# Are self-reports of breathing effort and breathing distress stable and valid measures among persons with asthma, persons with COPD, and healthy persons?

By: Paula M. Meek PhD, RN, Suzanne C. Lareau RN, MS, and Jie Hu PhD, RN,

**Abstract:**
**Background**
Breathing is a subjective experience that includes physical sensations, such as effort to breathe, and an affective element, such as breathing distress.
**Objective**
The overall purpose of this investigation was to evaluate whether measurement of the physical sensations (breathing effort) and affective response to these sensations of breathing (breathing distress) are consistent and valid.
**Design**
A longitudinal repeated measures design was used to evaluate a 2-week daily breathing with a sub-sample (n = 43) who also recorded their daily breathing during 4 weeks.
**Subjects**
Age-matched, stable subjects (n = 92) with an average age of 62 were evaluated. The sample consisted of 32 subjects with chronic obstructive pulmonary disease, 27 subjects with asthma, and 33 healthy subjects.
**Measures**
Visual Analogue Scales for breathing effort (VAS-E) and breathing distress (VAS-D) were scored daily.
**Results**
The VAS-E and VAS-D mean, highest, and lowest scores were found to be stable over time in the sub-sample and a significant difference (F = 2.56, P < .05) between VAS-E and VAS-D was found. Differences were found in mean and highest VAS-E and VAS-D by group, with the COPD group reporting the highest values.
**Conclusions**
This investigation provided initial evidence of the stability and validity of daily VAS-E and VAS-D measures and preliminary support for the use of daily VAS logs to evaluate differences in breathing effort and breathing distress.

**Article:**
*Introduction*
Breathing is a subjective experience that includes physical sensations and perceptions that contain an affective element, which can vary from breath to breath. Patient perceptions of breathing have multidimensional aspects described as physical (what they sense), affective (what they feel), and cognitive (what they think) dimensions.[1] Intra-individual differences influence the interpretation of physical sensations and the affective and cognitive elements of one's health perceptions associated with breathing. [2] The overall purpose of this investigation was to evaluate whether measurement of the physical sensations (breathing effort) and affective response to these sensations of breathing (breathing distress) are consistent and valid.

**Breathing in lung disease and healthy persons**
Sensations, perceptions, and interpretations of breathing vary both across persons and across pulmonary

conditions. Asthma is characterized as having a degree of reversibility in lung impairment and variability in the magnitude of breathing sensations.[3] Increases in breathing effort and distress experienced by persons with asthma can be characterized as intermittent episodes of hyper-reactivity, sensation of chest tightness, and distress. [4] Changes in lung impairment and the episodic patterns experienced with asthma differ from those with chronic obstructive pulmonary disease (COPD). COPD is characterized as nonreversible lung impairment with an insidious, constant pattern of increased breathing effort with fluctuations in the associated breathing distress. Persons with COPD describe their sensation of breathlessness with qualitative terms of effort, heavy, hunger, and gasping, whereas those with asthma use the terms deep, exhalation, concentration, heavy, and tight.[5] Recently, Harver and colleagues confirmed that, like those with cardiopulmonary disease, healthy persons also make judgments about their breathing and the associated descriptors. [6] Healthy persons experience the sensation of increased breathing effort with exercise [7] and describe this sensation as uncomfortable.[8] Healthy persons with induced dyspnea in the laboratory setting report clusters of breathing terms (eg, rapid, exhalation, and concentration) similar to those that patients with pulmonary disease report.[5, 6 and 9] Consequently, most persons, whether healthy or with lung disease, have experienced increased breathing effort and may use many various words and phrases to describe the physical sensations associated with breathing. However, given the physical sensations of breathing in these populations, breathing distress (ie, how upset a person is) is poorly understood and requires investigation.

The affective dimension of breathing has been described as distress, discomfort, or anxiety,[10, 11 and 12] associated with the physical sensation of breathing. [13] Typically, when measuring dyspnea, persons are only asked to indicate how intense the sensation is and are not asked to indicate the magnitude of the distress associated with that breathing intensity level. [14 and 15] Evaluation of breathing distress, the affective dimension of breathing, has received limited examination in the literature. [16] Initial research has shown that both the intensity of breathing effort and the resulting affective response contribute to a person's overall perception of breathlessness. [17] The difference between the distress and effort associated with breathing has been examined by Wilson and Jones in normal subjects during exercise. [10] In this study, variations in breathing intensity and distress indicated that a high intensity of breathing effort in healthy persons is not necessarily associated with perceptions of breathing distress. Steele and colleagues studied patients with COPD and found a difference between perceived breathing effort and breathing discomfort. [11] Carrieri-Kohlman and colleagues reported that persons with COPD who exercised identified different dimensions of breathlessness, where the breathing effort was correlated with the intensity of exercise, and breathing distress was correlated with general anxiety. [12] These findings support the premise that the intensity of breathing effort can be differentiated from affective breathing distress and that anxiety is associated with breathing distress. In all 3 of these investigations the perception of breathing effort was rated higher than perception of breathing discomfort or distress. [10, 11 and 12] Consequently, physical effort and affective discomfort can be differentiated by persons with COPD and healthy persons at least in a laboratory setting. To date, there have been no reports of a person's ability to differentiate breathing effort and the associated distress of breathing on more than 1 occasion, over an extended period of time, or in other than a laboratory setting. In addition there has been no clear examination of how these sensations might present in persons with asthma.

