration, unpleasantness, worry, anger, lack of energy, speechlessness, and fear (Janson-Bjerklie et al.; Schwartzstein, 2005). When asked to describe their sensations during episodes of shortness of breath, children with asthma used descriptive words such as being nervous, angry, scared, and afraid of dying (Carrieri, Kieckhefer, Janson-Bjerklie, & Souza, 1991). The well-known synergistic cycle of anxiety and shortness of breath observed in clinical situations provides further empirical evidence that unpleasant emotions are related to the perception of shortness of breath.

In laboratory experiments where various stimuli were used to induce dyspnea-- including hypercapnia, hypoxia, and increased inspiratory resistance-- healthy volunteers rated the unpleasantness of dyspnea as distinct from breathing effort and tightness (Banzett, Pedersen, Schwartzstein, & Lansing, 2008; Dunckley et al., 2005). Imaging studies provide additional evidence that distinguishes dyspnea’s sensory and affective dimensions. Functional magnetic resonance imaging has been used to examine the subcortical areas of the brain associated with rating the perceived intensity and the unpleasantness of dyspnea. Neuroimaging studies have shown activation of the anterior insular cortex, anterior cingulate gyrus, and the amygdala during laboratory-induced air hunger (Evans et al.,

2002; von Leupoldt et al., 2008). These findings indicate that the affective dimension of dyspnea is processed in areas of the brain that also are activated by the sensations of pain (Casey, 1999), thirst (Parsons et al., 2000), hunger (Del Parigi et al., 2002), and fear (LeDoux, 2003). The findings provide further evidence that affective sensations are associated with an individual's experience of shortness of breath.

Healthy volunteers in the laboratory (Banzett et al., 2000; Banzett et al., 2008), people with asthma and COPD (Meek, Lareau, & Hu, 2003), people with COPD during exercise (Carrieri-Kohlman, Gormley, Douglas, Paul, & Stulbarg, 1996a; Wilson & Jones, 1991), and patients with lung cancer (Bredin et al., 1999) have differentiated the sensory from the affective dimension of dyspnea. However, there is still a debate about which words should be used when the affective dimension is rated by the individuals.

Our research group previously reported that participants with moderate-to-severe COPD during incremental treadmill exercise could differentiate measures of the affective dimension of dyspnea (i.e., dyspnea-related anxiety and distress) from measures of the sensory dimension, the perceived intensity, and breathing effort (Carrieri-Kohlman, Gormley, Douglas, Paul, & Stulbarg, 1996b). Although investigators continue to measure the affective dimension of dyspnea in the laboratory, we know of no further efforts to validate the ability of patients with COPD to differentiate the affective from the sensory dimension of dyspnea, when exercise is the stimulus for increasing shortness of breath.

Purpose

The goal of this secondary analysis was to determine if we could replicate our previous findings (Carrieri-Kohlman et al., 1996b) with a larger sample of people with COPD. The primary purpose was to determine if participants with COPD rated two measures of the affective dimension of dyspnea (i.e., anxiety and distress) separately from intensity, a measure of the sensory dimension of dyspnea. A secondary purpose was to determine if dyspnea-related anxiety and distress were rated distinctly different from other measurements of anxiety as a mood, the personality characteristic of negative affect, and the anxiety rated by a participant before an incremental exercise test.

Theoretical Model

Using the theoretical model that has guided our studies over 2 decades, we proposed that a self-management program for dyspnea that included education, exercise, and repeated exposure to dyspnea in a safe environment with nurse coaching and modeling of coping strategies, would decrease dyspnea-related anxiety and distress (Carrieri-Kohlman, Douglas, Gormley, & Stulbarg, 1993). This model was derived from studies of the effect of exposure and modeling on the anxiety and fear people experience with certain phobias (Bandura, Blahard, & Ritter, 1969; Williams, Turner, & Peer, 1985). By repeated exposure to dyspnea, an individual's belief in his or her ability to control the symptom could increase along with an increased tolerance for escalating shortness of breath (Lazarus & Folkman, 1984).

In this model, we assumed that dyspnea-related anxiety and distress are different phenomena than the intensity (sensory dimension) of the symptom. This paper presents findings that support the proposed model. The conceptual validity of this model depended on a patient's ability to separately rate the anxiety he or she felt with escalating dyspnea from the intensity of the symptom. Equally essential was a patient's ability to determine if the anxiety and distress experienced with his or her increasing dyspnea was separate from the emotion of anxiety and the personality characteristic of negative affect. Further, some investigators had suggested that the reduction in dyspnea and anxiety a patient feels after an exercise program

might be due, in part, to becoming more comfortable or less anxious about walking on a treadmill (Agle, Baum, Chester, & Wendy, 1973; Levine, Weiser, & Gillen, 1986). Thus, we believed that the anxiety of walking on a treadmill needed to be measured to determine if it could also be separated from dyspnea-related anxiety.

Admittedly, we could not judge the validity of our hypothesis or the effectiveness of the nurse coaching intervention with exposure to dyspnea in a randomized clinical trial (RCT) unless the rating of dyspnea-related anxiety and distress was separate from the generic mood, allowing the sensations to be measured and treated separately. To determine if we were decreasing a patient's dyspnea-related anxiety and distress, rather than the state anxiety or negative mood caused by other environmental or personal stressors, we needed to determine if these phenomena were independent and different.

