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Symptom Perception in Childhood Asthma: The Role of Anxiety and Asthma Severity

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This study tested the relationship of anxiety and asthma severity to symptom perception. Eighty-six children diagnosed with mild or moderate asthma had symptom perception and pulmonary function measured throughout methacholine challenge (to induce bronchoconstriction). Higher trait anxiety was associated with heightened symptom perception (controlling for pulmonary function) at baseline. Greater asthma severity was associated with blunted symptom perception (controlling for pulmonary function) at the end of methacholine challenge and with a slower rate of increase in symptom perception across methacholine challenge. These results suggest that anxiety plays a role when children's symptoms are mild, whereas medical variables such as severity play a role in perception of changes in asthma symptomatology as bronchoconstriction worsens.

Keywords: asthma, symptom perception, anxiety

Perception of airway obstruction is an important component in the home management of asthma, particularly when a patient has worsening airway obstruction. Previous reports have documented that some adults with asthma have no sensation of difficulty breathing at times when they have marked reductions in pulmonary function, such as during treatment of asthma in an emergency setting (McFadden, Kiser, & DeGroot, 1973) or when bronchoconstriction is induced by inhaling a drug such as methacholine (Rubinfeld & Pain, 1976).

Inaccurate symptom perception can take two forms: blunted perception of symptoms and overperception of symptoms. Both have negative consequences. Blunted perception of symptoms has been associated with poor asthma management and with fatal or near-fatal asthma (Creer, 1983; Kikuchi et al., 1994; Zach & Karner, 1989). Conversely, overperception of symptoms has been associated with excessive medication usage and hospitalizations (Creer, 1983; Dirks, Schraa, Brown, & Kinsman, 1980). Thus it is important to determine whether overperceivers and underperceivers of asthma symptoms can be identified, especially given that asthma is the most common chronic illness of childhood (Pamuk, Makuc, Heck, Reuben, & Lochner, 1998).

With respect to overperception of symptoms, researchers have proposed that negative emotions are related to heightened symptom perception in asthma (for reviews see Lehrer, Feldman, Giardino, Song, & Schmaling, 2002; Rietveld, 1998; Rietveld & Brosschot, 1999). Within the general population, there is also consistent evidence demonstrating that individuals with high negative affect (or neuroticism) report more physical symptoms (Costa & McCrae, 1985, 1987; Watson & Pennebaker, 1989) and that these patterns often persist even when individuals high and low in negative affect do not differ in objective health or even when controlling for objective indicators of disease (Cohen et al., 1995; Feldman, Cohen, Doyle, Skoner, & Gwaltney, 1999; Pennebaker, 2000).

A number of explanations have been proposed for why higher levels of negative affect are associated with greater symptom reporting. First, individuals with high negative affect may be hypersensitive to stimuli, paying greater attention to bodily sensations and perhaps having a lower threshold for detecting symptoms (Hansell & Mechanic, 1985; Watson & Clark, 1984; Watson & Pennebaker, 1989). Second, high negative affect could lead individuals to have biases in how they interpret sensations (e.g., interpreting ambiguous symptoms negatively; Pennebaker, 1982; Watson & Clark, 1984; Watson & Pennebaker, 1989). Third, individuals with high negative affect may preferentially recall symptom experiences (Larsen, 1992). Alternatively, negative affect may be a consequence of disease symptoms, or negative affect may lead to disease with subsequent symptomatology (Cameron, Leventhal, Love, & Patrick-Miller, 2002; Diefenbach, Leventhal, Leventhal, & Patrick-Miller, 1996). Thus uncertainty remains about whether individuals high in negative affect perceive, report, and/or recall more symptoms or whether these individuals actually experience more symptoms biologically (Rabin, Ward, Leventhal, & Schmitz, 2001).

Many of the previous studies on negative affect have focused on healthy populations and have not included objective measures of disease (for some exceptions see Cameron et al., 2002; Cohen et al., 1995; Feldman et al., 1999). In chronic illnesses such as

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asthma, higher levels of anxiety and depression have been associated with greater perceived breathlessness in adults with asthma (Martinez-Moragon, Perpina, Belloch, De Diego, & Martinez-Frances, 2003). In addition, during a drug inhalation challenge to induce bronchoconstriction among adults with asthma, higher levels of state anxiety were correlated with higher levels of perceived breathlessness (Spinhoven, van Peski-Oosterbaan, van der Does, Willems, & Sterk, 1997). However, one daily diary study of adults with asthma found no relationship between negative moods and the within-person correlation between self-reported symptoms and lung function (Apter et al., 1997).