There is an implicit expectation that affective and physical dimensions of breathing would be dissimilar in persons with different pulmonary diseases, when compared with healthy persons. At present, little is known about how both breathing effort (physical dimension) and breathing distress (affective dimension) may vary over time in these groups. Variations in breathing in relation to the physical sensation, affective component, and judgments associated with various pulmonary conditions will affect the person's interpretation of symptoms and how they ultimately communicate with their health care provider. The overall aim of this investigation was to examine daily self-report measures of breathing effort and breathing distress in relation to the subject's ability to discriminate between these breathing components (effort and distress) in persons with stable COPD, persons with asthma, and healthy persons under non laboratory conditions over time. The specific research questions were:

1.Are daily self-reported measures of breathing effort and breathing distress reliable in healthy persons and

stable persons with asthma and COPD? 2.Are daily self-report measures of breathing effort and breathing distress able to discriminate between groups with differences in pulmonary function? 3.What is the relationship between the intensity and variability over time in self reports of breathing effort and breathing distress with a) severity of lung impairment, b) episode pattern, c) cognitive function, and d) mood?

## Methods
### Research design
This study is part of a larger longitudinal repeated measures investigation examining the interpretation of breathlessness. The original investigation obtained daily self-report measures of breathing effort and breathing distress in healthy persons and those with asthma and COPD over a 12-month period with only a portion of that information used here. This study is a secondary analysis that uses longitudinal measures of breathing effort and breathing distress to evaluate their consistency and validity when obtained over time in a non-laboratory setting.

### Subjects
A convenience sample of COPD, asthma, and healthy subjects participated in the study. Subjects were recruited from 3 cities (Tucson and Phoenix, Arizona and Loma Linda, California) in the southwestern United States from 1997 to 2001. The criteria for inclusion of subjects with COPD were a clinical diagnosis of COPD; moderate pulmonary impairment demonstrated by a ratio of FEV1 (forced expiratory volume in 1 second) to FVC (forced vital capacity) of ≤ 65% (FEV1/FVC); or an FEV1 ≤ 65% of predicted and no history of exacerbations of lung disease for 3 months before enrollment. Asthma group subjects met at least 1 of the National Heart, Lung, and Blood Institute criteria[18] for moderate asthma, with all of the subjects with asthma requiring daily medication a key criteria. Both the COPD group and the asthma group reported noticeable breathless episodes 2 to 3 times per week but no history of hospitalization or emergency room visits in the 9 weeks before the study and no history of uncontrolled congestive heart failure. Criteria used for the healthy group included no history of pulmonary disease, normal values for spirometry, and participation in aerobic exercise for at least 30 minutes 3 times per week. All participants were able to read and speak English.

### Data collection method
The study was approved by the Human Subjects Committees of participating institutions. A verbal explanation and a written consent form were given to participants before data collection. Subjects meeting the criteria were recruited into the study. The presence of lung impairment was validated with spirometry at baseline. Daily measures of breathing distress and effort were recorded in a daily log by all subjects using a Visual Analogue Scale (VAS) during a 2-week period or in a subset of subjects (n = 43) during a 4-week period. All subjects were instructed to record their breathing at the same time of day within a range of 1 hour over the course of the time requested (2 or 4 weeks). To encourage compliance with the procedures, each subject was allowed to select the time of day they preferred. In addition, measures of anxiety, irritability, poor memory, and helplessness or hopelessness from the Bronchitis-Emphysema Symptom Checklist (BESC), and cognitive function by both the Mini Mental State Exam (MMSE) and Babcock verbal recall test were also obtained at baseline.

### Instruments
Demographic questions were used to determine age, gender, frequency of hospitalizations, breathing awareness during the day, and the number of episodes of breathlessness per day. Awareness of breathing and number of episodes per day were used to reflect the episode pattern. Spirometry testing was done using Vitalograph alpha 1 Spirometer, according to guidelines established by the American Thoracic Society.[19] Values used in this analysis were FEV1 and FVC percent of predicted normal values (FEV1% and FVC%) using Morris predicted values.[20]

The vertical VAS was used to measure daily reports of breathing effort and breathing distress. The VAS has been widely used to quantify breathlessness[21] and as a measure of a subjects' feelings about breathlessness. [22] The repeatability and sensitivity of the VAS is well established in normal persons during exercise. [23] The validity of the VAS is also established in patients with stable COPD [24] and asthma. [25 and 26] The vertical

VAS has historically been highly correlated with the horizontal VAS (r = 0.97), and is easier to understand and use compared with the horizontal VAS. [27]

Two VAS measures were used in this study, one to evaluate breathing effort and one to evaluate breathing distress, and each vertical line was 100 millimeters in length. An anchor for evaluation of breathing effort was anchored from 0 (no effort) to 100 (the greatest possible effort). Breathing effort was defined as the amount of work or energy you feel is associated with breathing. Evaluation of breathing distress was labeled on a 0-to-100 scale with 0 representing no distress and 100 representingthe greatest possible distress. Breathing distress was defined as the amount of upset associated with breathing effort. Subjects were instructed to place a mark daily on each of the 2 lines during 14 consecutive days or, in a subset of subjects, 28 days, indicating the distress and effort associated with their breathing. Healthy subjects were instructed to evaluate breathing distress and effort in association with exercise on the days they exercised, and with other physical activity on days they did not. The BESC was used to provide general self-reported measures of mood and cognitive function to evaluate the validity of the VAS measures. The BESC is a self-administered 73-item questionnaire[28] consisting of 11 symptom categories of which 4 were used in this study: anxiety (6 items), irritability (5 items), poor memory (6 items), and helplessness or hopelessness (4 items). The BESC items are evaluated on a 5-point scale based on the frequency of occurrence, from never to always, with higher scores indicating greater occurrence. Previous reports of the internal consistency for each symptom category ranged from Cronbach alphas of 0.81 to 0.94.[16] Reliability for the subscales in this study was supported by Cronbach alphas of 0.90 for anxiety, 0.96 for poor memory, 0.96 for irritability, and 0.89 for helplessness or hopelessness.

