Perception of airway obstruction in asthma: Sequential daily analyses of symptoms, peak expiratory flow rate, and mood

Andrea J. Apter, MD,[a, c] Glenn Affleck, PhD,[b] Susan T. Reisine, PhD,[d] Howard A. Tennen, PhD,[b] Erik Barrows, BA,[c] Meredith Wells, BA,[c] Alice Willard, RN, BSN,[c] and Richard L. ZuWallack, MD[e]

Farmington and Hartford, Conn.

Background and objective: Studies have demonstrated a weak correlation between the degree of airways obstruction and the severity of asthma symptoms. Although the causes for this disparity are probably multiple, mood has been hypothesized to modulate symptoms. This investigation was designed to evaluate the effect of mood and other patient characteristics on the perception of airways obstruction.
Methods: We compared mood variables, symptom severity, albuterol use, and peak expiratory flow rate (PEFR) measured three times daily over a 21-day period in 21 adults with moderate to severe asthma. Electronic equipment was used for data collection. Analyses included both individual patient assessments and a within-subjects, time series, pooled regression of concurrent and time-lag data.
Results: After pooling 1323 observations, there was a weak concurrent relationship between symptoms and PEFR (beta = −0.17, $p < 0.001$). Only five patients (24%) were accurate perceivers, defined by a statistically significant relationship between symptoms and PEFR across time. Higher forced expiratory flow at 25% to 75% of capacity predicted perception accuracy ($p = 0.004$); active mood was marginally associated with accuracy ($p = 0.06$). These two variables together explained 41% of the variation in perception accuracy ($p = 0.004$). Mood did not independently predict symptoms, but conversely, increased symptoms predicted less pleasant mood (beta = 0.08, $p < 0.001$), less active mood (beta = −0.11, $p < 0.001$), and less active–pleasant mood (beta = −0.06, $p < 0.001$). PEFR did not predict mood, and only pleasant mood independently predicted higher PEFR (beta = 0.04, $p < 0.05$). Symptoms, but not PEFR, were concurrently associated with albuterol use (beta = 0.24, $p < 0.001$).
Conclusion: The relationship between changes in PEFR and symptoms over time was generally poor. Those patients with lower FEF_{25-75} values tended to be less accurate perceivers. Mood states were influenced by asthma symptoms, but the converse was not true. (J Allergy Clin Immunol 1997;99:605-12.)

Key words: Asthma, peak expiratory flow rate, symptom, mood, perception

Studies assessing asthma severity often demonstrate a weak correlation between the degree of airways obstruction and the magnitude of asthma symptoms.[1-7] Inaccurate perception of the degree of airways obstruction, through delays in seeking medical attention or poor compliance with therapy, may be responsible for some of the morbidity and mortality from this disease.[8-9] Although the factors influencing the perception of asthma are probably numerous, this study investigates whether modulation of symptoms by psychologic factors, such as mood, is important.

Mood is a fluctuating affective state.[10] Studies have associated many emotional states including panic, fear, anxiety, hostility, arousal, and fatigue with asthma symptoms.[11-18] Studies in other chronic diseases have also found an association between disease symptoms and emotional arousal.[19-21] In addition, panic and fear have been associated with the intensity of prescribed asthma medication and the length of hospitalization for treatment of asthma.[22, 23] Thus it is possible that emotional states could modulate perception of asthma symptoms, be affected by symptom changes, or both.

Two recent small studies examined the day-to-day relationship between pulmonary function and mood but ignored the relationships of either of these processes to symptom perceptions. Steptoe and Holmes[24] measured mood and peak expiratory flow rate (PEFR) four times daily over 20 days in seven men with asthma and seven nonasthmatic men. Mood was measured by using three visual analog scales labeled *angry-calm, relaxed-tense,* and *elated-depressed,* respectively, at the poles. No relationship between mood and PEFR was observed in the nonasthmatic men, but three of the men with asthma showed a significant relationship between one or more mood variables and PEFR. The findings failed to support either the causal priority of PEFR as a predictor of mood changes or of mood as a predictor of PEFR changes.

Hyland[13] examined the relationship between mood

From the [a]Department of Medicine, [b]the Department of Community Medicine and Health Care, [c]the General Clinical Research Center, and [d]the Department of Behavioral Sciences and Community Health of the University of Connecticut Health Center, Farmington; and [e]the Department of Medicine, St. Francis Hospital and Medical Center, Hartford.

Supported by American Lung Association of Connecticut and the University of Connecticut General Clinical Research Center (National Institutes of Health grant M01-RR06192).

Received for publication May 31, 1996; revised Oct. 1, 1996; accepted for publication Nov. 25, 1996.

Reprint requests: Andrea J. Apter, MD, Department of Medicine, University of Connecticut Health Center, Farmington, CT 06030-3945.