Methods

Design

The data for this secondary analysis were collected from a larger, longitudinal, RCT that compared the effects of adding more supervised exercise sessions (0, 4, or 24) to a dyspnea self-management program for people with COPD. Measurements from 3 days of baseline testing were collected before the participants with moderate-to-severe COPD were randomly assigned to one of three versions of the dyspnea self-management program. Because the RCT's methods and design have been reported in-depth elsewhere, they are only summarized here (Carrieri-Kohlman et al., 2005; Stulbarg et al., 2002). The study protocol was approved by the Committee on Human Research of the University of California, San Francisco and each patient provided written informed consent.

Protocol

On Day 1 of the 3-day baseline evaluation, participants in the original RCT received instruction and practiced rating dyspnea intensity, dyspnea-related anxiety (DA), and dyspnea-related distress (DD) using the Modified Borg Scale (Burdon, Juniper, Killian, Hargreave, & Campbell, 1982). They also completed questionnaires including the Profile of Mood States, Tension-Anxiety subscale (POMS-TA; McNair, Lorr, & Droppleman, 1992). They then completed the 6-minute walk (6MW) after which they rated the intensity of their shortness of breath (6MWSOB), dyspnea-related distress (6MWDD), and dyspnea-related anxiety (6MWDA) on a Modified Borg Scale. Participants who met the clinical and pulmonary function criteria returned on Day 2 to perform a symptom-limited incremental treadmill test (ITT). Prior to the test they completed the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and used the Modified Borg Scale to rate their anxiety about walking on the treadmill (TRANX). The ratings during and at the end of this first ITT were used in the analysis reported here. On Day 3 participants completed the Positive and Negative Affect Schedule (PANAS-NA; Watson, Clark, & Tellegen, 1988) and another ITT as well as other measures not included in this secondary analysis. The descriptions and psychometrics for the instruments used to measure the concepts are discussed in the Measurements section and are listed in Table 1.

Participants

Individuals with moderate-to-severe COPD were recruited from the Better Breathers Clubs of the American Lung Association, printed advertisements, and practicing physicians. Over 36 months, 814 patients were screened by telephone. Of these, the 183 with a history of COPD and exercise limited by dyspnea underwent a baseline evaluation. Individuals were included in the study if they (a) were aged ≥ 40 years; (b) had a confirmed diagnosis of moderate-to-severe COPD and had been clinically stable for at least a month; (c) had a

forced expiratory volume in 1 second (FEV₁) less than 60% of predicted or a ratio of FEV₁ to forced vital capacity (FVC) less than 60%; (d) had no formal exercise training or pulmonary rehabilitation for ≥ 1 year; and (e) had no other active symptomatic diseases that would interfere with exercise. In the screening process, 68 individuals were excluded because they did not meet the inclusion criteria or were unable to complete baseline testing. Of the 115 participants who were randomized, 103 participants completed the 2-month testing session; their baseline test results were used for this secondary analysis (Stulbarg et al., 2002).

Exercise and Dyspnea Measurements

Pulmonary Function—Participants performed a screening spirometry test 15 to 30 minutes after inhaling two puffs of albuterol administered by spacer (Aerochamber; Monaghan: Plattsburg, NY). The protocol published by the American Thoracic Society (ATS, 1987) was used for testing lung volumes and flows at baseline.

Exercise Performance

Six-minute walk: Two 6MWs were performed roughly 30 minutes apart, during which the participants were given no encouragement (Guyatt et al., 1985). The longer walk was used for analysis. If the walk distances were not within 10% of each other, a third walk was performed (ATS, 2002).

Symptom-limited incremental treadmill test: The participants, breathing room air, performed the ITT according to a previously reported protocol of increasing speed and grade (Carrieri-Kohlman et al., 1996b). Each stage was 80 seconds in length, and the number of stages completed was different for each participant. Cardiopulmonary measurements, including heart rate, oxygen saturation (SaO₂) measured by a pulse oximeter, respiratory rate, minute ventilation (V_E), oxygen consumption (VO₂), and carbon dioxide production (VCO₂), were completed during the last 20 seconds of each stage (Sensormedics 2900; Yorba Linda, CA). All equipment was calibrated before each test.

The Modified Borg Scale (Burdon et al., 1982), with anchors of *none* and *worst imaginable*, was used to measure SOB, DA, and DD at pre-determined increments: the beginning and end of the 6MW, at rest, every ITT stage, and at the end of the ITT. The participants rated sensations by pointing to the appropriate level on the scale in response to these questions: How short of breath are you? How anxious about your shortness of breath are you? How distressing is your shortness of breath to you? The Modified Borg Scale is a valid measure of dyspnea in healthy volunteers and people with COPD (Gift, 1989; Wilson & Jones, 1989).

Mood and Affect Measurements

Trait Anxiety—The STAI T-Anxiety scale, consisting of 20 items, was used to measure trait anxiety, defined as a stable person's predisposition to anxiety as determined by his or her personality. Scores can range from 20 to 80, with higher scores indicating increased trait anxiety. Test-retest reliability ranges from .73 to .86, and internal consistency ranges from $\alpha = .83$ to .92 (Spielberger et al., 1983). Internal consistency in this study was $\alpha = .88$.

