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Symptom Perception and Functional Morbidity Across a 1-Year Follow-up in Pediatric Asthma

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Summary

The purpose of this study was to examine the association between asthma symptom perception measured during a 5–6 week baseline and functional morbidity measured prospectively across a 1-year follow-up. Symptom perception was measured by comparing subjective ratings with peak expiratory flow rate (PEFR) and forced expiratory volume in one second (FEV₁). We hypothesized that accurate symptom perception (ASP) would be associated with less functional morbidity. Participants consisted of 198 children with asthma ages 7–17 recruited from three sites. The children used a programmable electronic spirometer in the home setting to guess their PEFR prior to exhalation. Each “subjective” guess was classified as being in an ASP, dangerous symptom perception (DSP; underestimation of symptoms), or symptom magnification (SM; overestimation) zone based upon the corresponding measurement of PEFR or FEV₁. An index of functional morbidity was collected by parent report at baseline and across 1-year follow-up. A greater proportion of ASP blows and a lower proportion of DSP blows based on PEFR predicted less functional morbidity reported at baseline, independent of asthma severity and race/ethnicity. A greater proportion of ASP blows (using PEFR and FEV₁) and a lower proportion of SM blows (using FEV₁) predicted less functional morbidity across 1-year follow-up. Symptom perception was not associated with emergency department visits for asthma at baseline or across follow-up. In comparison to PEFR, FEV₁ more frequently detected a decline in pulmonary function that children did not report. Symptom perception measured in naturalistic settings was associated with functional morbidity at baseline and prospectively across 1-year follow-up. Support was found for including multiple measures of pulmonary function in the assessment of asthma symptom perception.

Keywords

asthma; forced expiratory volume; morbidity; peak expiratory flow rate; perception

INTRODUCTION

Pediatric asthma continues to be a major public health concern despite improvements in pharmacologic management in recent years¹. The ability to recognize symptoms of asthma is an implicit, fundamental first step in asthma self-management. Failure to detect and treat symptoms of asthma can lead to emergency health care use, near-fatal, and fatal asthma attacks.^{2–5} Conversely, a child's oversensitivity to asthma symptoms may be associated with greater asthma morbidity perceived by the parent. This may lead to impaired health-related quality of life and unnecessary use of PRN (i.e., as-needed) asthma medications and iatrogenic side effects. Subjective estimates of asthma symptoms have been shown to be a better predictor of health-related quality of life⁶ and PRN medication use^{7,8} than objective measurements among adults.

There is little published research on the association between children's ability to perceive asthma symptoms and asthma morbidity. Fritz et al.⁹ asked children attending a 2-week asthma camp to guess their peak expiratory flow rate (PEFR) immediately before spirometry testing. Greater perceptual accuracy was associated with fewer school days missed (6% explained variance) and fewer emergency department (ED) visits (5% explained variance) during the past year after controlling for asthma severity⁹. This association was present when using mid-expiratory flow (FEF_{25–75}), but not PEFR, as the objective marker of pulmonary function. FEF_{25–75} is a measure of small, peripheral airway function, whereas PEFR measures large airway obstruction. This finding reflects the importance of incorporating multiple measures of pulmonary function when assessing asthma symptom perception.

The first step in designing a clinical intervention to improve symptom perception is to examine whether it can be adequately measured with home peak flow meters or whether spirometry is necessary. The previous literature^{10–12} has shown that PEFR is a less sensitive marker of bronchoconstriction than forced expiratory volume in one second (FEV₁; i.e., the volume of air expired during the first second of a forced vital capacity maneuver). Therefore, PEFR may have less clinical utility than FEV₁ in identifying underperception of symptoms. National Heart Lung and Blood Institute (NHLBI) guidelines^{13,14} recommend both PEFR and FEV₁ for assessment of asthma severity and as a guide for treatment decisions. The guidelines conclude that FEV₁ is more precise and less variable than PEFR. However, PEFR is more readily available and widely used due to inexpensive home peak flow monitors. Another important gap in the literature is whether symptom perception is associated prospectively with functional morbidity across follow-up periods, which include seasonal variations in functional morbidity.

