Perception of Pulmonary Function and Asthma Control: The Differential Role of Child Versus Caregiver Anxiety and Depression*

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Objective To examine child and caregiver anxiety and depression as predictors of children's perception of pulmonary function, quick-relief medication use, and pulmonary function. **Method** 97 children with asthma, ages 7 to 11 years old, reported their anxiety and depressive symptoms and completed spirometry. Caregivers completed a psychiatric interview. Children's predictions of their peak expiratory flow were compared with actual values across 6 weeks. Quick-relief medication use was assessed by Dosers. **Results** Children's anxiety symptoms were associated with over-perception of respiratory compromise and greater quick-relief medication use. Children's depressive symptoms were associated with greater quick-relief medication use, but not perception of pulmonary function. Children of caregivers with an anxiety or depressive disorder had lower pulmonary function than children of caregivers without anxiety or depression. **Conclusions** Child anxiety was associated with a subjective pattern of over-perception. Caregiver anxiety and depression were risk factors for lower lung function assessed by objective measurement.

Key words anxiety; asthma; depression; mental health.

Asthma and anxiety share strikingly similar symptoms, such as dyspnea, dizziness, chest tightness, choking, and sensations of smothering. The overlap in symptoms may lead individuals to mistake anxiety as an asthma attack, which has been shown in adults to result in excessive use of quick-relief medications for asthma and worse health-related quality of life (Feldman, Lehrer, Borson, Hallstrand, & Siddique, 2005). Anxiety and depressive disorders in children are associated with greater subjective reports of asthma symptoms, independent of disease severity (Richardson et al., 2006). The combination of negative emotions and ambiguous physical symptoms may lead children to over-perceive asthma symptoms (Rietveld & Prims, 1998).

Few studies have examined subjective estimates and objective measures of lung function in children concurrently, which is an essential component in the measurement of symptom perception due to the variable nature of asthma. For example, children may report experiencing asthma symptoms during the past couple of weeks to

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providers, but have normal pulmonary function at a clinic visit. The missing data in this situation would be whether or not the child experienced impaired pulmonary function at home during this time period. The evidence showing a relationship between children's anxiety, depression, and perception of pulmonary function has varied based on the methodology used. One laboratory-based study administered methacholine, a drug used to induce bronchoconstriction, and showed that trait anxiety in children with asthma was associated with over-perception of respiratory compromise when pulmonary function was normal or mildly compromised (Chen, Hermann, Rodgers, Oliver-Welker, & Strunk, 2006). This relationship between anxiety and over-perception was not present at more severe levels of bronchoconstriction.

Two studies conducted in the child's home have shown no relationship between children's anxiety and depressive symptoms and perception of pulmonary function with naturally occurring asthma (Fritz, McQuaid, Spirito, & Klein, 1996; Koinis-Mitchell et al., 2009). The methodology in these studies involved children predicting their peak expiratory flow (PEF) and receiving feedback by being able to see their actual PEF. Recent evidence, though, shows that children who predict PEF and then receive feedback have greater perceptual accuracy of pulmonary function and higher rates of adherence to controller medications for asthma compared with children who predict PEF but are blinded to their actual PEF values (Feldman et al., 2012). PEF prediction with feedback may have functioned as an intervention in these previous studies, thereby masking the relationship between children's anxiety and depressive symptoms and over-perception of respiratory compromise. Therefore, studies conducted in naturalistic settings without PEF feedback are needed. Furthermore, it is not clear whether children's anxiety or depressive symptoms are stronger predictors of perception of pulmonary function.

Caregiver depressive and anxiety symptoms are risk factors for higher levels of asthma morbidity in children, although most prior studies have not included measures of children's pulmonary function. Caregiver depressive symptoms are associated with more frequent asthma-related urgent care visits (Brown et al., 2006), emergency department use (Bartlett et al., 2001), and hospitalizations (Weil et al., 1999) in children. Children of caregivers with an anxiety disorder are also at greater risk for asthma-related hospitalizations versus children of caregivers without anxiety (Brown et al., 2006). The relationship between maternal depressive symptoms and children's asthma morbidity might be linked to lower maternal self-efficacy to manage attacks and lower asthma medication adherence (Bartlett et al., 2004). A limitation of the majority of prior studies is the use of caregiver self-report measures of depressive symptoms, as opposed to clinical interviews to determine psychiatric disorders. Furthermore, it is not clear whether caregiver depressive and anxiety disorders have an effect on children's actual pulmonary function and/or children's perception of pulmonary function.