Copyright © 1997 by Mosby–Year Book, Inc.

0091-6749/97 $5.00 + 0 **1/1/79710**

Abbreviations used
FEF_{25-75}: Forced expiratory flow at 25% to 75% of capacity
FVC: Forced vital capacity
PEFR: Peak expiratory flow rate

and PEFR in 10 adults with asthma by twice-a-day written reports of momentary mood, PEFR, and medication use for 15 days. Fourteen negative moods (afraid, scared, nervous, jittery, irritable, hostile, guilty, ashamed, distressed, upset, scornful, contemptuous, disgust, revulsion) and 10 positive moods (excited, enthusiastic, inspired, interested, alert, attentive, active, strong, proud, determined) were each rated by using a 4-point scale. In three patients, increases in positive mood were significantly associated with increases in PEFR. Further analyses suggested that pulmonary function affected mood more strongly than mood affected pulmonary function. Thus although patients' fluctuating moods may influence perception of symptoms, the reverse may also be true. Most important, neither of these patterns has been studied with simultaneous measurement of daily symptoms.

Our study evaluated the interrelationships of mood, asthma symptoms, and airway function measured during daily activities. Its design differed from previous studies in several other ways. Most studies of asthma perception have been conducted in the laboratory[2-4, 25]; only a few have been performed in patients in natural environments.[5-7, 13] Factors that might influence symptom perceptions such as demographic characteristics, baseline pulmonary function, and clinical asthma severity were also incorporated as study variables. Finally, an electronic diary, an electronic peak flow meter, and an MDI Chronolog (Medtrac Technologies, Inc.) were used to improve accuracy of data collection and compliance with reporting.

METHODS

Patients

The institutional review boards of the participating institutions approved the protocol. Informed consent was obtained from all study patients. Adults with moderate to severe asthma were recruited from the allergy and pulmonary clinics of a university hospital and a community hospital. Participants were required to have a prebronchodilator FEV_1 value of less than 80% of predicted value. In addition, all subjects demonstrated a 15% or greater increase in FEV_1 after bronchodilator administration within the year before entry into the study. All participants had at least four of the following pretreatment characteristics for National Heart, Lung, and Blood Institute criteria for moderate asthma:[26]

- Exacerbations of cough or wheeze more than once or twice per week
- Cough and wheeze between acute exacerbations often present
- Reduced exercise tolerance
- PEFR less than 80% of predicted value with a reversibility of 20% to 30%
- Nocturnal symptoms at least two to three times per week
- School or work attendance compromised by asthma
- Systemic steroids usually necessary to treat exacerbations
- Regular use of oral or inhaled corticosteroids or cromolyn required daily for more than 2 months of the year before entry into this study

All patients were nonsmokers with a less than 10-pack-year history of tobacco use. None of the patients had significant pulmonary disease other than asthma. During the initial orientation, each patient was required to demonstrate reliable use of the electronic devices.

Procedures

Initial evaluation. Before the start of daily data collection, the following baseline information describing subjects was obtained: (1) demographics including age, gender, highest level of education, and household income; (2) severity of asthma including age at diagnosis, lifetime number of hospitalizations, intensive care unit admissions, endotracheal intubations, emergency department visits, days of work missed over the previous year because of asthma, and current prescribed asthma medications; (3) current asthma symptoms (cough, wheeze, dyspnea, chest tightness, sputum production), each rated on a 0 to 6 scale; (4) physical examination; and (5) spirometry with American Thoracic Society criteria[27] including forced vital capacity (FVC), FEV_1, and forced expiratory flow rate at 25% to 75% of capacity (FEF_{25-75}).

Daily recording of symptoms, mood states, PEFRs, and β-agonist use. After the initial evaluation and one to three training sessions in the use of the electronic instruments, patients completed 21 consecutive days of data recording.

Electronic interviews of symptoms and mood. A small palmtop computer (PSION Organizer II; Psion, Inc., Concord, Mass.) (Fig. 1) was programmed to perform an electronic interview of symptoms and mood three times a day at random times during the morning, afternoon, and evening. The feasibility and reliability of this instrument have been demonstrated in previous daily diary studies of mood[28-31] and asthma symptoms.[32]

An audible beep prompted a request for data entry. At this point, the patient had the option to respond immediately or temporarily postpone answering the questions. Failure to respond to three prompts in 15 minutes resulted in a missing entry for that period. Each question was answered by scrolling across fixed response options with backward and forward arrows and then pressing an "enter" button to save the response and its time stamp on an EEPROM data pak. The response option appearing first on the screen with each new question was randomized to minimize set responses. At the completion of the study, the data were uploaded to a desktop computer, where they were entered automatically in a spreadsheet file for data analysis.