State Anxiety—Participants used the STAI S-Anxiety scale to rate their state anxiety before the ITT. State anxiety is defined as a person's transitory emotional response to a stressful situation. This 20-item, self-report questionnaire evaluates responses such as worry, nervousness, tension, and feelings of apprehension based on how people feel "right now" in a stressful situation. Scores can range from 20 to 80, with 80 representing the highest anxiety. This scale correlates highly with other measures of anxiety ($r = .80$), and test-retest

reliability ranges from $r = .16$ to $.54$ (Spielberger et al., 1983). Internal consistency was $\alpha = .89$.

Tension-Anxiety—The POMS-TA subscale on the instrument's short form was used in our secondary analysis to measure anxiety as a mood. The test-retest reliability of the short form has been reported as $r = .75$, and concurrent validity with the Manifest Anxiety Scale ($r = .36$ to $.80$) has been reported (McNair et al., 1992). Internal consistency for the POMS in this study was $\alpha = .74$.

Negative Affect—The PANAS, a measure of personality, consists of 10 adjectives to measure positive affectivity and 10 adjectives to measure negative affectivity (Watson et al., 1988). Participants rate the adjectives from 1 = *very slightly or not at all* to 5 = *extremely*. The subscales are scored separately; the higher the score, the more an affect is negative. In this secondary analysis, we only used the Negative Affect subscale (PANAS-NA), which is conceptually similar and related to anxiety as a mood. The adjectives in this subscale include distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, jittery, and afraid. The subscale has demonstrated concurrent validity with the Hopkins Symptom Checklist ($r = .74$), the Beck Depression Scale ($r = .58$), and the State-Trait Anxiety Inventory ($r = .51$). The test-retest reliability is reported to be $r = .48$ (Watson et al.). Internal consistency for this subscale for this sample was $\alpha = .75$.

Anxiety Associated with Walking on a Treadmill—The participants used the Modified Borg Scale to rate TRANX immediately before taking the ITT (Burdon et al., 1982). They were asked these questions: How anxious are you about walking on the treadmill today? By this I mean how nervous or apprehensive are you about walking on the treadmill today? In our previous study (Carrieri-Kohlman et al., 1996b), we used a vertical visual analogue scale (VAS) to measure this variable; thus, the Modified Borg Scale has not been previously validated for rating the feeling of anxiety about walking on the treadmill.

Data Analysis

Means and standard deviations were computed for all parameters. Magnitude differences in dyspnea measures at the end of the 6MW and at specific exercise levels during the ITT were compared by paired t -tests. Dyspnea at isostage was defined as the dyspnea rating that occurred at the highest stage during the two ITTs. For this secondary analysis, we used the ITT on the second baseline day to calculate these scores of dyspnea at isostage. The slope expressing the relationship between each dyspnea measure and minute ventilation (i.e., SOB/V_E) was determined for each participant and was based on the number of stages completed during the ITT. Each patient's slope was weighted equally when we calculated a mean slope for the total sample. We used the Wilcoxon matched pairs test to determine the differences between the mean slopes of measures of dyspnea over minute ventilation that was used as a proxy variable for escalating work during the ITT ($SOB/V_E - DD/V_E$, $SOB/V_E - DA/V_E$, $DD/V_E - DA/V_E$).

Pearson's correlation coefficient (r) was used to analyze the associations among all variables including the STAI T-Anxiety scale, STAI S-Anxiety scale, POMS-TA, TRANX, PANAS-NA, and the ratings of SOB, DD, and DA at the end of the 6MW and ITT. To further assess how the measures of the sensory and affective dimensions of dyspnea and various anxiety instrument scores grouped, a principal components factor analysis was used to identify the dimensions underlying the pattern of interrelationships among these variables. Dimensions with eigenvalues greater than 1.0 were extracted and rotated to a varimax solution. Factor loadings are reported for the rotated factor matrix.

Results

Sample and Baseline Measurements

The sample included 57 men and 46 women with moderate-to-severe COPD. Their mean age was 66 years ($SD = 8$). Demographic characteristics, pulmonary function variables, mood and negative affect scores, and means and standard deviations of the measures of the sensory and affective dimensions of dyspnea during both exercise tests are shown in Table 2.

Results Related to the Study's Primary Purpose

Differences in Magnitude Between Measures of the Sensory and Affective Dimensions of Dyspnea

Six-minute walk: At rest before the 6MW, the participants rated the intensity of dyspnea as significantly different from the affective dimension: SOB and DD (difference = 0.350, $p < .001$) and SOB and DA (difference = 0.345, $p < .005$). At the end of the walk, even greater differences were noted between the magnitude of dyspnea intensity and measures of the affective dimension (SOB-DD difference = 1.67, $p < .0001$; SOB-DA difference = 2.12, $p < .0001$; see Figure 1).

Incremental treadmill test: At rest before the ITT, no differences were noted between the intensity of dyspnea and the affective dimensions. However, at isostage, significant differences were observed in the magnitude between the sensory and affective pairs (SOB-DD difference = 1.08, $p < .001$; SOB-DA difference = 1.24, $p < .0001$). At the end of the ITT, the differences in the ratings of magnitude were significantly greater for both pairs: SOB-DD (difference = 1.25, $p < .001$); SOB-DA (difference = 1.45, $p < .001$; see Figure 2).