General cognitive measures were used in 2 ways: first to screen for severe cognitive dysfunction that could interfere with successful participation, and then to examine fluctuations in cognitive function relationship to breathing effort and the associated distress. The MMSE is a rater administered screening tool evaluating general cognitive function.[29] It consists of 20 items with scores ranging from 0 to 30, with scores above 24 considered normal. Scores (mean ± standard deviation) of 27.6 ± 1.7 (range 24-30) for normals and 27.0 ± 1.8 for patients with COPD (range 23-30) have been reported, with few scores below 24. [30] The Babcock Story Verbal Recall Test is also rater administered and was used to examine recall. [31] Patients are read a story and asked to immediately recall the story. The story is re-read to the subject and 10 minutes later they are asked to again recall the story. Scoring is based on 21 memory units and can range from 0 to 21, with published norms ranging from 8 to 18. Normative testing for those 60 years of age or older demonstrated average scores of 9.2 for immediate and 7.2 for delayed recall, with low average 7.7 and 4.7 respectively. [28] Changes in MMSE or Babcock scores are not expected without important organic changes in physical condition.

*Statistical analysis*
General descriptive statistics, Chi square and one-way analysis of variance (ANOVA) were used to describe the sample. To answer Question One concerning reliability (stability) of the daily breathing measures, the sub-sample of 43 subjects that logged breathing distress and effort over 28 days were used. The increased length of daily recordings was considered necessary to adequately assess the measures' reliability during stable periods. Two statistical procedures were performed on this subset of subjects. First, repeated measure analysis of variance (ANOVA) was used to determine differences over time and between scores of breathing distress and effort. The second statistical measure consisted of standard test-retest and interclass correlation procedures that required creating summary scores for each person for the daily VAS scores by week for this sub-sample. The individual mean, highest, and lowest scores for breathing effort and breathing distress for each week were calculated from the daily logs. The standard deviation and variance of the VAS was calculated and used in the study as a reflection of the individual variability in scores for a given week. Figure 1 illustrates a typical person's log during a 2-week period and the mean and standard deviation obtained by weeks. These values were then used in test-retest and interclass correlations to determine the overall stability by week. Because of the relatively small sample size in the sub-sample, the nonparametric Spearman rho correlation coefficient test was used as a conservative estimate of the test-retest relationships. Spearman rank-order correlation coefficient is reported to be 91% as efficient as the Pearson r correlation.[32]
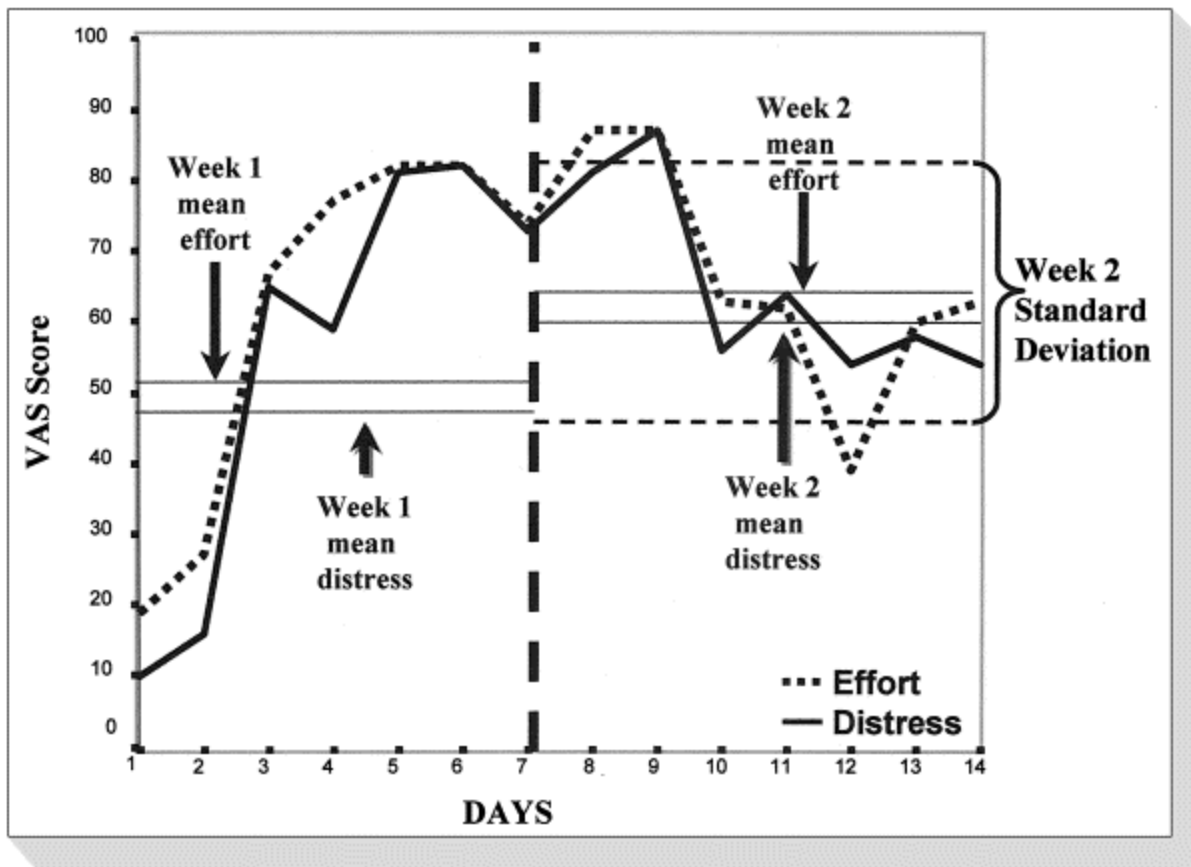
Figure 1. Example of a 14-day record for breathing effort and distress with a COPD subject with mean and standard deviation scores indicated.