The purpose of the present study was to examine which subjective versus objective components of asthma control are associated with child versus caregiver anxiety and depression. We hypothesized that children's anxiety and depressive symptoms would be associated with greater subjective impairment (i.e., over-perception of respiratory compromise, greater quick-relief medication use), whereas caregivers' anxiety and depressive disorders would be associated with greater objective impairment (i.e., worse pulmonary function).

Method

Participants

A convenience sample of children with asthma between the ages of 7 and 11 years old and their primary caregivers were recruited in the Bronx, NY, from outpatient clinics, letters from providers, and flyers. This age range was selected given that asthma management responsibilities are typically shared between children and caregivers in younger children, and the study's hypotheses on both child and caregiver anxiety and depression. Previous studies have shown that children aged $\geq$7 years are able to complete the protocol for perception of pulmonary function (Fritz et al., 2010; Koinis-Mitchell et al., 2009).

A total of 182 children within this age range were approached for the study, and 35 families were not interested in participation. Inclusion criteria for the study included physician diagnosis of asthma documented in medical records and report of breathing problems within the past 12 months. Twenty-six children were excluded for a cognitive learning disability, inability to perform spirometry, no reported asthma symptoms during the past year, or no asthma diagnosis documented in the chart. A total of 121 eligible child–caregiver dyads completed the baseline session. All children preferred to interview in English, and 12 adults preferred Spanish. Eleven children (9.0%) dropped out of the study before the second session, and 13 children (10.7%) had insufficient data (i.e., <20 data points) for perception of pulmonary function (McQuaid et al., 2007).

The final sample consisted of 97 child/caregiver dyads. Children who completed the study did not differ from the group who dropped on the child's age, ethnicity, sex, Forced expiratory volume in one second, percent predicted (FEV_1, % predicted) %FEV_1, inhaled corticosteroid treatment, or presence/absence of caregiver anxiety or depressive disorder. However, children who dropped from the study had higher levels of anxiety ($M = 64.00$, $SD = 8.84$) and depressive symptoms ($M = 56.09$, $SD = 11.26$) versus children who completed the study [$M = 55.79$, $SD = 10.47$, $t(119) = 3.48$, $p = .001$ for anxiety; $M = 51.11$, $SD = 9.68$, $t(119) = 2.15$, $p = .034$ for depression]. Participants were recruited from asthma clinics (52.0%), mailings from physicians (20.4%), general pediatric clinics (19.4%), and other sources (8.2%).

Procedure

Data presented in this study were part of a larger study examining children's perception of pulmonary function with PEF feedback versus without PEF feedback following PEF prediction (Feldman et al., 2012). The psychiatric data have not been previously reported. The subsample used for these analyses was the group who did not receive PEF feedback. The institutional review board at Albert Einstein College of Medicine approved the study protocol. All caregivers provided written informed consent and children provided informed assent.

The baseline session consisted of administering the child and parent measures, training with the AM2 electronic spirometer and diary (eResearch Technology, Philadelphia, PA), and attaching Doser devices to quick-relief medications. The AM2 device was used to measure perception of pulmonary function. Children entered their prediction of PEF directly into the AM2 device, and then conducted a forced vital capacity maneuver. Children were blinded to PEF during the 6 weeks and only saw their PEF during the baseline session. A colorful child-friendly sticker was attached to the AM2 depicting the child's predicted PEF values across the three traffic light zones, as per National Heart, Lung, and Blood Institute guidelines (NHLBI, 2007). All children and caregivers were trained extensively on the use of the AM2 and maximal effort blows during the baseline session. Children conducted three consecutive maneuvers and the best of the three blows was retained. This methodology requires a minimum of 20 data points per child to have sufficient data to calculate perception of pulmonary function (McQuaid et al., 2007).