During the ITT, the means of the individual slopes relating the dimensions of dyspnea to V_E were SOB/ $V_E = 0.23 \pm 0.18$, DD/ $V_E = 0.20 \pm 0.27$, and DA/ $V_E = 0.18 \pm 0.25$. The intensity (SOB/ V_E) slope was significantly different from the distress (DD/ V_E) slope (difference = 0.028, $p < .001$) and the anxiety (DA/ V_E) slope (difference = 0.046, $p < .001$; see Figure 3).

Differences in Magnitude and Relationship Between Two Measures of the Affective Dimension of Dyspnea During Exercise—At the end of the 6MW, the magnitude of the two measures of the affective dimension, DA and DD, was significantly different (difference = 0.434, $p < .001$; see Figure 1). During the ITT at isostage and at the end of the ITT, the magnitude of the two measures of the affective dimension also was significantly different (DD-DA isostage difference = 0.193, $p < .05$; DD-DA end difference = 0.201, $p < .0001$; see Figure 2). The slopes for DD/ V_E and DA/ V_E were also significantly different from each other (difference = 0.017, $p = .05$; see Figure 3). In contrast to the magnitude, the correlations between DA and DD during the 6MW ($r = .87$, $p < .01$) and the ITT ($r = .93$, $p < .01$) were strong and significant as shown in Table 3.

Results Related to the Study's Secondary Purpose

Relationships Among Measures of the Affective Dimension of Dyspnea and Measurements of Anxiety, and Treadmill Anxiety—As shown in Table 3, during the 6MW and ITT, the correlations among the participants' ratings of DA and DD and trait or state anxiety were weak and not statistically significant. The participants' TRANX before the ITT was weakly correlated to DA ($r = .13$) and DD ($r = .13$) during exercise. However, a moderate and significant relationship was observed between TRANX and the STAI S-Anxiety scale ($r = .34$, $p < .01$).

Relationships Between Measures of Anxiety and Negative Affect—A moderate and significant correlation was observed between trait anxiety and state anxiety, as measured by the STAI ($r = .41, p < .01$). Negative affect and tension/anxiety measured by the PANAS-NA subscale and the POMS-TA subscale were also moderately and significantly related ($r = .45, p < .01$). The measures of negative affect and tension/anxiety, the PANAS-NA and the POMS-TA subscales, were also moderately and significantly associated with trait and state anxiety (see Table 3).

Factor Analysis of the Sensory and Affective Dimensions of Dyspnea Measured During Exercise and the Measures of Anxiety and Negative Affect—

We used principal components factor analysis to identify the dimensions underlying the pattern of interrelationships among the various measures. This factor analysis yielded four distinct factors that accounted for 77.3 % of the total variance in the measures (see Table 4). Dyspnea intensity (6MWSOB) and affective measures of DA (6MWDA) and DD (6MWDD) at the end of the 6MW loaded predominately on Factor 1, which appeared to be a *6-minute walk factor* (eigenvalue = 3.7, 33.4%). The measures of dyspnea at maximum stage of the ITT (ITTSOB end, ITT DD end, ITT DA end) loaded on Factor 2, which was labeled a *treadmill exercise factor* (eigenvalue = 2.1, 19.3%). Measures of trait anxiety (STAI T-Anxiety scale), mood (POMS-TA) and negative affect (PANAS-NA) loaded predominately on Factor 3, which was labeled a *negative affect factor* (eigenvalue = 1.5, 13.8%). TRANX, rated before the ITT, loaded on a separate Factor 4 (eigenvalue = 1.1, 10.2%) and was labeled *treadmill anxiety*. State anxiety loaded the highest on Factor 4.

Discussion

The results of this secondary analysis confirm our previous findings and provide further evidence that the affective dimension of dyspnea, as measured by DA and DD, is a separate experience from the sensory dimension of dyspnea that is perceived separately by individuals with COPD. The new finding in this study is that dyspnea-related anxiety and distress appear to be independent concepts from state anxiety, negative affect, and anxiety about walking on a treadmill, providing beginning evidence that these dyspnea-related affective responses can and should be measured separately as outcomes in the evaluation of interventions.

Differences between the Sensory and Affective Dimensions of Dyspnea

During the ITTs and 6MWs, the intensity of dyspnea (SOB) was moderately and significantly related to measures of the affective dimension (DD and DA). The three sensations increased in the same direction, a finding that would be expected theoretically because an individual's work increases during exercise. However, as in our previous study, the magnitude of the dyspnea intensity ratings was consistently and significantly higher than DA and DD. Other investigators have found similar results. Healthy volunteers rated the intensity of dyspnea higher than distress during exercise (Wilson & Jones, 1991). Patients with lung cancer who were taught management strategies for dyspnea were able to rate their distress due to dyspnea as a separate phenomenon from the intensity of dyspnea before and after a program for symptom management (Bredin et al., 1999). In another study, 89 people with COPD or asthma and 33 healthy volunteers rated their breathing effort consistently higher than their breathing distress during 2 weeks of daily measurement (Meek et al., 2003). When healthy volunteers breathed against progressive inspiratory resistive loads, alternating with unimpeded breathing, they were able to differentiate between the two dimensions, but they rated their unpleasantness higher than the intensity of shortness of breath (von Leupoldt & Dahme, 2005).