A novel methodology for the measurement of asthma symptom perception has been recently developed to begin addressing these questions. Technological advances have led to programmable, portable spirometers (AMII, Jaeger) that allow children to record electronically subjective and objective measures of pulmonary function in naturalistic settings. Additionally, the Asthma Risk Grid^{15,16} (see Methods) was developed to quantify underestimation, accurate estimation, and overestimation of asthma symptoms. Accuracy indices used in previous studies were not able to examine associations between asthma morbidity and either underestimation or overestimation of symptoms. Baseline data on a smaller, overlapping subset of participants from the present study showed that the Asthma Risk Grid, calculated using PEFR, was associated with functional morbidity during the month prior to the study¹⁷. Accurate symptom perception (ASP) was *inversely* associated with functional morbidity, and under- and overestimation of symptoms were *directly* associated with morbidity.

The purpose of the present study was to examine whether asthma symptom perception collected at baseline would predict functional morbidity prospectively across a 1-year follow-up. We hypothesized that these baseline findings would be replicated across follow-up. Additionally,

this study addressed the clinical utility of calculating symptom perception with PEFR versus FEV₁ as the objective measure of pulmonary function. We hypothesized that FEV₁ would identify underperception of symptoms more frequently than PEFR.

MATERIALS AND METHODS

Participants

Data were collected as part of a study investigating symptom perception in children with asthma¹⁷. The study took place at three academic-based sites in the United States: Brown Medical School (RI), University of Texas Medical School (TX), and National Jewish Medical and Research Center (CO). Participants were recruited via flyers, physician referrals from primary care and specialized asthma clinics, advertising in the community, and an asthma summer camp. Inclusion criteria for the study were (i) 7–17 years old, (ii) physician-diagnosed asthma of 6 months or more duration, and (iii) an active prescription for anti-inflammatory or bronchodilator medication. Exclusion criteria were (i) other significant pulmonary conditions (e.g., cystic fibrosis), (ii) inability to complete the study protocol in English, and (iii) a cognitive learning disability that would preclude comprehension of protocol tasks, as determined by parent report of school placement. Child assent and parent consent were obtained and the institutional review boards at each of the three sites approved the study.

Measures

Asthma symptom perception accuracy was measured by comparing the child's subjective guess of PEFR to both objective measures (PEFR and FEV₁) collected at the same time point. Children's guesses on PEFR were compared to values on FEV₁ based on the rationale that children simply estimate their general lung function during the process of symptom perception. Both subjective and objective values were converted to units of "percent of objective personal best" for the individual child. The personal best value was determined based on the highest value achieved during the period of data collection.

The AMII is a hand-held, computerized spirometer that instructed children to guess their PEFR and then conduct three consecutive forced vital capacity maneuvers using maximal effort. Although spirometry is effort-dependent, well-instructed children are capable of performing spirometry and it is widely accepted as an objective assessment of lung function¹⁸. Participants were not able to change their original estimates of PEFR to prevent alterations from being made based on the actual PEFR recordings. Although participants were able to see their actual PEFR values, previous data showed that no learning effect takes place with regard to improvement in perceptual accuracy across a 2-week time period⁹. The AMII stored all measurements by automatically recording the dates and times of participants' responses and pulmonary function data.

The Asthma Risk Grid^{15,16} (Fig. 1) was used to calculate each subject's symptom perception accuracy zones. Each pulmonary function test was plotted against the corresponding subjective estimate of PEFR. The proportions of guesses in the ASP (subjective estimate corresponds closely to objective values), dangerous symptom perception (DSP; significantly underestimates asthma compromise), and symptom magnification (SM; significantly overestimates asthma compromise) zones were calculated. For example, a child's guess of PEFR equivalent to 90% personal best and actual PEFR value of 60% personal best would be categorized in the DSP zone. Each blow that the child performed was categorized into only one of these three zones. Cutoff values for the three zones were based on the clinical guidelines recommended by NHLBI^{13,14}. Additionally, the child's guess of PEFR had to be at least 10% higher or 10% lower than the actual PEFR value to be considered a DSP or SM blow, respectively (as depicted in the $\pm 10\%$ wedge of the ASP zone in Fig. 1).

The Asthma Risk Grids were calculated for each child separately using both PEFR and FEV₁ as the objective measures of pulmonary function. PEFR is considered a measure of large airways obstruction and FEV₁ measures the function of both large and small (i.e., peripheral) airways. A series of data reduction steps were used to clean the data, which are available upon request. The Asthma Risk Grid was not calculated using FEV₁ for five participants due to device malfunction.