In children with asthma a similar pattern emerges, although fewer studies exist. Negative emotions that were experimentally induced had an effect of increasing perceived symptoms during a physical exercise task (Rietveld & Prins, 1998). Among a community sample of adolescents (not selected on the basis of having asthma), those categorized as hyperperceivers (perceiving greater change in symptoms during a bronchoconstriction challenge test relative to their objective lung function change) showed a trend toward higher levels of anxiety and depression (Wamboldt, Bihun, Szefler, & Hewitt, 2000). Although these differences were not statistically significant, the fact that the sample consisted of healthy adolescents may have weakened the effects. One other study found no relationship between anxiety and the ability to predict the results of one's lung function test in a sample of children with asthma (Fritz, McQuaid, Spirito, & Klein, 1996).

Of the negative emotions, anxiety in particular has been implicated in asthma, because of the overlap between anxiety disorders, such as panic, and asthma (Lehrer et al., 2002). In the present study, we sought to add to the symptom perception literature by investigating a sample of children with a chronic illness in which symptom perception is important. We tested the hypothesis that children with asthma who have higher levels of trait anxiety would perceive greater symptoms independent of objective pulmonary function during the course of an experimental manipulation to induce bronchoconstriction (methacholine challenge). To our knowledge, this study design has not been used to investigate anxiety and symptom perception in children with asthma and provides a rigorous test of associations in the face of changing pulmonary function.

With respect to underperception of symptoms, some researchers have proposed that symptom perception becomes less accurate over time after repeated experience with symptoms (Bishop, 1987; Pennebaker, 1981). This may be due to habituation to chronic symptoms, such that symptoms no longer bother or no longer are noticed by a patient (Burdon, Juniper, Killian, Hargreave, & Campbell, 1982; Rietveld, 1997). For example, Chetta et al. (1998) used methacholine challenge to induce bronchoconstriction to define hypoperceivers, normoperceivers, and hyperperceivers. They found more hypoperceivers among adults with severe asthma. Similarly lower baseline lung function (FEV_1) was associated with lower symptom perception, as well as fewer perceived changes in lung function during methacholine challenge among adults with asthma (Bijl-Hofland, Cloosterman, Folgering, Akkermans, & van Schayck, 1999; Killian, Watson, Otis, Amand, & O'Byrne, 2000). Daily diary approaches of adults with asthma have found that lower baseline lung function is associated with smaller within-person correlations between symptom and peak-flow lung function (Apter et al., 1997). In addition, treatment of asthma with an inhaled corticosteroid improved perceptual accuracy of symptoms (Boulet et al., 1998; Salome et al., 2002).

Researchers have documented that children with life-threatening asthma have lower perceptions of breathlessness compared with children with non-life-threatening asthma (Julius, Davenport, & Davenport, 2002). Researchers also found that children with severe asthma have subjective ratings of asthma that are less congruent with objective lung function than do children with mild or moderate asthma (Yoos, Kitzman, McMullen, & Sidora, 2003). In turn, reduced ability to predict one's lung function was associated with morbidity outcomes, such as a greater number of emergency department visits because of asthma (Fritz et al., 1996). However, one study found that after controlling for numerous medical and demographic variables, perceived breathlessness was not associated with asthma severity after a bronchoconstriction challenge test (Rietveld, Prins, & Colland, 2001).

Studies in which researchers used daily diary approaches have not found consistent patterns for symptom perception. For example, the within-person correlation between symptoms and lung function did not differ by severity group and was not related to morbidity outcomes, such as number of hospitalizations, among children with asthma (Cabral, Conceicao, Saldiva, & Martins, 2002; Fritz, Klein, & Overholser, 1990).

Overall, there is evidence to support the notion that patients with more severe asthma have blunted symptom perception, although the evidence appears less strong with repeated daily assessment techniques. In the present study, we tested the hypothesis that children with greater severity of asthma would perceive fewer symptoms relative to objective pulmonary function during the course of an experimental manipulation to induce bronchoconstriction using methacholine. Although not as generalizable as daily diary studies, the manipulation of bronchoconstriction in the laboratory provides a tightly controlled environment in which to detect associations with symptom perception. Thus, the overall goals of this study were to test whether childhood anxiety and asthma severity were associated with symptom perception in a sample of pediatric asthma patients tested under conditions of increasing concentrations of a drug that causes bronchoconstriction.