The proposition that the affective dimension of dyspnea is separate from the sensory dimension has been strengthened recently by reports that describe the subcortical areas that are specific to the rating of the unpleasantness of dyspnea (Schon et al., 2008; von Leupoldt et al., 2008). In addition, investigators have shown that an intervention can bring about distinct changes in the sensory and affective dimensions (von Leupoldt, Seemann, Gugleva, & Dahme, 2007).

The factor analysis in this secondary analysis yielded four distinct factors that accounted for 77.3 % of the total variance in the measures. The factors appeared to be test-specific for the sensory and affective dimensions of dyspnea; the factor loading was dependent on the timing or test of the measurement of the dimension and was not dependent on the type of dimension.

Differences Between the Two Measures of the Affective Dimension

Similar to a recent review on the measurement of pain (Wells & Ridner, 2008), advances in studying the affective dimension in patients with chronic dyspnea have been hindered by inconsistent terminology for measuring the dimension, the wording of questions used to elicit the affective dimension, and the instruments used to measure the emotions. Investigators have used different words, such as anxiety, distress, discomfort, and unpleasantness, when asking healthy volunteers or patients to rate the affective dimension of dyspnea. In laboratory studies, the word *unpleasant* has been used to elicit the affective dimension in contrast to sensory dimension labels such as *breathing effort* and *tightness* (Banzett et al., 2000; von Leupoldt et al., 2006). Other investigators have asked terminally ill cancer patients to rate their anxiety on a VAS, anchored by *no anxiety* and *worst possible anxiety*, to measure the anxiety that may be increasing the patients' shortness of breath (Dudgeon, Lertzman, & Askew, 2001). Conceptually, most investigators have measured the DA rated by a patient, while others have measured the emotion or mood of state anxiety during times that patients with COPD were acutely short of breath (Gift, Plaut, & Jacox, 1986). Among the instruments that have been used to measure the affective dimension of dyspnea are the VAS, the Modified Borg Scale, the STAI (Gift et al., 1986), and daily self-report measures of breathing distress (Meek et al., 2003).

At the time our theoretical model was proposed (Carrieri-Kohlman et al., 1993), the approach used by nurse researchers was to ask patients, especially those with cancer and cardiovascular disease, to rate their *distress* from pain and other symptoms (McCorkle, 1987; Wells & Ridner, 2008). In contrast, our theoretical model targets the *anxiety* accompanying the symptom (or phobia) that is to be reduced with exposure, modeling, and teaching coping strategies (Bandura, 1986). In our research program we included the measurements of DA and DD. The construct validity of these two measures of the affective dimension was supported by the findings that both ratings progressively increased as work and shortness of breath increased during the incremental exercise test (Carrieri-Kohlman et al., 1996b).

In our previous work, the slope of the distress related to ventilation during exercise was significantly greater than that for anxiety, suggesting that these two ratings may reflect different aspects of the symptom (Carrieri-Kohlman et al., 1996a). This finding signaled the importance of continuing to measure both sensations in the larger RCT (Carrieri-Kohlman et al., 2005) from which the data for this secondary analysis was taken. In our study, the two measures of the affective dimension, DA and DD, were again highly correlated and moved in the same direction. However, there were significant differences in the magnitude of these two measures during the 6MW and ITT, and the slopes relating the sensations to ventilation also were significantly different.

In his research on pain, Price (2000) has described two stages of symptom perception that may apply to the study of dyspnea. When measuring dyspnea during laboratory exercise, investigators may be capturing only its first stage, which Price (2000) has described as the immediate appraisal and emotional feeling. These feelings of unpleasantness, distress, and possible annoyance are associated with the immediate context and the sensory features of pain. However, Price also proposes a second stage of affect that is associated with the long-term implications of having pain and is based on more reflection, concern for the future, and memories and imagination about the implications. If dyspnea perception is similar to pain, this study captured only the first stage of perception. It is important that future investigations continue to study the long-term implications of living with chronic dyspnea.

The finding that the amygdala is activated during air hunger, which suggests that fear may be the response to dyspnea (von Leupoldt et al., 2008); the strong correlation between the participants' ratings of DA and DD in this study, calls for a reevaluation of the specific sensation or emotion being measured during increasing dyspnea in the laboratory. Identifying the specific sensation(s) a patient is feeling is important if treatment efforts to decrease the affective response to dyspnea are to be successful (Berkowitz, Coplan, Reddy, & Gorman, 2007; Etkin & Wager, 2007).

Differences Between the Affective Dimension of Dyspnea and Measures of Anxiety as a Mood, Emotion or Before Treadmill Walking Response

In our theoretical model for managing dyspnea, we hypothesized that if an individual experienced repeated and progressive exposure to dyspnea with nurse coaching and modeling of coping strategies in a safe environment, their perception of their control of dyspnea would be heightened and DA and DD would decrease, similar to the process of treating other symptoms or phobias (Bandura et al., 1969; Williams et al., 1985). To test this model, DA was viewed as a separate (or overlapping) concept from other measures of anxiety, including the emotion felt in the experimental situation or anxiety heightened due to the impending threat of walking on a treadmill. The relationships between the participants' ratings of DA and DD and these measures of mood, including state anxiety and anxiety about walking on the treadmill measured immediately before the exercise test, were small and not statistically significant. This lack of association provides the initial evidence that the anxiety individuals experience when their shortness of breath is escalating is not exactly the same phenomenon as their anxiety about the situation or their fear of an incremental treadmill test.