Interview questions on symptoms and mood were presented one at a time in a fixed order on a liquid crystal display (2 lines by 20 characters per line). Symptom and mood electronic interviews were scheduled three times each day: at randomly selected moments within response windows opened between 9:45 AM and 11:15 AM (morning interview), between 2:45 PM and 4:15 PM (afternoon interview), and between 7:45 PM and 9:15 PM (evening interview). At this time, participants rated the severity during the last 30 minutes of four symptoms: wheeze, cough, chest tightness, and shortness of breath, each on a scale

FIG. 1. Electronic instruments used in the study: electronic diary *(left)*, Chronolog *(top)*, and Peaklog *(bottom)* (Courtesy Penny Z. Apter, BA, 1996).

of 0 to 6 (anchored at 0 = none, 2 = mild, 4 = moderate, 6 = severe). Symptom severity for that interview was scored as the sum across these ratings.

Mood is defined as a rapidly fluctuating affective state and can be measured by either of two approaches[10]: the specific affects approach, which samples many isolated moods such as "fear" or "happiness," and the dimensional approach, which samples moods to reflect their underlying structural dimensions (e.g., pleasurable vs unpleasurable mood states). We combined these two approaches in this study.

The mood interview inquired about several dimensions of mood experience. It consisted of 20 mood adjectives, each rated for its extent in the past 30 minutes (anchored at 0 = not at all, 2 = slightly, 4 = moderately, 6 = very much). Sixteen were drawn from mood circumplex dimensional approach of Larsen and Diener,[33] which classifies mood experience as pleasant or unpleasant, as active or passive, or as some combination of these dimensions. Each of the resulting eight categories of mood were measured by two adjectives: (1) pleasant mood (happy, cheerful), (2) unpleasant mood (sad, blue), (3) active mood (active, lively), (4) passive mood (quiet, passive), (5) active-pleasant mood (stimulated, peppy), (6) active-unpleasant mood (nervous, anxious), (7) passive-pleasant mood (calm, relaxed), and (8) passive-unpleasant mood (tired, drowsy). According to the specific affects approach, four more adjectives—two for angry mood (hostile, angry) and two for fearful mood (fearful, panicky)—were added in view of research linking these mood states with asthma symptoms.[34]

Electronic peak flow meter (Peaklog)

The PEFR determined by using an electronic peak flow meter (Peaklog; Medtrac Technologies, Inc., Lakewood, Colo.) was the measure of airway obstruction. This instrument, which is 13 by 6 by 2.5 cm and weighs 138 gm, measures airflow with a hot-wire anemometer. Accuracy was tested by the manufacturer, using recommendations by the National Asthma Education Program. This involved injecting nine standardized wave forms into each of 10 devices five times by using a computer-driven pulmonary wave-form generator. All instruments were within 10% of the target values and were within 5% of each other (a description of the operations for the Peaklog has been filed with the Food and Drug Administration). A built-in barometer allows for self-correction of fluctuations in barometric pressure. The device received approval from the Food and Drug Administration on November 1, 1994.

The PEFR was recorded along with the time and date of measurement by the electronic peak flow meter after each electronic interview. Patients were given standardized instructions and were observed in the use of the device during prestudy training. Three forced expiratory maneuvers were obtained in a fashion similar to maneuvers with portable mechanical devices. PEFR results were blinded to the participant. Uploading of the PEFR data to a desktop computer took place at the end of the 21-day period.

Electronic recording of β-agonist use (MDI Chronolog)

The only short-acting β-agonist allowed in the study was albuterol administered by metered dose inhalation, prescribed on an as-needed basis. The canister was housed in an MDI Chronolog, which recorded time and date of each actuation. This information was also uploaded to a desktop computer at the end of the study period.

Data analysis

The major data analyses examined the relationships among variables at the within-person level of change over time. Two approaches to within-person analysis were followed. The first examined within-person relationships expressed across the en-

TABLE I. Clinical characteristics of patients (14 female, 7 male)

Demographics*	
Age (yr)	43.4 (14.7)
Age at diagnosis (yr)	14.9 (15.9)
Years of formal education	15 (2.2)
Household income†	39,100 (19,600)
Asthma severity*	
Lifetime hospitalizations for treatment of asthma	3.33 (6.2)
Lifetime emergency department visits	1.9 (2.8)
Oral steroid use (no. of days/previous year)	52.0 (83.3)
Nocturnal awakenings in previous month	4.0 (6.2)
Work missed for asthma (no. of days/previous year)	7.1 (26.1)
Baseline FEV_1 (% predicted)	79 (17)
Current medications (no. of patients)	
Inhaled corticosteroids	19
Oral corticosteroids	5
Nedocromil	2
Ipratropium	1
Theophylline	1

*Results expressed as mean (standard deviation) values.
†Data collected from 18 patients.

tire pooled data set of 1323 person-assessments (21 patients × 21 days × 3 times a day). The general statistical procedure adopted was a pooled regression analysis with (patient) dummy variables and fixed effects,[35] which has been used for many similarly structured multilevel data sets in behavioral medicine.[36-39] This analysis removes all variance caused by differences between persons by incorporating N-1 dummy variables to capture subject identity in the prediction equation, leaving only variance caused by change within-persons over time to be explained. The problem of serial autocorrelation in these nonindependent data was solved with a generalized least-squares procedure.[40] Individual patient means were inserted for missing data values.