Data were collected at home over the next 6 weeks on children's perception of pulmonary function and use of quick-relief medication for asthma. Children used the AM2 at home before taking asthma medication in the morning and evening. Caregivers were encouraged to help children in their use of the AM2, but it was made clear that predictions of PEF should be the child's guesses. These data were downloaded at the second session at the end of the 6-week monitoring period, and the Childhood Asthma Control Test (C-ACT) was administered.

Measures

Perception of Pulmonary Function

The child's subjective prediction of PEF was compared with actual PEF to calculate perception of pulmonary function using the Asthma Risk Grid (Klein et al., 2004).

Each PEF prediction and blow was categorized in the Accurate, Danger (under-perception), or Magnification (over-perception) zone. Children's predictions of PEF must be at least 10% higher or 10% lower than the actual PEF value to be considered outside the Accurate zone. For example, a child's PEF prediction that corresponds to 60% personal best with an actual PEF value of 90% personal best would be categorized in the Magnification zone. Percentages are treated as continuous variables in each zone for each child, and thus, children are not categorized as 'under-perceivers' or 'over-perceivers.' Data reduction steps eliminated extremely high forced vital capacity values (>3 SD above mean for each child) or low PEF values ($\leq$25% personal best PEF). Validity for this methodology has been provided across several studies, showing greater perceptual accuracy of pulmonary function is associated with less asthma morbidity during the past year (Fritz et al., 2007, 2010) and prospectively across a 1-year follow-up (Feldman et al., 2007).

Children's Anxiety Symptoms

The Multidimensional Anxiety Scale for Children (MASC; [March, Parker, Sullivan, Stallings, & Conners, 1997]) is a 39-item self-report measure designed to assess anxiety symptoms in youth. The MASC assesses four dimensions—harm avoidance, social anxiety, physical symptoms, and separation/panic—and participants respond to items using a 4-point Likert scale ranging from 0 *never true about me* to 3 *often true about me*. Scores were calculated for each of the four dimensions, the combined Total Anxiety scale score, and a 10-item Anxiety Disorder Index (ADI). Raw scores were converted to T-scores based on norms for age and gender. Internal consistency and test–retest reliability has been found to be satisfactory to excellent, with α-coefficients ranging from .74 to .85 for the four subscales and .87 to .93 for the total anxiety score, and mean intra-class correlation coefficients all exceeding .71 (March et al., 1997; March, Sullivan, & Parker, 1999). The MASC also has strong convergent and divergent validity (March et al., 1997). Both the Total Anxiety and ADI scores have been shown to discriminate between anxious and non-anxious children, including children with depression (Grills-Taquechel, Ollendick, & Fisak, 2008; March et al., 1997; Rynn et al., 2006). For this study, the total anxiety T-score was the primary measure of anxiety.

Children's Depressive Symptoms

Self-reported depressive symptoms were assessed using the Children's Depression Inventory (CDI; [Kovacs, 1992]). The CDI is a 27-item self-report measure designed to assess levels of cognitive, affective, and behavioral aspects of depression in children and adolescents during the past two weeks. Each item was rated on a scale from 0 to 2 and added together to determine the total raw score for each child. Total raw scores were then converted to T-scores based on a normative sample of 1266 youth and calculated on the basis of age and gender. In non-clinical populations, the CDI has good internal consistency ($\alpha = .86$), test–rest reliability, and validity (Kovacs, 1992; Timbremont, Braet, & Dreessen, 2004).