Functional morbidity was assessed with the asthma functional severity scale (AFSS)¹⁹. The AFSS is a six-item scale completed by parents and includes questions on the frequency of asthma attacks and symptoms, nighttime awakenings, and interference with activities due to asthma. The AFSS has good reliability and validity based on a large standardization sample (n=1267). Scores on the AFSS were associated with asthma-related school absences, functional impairment, asthma-related health care use, and medication use¹⁹. Parents completed the AFSS with reference to the past month for baseline, and then with respect to the time period since the last administration of the AFSS during each of the follow-up assessments. Therefore, baseline functional morbidity was focused on the month prior to the symptom perception protocol. Assessment of follow-up functional morbidity started with the time period that the child completed the symptom perception protocol. A mean functional morbidity score per month was calculated across this time period and all subsequent follow-up periods for a total duration of 1 year. This follow-up index maximized the potential to capture seasonal variations in asthma control across the year and also restricted the number of dependent measures. Additionally, parents were asked whether their child had an ED visit related to asthma during the past month at baseline and across follow-up in order to have a measure of health care use.

Asthma severity categories were assigned by consensus ratings from two pediatric asthma specialists based on the four levels defined by NHLBI: mild intermittent, mild persistent, moderate persistent, and severe persistent^{13,14}. The severity ratings were based on parent responses obtained from a questionnaire. This information included prescribed asthma medications and dosing, asthma symptoms, health care use, and functional impairment during the past 12 months.

Self-report data were collected on sociodemographic information, including the child's age, race/ethnicity, parental occupation, and marital status. The National Opinion Research Council²⁰ coding system was used to calculate occupational prestige ratings, which were used as an indicator of socioeconomic status. Use of occupational prestige ratings as a proxy for socioeconomic status has been widely employed in the pediatric literature^{21,22}. Each family was assigned the higher rating (i.e., more "prestigious" occupation) if both parents were employed.

Procedure

Both child and parent were trained in using the AMII device during a baseline visit to our laboratory. Training on the AMII involved instructions on how to use the device, enter answers to the questions, and perform spirometry. Participants first observed a trained research assistant perform spirometry using maximal effort on the AMII. Children then demonstrated maximal effort blows into the AMII until they consistently displayed correct form. The importance of maximal effort during spirometry was emphasized to both parents and children. The questionnaires for the study were also administered during this baseline visit.

The children took the AMII home with them and were instructed to use the device over the next 5–6 weeks before taking medications each morning and evening, and at times when they were having trouble breathing. Children were instructed to guess their PEFR without input from their parents. A research assistant called the family at least three times during this time period as a reminder to use the AMII and to troubleshoot any potential problems. A second

visit to the laboratory was scheduled approximately 5–6 weeks later in order to collect the AMII device and to administer the AFSS. Additionally, 4–5 follow-up assessments were conducted via telephone calls to assess functional morbidity and ED visits for up to 1 year following baseline.

Data Analysis

Hierarchical multiple regression analyses were carried out to predict functional morbidity from parameters of asthma symptom perception. Asthma severity and race/ethnicity were entered as predictors in the model at step 1 based on associations with functional morbidity at baseline (see Results). Age, gender, and occupational prestige were not associated with functional morbidity. The proportion of blows that children had in the ASP, DSP, and SM zones were each entered as predictors in separate models at step 2. A probit transformation²³ was applied to normalize these proportional data. The primary-dependent measures were functional morbidity (AFSS) at baseline and across follow-up. These analyses were conducted separately for Asthma Risk Grid zones calculated with PEFR and FEV₁ as the pulmonary function measure. Secondary measures in the present study were ED visits reported at baseline and across follow-up. Logistic regression analyses were conducted to predict the presence or absence of ED visits from parameters of asthma symptom perception after controlling for asthma severity and race/ethnicity. Paired-samples t-tests were conducted to compare the proportion of blows in the three Asthma Risk Grid zones for PEFR and FEV₁.