Method

Participants

Study patients were 103 children ages 8–16 years, who were diagnosed with mild to moderate asthma and enrolled in the St. Louis, Missouri, center of the Childhood Asthma Management Program (CAMP). CAMP was designed to evaluate whether continuous, long-term treatment with an inhaled anti-inflammatory drug safely produced an improvement in lung growth as compared with treatment for symptoms only. The design and methods for CAMP have been described previously (CAMP Research Group, 1999a, 1999b).

Measures

Asthma severity. Severity was assessed at the first screening visit on a 4-point scale of 0 = *none*, 1 = *mild*, 2 = *moderate*, or 3 = *severe*, which was based in part on the National Asthma Education and Prevention Program guidelines (National Heart, Lung, and Blood Institute, 1991). Severity was classified by physicians or nurse coordinators on the basis of asthma history. Only children with mild to moderate asthma were eligible for the study. Mild or moderate asthma was defined as 6 months or more in the previous year of having at least one of the following: asthma symptoms at least twice a week, use of an inhaled bronchodilator at least twice a week, and daily asthma medication. In addition, children participated in a 28-day screening period while only on bronchodilator medication as needed. To remain eligible on the basis of categorization as mild or moderate asthma, children had to report a diary symptom score of greater than or equal to one (on the 0–3 scale mentioned above) or peak-flow readings less than 80% of personal best on 8 or more days of the 28-day screening. Asthma was considered severe if children needed prednisone bursts more than five times in the previous year, had been hospitalized for asthma more than once in the previous year, required intubation for asthma, or if during the 28-day screening, had used more than eight puffs of bronchodilator medication during 3 consecutive days, had an average of more than 1.5 night awakenings as a result of asthma per week, had a mean diary card symptom score greater than 2, or needed medication other than bronchodilators to control their asthma. These children were excluded from study participation.

Anxiety. The Revised Children's Manifest Anxiety Scale (Reynolds & Richmond, 1992) was administered as a measure of trait anxiety. This scale contains 37 questions that children answer in a yes–no format. This measure has demonstrated high reliability and validity in children Grades 1 and higher (Reynolds & Richmond, 1992). To facilitate comprehension, researchers read questions out loud to children 10 years of age and younger. One child did not complete the anxiety measure.

Symptom perception. We assessed symptom perception using a self-report Likert scale. Children were asked to rate how bad their asthma was on a 5-point scale ranging from 0 (*no asthma*) to 4 (*really bad asthma*). Each number was accompanied by a descriptor to help children in understanding the scale. The term *bad* was the standard intensity descriptor used in routine CAMP methacholine challenges. In this study, symptom perception ratings were taken at baseline, after each dose of methacholine challenge, and at the end of the challenge.

Pulmonary function. We measured pulmonary function using spirometry to assess FEV_1 (CAMP Research Group, 1999b). All pulmonary function values were calculated as a percentage of predicted values on the basis of age, gender, ethnicity, and height. Higher numbers indicated better pulmonary function.

Methacholine challenge. Methacholine challenge is a methodology for assessing airway responsiveness. Methacholine is a drug that induces bronchoconstriction. Methacholine challenge involves a patient inhaling increasing doses of methacholine (starting from a baseline administration of only normal saline up to a maximal dose of 25 mg/mL methacholine) until the patient reaches the point at which the methacholine produces a 20% decrease in FEV_1 compared with baseline (known as *provocative concentration* that reduced FEV_1 by 20%, or PC_{20}). All children in this study had a positive methacholine challenge (reached PC_{20}) before randomization into the study trial. During the CAMP study, methacholine challenge testing was done once a year by a CAMP-certified pulmonary function technician in accordance with a protocol (CAMP Research Group, 1999b) at least 4 hr after the last use of any short-acting bronchodilator medication and at least 24 hr after the last use of any long-acting bronchodilator medication.

Medication. Children in this study in both severity groups were randomized to receive either budesonide (inhaled glucocorticoid) plus albuterol (bronchodilator), nedocromil (inhaled nonsteroidal anti-inflammatory) plus albuterol, or albuterol only. Children were required to not have been on any oral steroids for at least 30 days prior to study visits when methacholine challenge occurred.