The second approach examined within-person relationships between symptoms and peak flow for each patient (n = 21) separately to identify and account for individual differences in symptom perception accuracy. Individual multiple regressions were performed on each patient's 63 assessments, controlling for autocorrelation with a generalized least-squares solution. The regression coefficients for each individual were then analyzed in relation to patient characteristics to determine whether individual differences in perception accuracy could be predicted. These characteristics included demographic variables, baseline lung function, and average levels of mood over the 21-day diary period.

RESULTS

Twenty-two adults completed the protocol between October 1994 and October 1995. Symptom and mood electronic data from one patient were lost, leaving 21 patients for data analysis. One patient had difficulty using the electronic peak flow meter and subsequently used a mechanical device, recording the results in a paper diary. Missing electronic diary data comprised 1.4% of possible electronic diary entries and 6.4% of PEFR entries. Data on albuterol use were lost for one patient because of a malfunction in the Chronolog.

TABLE II. Symptoms and PEFR data during the observation period

Patient No.	Symptom score*	PEFR*	Percent of PEFRs <60% of predicted	Percent of PEFRs <80% and ≥60% of predicted
1	4.98 ± 1.99	214 ± 25	12	77
2	1.92 ± 2.56	354 ± 38	0	60
3	0.92 ± 2.25	333 ± 49	3	44
4	2.32 ± 1.69	389 ± 33	0	7
5	0.50 ± 1.20	484 ± 71	0	2
6	5.35 ± 4.22	517 ± 100	5	30
7	3.98 ± 2.16	232 ± 42	16	60
8	7.05 ± 3.27	292 ± 47	12	50
9	0.54 ± 1.43	422 ± 16	0	0
10	5.30 ± 4.94	357 ± 55	12	55
11	2.68 ± 2.51	408 ± 49	0	2
12	3.33 ± 1.93	394 ± 38	0	2
13	4.70 ± 3.63	324 ± 60	9	36
14	0.32 ± 1.13	405 ± 74	25	53
15	0.46 ± 1.15	426 ± 51	0	3
16	6.02 ± 2.98	365 ± 49	7	48
17	0.40 ± 0.83	303 ± 57	51	48
18	6.03 ± 3.66	307 ± 58	10	26
19	1.11 ± 1.02	233 ± 89	49	32
20	3.03 ± 2.06	571 ± 40	0	0
21	2.60 ± 2.06	275 ± 44	11	65

*Mean ± standard deviation

The characteristics of the 21 patients (14 women and 7 men) including demographics, asthma severity variables, and current asthma medications appear in Table I. The ages ranged from 23 to 67 years. Ten patients had been hospitalized for treatment of asthma previously; one patient had been hospitalized 25 times. Nine patients had sought emergency department care; one patient sought emergency department care 10 times. Four patients had been admitted to an intensive care unit in the course of asthma treatment; and one patient had been admitted twice. All were using a short-acting β-agonist; one patient was using salmeterol.

Table II displays the mean scores with standard deviations for symptoms and PEFR for each patient over the 21-day observation period. Also shown are the percentages of PEFRs less than 60% and between 60% and 80% of predicted value for each patient. The high frequency of severely reduced PEFRs (<60% of predicted value) and moderately reduced PEFRs (60% to 80% of predicted value) along with considerable variability in this measure reflects the inclusion criteria that selected patients with moderate to severe asthma.

Table III lists the grand means and standard deviations for 1323 observations of mood scores, symptom ratings, PEFR, and number of albuterol doses. Patients generally described their momentary mood in positive rather than negative terms.

TABLE III. Observations* of ten mood scores,† symptom ratings,‡ PEFRs, and number of albuterol doses

Variable	Mean (SD)
Mood†	
Pleasant	7.26 (2.20)
Unpleasant	0.69 (1.64)
Active	6.36 (2.38)
Passive	4.82 (2.73)
Active pleasant	5.60 (2.51)
Active, unpleasant	1.16 (2.06)
Passive, pleasant	7.11 (2.33)
Passive, unpleasant	2.62 (2.96)
Fearful, panicky	0.31 (1.10)
Angry, hostile	0.23 (0.94)
Symptom‡	3.01 (3.32)
PEFR (% predicted)	0.87 (0.19)
Albuterol dose per observation period*	0.15 (0.51)

*Three observations per day for 21 patients collected for 21 days (approximately 1323 observations).
†Each mood category was measured by two adjectives, each scored from 0 to 6 (see text) with 0 = not at all and 6 = very much. Thus the range of values for each mood category above is 0 to 12.
‡Wheeze, cough, chest tightness, and shortness of breath were each scored on a scale of 0 to 6, with 0 = none and 6 = severe (see text). These symptoms were summed to obtain the symptom score.