RESULTS

Patient Characteristics

A total of 226 children and caregivers participated in the study. Twenty-eight participants were excluded from data analyses based on a minimum requirement of 20 subjective/objective paired data points on the AMII device. No differences were found on age, socioeconomic status, race/ethnicity, or asthma severity among these participants who were excluded versus those included in the analysis. Children used the AMII devices an average of 31 out of 46 assigned days with an average of 42 data points for each child. Follow-up data were available for 150 children out of 198 children (76%) who completed baseline data. Families were required to complete at least three assessments of functional morbidity during the follow-up period to be included in data analysis. No differences were found on demographics or asthma severity between participants who completed follow-up assessments versus participants who dropped out of the study. No site differences were found on demographic data, functional morbidity, or ED visits.

Demographic characteristics of the sample at baseline are presented in Table 1. The sample was predominantly white/non-Hispanic (70%) with mild persistent asthma (62%). The mean occupational prestige score was consistent with technical/sales/administrative support.²⁰ The primary caregiver was most often the mother (91%), followed by the child's father (6%), and grandmother (3%).

Perceptual Accuracy and Baseline Functional Morbidity

The ASP zone (4%) and DSP zone (5%) explained a significant proportion of variance in baseline functional morbidity, independent of asthma severity, and race/ethnicity, using PEFR as the objective measure (see Table 2). Functional morbidity was *negatively* associated ($r = -0.21$, $P < 0.01$) with ASP blows and *positively* associated ($r = 0.24$, $P < 0.01$) with DSP blows. The SM zone was not associated with functional morbidity. None of the three Asthma Risk Grid zones were associated with functional morbidity when using FEV₁ as the objective measure and controlling for asthma severity and race/ethnicity (see Table 3).

Approximately 10% of caregivers reported an ED visit during the past month for their children at baseline. The ASP zone (OR=0.59, 95% CI, 0.30–1.17), DSP zone (OR=0.91, 95% CI, 0.38–2.17), and SM zone (OR=1.67, 95% CI, 0.93–3.02) were not significantly associated with the presence of an ED visit when using PEFR as the objective measure. These analyses controlled for asthma severity and race/ethnicity. Logistic regression analyses using FEV₁ also showed that the ASP zone (OR=0.71, 95% CI, 0.37–1.39), DSP zone (OR=0.79, 95% CI, 0.43–1.46), and SM zone (OR=1.55, 95% CI, 0.92–2.62) were not significantly associated with ED visits.

Perceptual Accuracy and Follow-up Functional Morbidity

The ASP zone explained a significant proportion of variance (3%) in functional morbidity scores across follow-up when race/ethnicity and asthma severity were controlled and PEFR was the objective measure (see Table 4). A greater proportion of ASP zone blows was associated ($r=-0.20$, $P < 0.05$) with less functional morbidity. The ASP zone (3%) and SM zone (3%) both contributed unique variance to functional morbidity across follow-up when using FEV₁ as the measure of pulmonary function and controlling for race/ethnicity and asthma severity (see Table 5). The proportion of scores in the SM zone was *positively* associated ($r=0.21$, $P < 0.05$) with functional morbidity, whereas the proportion of ASP zone scores was *negatively* associated ($r=-0.22$, p) with functional morbidity over the 1-year follow-up.

Twenty-one percent of caregivers reported that their child had an ED visit during follow-up. The ASP zone (OR=1.13, 95% CI, 0.71–1.79), DSP zone (OR=0.84, 95% CI, 0.42–1.65), and SM zone (OR=1.00, 95% CI, 0.64–1.57) were not significant predictors of follow-up ED visits when using PEFR as the objective marker. Race/ethnicity and asthma severity were controlled in these analyses. Similar results were found when using FEV₁ to measure pulmonary function: ASP zone, OR=1.11, 95% CI, 0.70–1.78; DSP zone, OR=1.18, 95% CI, 0.77–1.81; and SM zone, OR 0.82, 95% CI, 0.53–1.28.

Symptom Perception Accuracy: FEV₁ Versus PEFR

Paired-samples t-test showed that a greater proportion of blows were in the DSP zone when using FEV₁ versus PEFR as the measure of pulmonary function [$t(192) = 7.42$, $P < 0.001$; $r = 0.28$]. A smaller proportion of blows were in the ASP zone for FEV₁ versus PEFR [$t(192) = 6.65$, $P < 0.001$; $r = 0.41$]. No difference was found between FEV₁ and PEFR for the SM zone [$t(192) = 1.26$, ns; $r = 0.77$]. These findings indicate that, in comparison to PEFR, FEV₁ more frequently identified declines in pulmonary function that children did not report. Table 6 displays the percentage of blows in each of the three Asthma Risk Grid zones. Children showed a wide range in perceptual ability regardless of the pulmonary function measure used. Additionally, only 13% of the children were always in the accurate zone using PEFR as the objective measure. Only 3% of the children were in the accurate zone 100% of the time using FEV₁ as the measure.