To answer Question Two concerning the ability of the measures to discriminate between groups, one-way ANOVA techniques were used. Nonparametric statistical analysis was used when the assumptions of a parametric test were not met.[33] In addition, if the Levene Test for homogeneity of variance was significant, the Kruskal-Wallis test was used. Kruskal-Wallis is analogous to a one-way ANOVA and is a commonly used and powerful nonparametric statistical test. [34] The alpha level of significance was set at .05.
Question Three deals with the validity of the daily breathing measures based on the proposed relationships between breathing distress and effort scores and number of episodes of breathlessness per day; lung impairment (FEV1 and FVC); cognitive function (MMSE and Babcock Delayed Recall); and mood (subscales of the BESC). Pearson correlations were used. All subjects (n = 92) were used in the correlations between the summary measures (calculated over 2 weeks) of breathing effort or distress and the other variables. A positive relationship would exist between years of diagnosis, number of breathless episodes per day, and both breathing VAS scores. Breathing effort presumably would demonstrate a strong inverse relationship to lung function. On the basis of the literature, a stronger positive relationship should be seen between breathing distress and mood variables than with breathing effort.

## Results
### Sample
A total of 92 age-matched subjects were studied, consisting of 32 persons with COPD, 27 persons with asthma, and 33 healthy persons (Table 1). The mean age of the total sample was 62.1 ± 9.6, 55% (n = 50) of which were male and 45% (n = 42) of which were female, with no difference in age between groups. There was a significant difference in gender ($\chi2 = 7.13$, P < .05), with more males and fewer females among both the COPD and asthma groups compared with healthy subjects (Table 1). Consequently, gender was treated as a covariate in the analysis to determine the potential impact on intensity scores. In response to the demographic question do you "notice your breathing during day," none of the healthy persons responded affirmatively, whereas 48% of those

with asthma and 68% of those with COPD did. No healthy subjects reported being hospitalized in the last year because of breathing difficulties, whereas 15% of those with asthma and 30% of those with COPD had been hospitalized. The number of years subjects reported experiencing breathing difficulty was different ($P < .001$) between groups; subjects with COPD and those with asthma experienced the highest number of years ($14.9 \pm 16.6$ and $17.4 \pm 17.7$ years respectively), and healthy subjects essentially none ($0.1 \pm 0.8$). The mean number of mild breathlessness episodes (noticing breathing) per day for all subjects was different ($F = 12.34$, $P < .001$) between groups. Subjects with COPD had more frequent episodes of breathlessness compared with healthy subjects. There were no differences between the frequency of episodes between the asthmatic and healthy subjects (Table I). There was a significant difference among groups ($F = 58.83$, $P < .001$) in level of airway obstruction. Subjects with COPD had moderate to severe lung impairment, as demonstrated by an average FEV1 of 39% predicted, whereas the subjects with asthma had normal to mild airway obstruction and healthy subjects had normal lung function. The sub-sample that obtained VAS measures over 28 days consisted of a total of 43 subjects, 13 with COPD (Males, Females; M = 8, F = 5), 15 with asthma (M = 6, F = 9) and 15 who were healthy and older (M = 9, F = 6). All subjects reported being stable (ie, no atypical episodes of breathing or breathlessness requiring additional treatment or care seeking) during the measurement time. Additional treatment was defined by the subject reporting greater than normal inhaler use.

Table I. Demographics measures for COPD, asthma and healthy age-matched subjects.

| | COPD N = 32 | Asthma N = 27 | Healthy N = 33 |
|---|---|---|---|
| Age (Years) | $63.6 \pm 7.4$ | $60.0 \pm 11.3$ | $62.5 \pm 10.1$ |
| Genderχ | | | |
| Male | 21 (66%) | 17 (63%) | 12 (36%) |
| Female | 11 (34%) | 10 (37%) | 21 (64%) |
| Do you notice your breathing during the day?* | 64% (n = 21) | 48% (n = 13) | 0% (n = 0) |
| Hospitalizations (past year)χ | 30% (n = 10) | 15% (n = 4) | 0% (n = 0) |
| Years of breathing difficulty[a] | $14.9 \pm 16.6$ | $17.4 \pm 17.7$ | δ#+$0.1 \pm 0.8$ |
| Episodes of breathlessness/day[a] | $4.1 \pm 4.6$ | $2.1 \pm 3.2$ | #$0.1 \pm 0.6$ |
| Spirometry | | | |
| FEV1 %[a] | $39.3 \pm 16.0$ | $83.4 \pm 22.0$ | *$103.5 \pm 15.0$ |
| FVC %[a] | $52.8 \pm 17.0$ | $86.6 \pm 20.0$ | $98.3 \pm 16.0$ |
| MMSE | $28.7 \pm 1.8$ | $28.7 \pm 2.7$ | $29.2 \pm 1.0$ |
| Babcock | | | |
| Immediate | $13.9 \pm 3.0$ | $14.8 \pm 2.8$ | $14.3 \pm 3.2$ |
| Delayed | $9.8 \pm 3.2$ | $10.71 \pm 3.2$ | $9.8 \pm 3.4$ |
| BESC | | | |
| Poor memoryχ | $13.2 \pm 4.3$ | $13.7 \pm 10.0$ | $7.5 \pm 3.1$ |
| Helplessnessχ | $7.8 \pm 3.6$ | $6.9 \pm 5.1$ | $3.4 \pm 0.9$ |
| Anxietyχ | $17.1 \pm 5.1$ | $16.0 \pm 9.5$ | $8.0 \pm 3.5$ |
| Irritabilityχ | $12.2 \pm 4.3$ | $13.8 \pm 8.1$ | $6.2 \pm 2.5$ |