Caregiver Depressive and Anxiety Disorders

The Structured Clinical Interview for DSM-IV-TR Axis I Disorders (SCID; research version, English and Spanish, patient edition [First, Spitzer, Gibbon, & WIlliams, 2002]) is widely considered the gold-standard psychiatric interview. The inter-rater reliability across disorders is moderate to excellent (Lobbestael, Leurgans, & Arntz, 2011; Zanarini et al., 2000). Clinical psychology graduate students administered the SCID to primary caregivers. A licensed clinical psychologist listened to all SCID interviews and verified diagnoses during supervision, which was conducted for each interview. If additional questions were deemed necessary to establish diagnoses from the baseline session, then the graduate student asked follow-up questions at the second session. Caregivers with a current depressive disorder had diagnoses of major depressive disorder or dysthymia. Caregivers with a current anxiety disorder were diagnosed with generalized anxiety disorder, panic disorder (with or without agoraphobia), post-traumatic stress disorder, social phobia, or obsessive-compulsive disorder.

Asthma Control

The C-ACT (Liu et al., 2007) consists of questions for children (ages 7 to 11 years; 4 items) and parents (3 items). Final scores are a combination of both caregiver and child responses. The C-ACT assesses interference with activities, asthma symptoms, and nighttime awakenings during the past month. This instrument ($\alpha = .79$) exhibits good reliability and validity, and classifies children as poorly controlled or well controlled (Liu et al., 2007). The C-ACT was administered at the second session to correspond to the time period during the study (i.e., perception of pulmonary function task, use of quick-relief medication).

Asthma Severity

Ratings for asthma severity were based on coding using National Heart, Lung, and Blood Institute guidelines (NHLBI, 2007). Severity was estimated by incorporating three domains assessed at baseline: (1) asthma symptoms/impairment, (2) current asthma medications, (3) pulmonary function (FEV_1, % predicted). FEV_1 is the volume of air expired during the first second of a forced vital capacity maneuver. Overall severity was based on the most severe level reached across these three categories. Spirometry was conducted during the baseline session using a clinical spirometer (nSpire Health, Longmont, CO) according to American Thoracic Society standards (ATS, 1995). Asthma symptoms/impairment were assessed by seven questions based strictly on NHLBI guidelines, and an asthma medication checklist was administered at baseline.

Quick-Relief Medication Use

Doser devices (MediTrack Products, Hudson, MA) were attached to the top of children's quick-relief metered dose inhalers (MDI) for asthma. Dosers are more accurate for monitoring medication use than self-report or pharmacy records, which tend to over-estimate the rate of medication use (Jentzsch, Camargos, Colosimo, & Bousquet, 2009). Doser devices recorded the number of actuations taken per day across the past 30 days. Data reduction steps eliminated puffs that appeared to reflect outlier values (>12 puffs/day). Doser data were available for 81 children, as 7 children did not have quick-relief MDI to attach a Doser and 9 children lost their Dosers.

Data Analyses

Hierarchical regression models were conducted to assess the child psychological variables as predictors of perception of pulmonary function and quick-relief medication use. Separate analyses were conducted for each accuracy category. Children's asthma severity was entered as a covariate at step 1. Children's anxiety and depressive symptoms were entered at step 2 in separate regression models from each other. Asthma severity plays an important role in the relationship between children's anxiety and asthma symptom perception (Chen et al., 2006). Additionally, Pearson product correlations are reported to evaluate the relationship between the subscales of the MASC, children's perception of pulmonary function, and quick-relief medication use. Pearson product correlations were also used to examine the relationship between children's anxiety and depressive symptoms and objective measures of lung function. Analyses of variance or t-tests were conducted, as appropriate, to examine whether differences existed within key demographic variables (e.g., boys versus girls) on the zones of perception of pulmonary function. Logistic regression was used for the dichotomous variable of asthma control (poorly controlled vs. well-controlled). Analyses of covariance were conducted to examine differences between caregivers with depressive/anxiety disorders versus caregivers without depressive/anxiety disorders on children's perception of pulmonary function and quick-relief medication use, controlling for asthma severity. Analyses were conducted with SPSS Statistics V20.