Pooled within-person concurrent and lagged data analyses (n = 1323)

After pooling the data across patients and observations and adjusting for autocorrelation and between-person differences in the data, there was a significant but weak concurrent relationship between symptoms and PEFR (beta = −0.17, $p < 0.001$): lower PEFR was associated with increased symptoms. However, when time-lag analysis was used, PEFR did not predict symptoms in the next period nor did symptoms predict subsequent PEFR.

Symptoms were concurrently related to albuterol use (beta = 0.24, $p < 0.001$), controlling for the relationship between peak flow and albuterol use: increased symptoms were associated with more albuterol use. On the other hand, PEFR did not relate to albuterol use after controlling for symptoms (beta = 0.002).

Table IV lists the pooled regression coefficients reflecting the average within-person relationships between mood and symptoms over the 1323 person-assessments. These analyses controlled for peak flow at the time symptoms were rated. Three sets of analyses are reported. The first is the concurrent relationship between mood and symptoms. The second and third analyses used time-lag procedures to examine: (1) whether mood could predict symptoms at the next assessment point that day and (2) whether symptoms could predict mood at the next assessment. Increases in symptoms were associated with concurrent changes in several of the mood variables. Specifically, increases in unpleasant mood, active-unpleasant mood, fearful-panicky mood, and passive-unpleasant mood accompanied worsening symptoms. When time-lag procedures were used, mood did not predict symptoms at the next assessment point. However, an increase in symptoms predicted less pleasant, less active, and less active-pleasant moods at the next time point.

TABLE IV. Comparison of symptoms and mood*

Mood dimension	Simultaneous relation with symptoms	Mood leading symptoms†	Symptoms leading mood†
Pleasant mood (happy, cheerful)	−0.12‡	−0.01	−0.08‡
Unpleasant mood (sad, blue)	0.13‡	0.02	0.03
Active mood (active, lively)	0.03	−0.02	−0.11‡
Passive mood (passive, quiet)	0.01	0.03	−0.01
Active-pleasant mood (stimulated, peppy)	−0.03	−0.01	−0.06§
Active-unpleasant mood (anxious, nervous)	0.10‡	0.01	0.00
Passive-pleasant mood (calm, relaxed)	−0.11‡	−0.03	−0.01
Passive-unpleasant mood (tired, drowsy)	0.08‖	0.01	0.02
Fearful-panicky mood	0.10‡	0.03	0.00
Angry-hostile mood	0.00	0.01	0.00

*Pooled within-person, within-day relations (standardized regression coefficients [maximum likelihood estimates]) between momentary symptom severity and mood assessed three times a day, controlling for momentary peak flow readings, autocorrelation, and between-persons variance.
†Controlling for simultaneous relation between mood and symptoms.
‡$p < 0.001$.
§$p < 0.05$.
¶$p < 0.01$.

Table V shows the results of parallel analyses of the average within-person relationship between mood and PEFR, controlling for symptom ratings. Increased PEFR was associated concurrently with several mood variables: it correlated directly with active mood and active-pleasant mood and inversely with passive mood, passive-unpleasant mood, and unpleasant mood. When the time-lag procedure was used, pleasant mood was the only mood variable that was associated with PEFR at the next time point: more pleasant mood predicted higher PEFR. PEFR did not predict changes in subsequent mood.

Individual within-person analyses (n = 21)

Reflecting the modest pooled within-person relationship between symptoms and peak flow reported above, a significant correlation between these two variables was present in only five (24%) patients. The correlation coefficients for these five subjects ranged from −0.39 to −0.25. Fig. 2 displays the time series plot for the patient who showed the highest concordance between symptoms and peak flow rate.