The measures of the affective dimension loaded on a different factor than the measures of anxiety as a mood or the negative affect of an individual. Treadmill anxiety loaded on Factor 4 giving evidence that it is different from the dyspnea-related measures. Patients completed the measures of treadmill anxiety and state anxiety at the same time, immediately before the treadmill exercise test, explaining in part why state anxiety was closest to the fourth factor. These initial findings validate our proposed model that the anxiety and distress an individual senses with increasing dyspnea is separate from other types of anxiety and can be individually targeted with various cognitive-behavioral interventions.

Relationships Among the Measures of Anxiety as a Mood, Emotion, or Treadmill Walking

Trait and state anxiety were moderately and significantly related. The two measures of negative mood, tension-anxiety (POMS) and negative affectivity (PANAS) were moderately and significantly related and grouped into the same factor. Although negative affectivity has been found to influence symptom reporting by others (Kvaal & Patodia, 2000; Put, Demedts, Van Den Bergh, Demyttenaere, & Verleden, 1999), affect did not appear to

influence the participants' rating of intensity or measures of the affective dimension of dyspnea during exercise in this study.

Study Limitations

Although a strength of this secondary analysis is that the sample consisted of people who were experiencing shortness of breath daily rather than healthy volunteers who rated their perceived dyspnea in laboratory studies, it has several limitations. It was necessarily limited by the timing and methods used to measure the dimensions of dyspnea. There was only a one-time administration of the instruments before the participants were randomized to the intervention. The instruments were also administered on 1 of 3 baseline days, thus *when* the participants completed the instruments may have erroneously reflected differences in their moods or affect. Further, during the exercise tests, it was not possible to state the questions to elicit the rating of sensory and affective dimensions in random order; it is possible, therefore, that the study's findings were influenced by an order effect.

The participants practiced using the Modified Borg Scale by rating the level of another sensation, thirst, in a clinical situation to approximate their accuracy in rating sensations; this was the first time the participants would use the Modified Borg Scale in the year-long larger study. The participants were not asked to describe their sensations of anxiety or distress during escalating shortness of breath; only generic questions were asked. These generic questions may not have had the same meaning for all participants. Because exercise has been the stimulus for participants to separately rate the dimensions, a different stimulus for inducing shortness of breath should be studied.

Conclusion

The interdisciplinary research on the mechanisms, measurement, and management of dyspnea over the past 3 decades has been focused largely on the sensory dimension of dyspnea (O'Donnell et al., 2007). The significant findings from these efforts, however, have not been widely accepted or integrated into the clinical care of patients with pulmonary disease. Researchers and clinicians must continue to study and translate into practice the findings related to the sensory, or intensity, dimension of dyspnea. However, they have an even larger responsibility to study, measure, and treat the affective dimension of dyspnea for persons who suffer from the chronic symptoms of cardiopulmonary diseases.

Measuring the affective dimension of dyspnea and using evidence-based treatments become critical when medical therapies have been exhausted and dyspnea still persists or is escalating in the later stages of illness. It is then that patients, families, and health care providers must find methods to reduce the breathlessness, suffering, and panic that patients with advanced pulmonary disease experience. Findings from this study provide additional evidence that the affective dimension of dyspnea can be rated separately from the intensity of dyspnea and that the affective dimension is separate from measures of anxiety as an emotion or mood.

Recent research studies have shown that a self-management program of education and exercise for people with COPD (Carrieri-Kohlman et al., 1996b; Carrieri-Kohlman et al., 2001), a yoga training program for people with chronic dyspnea (Donesky-Cuenca, Nguyen, Paul, & Carrieri Kohlman, 2009), a nurse-directed clinic with a symptom management education program (Bredin et al., 1999), and attentional-distraction cognitive interventions (Bauldoff, Hoffman, Zullo, & Sciurba, 2002; von Leupoldt, Seemann et al., 2007) may decrease the affective unpleasant and distressful aspects of dyspnea for patients, apart from the intensity of the symptom. The lack of a valid and routine measurement for the intensity

or sensory dimension of dyspnea in the clinical setting is well-known, and the measurement of the affective dimension is almost nonexistent (Carrieri-Kohlman & Dudgeon, 2006). Measuring the affective dimension of dyspnea in the clinical setting will provide individual baselines and norms that can be used to institute and evaluate specific cognitive-behavioral therapies that may reduce this distressing symptom for people with pulmonary disease.

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FIGURE 1.

Modified Borg scores (Mean $\pm$ SD) for the magnitude of the measures of the sensory and affective dimensions of dyspnea before and after the 6-minute walk. Note: Before the 6-minute walk (6MW) at rest, the difference between the magnitude of dyspnea intensity (SOB) and dyspnea-related distress (DD) was .35 ($p < .001$), the difference between the magnitude of SOB and dyspnea-related anxiety (DA) was .345 ($p < .005$), and the difference between the magnitude of DD and DA was not significant. At the end of the 6MW, the difference between the magnitude of SOB and DD was 1.67 ($p < .0001$), the difference between the magnitude of SOB and DA was 2.12 ($p < .0001$), and the difference between the magnitude of DD and DA was .434 ($p < .001$).

FIGURE 2.