Results

Descriptive characteristics of the children and caregivers are presented in Table I. Approximately half of the sample was Puerto Rican. The majority of caregivers were biological mothers who preferred to conduct the interview in English. Eighty-six percent of the children were classified as having moderate or severe persistent asthma, and slightly more than half reported poorly controlled asthma. The child's age was not associated with the percentage of PEF predictions in the accurate zone, $r(95) = .15$, $p = .14$; danger zone, $r(95) = -.08$, $p = .41$; or magnification zone, $r(95) = -.08$, $p = .44$. The child's sex, maternal educational level, poverty threshold, ethnicity, and inhaled corticosteroid treatment were not related to any of the zones of perception of pulmonary function. The breakdown of psychiatric diagnoses in the caregivers for current depressive (28.1%) and anxiety disorders (37.5%) is provided in Table I. Major depressive disorder (16.7%) and generalized anxiety disorder (21.1%) were the most common depressive and anxiety disorders, respectively. Children reported similar levels of severity for anxiety (T-score [$M = 55.81$, $SD = 10.55$, Range = 30.0–76.0]) and depressive symptoms (T-score [$M = 51.16$, $SD = 9.74$, Range = 35.0–84.0]) on the total MASC and CDI, respectively. The correlation between the MASC and CDI was not significant, $r(95) = .17$, $p = .09$.

Table I. *Participants' Characteristics (N = 97)*

Variable	Mean (SEM)
Child age (years)	9.45 (0.14)
Caregiver age (years)	39.48 (0.77)
Child anxiety (T-score, MASC)	55.81 (1.07)
Child depression (T-score, CDI)	51.16 (0.98)
% FEV_1	78.98 (1.59)
	N (%)
Child sex (% male)	55 (56.7)
Ethnicity	
Puerto Rican	48 (49.5)
African American	22 (22.7)
Afro-Caribbean	16 (16.5)
Mexican	11 (11.3)
Biological mother primary caregiver (% yes)	87 (89.7)
% Below federal poverty threshold	39 (43.3)
Maternal education	
Less than high school	37 (38.1)
High school graduate	20 (20.6)
At least some college	40 (41.2)
Married, caregiver (% yes)	25 (26.3)
% Foreign born, caregiver	41 (43.2)
Inhaled corticosteroids, child (% yes)	57 (58.8)
Asthma severity, child	
Intermittent/mild	13 (13.7)
Moderate persistent	58 (61.1)
Severe persistent	24 (25.3)
% Well-controlled asthma, child	47 (48.5)
Any current depressive disorder, caregiver (% yes)	27 (28.1)
Major depressive disorder, caregiver (% yes)	16 (16.7)
Dysthymia, caregiver (% yes)	11 (11.5)
Any current anxiety disorder, caregiver (% yes)	36 (37.5)
>1 anxiety disorder, caregiver (% yes)	16 (16.7)
Generalized anxiety disorder, caregiver (% yes)	20 (21.1)
Panic disorder (with or without agoraphobia), caregiver (% yes)	11 (11.2)
Post-traumatic stress disorder, caregiver (% yes)	9 (9.5)
Social phobia, caregiver (% yes)	9 (9.3)
Obsessive-compulsive disorder, caregiver (% yes)	8 (8.2)

Children's Anxiety Symptoms, Perception of Pulmonary Function, and Quick-Relief Medication Use

Children's anxiety symptoms were associated with greater over-perception of respiratory compromise and greater use of quick-relief medications. Table II shows that children's anxiety symptoms (Step 2) explained a significant proportion of the variance (6%) in the percentage of PEF predictions in the Magnification zone, independent of asthma severity (Step 1). The full model explained 9% of the variance, $F(1, 91) = 6.22$, $p = .01$. Children's anxiety symptoms (Step 2) did not explain a significant proportion of the variance (2%) in the percentage of PEF predictions in the Danger zone, after controlling for asthma severity (Step 1). The full model explained 6% of the variance, $F(1, 91) = 1.70$, $p = .20$. No significant association was found between children's anxiety symptoms and the percentage of PEF predictions in the Accurate zone. Children's anxiety symptoms explained 9% of the variance in quick-relief medication use, independent of asthma severity. The

Table II. *Child Anxiety Symptoms as Predictors of Perception of Pulmonary Function and Quick-Relief Medication Use*