MMSE = Mini Mental State Exam; Babcock = Babcock Verbal Recall Test scores; BESC = Bronchitis Emphysema Symptom Checklist subscales; FEV1 % = percentage of predicted forced expiratory volume in one second; FVC % = percentage of predicted forced vital capacity.

**Post hoc differences were found between:**

To answer Question One: Are daily self-reported measures of distress and effort reliable in stable healthy

persons, persons with asthma, and persons with COPD?, participants in the subset completing measures over 28 days were evaluated. Repeated measures ANOVA using the daily scores showed no significant differences in breathing distress (F = 1.28, P > .05) or effort (F = 1.18, P > .05) scores by day or week (Figure 2), nor was there an interaction effect. However, a significant overall difference was seen between distress and effort scores (F = 2.56, P< .01) as breathing effort was consistently scored greater than breathing distress. It is important to note that the difference between breathing effort and breathing distress was frequently small when examining the daily means across groups. On average only 20% of the time was the difference greater than a 10 mm difference between breathing effort and breathing distress.
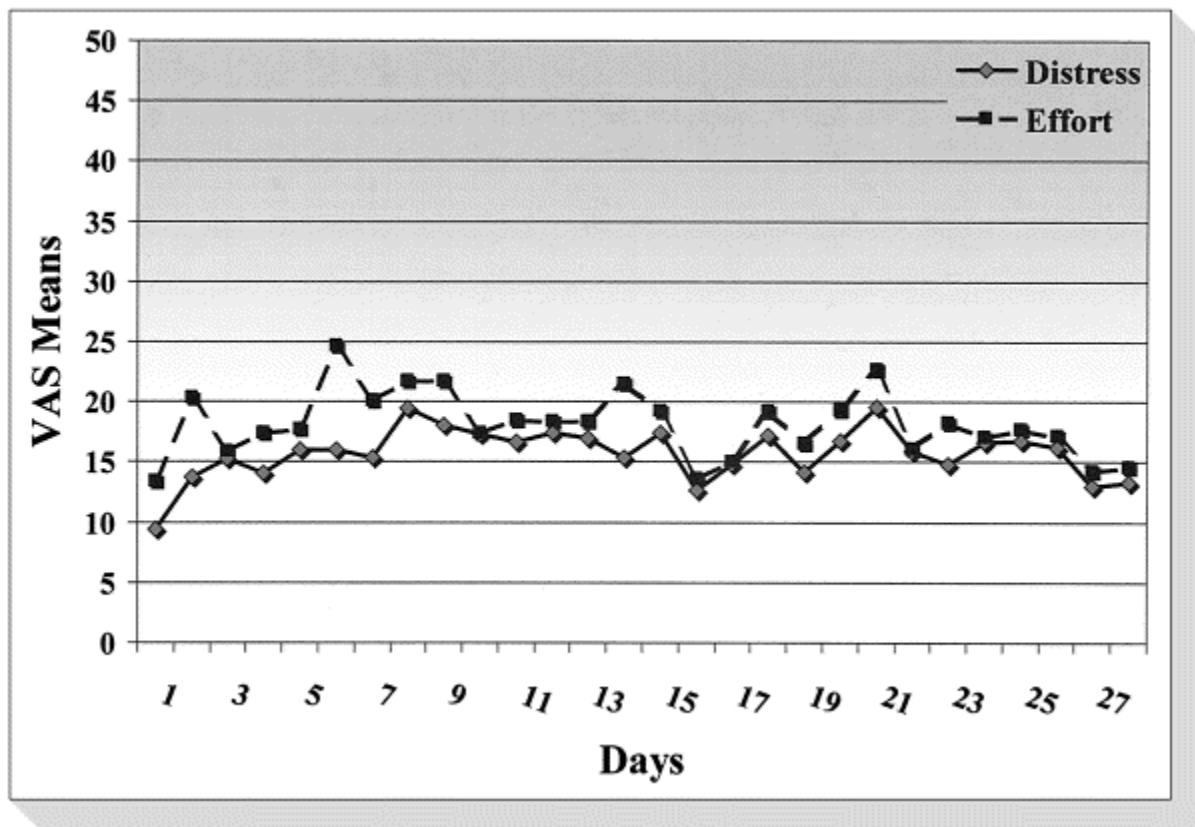


Figure 2. Repeated measure marginal means graph of breathing effort and distress over 28 days.

Spearman Rho Rank order correlations (rs) were used to evaluate the test-retest relationship of the computed values (Table II). All correlations were significant at the P < .05 level. Mean scores were found to demonstrate the greatest stability, whereas standard deviation and the variance demonstrated the lowest stability (Table II). The weakest relationships were seen between weeks 1 and 2, whereas the strongest correlations were between weeks 2 and 3 and weeks 3 and 4. Interclass correlations were also calculated and were consistent with the test-retest correlations.