Procedures

Collection of anxiety and methacholine data was included in the main consent for CAMP. Permission to collect symptom perception data during methacholine challenge was obtained from the Institutional Review Board. Patients first participated in a series of visits, including an introductory visit to describe the study, a second visit for a checkup, a third visit to establish methacholine sensitivity, and a 28-day screening of symptoms and peak flow. At the fourth visit, patients completed a psychosocial battery of questionnaires, including the Revised Children's Manifest Anxiety Scale. This completed the baseline period, and children were then randomized into their study condition. Patients were scheduled for yearly methacholine challenges as part of the regular study protocol. During one regularly scheduled methacholine challenge (average 3 years after beginning the study), patients were asked to rate their perception of asthma after each concentration of methacholine was inhaled. Ratings were made within 2 min after methacholine was inhaled. Spirometry was then conducted after the symptom perception ratings were taken. This procedure was repeated for each dose of methacholine inhalation.

Results

Descriptive Information

Although all children showed a positive methacholine challenge when they were entered into the study, not all children continued to show a methacholine response during their regularly yearly methacholine challenges. Seventeen children in our sample did not exhibit a decrease in FEV_1 of at least 20% at the highest dose of methacholine (i.e., did not reach PC_{20}) during the methacholine challenge in which symptom-perception questions were administered. Thus analyses were conducted with only those children (n = 86) who had positive methacholine challenges so that analyses could be performed both during the challenge and after a significant reduction in lung function had occurred (at PC_{20}). Children who did not show a positive methacholine challenge were not more likely to come from one severity group (20% from the mild group, $n = 10$; 20% from the moderate group, $n = 7$), and PC_{20} values across the sample did not differ for children from the mild versus those from the moderate groups ($ps > .5$).

See Table 1 for descriptive information about the study sample. We examined whether age, gender, or treatment group were associated with any study variables. Neither age nor treatment group was associated with anxiety, severity, symptom perception pre- or postmethacholine challenge, or pulmonary function pre- or postmethacholine challenge ($ps > .2$). Gender was not associated with severity, symptom perception pre- or postmethacholine challenge, or pulmonary function premethacholine challenge ($ps > .2$); however, boys had marginally higher pulmonary function postmethacholine challenge, $t(83) = 1.91$, $p = .06$, and marginally higher anxiety scores, $t(83) = 1.98$, $p = .05$. Analyses below were repeated controlling for gender, and no results changed. Across the sample, higher symptom perception was correlated with lower pulmonary function, $r(84) = -.34$, $p < .01$. Patient anxiety and asthma severity were not associated with each other ($p > .3$).

Associations With Anxiety

We tested hypotheses about the relationship of anxiety to symptom perception over the course of methacholine challenge. See Table 2 for a summary of results. Before methacholine challenge, children who had higher anxiety had higher symptom perception, both in bivariate correlations and after controlling for pulmonary function (FEV_1). This finding indicates that above and beyond

Table 1
Childhood Asthma Management Program Sample Characteristics

Characteristic	Severity Level: Mild	Severity Level: Moderate
n	52	34
Mean age	11.96 (1.94)	12.21 (2.27)
% male children	65	59
% Caucasian	86	79
Mean anxiety (T score)	43.33 (10.62)	46.88 (9.25)
Mean symptom perception premethacholine	0.46 (0.58)	0.59 (0.66)
Mean symptom perception postmethacholine	2.94 (1.06)	2.20 (1.17)
Mean FEV_1 premethacholine	99.00 (12.88)	94.41 (11.66)
Mean FEV_1 postmethacholine	71.56 (10.93)	68.19 (12.06)

Note. Numbers in parentheses are standard deviations. Symptom perception scores range from 0–4. FEV_1 refers to forced expiratory volume in the 1st s of an expiratory maneuver. It is a measure of pulmonary function and is reported as percentile based on age, gender, ethnicity, and height.

objective pulmonary function, higher anxiety levels are associated with higher symptom perception at baseline.

In contrast, after methacholine challenge, there was no association of anxiety with symptom perception in either bivariate correlations or after controlling for FEV_1. Similarly, there were no associations of anxiety with symptom slopes, $r(83) = -.02$, *ns*. These associations suggest that anxiety is associated with symptom perception only when symptoms are mild, rather than when changes in bronchoconstriction occur.

Associations With Asthma Severity Status

We then tested the hypothesis that children with more severe asthma would underperceive symptoms. We conducted associations using *t* tests and analyses of variance given that there were two severity categories (mild vs. moderate). See Table 2 for results.