Predictor	R^2 change	β	*t*	*p*
% Magnification zone				
Step 1				
Asthma severity	.03	0.18	1.70	0.09
Step 2				
Anxiety symptoms	.06*	0.25	2.50	0.01
% Danger zone				
Step 1				
Asthma severity	.05*	−0.21	−2.07	0.04
Step 2				
Anxiety symptoms	.02	−0.13	−1.30	0.20
% Accurate zone				
Step 1				
Asthma severity	.01	0.10	0.92	0.36
Step 2				
Anxiety symptoms	.00	−0.05	−0.46	0.65
Quick-relief medication use				
Step 1				
Asthma severity	.00	−0.06	−0.49	0.63
Step 2				
Anxiety symptoms	.09*	0.29	2.64	0.01

*$p < .05$.

full model explained 9% of the variance, $F(1, 75) = 6.95$, $p = .01$.

The physical symptoms subscale of the MASC had the strongest correlations of all subscales with the Magnification zone, $r(95) = .26$, $p = .009$, and quick-relief medication use, $r(95) = .33$, $p = .003$. The social anxiety subscale was also associated with the Magnification zone, $r(95) = .21$, $p = .04$. The harm avoidance and separation/panic subscales were not associated with perception of pulmonary function or quick-relief medication use. Finally, the Anxiety Disorder Index score was associated with the Magnification zone, $r(95) = .23$, $p = .03$. These findings did not change when including asthma severity a covariate (Step 1) in hierarchical regression models.

Children's Depressive Symptoms, Perception of Pulmonary Function, and Quick-Relief Medication Use

Children's depressive symptoms (Step 2) were not associated with any of the zones of perception of pulmonary function: Accurate zone [R^2 change = .00, $F(1,92) = 0.02$, $p = .89$], Magnification zone [R^2 change = .03, $F(1, 92) = 2.89$, $p = .09$], or Danger zone [R^2 change = .01, $F(1, 92) = 1.12$, $p = .29$] after controlling for asthma severity (Step 1). However, children's depressive symptoms (Step 2) were associated with greater use of quick-relief medication [R^2 change = .05, $F(1, 76) = 4.04$, $p = .048$] after controlling for asthma severity.

Children's Anxiety and Depressive Symptom, Pulmonary Function, and Asthma Control

Children's anxiety and depressive symptoms were not associated with objective measures of lung function. Correlation coefficients between anxiety and depressive symptoms, and baseline $\%FEV_1$ and PEF (mean across the 6 weeks) ranged between $r = -0.06$ and $r = 0.03$. Furthermore, children's anxiety, OR = 1.00, 95% CI [0.97, 1.05], $p = .72$, and depressive symptoms, OR = 1.00, 95% CI [0.95–1.04], $p = .86$, did not predict reported asthma control during the study.

Caregiver Depressive and Anxiety Disorders

Caregivers with a depressive disorder had children with greater levels of depressive symptoms ($M = 54.59$, $SD = 11.81$) versus caregivers without a depressive disorder ($M = 49.70$, $SD = 8.62$), $t(94) = 2.25$, $p = .03$. No significant difference was found on anxiety symptoms between children of caregivers with a depressive disorder ($M = 59.07$, $SD = 10.23$) versus children of caregivers without a depressive disorder ($M = 54.75$, $SD = 10.36$), $t(94) = 1.84$, $p = .07$. No differences were observed in children's anxiety or depressive symptoms between children of caregivers with an anxiety disorder versus without an anxiety disorder. Two thirds of caregivers with a depressive disorder also had an anxiety disorder. No between-group differences were found between caregivers with depressive/anxiety disorders versus without depressive or anxiety disorders on children's asthma severity and prescribed inhaled corticosteroid treatment.