Table II. Test-retest correlations (r) for symptom intensity by week and interclass correlation (ICC) across 4 weeks (n = 43).

| Scores | Distress | | Effort | |
|---|---|---|---|---|
| | ICC | rs* | ICC | rs* |
| Mean | 0.83 | 0.82–0.93 | 0.81 | 0.74–0.89 |
| Highest | 0.74 | 0.68–0.87 | 0.75 | 0.67–0.87 |
| Lowest | 0.74 | 0.52–0.81 | 0.72 | 0.68–0.80 |
| SD | 0.59 | 0.58–0.82 | 0.59 | 0.50–0.71 |
| Variance | 0.48 | 0.55–0.82 | 0.54 | 0.50–0.71 |

Full-size table (5K)

In summary, repeated measures analysis showed good stability of the raw scores across days and weeks. Fluctuations were found when Spearman Rho correlations were done on the calculated values by week, suggesting that the mean, highest, and lowest values are the most stable and summary score of the variance the least stable. These results were supported by the interclass correlations results. As a result, the variance summary score was not used in further analysis and the standard deviation summary score which demonstrated better stability was used to reflect variability in the scores over the period of time analyzed.

The second research question: Are daily self-report measures of breathing effort and distress able to discriminate between groups with known differences in pulmonary function? builds on the results of the first research question. Using the entire sample of 93 subjects, the mean, minimum (lowest), maximum (highest) and standard deviation scores on the self-report measures were calculated over the first 2 weeks of the study for each group. Summary scores were used to determine the ability of daily self-report measures of breathing to discriminate between known groups who varied in pulmonary function (Table III). A Multivariate ANOVA by group with gender as a covariate found an overall group effect on all summary VAS values ($F = 3.10$, $P < .001$) but not by gender ($F = 1.58$, $P > .10$). One-way ANOVA were then used to evaluate homogeneity of variance by groups and conduct post-hoc analysis. The Levene test for homogeneity of variance was significant for the mean and lowest values for both distress and effort. Thus, the nonparametric testing with the Kruskal Wallis Test occurred, with the results supporting the ANOVA results. The mean and lowest effort and distress scores were significantly ($X^2 \geq 10.77$, $P < .01$) different by group. Post-hoc evaluation of the group difference for the mean and lowest scores were carried out using the Tamhane's T2, which is a conservative pairwise comparison based on the t test that is appropriate when the variances are unequal.[35]

Table III. Scores for breathing distress and effort by groups measured daily over 2 weeks (n = 92).

| | Average calculated values | | | | |
|---|---|---|---|---|---|
| | Mean | Highest | Lowest | SD | Variance |
| Distress[a] | | | | | |
| Healthy (n = 32) | 7.57 (8.2) | 22.09 (24.4) | 1.59 (1.7) | 6.56 (7.9) | 102.9 (181.3) |
| Asthma (n = 27) | 16.75 (15.2) | 36.85 (29.2) | 4.33 (8.0) | 10.17 (9.3) | 187.3 (276.9) |
| COPD (n = 33) | **34.23 (22.0) | **58.42 (26.5) | #10.21 (15.1) | #15.21 (8.3) | 297.8 (292.6) |
| Effort[a] | | | | | |
| Healthy | 9.50 (11.5) | 24.38 (27.0) | 1.78 (1.9) | 7.61 (9.5) | 145.2 (259.5) |
| Asthma | 18.24 (14.4) | 41.19 (28.1) | 4.37 (7.4) | 12.05 (9.7) | 235.4 (313.5) |
| COPD | **37.18 (20.8) | *65.06 (23.8) | **11.12 (14.3) | #16.68 (7.8) | 338.0 (269.7) |

Scores could range from 0 to 100.

Scores for each variable were obtained by calculating the mean and standard deviation of the following scores: mean, lowest, highest, standard deviation and variance, for each subject within the group over two weeks.

Post hoc differences were found (P < .05) between:

Scores for distress and effort had the potential for ranging from a low of 0 (no distress or effort) to 100 (the highest possible distress or effort). The mean level of distress (Table III) over the 2 weeks was significantly different (F = 22.42, P < 001; $X^2$ 31.70, P < .001) between groups. Values were twice as high for subjects with COPD compared with subjects with asthma, and values for subjects with COPD were 4 times higher than those for healthy subjects. Post-hoc testing (Tamhane's T2) demonstrated that these differences were not significant between asthma and healthy groups (P > .05). A similar (F = 24.80, P < .001; $X^2$ 35.60, P < .001) pattern was seen when the mean effort level was evaluated. Similar to distress, post-hoc testing (Tamhane's T2) demonstrated that these differences were significant between the COPD, asthma, and healthy groups (P <. 001). Post-hoc Scheffe procedures revealed that the highest scores on effort discriminated between all 3 groups, whereas the mean and lowest scores discriminated between subjects with COPD, subjects with asthma, and healthy subjects for both distress and effort (P < .05). This pattern of post-hoc results also held true for the lowest scores with effort (P < .01), but not on the lowest distress scores. Only the COPD and healthy groups had significant differences in standard deviation for both distress and effort. Overall, there was a consistent pattern across the summary scores where the highest values were seen in the COPD group followed by the asthma and healthy groups as seen in Figure 3.
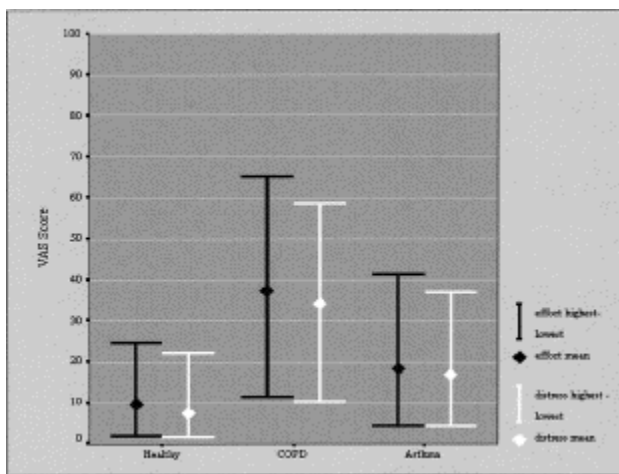