DISCUSSION

This study showed that children's asthma symptom perception ability was associated with functional morbidity prospectively across 1-year follow-up using both PEFR and FEV₁ as measures of pulmonary function. These findings were independent of asthma severity and race/ethnicity. To our knowledge, this is the first study to show an association between asthma symptom perception and functional morbidity measured prospectively. The present study provides some evidence for the validity of the Asthma Risk Grid^{15,16} method for the measurement of symptom perception. Accurate perception, underestimation, and overestimation of asthma symptoms were each associated with functional morbidity in the expected direction.

These findings suggest that measurement of children's symptom perception ability across a relatively short time period in a naturalistic setting may be a useful predictor of subsequent functional morbidity. The proportion of scores in the ASP zone predicted functional morbidity across 1-year follow-up, regardless of which pulmonary function measure was used. This finding is particularly salient given that different informants were involved in symptom perception (children) and report of functional morbidity (parents). Previous research on younger children between the ages of 3 and 7 has shown that parents tend to underreport their children's asthma symptoms²⁴. The present study involved children between the ages of 7 and 17 and, thus, communication regarding asthma symptoms may improve among this age group. Parents are often responsible for the final decisions on medical care use and asthma medications^{25,26}. Therefore, this finding may reflect an adaptive pattern of family management of the child's asthma over the course of the year. The association between the proportion of scores in the SM zone (using FEV₁) and functional morbidity also indicates concordance between child and parent in their perception of asthma symptoms. However, this pattern may be maladaptive given baseline data suggesting oversensitivity to asthma symptoms. Although the proportion of scores in the DSP zone was not associated with follow-up functional morbidity, this zone (using PEFr) accounted for the greatest percentage of explained variance (5%) in functional morbidity at baseline. The absence of an association across follow-up might be attributed to the self-report nature of the study. The child may not have detected asthma symptoms and, in turn, the parent did not report functional morbidity. No objective data were collected across follow-up. Additionally, a child may be classified in the DSP zone although he/she detected breathing problems and initiated appropriate self-management, but underestimated the actual lung function value. Future research should attempt to tease apart potential subgroups of children within the DSP zone.

The present study demonstrates that both FEV₁ and PEFr each contribute unique advantages in the assessment of asthma symptom perception. Approximately 20% of blows across all subjects were in the DSP zone when using FEV₁ as the measure of pulmonary function compared to 8% when using PEFr. Therefore, measurement of FEV₁ is important for detecting underestimation of asthma symptoms. Children may be at risk for potentially missing asthma exacerbation if they rely exclusively on peak flow meters. This finding is consistent with the previous literature on children^{10,11} and adults¹² showing that bronchoconstriction is more frequently detected by FEV₁ than PEFr. These studies used predicted values and compared PEFr using a peak flow meter versus FEV₁ measured with a spirometer. The present study used personal best values and measured PEFr and FEV₁ with a spirometer to minimize these potential differences. Therefore, the present study may be an underestimate of these differences on DSP zone blows if PEFr were measured using a standard peak flow meter. Additionally, studies of adults²⁷ and children¹⁸ have shown that FEV₁ has greater repeatability than PEFr when both are measured with spirometry.

Nevertheless, the associations between symptom perception using PEFr and functional morbidity also support the clinical utility of using PEFr as a marker of pulmonary function. The only significant association between underestimation of symptoms and functional morbidity was found when using PEFr, which may be attributed to the higher threshold for identifying underestimation of symptoms. Therefore, children and parents might be more aware of the link between underestimation of symptoms and functional morbidity during interventions with structured feedback using peak flow meters. Baseline findings only provided support for PEFr, and not FEV₁, in the associations between symptom perception and functional morbidity. Therefore, optimal measurement of symptom perception should include both peak flow meters at home/school and spirometry during office visits.