Modified Borg scores for the magnitude of intensity and affective dimensions of dyspnea during incremental treadmill exercise. Note: At rest prior to the Incremental Treadmill Test (ITT), the differences between the magnitude of dyspnea intensity (SOB), dyspnea-related distress (DD), and dyspnea-related anxiety (DA) were not significant. At ITT Isostage, defined as the highest stage completed during two ITTs, the difference between the magnitude of SOB and DD was 1.08 ($p < .001$), the difference between the magnitude of SOB and DA was 1.24 ($p < .0001$), and the difference between the magnitude of DD and DA was .193 ($p < .05$). At the end of the ITT, the difference between the magnitude of SOB and DD was 1.25 ($p < .001$), the difference between the magnitude of SOB and DA was 1.45 ($p < .001$) and the difference between the magnitude of DD and DA was .201 ($p < .0001$).

FIGURE 3.

Mean slopes of modified Borg scores of intensity and affective dimensions of dyspnea related to minute ventilation (VE) during incremental treadmill exercise. Note: The mean slope of dyspnea intensity (SOB) related to minute ventilation (VE) over time during incremental treadmill test (ITT) was .23 (SD $\frac{1}{4}$.18). The mean slope of dyspnea-related distress (DD) related to VE over time during ITT was .20 (SD $\frac{1}{4}$.27). The mean slope of dyspnea-related anxiety (DA) related to VE over time during ITT was .18 (SD $\frac{1}{4}$.25). The difference between the mean slope of SOB related to VE (SOB/VE) and the mean slope of DD related to VE (DD/VE) was .028 ($p < .001$). The difference between SOB/VE and the mean slope of DA related to VE (DA/VE) was .046 ($p < .001$). The difference between DD/VE and DA/VE was .017, $p \frac{1}{4}$.05.

Table 1

Concepts of Sensory and Affective Dimensions of Dyspnea and Mood/Emotion/Affect, Abbreviations, Instruments, and Day of Measurement

Concept /Variable	Abbreviation	Instrument	Day Measured
Measure of sensory dimension of dyspnea			
Dyspnea intensity at end of ITT.	ITTSOB end	Modified Borg Scale "How short of breath are you?"	2
Dyspnea intensity at end of 6MW.	6MWSOB end	Modified Borg Scale "How short of breath are you?"	1
Measures of affective dimension of dyspnea			
Dyspnea-related distress at end of ITT.	ITTDD end	Modified Borg Scale "How distressing or bothersome is your shortness of breath?"	2
Dyspnea-related distress at end of 6MW.	6MWDD end	Modified Borg Scale "How distressing or bothersome is your shortness of breath?"	1
Dyspnea-related anxiety at end of ITT.	ITTDA end	Modified Borg Scale "How anxious about your shortness of breath are you?"	2
Dyspnea-related distress at end of 6MW.	6MWDA end	Modified Borg Scale "How anxious about your shortness of breath are you?"	1
Measures of mood/emotion/affect			
Tension-anxiety.	POMS-TA	Profile of Mood States, Tension-Anxiety subscale	1
Negative affect.	PANAS-NA	Positive and Negative Affect Schedule, Negative Affective subscale	3
Trait anxiety.	STAI	State-Trait Anxiety Inventory, T-Anxiety scale	2
State (situational) anxiety.	STAI	State-Trait Anxiety Inventory, S-Anxiety scale	2
Anxiety rated by participant before the incremental treadmill test.	TRANX	Modified Borg Scale, "How anxious are you walking on the treadmill?"	2

Note. ITT = incremental treadmill test; ITTSOB = incremental treadmill test, shortness of breath; 6MW = 6-minute walk; 6MWSOB = 6-minute walk, shortness of breath; ITTDD = incremental treadmill test, dyspnea-related distress; 6MWDD = 6-minute walk, dyspnea-related distress; ITTDA = incremental treadmill test, dyspnea-related anxiety; 6MWDA = 6-minute walk, dyspnea-related distress; POMS-TA = Profile of Mood States, Tension-Anxiety subscale; PANAS-NA = Positive and Negative Affect Schedule, Negative Affective subscale; STAI = State-Trait Anxiety Inventory; TRANX = treadmill anxiety.

Table 2

Sample Characteristics and Baseline Means and Standard Deviations (N = 103)

Variable	Mean $\pm$ SD
Age	66 $\pm$ 8
Gender (M/F)	57/46
Height, cm	166.8 $\pm$ 8.7
Weight, kg	72.1 $\pm$ 15.6
FEV ₁ , L	1.08 $\pm$ 0.32
FEV ₁ , % predicted	44.8 $\pm$ 14.3
FVC, L	2.6 $\pm$ 0.59
FVC, % predicted	76.1 $\pm$ 15.0
FEV ₁ /FVC %	42.0 $\pm$ 11.6
STAI T-Anxiety scale (20-80)	37.4 $\pm$ 9.5
STAI S-Anxiety scale (20-80)	30.14 $\pm$ 9.54
POMS-TA (0-20)	4.5 $\pm$ 3.2
PANAS-NA (10-50)	15.93 $\pm$ 5.7
TRANX (treadmill anxiety; 0-10)	1.10 $\pm$ 1.68
Six-Minute Walk Test End	
6MWSOB end (0-10)	4.2 $\pm$ 2.2
6MWDD end (0-10)	2.5 $\pm$ 2.6
6MWDA end (0-10)	2.1 $\pm$ 2.6
Incremental Treadmill Test	
SOB/V _E slope	0.53 $\pm$ 0.35
DD/V _E slope	0.45 $\pm$ 0.50
DA/V _E slope	0.42 $\pm$ 0.55
ITTSOB end	5.10 $\pm$ 2.1
ITTDD end	3.9 $\pm$ 2.6
ITTDA end	3.7 $\pm$ 2.9