Figure 3. Range of breathing (highest, mean, lowest) effort and distress scores by group.

To answer Question Three: What is the relationship between the intensity and variability over time in self reports of breathing distress and effort with a) severity of lung impairment, b) episode pattern, c) cognitive function, and d) mood?, correlational analysis was used (Table IV).

Table IV. Correlations of symptom intensity with disease severity, episode pattern, cognitive function, and mood factors.

| n = 92 | Distress | | | | Effort | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Highest | Lowest | SD | Mean | Highest | Lowest | SD |
| FEV1% | **−0.55 | **−0.51 | *−0.30 | *−0.41 | **−0.56 | **−0.55 | **−0.33 | **−0.41 |
| FVC% | **−0.54 | **−0.50 | *−0.28 | **−0.42 | **−0.54 | **−0.52 | **−0.30 | **−0.40 |
| # episode/day | **0.48 | **0.47 | **0.36 | **0.38 | **0.56 | **0.51 | **0.48 | **0.36 |
| Years with Dx | *0.25 | *0.25 | *0.23 | 0.18 | **0.29 | **0.31 | **0.29 | *0.23 |
| MMSE | *−0.21 | −0.16 | −0.11 | −0.13 | *−0.19 | −0.12 | −0.10 | −0.05 |
| Babcock# | *−0.24 | *−0.22 | *−0.24 | −0.17 | *−0.23 | −0.19 | **−0.28 | −0.10 |
| BESC | | | | | | | | |
| Poor memory | **0.28 | **0.28 | 0.16 | *0.27 | **0.31 | **0.31 | **0.22 | **0.25 |
| Helplessness | **0.32 | **0.30 | **0.23 | *0.21 | **0.35 | **0.31 | **0.29 | *0.21 |
| Anxiety | **0.41 | **0.42 | *0.23 | **0.35 | **0.45 | **0.44 | **0.27 | **0.36 |
| Irritability | *0.26 | *0.25 | 0.16 | *0.21 | **0.30 | *0.28 | *0.23 | *0.21 |

We first determined if increasing levels of disease severity would demonstrate a relationship with symptom intensity (distress and effort). All distress and effort scores were significantly correlated and negatively related to the severity of pulmonary impairment as measured by spirometry. In addition, there was a strong positive relationship between the number of episodes reported per day and all breathing distress and effort scores. A similar pattern was seen with the years since diagnosis and all of the breathing effort and distress summary scores, except the breathing distress standard deviation. The Babcock delayed recall was significantly related to the mean scores for both breathing distress and effort such that as verbal recall scores decreased the reported intensity scores increased. Significant relationships were also seen in general cognitive function (MMSE) with the mean breathing effort and breathing distress scores, indicating mean breathing distress worsened with worsening cognition.

Subscales of the BESC were used to determine the subjective perception of poor memory, helplessness, anxiety, and irritability, with higher scores representing more frequent occurrence. The majority of the BESC subscales significantly and positively correlated with all of the breathing effort and distress summary scores (Table IV). The exceptions were the lowest breathing distress scores with poor memory and irritability ($r = 0.16$, $P > .05$). Differences in the pattern of relationships with the breathing distress and the BESC subscales were not seen. In fact, the only non-significant correlations were with the lowest score for breathing distress.

## *Discussion*

This study was a first step in establishing the stability of daily VAS measures of breathing distress and effort. We found that daily reports of breathing effort and breathing distress were stable over time. We also were able to detect differences in the intensity of breathing effort and breathing distress among healthy subjects and those with lung impairment. The calculated mean and highest scores for both breathing effort and breathing distress were the most stable of the scores during 4 weeks on test-retest and interclass correlational analysis (Table II). Fluctuations were found by week, when Spearman Rho correlations were done on the calculated values, suggesting that the use of mean and highest summary scores is the most stable. These findings were supported by the interclass correlation results. Nevertheless, it may be useful to also consider using the lowest score and the calculated standard deviation for periods greater than a week, because these values became more stable after the first week of testing. Potentially, the lowest intensity levels and variability in intensity scores may be a critical feature when examining breathing changes over time or evaluating interventions. However, it does not appear that the variance for the calculated values for breathing distress and effort will ever be stable enough to use as a measure of change over time. Further testing will be needed to support the use of these calculated values in future analyses.