Children displayed wide variability in their ability to detect asthma symptoms. This marked variability is consistent with low correlations that have been reported between asthma symptom

report and both FEV₁ and PEF_R among children with asthma^{9,28–30}. Overall, only 61% and 73% of blows were in the ASP zone using FEV₁ and PEF_R, respectively. Yoos et al. found that children were categorized as being accurate approximately 63% of the time when using PEF_R as the measure³¹. The ability of children to detect asthma symptoms may depend on several characteristics of the symptoms, including acute versus prolonged onset of bronchoconstriction³² and diurnal versus nocturnal symptoms³⁰. Delayed onset and nocturnal symptoms may both be independent risk factors for underestimation of asthma symptoms. Hypoxia may be a contributing factor to blunted asthma symptom perception^{4,33}. Experimental manipulations have shown that feedback involving false sounds of wheezing among children³⁴ and CO₂ conditioning trials among adults³⁵ may increase report of asthma symptoms despite no changes in pulmonary function. Therefore, behavioral and biological factors are likely involved in asthma symptom perception.

There are several limitations that should be considered when interpreting the results. Functional morbidity and ED visits were based on retrospective self-report and not confirmed by medical chart review. However, parent report of asthma symptoms, health care utilization, and functional health status has been shown to be a better predictor than pulmonary function tests of change in asthma status across 1-year follow-up³⁶. The duration of data collection for symptom perception was 5–6 weeks, which may not have been long enough to capture adequately the variability in pulmonary function. Fewer data points in the SM and DSP zones may have limited power in the present study. These factors may explain the absence of an association between symptom perception accuracy and ED visits at baseline or follow-up. Furthermore, perceptual ability only explained a small percentage of the variance ($\leq 5\%$) in predicting functional morbidity. Several other factors (e.g., health insurance, environment, provider characteristics) not measured in the present study likely play a role in predicting functional morbidity. Additionally, the measurement of symptom perception relied upon spirometry, which is highly effort dependent, being performed at home. Our inability to monitor children's efforts may have compromised the quality of pulmonary function data, which is a consequence of a naturalistic study. However, these limitations would likely have reduced the possibility of finding associations between symptom perception and functional morbidity. Thus, limitations of the present study may have contributed to the relatively small percentage of variance in functional morbidity explained by symptom perception.

CONCLUSIONS

Symptom perception measured during a 5–6 week period predicted functional morbidity at baseline and prospectively across 1-year follow-up among children with asthma. The present study also demonstrated the importance of including multiple measures of pulmonary function when examining symptom perception. However, interventions to improve symptom perception accuracy in clinical practice are likely to focus only on home peak flow monitoring given the accessibility of peak flow meters. Relying on objective measures, such as PEF_R, may be useful in reducing functional morbidity and improving symptom perception accuracy. Nevertheless, limitations in peak flow meters should be emphasized to families, including lower sensitivity for detecting bronchoconstriction. Therefore, asthma education focusing on early warning signs, symptoms, and triggers of asthma will also likely be critical for improving children's symptom perception ability.

Interventions will likely need to be carried out over an extended period of time that captures variability in pulmonary function. Children and parents may also require meetings with a therapist who reviews the child's graph of PEF_R values and subjective guesses. This format would provide consistent feedback in a structured manner that would allow both the child and parent to be aware of symptom perception accuracy levels. In particular, specific instances of errors in perception should be emphasized. This area of research is critical given the link

between underestimation of asthma and near fatal as well as fatal asthma attacks^{2–5}. Future research should examine how parents influence children's asthma symptom perception and how these factors are related to the use of as-needed medications. Finally, more ethnically diverse samples are needed to determine which cultural factors may be associated with asthma symptom perception. This research is needed to inform clinical interventions designed to improve children's asthma symptom perception.

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Fig. 1.
 Asthma Risk Grid, ASP zone: boxes 1, 5, 9, and $\pm 10\%$ wedge; DSP zone: boxes 4, 7, and 8;
 SM zone: boxes 2, 3, and 6.