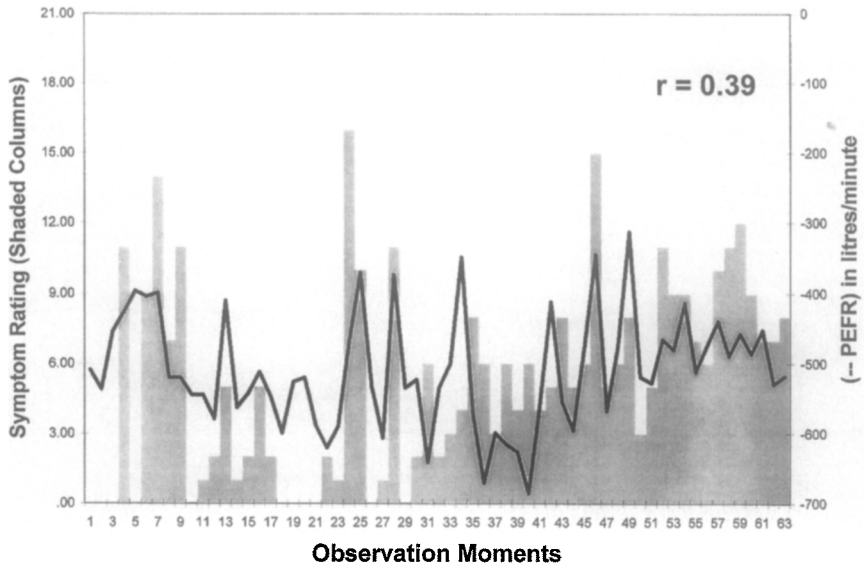

FIG. 2. Time series plot for the patient who showed the highest concordance between symptoms and peak flow rate ($r = 0.42$, where r is a correlation coefficient). The abscissa represents 63 moments of data collection. The left ordinate shows the symptom scale range for this patient. Negative values of PEFRs are depicted on right ordinate scale. PEFR values are multiplied by −1 so that variation between PEFR and symptoms would be in the same rather than opposite directions.

TABLE V. Comparison of peak flow rates and mood*

Mood dimension	Simultaneous relation with peak flow	Mood leading peak flow†	Peak flow leading mood†
Pleasant mood (happy, cheerful)	0.03	0.04‡	0.00
Unpleasant mood (sad, blue)	−0.04‡	−0.03	0.00
Active mood (active, lively)	0.08§	0.00	0.00
Passive mood (passive, quiet)	−0.06§	0.02	0.00
Active-pleasant mood (stimulated, peppy)	0.08§	−0.01	0.00
Active-unpleasant mood (anxious nervous)	0.02	0.01	0.00
Passive pleasant mood (calm, relaxed)	−0.02	0.02	0.00
Passive-unpleasant mood (tired, drowsy)	−0.07§	0.00	0.00
Fearful-panicky mood	−0.02	0.00	0.00
Angry-hostile mood	0.00	0.00	0.00

*Pooled within-person, within-day relations (standardized regression coefficients [maximium likelihood estimates]) between momentary peak-flow readings and mood assessed three times a day, controlling for momentary symptom severity, autocorrelation, and between-persons variance.
†Controlling for simultaneous relation between mood and peak flow.
‡$p < 0.05$.
§$p < 0.001$.

Factors related to individual patient symptom-PEFR accuracy were evaluated by stepwise regression with the correlation coefficients as the dependent variable and demographic baseline spirometry, mood, and asthma severity factors as independent variables. None of the demographic or mood variables was significantly related to symptom-PEFR accuracy, although a younger age and a more active mood tended to predict accurate perception ($r = -0.40$, $p. = 0.07$; and $r = -0.38$, $p = 0.09$, respectively). A higher baseline FEF_{25-75} was the spirometric variable most predictive of symptom accuracy ($r = 0.59$, $p = 0.005$). When these three variables were entered into multiple regression analysis, only FEF_{25-75} was a statistically significant predictor of perception accuracy ($p = 0.004$), but active mood was marginally associated with accuracy ($p = 0.06$). These two variables together explained 41% of the variation in perception accuracy ($p = 0.004$).

DISCUSSION

This study evaluated the accuracy of symptom perception in patients with moderate to severe asthma. Perception accuracy was defined as the correlation between simultaneously recorded asthma symptoms and PEFR, which, along with mood, were measured during normal daily activities. Additionally, we tested mood, patient demographics, and asthma severity as possible modifiers of perception accuracy. Data analysis procedures allowed us to examine both concurrent and time-lagged associations by using 1323 observations provided by 21 patients.

By using pooled ($n = 1323$) data with the variation between individuals removed, we found only a weak relationship between concurrent symptoms and PEFR. Individual patient time series analyses ($n = 21$) also showed a weak symptom-PEFR association: in only five of 21 patients was there a statistically significant correlation. This dichotomy between symptoms and asthma severity has been observed both in the laboratory and in clinical investigations,[1-7, 41] mostly when bronchoprovo-

cation was used to induce airway obstruction. None of the above studies has used time series analysis to control for autocorrelation.

The most important variable related to perception accuracy was the baseline FEF_{25-75} value. Thus those patients with more severe obstructive disease, who are hence at greater risk for asthma morbidity, are more likely to fail to perceive changes in airway tone. Because the FEF_{25-75} is a more sensitive marker of airway obstruction than is the FEV_1 or PEFR,[42] its better correlation with symptom perception is understandable. An alternative explanation is that the FEF_{25-75} was measured under standard laboratory conditions by a trained technologist, whereas the PEFRs were measured unsupervised at home. Indeed, had we been able to study relationships between symptom changes and changes in FEF_{25-75} from day to day, these patients may have appeared to be more accurate perceivers of the severity of their asthma.