Table III shows that children of caregivers with a depressive disorder had lower $\%FEV_1$ during baseline spirometry than children of caregivers without a depressive disorder, $t(91) = 3.33$, $p = .001$. Children of caregivers with an anxiety disorder also had lower $\%FEV_1$ at baseline than children of caregivers without an anxiety disorder, $t(91) = 2.25$, $p = .03$. Furthermore, children of caregivers with a depressive disorder were more likely to have poorly controlled asthma (52.0%) reported during the time period of the study, OR = 3.83, 95% CI [1.45, 10.10], $p = .007$, than children of caregivers without a depressive disorder (22.1%). However, children of caregivers with an anxiety disorder were not significantly more likely to have poorly controlled asthma (37.1%), OR = 1.69, 95% CI [0.69, 4.18], $p = .25$, in comparison with children of caregivers without an anxiety disorder (25.9%). No between-group differences were found between caregivers with depressive/anxiety disorders versus caregivers without

Table III. *Group Differences Between Caregivers With and Without a Depressive or Anxiety Disorder*

	Current depressive disorder		Current anxiety disorder	
Variable	Yes	No	Yes	No
%FEV_1	70.69 (2.88)**	81.99 (1.79)	74.39 (2.34)*	81.61 (2.08)
Magnification zone[a], %	10.46 (3.67)	10.16 (2.27)	9.41 (3.04)	9.99 (2.41)
Danger zone[a], %	41.95 (5.20)	41.95 (3.22)	42.30 (4.35)	41.29 (3.45)
Accurate zone[a], %	47.59 (4.87)	47.89 (3.01)	48.29 (4.10)	48.72 (3.26)
Quick-relief medication use[a]	25.06 (6.57)	20.79 (3.84)	22.11 (5.43)	22.88 (4.46)

Note. Mean (SEM).
[a]Controlling for asthma severity.
*$p < .05$. **$p < .01$.

depressive/anxiety disorders on any of the children's perception of pulmonary function zones or quick-relief medication use, after controlling for asthma severity.

Discussion

Higher levels of children's anxiety symptoms predicted over-perception of respiratory compromise and greater quick-relief medication use, after controlling for the child's asthma severity. Children's depressive symptoms were not associated with perception of pulmonary function, but were associated with greater quick-relief medication use. Children of caregivers with a depressive disorder had lower pulmonary function and worse asthma control than children of caregivers without a depressive disorder. Caregivers with an anxiety disorder also had children with lower pulmonary function than caregivers without an anxiety disorder. These results demonstrate a differential effect for child versus caregiver anxiety and depression on children's asthma management. Children with anxiety may feel subjectively more impaired by their asthma symptoms and request more quick-relief medication, which is consistent with the adult literature (Feldman, Siddique, Thompson, & Lehrer, 2009). The clinical implications of over-perception of respiratory compromise for children can include lower health-related quality of life and unnecessary use of quick-relief asthma medications and anxiogenic side effects.

Caregiver anxiety and depressive disorders may pose an even greater risk for poor asthma outcomes given links with objective markers of pulmonary function.

The relationship between children's anxiety, over-perception of respiratory compromise, and quick-relief medication use was primarily attributed to the physical symptoms subscale on the MASC. The items on this subscale include numerous physical symptoms of anxiety that can be confused with asthma symptoms (e.g., 'I have trouble getting my breath'). These physical symptoms (e.g., 'I get shaky or jittery') can also occur as side effects of quick-relief medication for asthma, which are short-acting β_2-agonists (Scalabrin, Sole, & Naspitz, 1996). Children may be in a maladaptive cycle of treating emotional distress with quick-relief medication, which then exacerbates anxiety due to sympathetic activation and more physical symptoms.

The cognitive–affective model of symptom perception posits that negative affect may be linked with over-perception via Pavlovian conditioning (Janssens, Verleden, De Peuter, Van Diest, & Van den Bergh, 2009). Empirical evidence to support this theory is derived from studies showing that asthma symptoms can be 'learned' via repetitive pairings of previously neutral stimuli (conditioned stimulus) with CO_2-enriched air (unconditioned stimulus) (De Peuter et al., 2005). Individuals high in negative affect are particularly vulnerable to these conditioning effects and will report more somatic symptoms in response to conditioned stimuli (Devriese et al., 2000). Thus, asthma symptoms (unconditioned stimulus) may trigger negative affect as an immediate unconditioned response, particularly in children with anxiety symptoms. After repeated pairings of negative affect and asthma, subsequent anxious feelings, thoughts, and somatic sensations may result in the report of severe symptoms in the presence of mild or no airway obstruction. Findings from the present study suggest that children's anxiety is the more salient component of negative affect than depression in the relationship with asthma symptom perception. Children's depressive symptoms might be less susceptible to conditioning effects in comparison with anxiety symptoms owing to less overlap and confusion with asthma symptoms.