TABLE 1**Participants Characteristics**

	Mean $\pm$ SD (%)
Age (year)	11.7 $\pm$ 2.3
Child's gender (%)	
Female	46.0
Male	54.0
Child's race/ethnicity (%)	
White/non-Hispanic	69.8
Black/non-Hispanic	15.1
Hispanic	6.1
Other	9.0
Socioeconomic status (Occupational prestige)	51.5 $\pm$ 14.7
Marital status of parent (%)	
Married	72
Divorced/separated	18
Single	6
Other	4
Asthma severity (%)	
Mild intermittent	7.3
Mild persistent	61.7
Moderate persistent	25.7
Severe persistent	5.3

TABLE 2

Predicting Baseline Functional Morbidity from Asthma Symptom Perception Using PEFr as the Objective Measure

Predictors	F Change	df	R ²	Standardized β
Accurate symptom perception				
Step 1				
Asthma severity	20.23**	2,195	0.17	0.33
Race/ethnicity				0.16
Step 2				
ASP zone	8.81*	1,194	0.21	-0.19
Underestimation of symptoms				
Step 1				
Asthma severity	20.23**	2,195	0.17	0.34
Race/ethnicity				0.19
Step 2				
DSP zone	11.81*	1,194	0.22	0.22
Overestimation of symptoms				
Step 1				
Asthma severity	20.23**	2,195	0.17	0.33
Race/ethnicity				0.18
Step 2				
SM zone	1.22	1,194	0.18	0.07

* $P < 0.01$.

** $P < 0.001$.

TABLE 3

Predicting Baseline Functional Morbidity from Asthma Symptom Perception Using FEV₁ as the Objective Measure

Predictors	<i>F</i> Change	<i>df</i>	<i>R</i> ²	Standardized β
Accurate symptom perception				
Step 1				
Asthma severity	22.35*	2,190	0.19	0.35
Race/ethnicity				0.2
Step 2				
ASP zone	2.76	1,189	0.2	-0.11
Underestimation of symptoms				
Step 1				
Asthma severity	22.35*	2,190	0.19	0.36
Race/ethnicity				0.22
Step 2				
DSP zone	0.48	1,189	0.19	0.05
Overestimation of symptoms				
Step 1				
Asthma severity	22.35*	2,190	0.19	0.34
Race/ethnicity				0.2
Step 2				
SM zone	1.61	1,189	0.2	0.09

* $P < 0.001$.

TABLE 4

Predicting Functional Morbidity Across 1-year Follow-up from Asthma Symptom Perception Using PEFR as the Objective Measure

Predictors	F Change	df	R ²	Standardized β
Accurate symptom perception				
Step 1				
Asthma severity	16.90 ^{**}	2,147	0.19	0.42
Race/ethnicity				0.07
Step 2				
ASP zone	6.28 [*]	1,146	0.22	-0.19
Underestimation of symptoms				
Step 1				
Asthma severity	16.90 ^{**}	2,147	0.19	0.42
Race/ethnicity				0.07
Step 2				
DSP zone	2.54	1,146	0.20	0.12
Overestimation of symptoms				
Step 1				
Asthma severity	16.90 ^{**}	2,147	0.19	0.42
Race/ethnicity				0.07
Step 2				
SM zone	3.38	1,146	0.21	0.14

* $P < 0.05$.

** $P < 0.001$.

TABLE 5

Predicting Functional Morbidity Across 1-year Follow-up from Asthma Symptom Perception Using FEV₁ as the Objective Measure

Predictors	<i>F</i> Change	df	<i>R</i> ²	Standardized β
Accurate symptom perception				
Step 1				
Asthma severity	18.69**	2,143	0.21	0.44
Race/ethnicity				0.10
Step 2				
ASP zone	6.88*	1,142	0.24	-0.2
Underestimation of symptoms				
Step 1				
Asthma severity	18.69**	2,143	0.21	0.44
Race/ethnicity				0.10
Step 2				
DSP zone	0.75	1,142	0.21	0.02
Overestimation of symptoms				
Step 1				
Asthma severity	18.69**	2,143	0.21	0.44
Race/ethnicity				0.10
Step 2				
SM zone	6.48*	1,142	0.24	0.19

* $P < 0.05$.

** $P < 0.001$.

TABLE 6Percentage of Blows in Asthma Risk Grid Zones Using PEF_R Versus FEV₁

	PEFR (%)	PEFR (Range)	FEV ₁ (%)	FEV ₁ (Range)
ASP zone	72.7	3.3–100.0	60.5	0.0–100.0
DSP zone	8.3	0.0–78.1	20.5	0.0–92.1
SM zone	19.0	0.0–96.7	19.0	0.0–100.0