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ORIGINAL ARTICLE

Discomfort Intolerance in Relation to Asthma Outcomes

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Abstract
Anxiety symptoms and disorders are common among those with asthma and contribute to poorer health outcomes. Building on work examining anxiety-related cognitive-affective risk factors in asthma, the current study sought to explore associations between discomfort intolerance (i.e., the inability to withstand or tolerate unpleasant bodily sensations) in relation to lung function, asthma control, and quality of life. Participants were 61 adults with asthma (61.9% female; 54.8% African American; M_{age} = 34.72, *SD* 13.58) who were administered a self-report assessment battery and a lung function assessment. We found that, above and beyond the effects of anxiety sensitivity-physical concerns, greater discomfort intolerance was significantly associated with poorer lung function (9.5% variance), asthma control (9.9% variance), and overall asthma-related quality of life (11.7% variance) as well as the specific quality of life domains of activity limitations (12.6% variance) and asthma symptoms (6.8% variance). Thus, individuals with asthma who are unable to tolerate physical discomfort may be at risk for poor asthma outcomes and interventions to reduce discomfort intolerance could potentially be useful in this population.

Keywords Asthma · Asthma control · Discomfort intolerance · Lung function · Quality of life

Asthma is an obstructive lung condition that involves inflammation of the airways combined with episodes of exacerbation in response to certain triggers. These airway exacerbations, or asthma attacks, consist of increased swelling of the airways, constriction of the muscles surrounding the airways, and increased mucus production that result in a number of aversive and anxiety-provoking physical sensations, including wheezing, dyspnea, tightness in the chest, and coughing (American Lung Association [ALA] 2018). Asthma affects approximately 20 million, or 1 out of every 12, adults in the United States (U.S.; Centers for Disease Control and Prevention [CDC] 2017). This number is expected to grow substantially in the coming years as rates of asthma in the U.S. have increased by 15% in the last decade (CDC 2016). Individuals with asthma can experience high levels of morbidity and even death, particularly if the individual is unable to obtain good asthma control (CDC 2017). For example, individuals with asthma are at increased risk for cardiovascular disease-related death (Iribarren et al. 2012) and complications from respiratory illnesses (e.g., influenza, bronchitis, pneumonia; ALA 2018). Unfortunately, although there are a number of effective treatment options for asthma, approximately 85% of asthma patients report symptoms of poorly controlled asthma (Marcus et al. 2008).

Anxiety symptoms and disorders are more commonly found among individuals with asthma (Goodwin et al. 2010; Opolski and Wilson 2005; Zielinski et al. 2000). On average, 34% of individuals with asthma have an anxiety disorder, and this number is primarily driven by increased rates of panic disorder (12%), agoraphobia (12%), and generalized anxiety disorder (9%; Weiser 2007). Although there is little information about rates of asthma among individuals with anxiety disorders, the relationship does appear to be bidirectional. For example, in a 20-year longitudinal study, Hasler et al. (2005) found that asthma was a predictor of future panic disorder (OR 4.5), and panic disorder predicted later asthma activity (OR 6.3). In addition to being more common, anxiety has been identified as one important contributor to poor asthma outcomes. Indeed, co-occurring anxiety symptoms and disorders are associated with greater

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bronchodilator use, shortness of breath, wheezing, emergency department or doctor's office visits, and frequency of asthma attacks (Lavoie et al. 2005; Goldney et al. 2003; Strine et al. 2008) as well as poorer quality of life and increased functional limitations (Eisner et al. 2005; Feldman et al. 2005; Fernandes et al. 2010; Kullowatz et al. 2007; Lavoie et al. 2005; McCauley et al. 2007). Further, regardless of actual lung function, asthma patients with anxiety tend to use short-acting beta agonist (SABA) medication too frequently, receive more intensive corticosteroid treatments, and are hospitalized more often and for longer durations (Cordina et al. 2009; Dahlem et al. 1977; Dirks et al. 1977, 1978; Fernandes et al. 2010; Mawhinney et al. 1993).