Before methacholine challenge, there were no differences by severity group in symptom perception either in *t* tests or after controlling for FEV_1. After methacholine challenge, however, those with more severe asthma had lower symptom perception (see Table 2). Even after including postchallenge FEV_1 as a covariate, those with more severe asthma still had lower symptom perception. This finding indicates that above and beyond objective pulmonary function, higher asthma severity is associated with lower symptom perception after induction of symptoms via methacholine challenge.

In addition, given that symptom perception and pulmonary function were measured at each dose of methacholine challenge, we also investigated whether asthma severity was related to change in symptom perception across the course of methacholine challenge. We calculated a slope score for each child for both symptom perception and FEV_1 across the methacholine challenge. Children with moderate asthma showed flatter symptom perception slopes compared with children with mild asthma, $t(84) = 3.27$, $p < .01$. A one-way analysis of variance with FEV_1 slope as a covariate revealed the same pattern of higher severity associated with flatter symptom slope even after controlling for objective lung function changes, $F(1, 83) = 10.46$, $p < .01$. These findings indicate that above and beyond objective pulmonary function changes, greater severity of asthma is associated with exhibiting a

Table 2
Associations of Anxiety and Severity With Symptom Perception Pre- and Postmethacholine Challenge

Symptom perception	Anxiety	Severity: Value	Severity: *df*(s)
Premethacholine	.26*	0.94	84
Postmethacholine	−.01	3.02**	84
Controlling for pulmonary function			
Premethacholine	.25*	0.17	1, 83
Postmethacholine	−.01	10.46**	1, 83

Note. Anxiety analyses in the top part of the table represent bivariate correlations between anxiety and symptom perception. In the bottom part of the table, anxiety analyses represent partial correlations controlling for pulmonary function. Severity analyses in the top part of the table represent *t*-test values (as there were two severity groups) for the difference between severity groups in symptom perception. In the bottom part of the table, severity values are *F* statistics from one-way analyses of variance of severity group predicting symptom perception with pulmonary function as a covariate.
* $p < .05$. ** $p < .01$.

slower increase in perceived symptoms over the course of a methacholine challenge. In addition, when we regressed children's symptom perception scores over the course of methacholine challenge onto their FEV_1 scores during methacholine challenge, we found that children with more severe asthma had less steep slopes, $t(83) = 2.38$, $p < .05$, indicating that symptom perception scores increased at a slower rate as FEV_1 dropped in children with moderate compared with mild asthma (see Figure 1).

Discussion

This study demonstrated that anxiety was associated with symptom perception during times when children's asthma was more mild (at baseline before worsening asthma was induced by methacholine). These findings held true even after controlling for objective pulmonary function. The findings are consistent with previous findings primarily in adults with asthma that anxiety is associated with heightened perception of symptoms (Martinez-Moragon et al., 2003; Spinhoven et al., 1997; Wilson & Jones, 1991).

In contrast, when asthma was worse (after methacholine challenge), anxiety was unrelated to perceived symptoms. This suggests that psychological factors such as anxiety affect symptom perception most strongly when symptoms are somewhat ambiguous (e.g., difficult to discern because they are mild). Higher levels of anxiety may result in children with asthma being more likely to interpret mild symptoms more negatively or having a lower threshold for detecting symptoms (Rietveld, 1998), leading to an overperception of symptoms. In contrast, when pulmonary function is worse, both children who are low and high in anxiety may perceive symptoms because symptoms are more intense. Our finding is consistent with previous empirical research that has demonstrated an association between negative affect and symptom reporting at baseline but not after receiving symptom-inducing inoculations (Diefenbach et al., 1996), although some researchers have found associations of negative affect and symptom reporting after exposure to a respiratory virus (Cohen et al., 1995; Feldman et al., 1999).

Our findings also contribute to the general symptom-perception literature (Costa & McCrae, 1985; Watson & Pennebaker, 1989).