Note. FEV₁ = forced expiratory volume in 1 second; FVC = forced vital capacity; STAI = State-Trait Anxiety Inventory; POMS-TA = Profile of Mood States, Tension-Anxiety subscale; PANAS-NA = Positive and Negative Affect Schedule, Negative Affect subscale; TRANX = treadmill anxiety related to exercise during the incremental treadmill test; 6MWSOB = 6-minute walk, shortness of breath, (dyspnea) intensity; 6MWDD = 6-minute walk, distress related to dyspnea; 6MWDA = 6-minute walk, dyspnea-related anxiety; SOB/V_E slope = shortness of breath (dyspnea intensity) related to minute ventilation over time during incremental treadmill test; DD/V_E slope = dyspnea-related -distress related to minute ventilation over time during incremental treadmill test; DA/V_E slope = dyspnea related -anxiety related to minute ventilation over time during incremental treadmill test; ITTSOB end = shortness of breath, (dyspnea intensity) at end of incremental treadmill test; ITTDD end = dyspnea-related distress at end of incremental treadmill test; ITTDA end = dyspnea-related anxiety at end of incremental treadmill test.

Table 3

Correlation Coefficients Among Sensory and Affective Dimensions of Dyspnea at the End of Incremental Treadmill Exercise and Six-Minute Walk Test and Measures of Anxiety, Negative Affect, and Treadmill Anxiety (N=103)

	1	2	3	4	5	6	7	8	9	10	11
1. ITTSOB end	–										
2. ITTDD end	.64**	–									
3. ITTDA end	.56**	.93**	–								
4. 6MWSOB end	.30**	.31**	.23*	–							
5. 6MWDD end	.15	.41**	.37**	.63**	–						
6. 6MWDA end	.18	.49**	.48**	.59**	.87**	–					
7. POMS-TA	.07	.18	.12	.12	.18	.32**	–				
8. PANAS-NA	.05	.15	.10	-.03	.06	.16	.45**	–			
9. STAI T-Anxiety scale	.12	.11	.11	.01	.03	.19	.59**	.52**	–		
10. STAI S-Anxiety scale	.04	.15	.11	.16	.13	.24*	.27**	.45**	.41**	–	
11. TRANX	-.15	.13	.15	.10	.15	.18	.08	.01	.00	.34**	–

Note. ITTSOB end= shortness of breath (dyspnea intensity) at end of incremental treadmill test; ITTDD end = dyspnea-related distress at end of incremental treadmill test; ITTDA end= dyspnea-related anxiety at end of incremental treadmill test; 6MWSOB end = shortness of breath, (dyspnea) intensity at end of 6-minute walk; 6MWDD = dyspnea-related distress at end of 6-minute walk; 6MWDA = dyspnea-related anxiety at end of 6-minute walk; POMS-TA = Profile of Mood States, Tension-Anxiety subscale; PANAS-NA = Positive and Negative Affect Schedule, Negative Affect subscale; STAI = State-Trait Anxiety Inventory; TRANX = treadmill anxiety related to exercise during the incremental treadmill test.

*
p < .05, two-tailed.

**
p < .01, two-tailed.

Table 4

Rotated Factor Loadings of Sensory and Affective Dimensions of Dyspnea At End of Exercise Tests and Measures of Anxiety, Negative Affect, and Treadmill Anxiety in Patients with Chronic Obstructive Pulmonary Disease

	Factor 1	Factor 2	Factor 3	Factor 4
6MWDD end	0.92	0.15	0.33	0.08
6MWDA end	0.87	0.24	0.20	0.13
6MWSOB end	0.81	-0.14	-0.01	-0.00
ITD end	0.27	0.92	0.08	0.13
ITDA end	0.23	0.90	0.04	0.16
ITTSOB end	0.07	0.81	0.07	-0.24
STAI (Trait-Anxiety)	-0.01	0.07	0.86	-0.02
PANAS-NA	-0.03	0.07	0.79	0.09
POMS-TA	0.21	0.03	0.77	-0.02
TRANX	0.10	0.00	-0.04	0.92
STAI (State-Anxiety)	0.08	0.05	0.55	0.58

Note. 6MWDD = dyspnea-related distress at end of 6-minute walk; 6MWDA = dyspnea-related anxiety at end of 6-minute walk; 6MWSOB end = shortness of breath, (dyspnea) intensity at end of 6-minute walk; ITD end = dyspnea-related distress at end of incremental treadmill test; ITDA end = dyspnea-related anxiety at end of incremental treadmill test; ITTSOB end = shortness of breath (dyspnea intensity) at end of incremental treadmill test; STAI = State-Trait Anxiety Inventory; PANAS-NA = Positive and Negative Affect Schedule, Negative Affect subscale; POMS-TA = Profile of Mood States, Tension-Anxiety subscale; TRANX = treadmill anxiety related to exercise during the incremental treadmill test. The variables that loaded together on the same factor are enclosed in brackets.