We also evaluated the interrelationships of mood, symptoms, and PEFR. Increased symptoms were directly and concurrently associated with unpleasant and fearful-panicky mood states and inversely associated with pleasant mood states. Because symptoms predicted mood in time series analysis and mood did not predict symptoms, symptom changes were more likely responsible for mood changes, not the reverse. This does not support the concept that asthma symptoms are modulated by mood. This is in agreement with the tentative conclusion of Hyland[13] that "pulmonary function affects mood rather than the reverse." Interestingly, higher peak flow rate was associated uniquely with concurrent active pleasant mood. One interpretation is that with more active mood, the patient is more likely to give a maximal effort when recording a PEFR.

There are several limitations to our study. First, although there were a total of 1323 time points analyzed, the number of patients was relatively small. It is evident from Table I that these patients were highly educated, which may reflect the bias that occurs in recruiting patients able to carry out the complex protocol. Thus the generalizability of this study to other patients with asthma may be questioned.

Second, patients did not display a wide range of mood variability for some dimensions, particularly those with negative connotations. This finding echoes the mood reports in other daily studies of patients with asthma[24] and patients with rheumatoid arthritis.[19] This may have inhibited significant findings for some moods, such as fear and anger.

A third concern is that our time-lag analyses were limited to relationships between variables measured several hours apart. It is conceivable that different relationships between mood and PEFR would emerge if longer time lags, such as a day or two, were considered.

A final concern is whether unsupervised determinations of PEFR reliably measure true lung function.[41] Although the electronic peak flow meter was tested according to National Asthma Education Program criteria, the highly effort-dependent nature of the PEFR maneuver may in part be responsible for the poor concordance between symptoms and airflow obstruction.

In summary, we found that changes in symptoms were at best only weakly associated with changes in PEFR in this group of patients with moderate to severe asthma. Because a lower FEF_{25-75} was such a strong predictor of poor perception accuracy, simple office spirometry may serve to alert the physician to those patients at greater risk. Finally, mood states were influenced by asthma symptoms, but not the reverse.

REFERENCES

1. McFadden EF Jr, Kiser R, DeGroot WJ. Acute bronchial asthma: relationships between clinical and physiologic manifestations. N Engl J Med 1973;288:221-5.
2. Rubinfeld AR, Pain MCF. Perception of asthma. Lancet 1976;1: 882-4.
3. Burki NK, Mitchell K, Chaudhary BA, Zechman FW. The ability of asthmatics to detect added resistive loads. Am Rev Respir Dis 1978;117:71-5.
4. Burdon JGW, Juniper EF, Killian KJ, Hargreave FE, Campbell EJM. The perception of breathlessness in asthma. Am Rev Respir Dis 1982;126:825-8.
5. Apter AJ, ZuWallack RL, Clive J. Common measures of asthma severity lack association for describing its clinical course. J Allergy Clin Immunol 1994;94;732-7.
6. Kendrick AH, Higgs CMB, Whitfield MJ, Laszlo G. Accuracy of perception of severity of asthma: patients treated in general practice. BMJ 1993;307:422-4.
7. Peiffer C, Marsac J, Lockhart A. Chronobiological study of the relationship between dyspnoea and airway obstruction in symptomatic asthmatic patients. Clin Sci 1989;77:237-44.
8. Li JTC, O'Connell EJ. Clinical evaluation of asthma. Ann Allergy 1996;76:1-14.
9. Kikuchi Y, Okabe S, Tamura G, Hida W, Homma W, Shirato R, et al. Chemosensitivity and perception of dyspnea in patients with a history of near-fatal asthma. N Engl J Med 1994;330:1329-34.
10. Stone AA. Measurement of affective response. In: Cohen S, Kesler R, Gordon L, editors. Measuring stress: a guide for health and social scientists. New York: Oxford University Press, 1995:149-71.
11. Steiner H, Higgs CMB, Fritz GK, Laszlo G, Harvey JE. Defense style and perception of asthma. Psychosom Med 1987;49:35-44.
12. Dales RE, Spitzer WO, Schechter MT, Suissa S. The influence of psychological status on respiratory symptom reporting. Am Rev Respir Dis 1989;139:1459-63.
13. Hyland ME. The mood-peak flow relationship in adult asthmatics: a pilot study of individual differences and direction of causality. Br J Med Psychol 1990;63:379-84.
14. Hyland ME, Kenyon CAP. Mood variability. I. Asthmatic patients: a case report. Br J Gen Pract 1992;42:395.
15. Hyland ME, Browne S. Mood and peak flow in asthma. Lancet 1992;339:118-9.
16. Kleiger JH, Dirks JF. Psychomaintenance aspects of alexithymia: relationship to medical outcome variables in a chronic respiratory illness population. Psychother Psychosom 1980;34:25-33.
17. Janson-Bjerklie S, Ferketich S, Benner P, Becker G. Clinical markers of asthma severity and risk: importance of subjective as well as objective factors. Heart Lung 1992;265-72.
18. Kinsman RA, Luparello T, O'Banion K, Spector S. Multidimensional analysis of the subjective symptomatology of asthma. Psychosom Med 1973;35:250-66.
19. Affleck G, Tennen H, Urrows S, Higgins P. Neuroticism and the pain-mood relation in rheumatoid arthritis: insights from a prospective daily study. J Consult Clin Psychol 1992;60:119-26.
20. Affleck G, Tennen H, Urrows S, Higgins P. Person and contextual features of daily stress reactivity: individual differences in relations of undesirable daily events with mood disturbance and chronic pain intensity. J Pers Soc Psychol 1994:66:329-40.