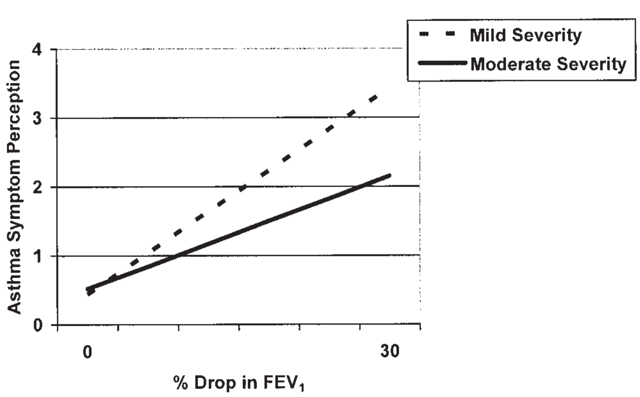

Figure 1. Symptom perception as a function of change in pulmonary function, measured in forced expiratory volume in 1 s (FEV_1), over the course of methacholine challenge for children with mild versus moderate asthma. Higher numbers indicate greater perceived symptoms.

Because many previous studies have been unable to obtain objective verification of disease, it is not entirely clear whether individuals high in negative affect perceive versus experience greater symptoms. Our study included an objective measure of pulmonary function (FEV_1); thus, we were able to demonstrate that higher trait anxiety is associated with heightened symptom perception independent of objective indicators of pulmonary function. This finding is consistent with negative affect and symptom reporting findings in acute respiratory illness, controlling for objective verification of disease (Cohen et al., 1995; Feldman et al., 1999). In addition, previous research has not always been able to discriminate whether individuals high in negative affect attend to and interpret sensations more negatively or whether they recall symptoms more negatively (given the retrospective nature of some of these study designs). Our study was able to demonstrate that associations exist on the perception side, given that children were asked about symptoms immediately after each dose of methacholine (thus no recall was involved).

The second major finding from this study was that asthma severity was associated with symptom perception when change was induced by acute manipulation of pulmonary function. Greater asthma severity was associated with blunted perception—lower perceived symptoms even after controlling for pulmonary function—when lung function was reduced at the end of methacholine challenge. Greater severity also predicted a flatter slope, or slower change in symptom perception, over the course of methacholine challenge. These findings are consistent with previous research documenting that greater asthma severity is associated with decreased symptom perception (Chetta et al., 1998; Julius et al., 2002; Yoos et al., 2003).

These findings contribute to the literature by suggesting that asthma severity specifically affects children's ability to notice acute changes in symptoms in response to stimuli. Children with more severe asthma may have become habituated to symptoms (Rietveld, 1997; Rietveld & Brosschot, 1999) and thus may be less quick to perceive changes in symptoms. If this is true, these children may not be managing their asthma ideally, given that blunted perception of symptoms may lead to slower response times during acute exacerbations of asthma. These findings have implications for asthma management, in suggesting that children who are most in need of asthma care may not be getting it as they are not as sensitive to changes in their asthma symptoms.

Only one other childhood asthma study that we know of investigated the relationship between severity and perceived breathlessness in a similar type of pre- and postchallenge test; these authors reported that after controlling for numerous medical and demographic variables, severity of asthma was not independently associated with perceived breathlessness postchallenge (Rietveld et al., 2001). However, we would argue that it is also important to document the direct role of asthma severity in symptom perception (not just its unique contribution).

Limitations of the present study include the restricted range of severity (two groups: mild and moderate). Future studies that contain large samples and include intermittent and severe asthma groups would be informative for documenting symptom perception across the range of asthma. A second limitation involves not testing other individual difference variables in the context of symptom perception. In addition, trait anxiety was assessed at one of the baseline visits, on average several years prior to the methacholine challenge visit. Thus anxiety was assessed prior to symptom perception assessment and was conceptualized as a stable trait variable; however, the long time frame between anxiety and symptom perception assessment may mean that anxiety had changed in some children over time. Finally, future studies that are able to repeatedly administer methacholine challenges to children could track how anxiety or severity status affects changes in symptom perception over time.

In sum, symptom perception in children was affected by both child anxiety and asthma severity status. Anxiety was associated with heightened perception of symptoms, particularly during times when asthma was more mild. Severity was associated with blunted symptom perception, particularly after an acute manipulation of lung function. These findings suggest that psychological factors such as anxiety play a role during times when a child's symptoms are more ambiguous (e.g., during times of mild symptomatology) and that medical variables such as severity play a role in perception of changes in asthma symptomatology. Because asthma management relies on a patient's ability to detect and respond to symptoms, interventions aimed at increasing the accuracy of children's asthma symptom perception may help maximize a child's ability to respond quickly to symptoms and minimize the duration and severity of acute exacerbations of asthma.

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