What has not been previously described is whether subjects could distinguish between breathing effort and breathing distress when a) recorded as a daily log, b) not associated with a laboratory stimulus, or c) in a laboratory setting. In this investigation, there was a consistent pattern of differences in subjects' ratings of breathing effort and breathing distress over 28 days (Figure 2). The mean difference between the two ratings appears to be small, and therefore it is not clear whether this is an important amount of change. However, two important points need to be made. First, the repeated measure analysis was done using the entire sub-sample. Potentially the differences seen might have been larger in a larger group with pathology (eg, subjects with COPD or asthma). In addition, most persons during the 2 weeks ( Figure 1), demonstrated at some point a larger separation (greater than 5-10 mm) between the breathing effort and breathing distress scores than that seen in the repeated measures analysis. One investigation measuring breathing distress and effort in patients with congestive heart failure during an emergent event also did not find an important difference between reports of distress and effort. [36] Further testing is needed to determine the clinical utility of these observations, particularly in relation to monitoring stable persons.

Despite the fact that group composition was significantly different by gender, significant differences were not seen in this investigation when gender was used as a covariate in the analysis of breathing intensity scores.

However, a main effect for groups was found, suggesting that these VAS scores were more heavily influenced by loss of pulmonary function than by any potential gender bias.

The mean breathing effort and breathing distress scores for subjects with COPD were higher than those for either subjects with asthma or healthy subjects (Table III). These findings are similar to those found by Janson-Bjerklie et al. [13] In their study of subjects with COPD (n = 26) and asthma (n = 23), they determined the usual and worst breathlessness on a VAS from 0 (not breathless at all) to 100 (extremely breathless). The usual score of that study is comparable to our mean score, and their worst score is comparable to our highest score on breathing distress. In their study, the degree of usual breathlessness in COPD was 35.6 ± 17.8 and in asthmatic subjects 25.3 ± 22.6. These scores for asthmatic subjects were somewhat higher than the present study of 16.75 ± 15.2. Comparing their findings for worst breathlessness, subjects with COPD reported 72.2 ± 19.9, whereas asthmatic subjects reported 87.8 ± 13.6. Our subjects reported their highest breathing distress for COPD as 58.42 ± 26.5 and for asthma 36.85 ± 29.2. These differences in findings may reflect the differences in the self-reporting procedures for the 2 studies. For example, the current study asked subjects to report real time dyspnea on daily logs, whereas Janson-Bjerklie et al attempted to capture the overall dyspnea experience of subjects by eliciting a summary score. Nonetheless, the current study reaffirms the trend seen in both studies of stable subjects with COPD generally reporting a higher intensity of dyspnea than stable asthmatic subjects (Figure 3).

In an attempt to evaluate the validity of these measures we correlated breathing effort and breathing distress with variables related to lung function, daily episodes, cognition, and mood (Table IV). We found a strong relationship between spirometry values with higher scores for breathing effort and breathing distress summary scores associated with poorer lung function. In addition, the number of episodes reported per day followed a similar pattern. These relationships have always been intuitively obvious, however, dyspnea scores have generally correlated only moderately with tests of lung function and not always with general reports of daily symptoms. [37] It is possible that by combining all subjects, healthy as well as impaired, we were able to observe a clearer relationship between spirometry, general reports of symptom occurrence, and perceptions of breathing.

Measures of cognitive function correlated with the mean value of breathing effort and distress. These values, however, were some of the lowest correlations seen. Although further testing is needed, these findings consistently demonstrate a relationship between cognitive function measures (whether obtained through self-reported or screening tests) and measures of breathing effort and distress. Further, these findings are consistent with a recent report that the MMSE scores contributed approximately 10% of the explained variance in a general measure of dyspnea.[38]

Scores on the BESC correlated with both breathing distress and breathing effort. Reports by subjects of the frequency of symptoms related to anxiety, irritability, and helplessness increased as breathing effort and breathing distress increased. General self-reports of anxiety showed the strongest relationship among these 3 symptoms. Carrieri-Kohlman et al[12] found that when COPD patents were exercising, they reported general anxiety correlated with breathing distress but not effort. Though anxiety may be increased during exercise, in this investigation breathing distress was not exclusively associated with self-reports of anxiety. Anxiety in our study correlated with effort (r = 0.45, P < .001) and distress. If breathing distress and anxiety were uniquely related, we would have expected that at the very least, the correlations for the highest scores on breathing distress would have been different than effort, which they weren't. However the anxiety measure used in this study is a general measure that lacks the preciseness of formal anxiety questionnaires. More testing with different measures of anxiety is needed to determine what associations if any, exist during stable periods in persons with COPD and Asthma.

## Conclusions

Breathlessness is a subjective experience with multidimensional components. This investigation was a first step in determining the stability and potential value of VAS measures of breathing distress and effort. We were able to demonstrate that subjects are capable of reporting their level of effort and distress with their breathing on more than one occasion and in a setting other than the laboratory. Though it appears that persons can

consistently distinguish between breathing effort and distress during stable periods, the clinical utility of these observations is unclear. Presumably, in unstable situations, breathing effort and the associated distress would be vital to determinations of treatment options and effectiveness, but further investigations are needed. Subjects with COPD rate breathing effort and distress higher than either healthy persons or those with asthma. When patients with asthma are stable, their rating of breathlessness may be difficult to distinguish from healthy persons'. Further longitudinal research is needed to further delineate patterns of these perceptions among groups with different disease states and in unstable patients.

## *Glossary*

FVC: Maximum amount of air that can be expelled with a maximal effort after a maximal inspiration.

FEV1: The volume of air exhaled during the first second of an FVC maneuver.

The Kruskal-Wallis One-Way ANOVA by Ranks: nonparametric test, "derived from the one-way ANOVA, with the actual observations being replaced by their ranks" (Kruskal & Wallis, 1952).

Tamhane's T2 Post Hoc comparison: Conservative pairwise comparisons test based on a t-Test. This test is appropriate when the variances are unequal.

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