The conflicting findings between the current study and previous studies might be partially explained by the current study's focus on children < 12 years old, who might be especially frightened and confused about asthma. Previous work with older samples (7 to 17 years old [Koinis-Mitchell et al., 2009]; 8 to 15 years old [Fritz et al., 1996]) did not show a relationship between children's anxiety and perception of pulmonary function. The current study's young inner-city sample (7 to 11 years old) had elevated rates of trait anxiety compared with these previous studies. Children in this age range have less understanding of asthma, and they are more dependent on their caregivers for asthma management (Pradel, Hartzema, & Bush, 2001). The final decision to administer quick-relief medication in younger children is often determined by caregivers (Pradel et al., 2001). Our findings suggest that anxious children are likely communicating their perceived need for quick-relief medication to caregivers. The more realistic setting of children not seeing daily PEF values in the current study might also explain the conflicting findings versus children who were able to see PEF (Fritz et al., 1996; Koinis-Mitchell et al., 2009) Therefore, the relationship between anxiety and over-perception of asthma symptoms might be most pronounced in younger children in naturalistic settings.

This study shows the importance of targeting caregiver depressive and anxiety disorders in the management of pediatric asthma. Caregivers in our sample had substantially elevated rates of current depressive (28%) and anxiety disorders (38%) compared with the general population (8% and 18%, respectively [Kessler, Chiu, Demler, Merikangas, & Walters, 2005]). The rate of depressive disorders in this sample was slightly higher compared with other studies using diagnostic interviews with caregivers of children with asthma (19–27%) (Brown et al., 2006; Feldman et al., 2011). Rates of anxiety disorders in the present study were substantially greater than those found by others (12–21%) (Brown et al., 2006; Feldman et al., 2011). This finding might be attributable to the high percentage of Puerto Rican caregivers in the current study, given prior data showing elevated rates of anxiety disorders in Puerto Rican adults living in the mainland United States (Alegria et al., 2007). Lower levels of medication adherence and self-efficacy to manage children's asthma might mediate the relationship between caregiver psychiatric disorder and asthma morbidity (Bartlett et al., 2004). The measure of asthma control (C-ACT) in this study incorporated both child and caregiver report, thereby minimizing the possibility that worse asthma control was simply due to biased reports in caregivers with psychiatric disorders. Furthermore, lower asthma control in these children was corroborated by baseline spirometry results showing lower %FEV_1.

Limitations of this study include the use of a clinic-based sample, as opposed to a larger population-based sample. Higher levels of anxiety and depressive symptoms might have interfered with some children's ability to complete the study, as evidenced by differences between children who completed versus dropped from the study. However, it is possible that the study's effects for children's anxiety would have been even larger if these children were able to be included in the final sample. A limitation of this study was the use of self-report measures of children's anxiety and depressive symptoms, and future studies should use clinical interviews to assess whether these findings extend to psychiatric disorders. Future research should also collect data on adherence to controller medications. Prospective longitudinal studies are needed to collect measures of asthma morbidity over a longer period of time than the current study.

In conclusion, children's anxiety and depression are related to asthma management via a different mechanism than caregiver anxiety and depression. Children's anxiety symptoms were associated with a subjective pattern of over-perception of asthma symptoms, whereas caregiver psychiatric disorders were associated with lower lung function as assessed by FEV_1. Interventions focused on improving children's perception of pulmonary function and treating caregiver psychiatric disorders might be effective mechanisms for reducing pediatric asthma morbidity.

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