21. Brantley P, Jones G. Daily stress and stress-related disorders. Ann Behav Med 1993;15:17-25.
22. Dirks JF, Kinsman RA, Horton DJ, Fross KH, Jones NF. Panic-fear in asthma: rehospitalization following intensive long-term treatment. Psychosom Med 1978;40:5-13.
23. Dirks JF, Jones NF, Kinsman RA. Panic-fear: a personality dimension related to intractability of asthma. Psychosom Med 1977;39: 120-6.
24. Steptoe A, Holmes R. Mood and pulmonary function in adult asthmatics: pilot self-monitoring study. Br J Med Psychol 1985;58: 87-94.
25. Boulet LP, Cournoyer I, Deschesnes F, Leblanc P, Nouwen A. Perception of airflow obstruction and associated breathlessness in normal and asthmatic subjects: correlation with anxiety and bronchodilator needs. Thorax 1994;49:965-70.
26. Guidelines for the Diagnosis and Management of Asthma. Bethesda (MD): Public Health Service, National Institutes of Health, 1991. Publication no. 91-3042.
27. American Thoracic Society. Standardization of spirometry 1987 update. Am Rev Respir Dis 1987;130:1296-2009.
28. Penner L, Shiffman S, Paty J, Fritzche B. Individual differences in intraperson variability in mood. J Pers Soc Psychol 1994;66:712-21.
29. Stone A, Broderick J, Porter L, Krupp L, Gnys M, Paty J, et al. Fatigue and mood in chronic fatigue syndrome patients: results of a momentary assessment protocol examining fatigue and mood levels and diurnal patterns. Ann Behav Med 1994;16:228-34.
30. Totterdell P, Folkard S. In situ repeated measures of affect and cognitive performance. Behav Res Methods, Instruments, Comput 1992;24:545-53.
31. Totterdell P, Reynolds S, Parkinson B, Briner R. Associations of sleep with everyday mood, minor symptoms, and social interaction experience. Sleep 1993:17:466-75.
32. Hyland ME, Kenyon CAP, Allen R, Howarth P. Diary keeping in asthma: comparison of written and electronic methods. Br Med J 1993;306:487-9.
33. Larsen R, Diener E. Promises and problems with the circumplex model of emotion. In: Clark M, editor. Emotion. Newbury Park (CA): Sage Publications, 1992.
34. Lehrer PM, Isenberg S, Hochron SM. Asthma and emotion: a review. J Asthma 1993;30:5-21.
35. Jaccard J, Wan C. Statistical analysis of temporal data with many observations: issues for behavioral medicine data. Ann Behav Med 1993;15:41-50.
36. Affleck G, Urrows S, Tennen H, Higgins P, Pav D, Aloisi R. A dual pathway model of daily stressor effects on rheumatoid arthritis. Ann Behav Med. In press.
37. Marco C, Suls J. Daily stress and the trajectory of mood: spillover, response assimilation, contrast, and chronic negative affectivity. J Pers Soc Psychol 1993;64:1053-63.
38. Shiffman S, Fischer L, Paty J, Gnys M, Hickcox M, Kassel J. Drinking and smoking: a field study of their association. Ann Behav Med 1994;16:203-9.
39. Suls J, Wan C, Blanchard E. A multilevel data-analytic approach for evaluation of relationships between daily life stressors and symptomatology: patients with irritable bowel syndrome. Health Psychol 1994;13:103-13.
40. Johnston J. Econometric methods. New York: McGraw-Hill, 1984.
41. Atherton HA, White PT, Hewett G, Howells K. Relationship of daytime asthma symptom frequency to morning peak expiratory flow. Eur Respir J 1996;9:232-6.
42. Klein RB, Fritz GK, Yeung A, McQuald EL, Mansell A. Spirometric patterns in childhood asthma: peak flow compared with other indices. Pediatr Pulmonol 1995;20:372-9.