Researchers have begun to explore how anxiety-related cognitive-affective risk factors may serve as potential mechanisms for understanding the co-occurrence of anxiety and asthma. This work has primarily examined relations between asthma and anxiety sensitivity (i.e., fear of arousal-related sensations; McNally 2002) and indicates that greater anxiety sensitivity is associated with decreased asthma control and asthma-related quality of life as well as greater reactivity and decreased lung function as a function of asthma-like sensations (Avallone et al. 2012; McLeish et al. 2011, 2016). These associations appear to be relatively specific to the physical concerns domain of anxiety sensitivity as previous research has not found significant associations between the cognitive or social concerns domains and asthma outcomes (McLeish et al. 2011, 2016). Given the significant role that anxiety sensitivity plays in asthma, it is likely that other anxiety-related cognitive-affective vulnerabilities also play a role in asthma management.

One potentially useful vulnerability factor to examine is discomfort intolerance, defined as the inability to tolerate or withstand aversive or unpleasant physical sensations (Schmidt et al. 2006). Although related to the constructs of distress tolerance and the physical concerns domain of anxiety sensitivity, discomfort intolerance is conceptually distinct in that it reflects the ability to withstand physical distress rather than the ability to withstand emotional distress or one's emotional responses to physical distress. Discomfort intolerance is elevated among those with anxiety disorders, particularly panic disorder, and may serve as a premorbid vulnerability factor for the development of anxiety psychopathology more generally (Schmidt et al. 2006, 2007). Research has also demonstrated that discomfort intolerance uniquely predicts greater reactivity to a biological challenge, and interacts with anxiety sensitivity to predict greater anxiety symptoms (Schmidt et al. 2007). Furthermore, discomfort intolerance is associated with greater health anxiety (Fergus et al. 2015) as well as adverse outcomes in chronic medical conditions other than asthma, such as irritable bowel syndrome and Hepatitis C (Keough et al. 2011; Tsui et al. 2011).

Theoretically, individuals with asthma who are high in discomfort intolerance may not be able to withstand the aversive physical sensations associated with the disease, particularly when experiencing exacerbations. They may be more likely to take steps to immediately reduce these symptoms (e.g., by using SABA medication) without determining whether such an action is truly necessary. Such a scenario could result in overuse of asthma medications or even the perception that the person's asthma is worse than it objectively is, given the frequency of SABA use. Moreover, SABAs can also produce anxiety-like symptoms (ALA 2009), which could lead to a vicious cycle of increasing anxiety and medication use. In addition, such individuals might also experience greater functional impairment and poorer quality of life by trying to avoid eliciting any asthma-like sensations. As the first test of this theory, the goal of the present study was to explore the role of discomfort intolerance in relation to several important asthma outcome measures (i.e., lung function, asthma control, and overall asthma-related quality of life) among individuals with asthma. After controlling for the physical concerns domain of anxiety sensitivity, we expected that greater discomfort intolerance, would be associated with poorer lung function, asthma control, and asthma-related quality of life. A secondary aim of the study, should there be significant associations between discomfort intolerance and overall asthma-related quality of life, would be to explore associations between discomfort intolerance and the specific facets of asthma-related quality of life (i.e., activity limitations, symptoms, emotional functioning, environmental stimuli).

Method

Participants

Participants were 61 adults with asthma (61.9% female; 54.8% African American; $M_{age} = 34.72$, *SD* 13.58). Participants were eligible for the current study if they: (1) were between 18 and 65 years of age; (2) met biochemical cutoff values for being a nonsmoker, indexed by an expired carbon monoxide level of < 5 ppm (Perkins et al. 2013); (3) self-reported a physician diagnosis of asthma; and (4) scored ≥ 4 on the Asthma Screening Questionnaire, which is indicative of an asthma diagnosis (Shin et al. 2010). 54.8% of the sample self-identified as African American, 41.9% as Caucasian, and 3.2% as other. Only one participant reported Hispanic ethnicity. Participants were approximately 16.5 (*SD* 14.13) years old at asthma diagnosis. Nearly 80% of participants reported experiencing at least one asthma attack in the past 6 months, and 47.6% reported an emergency room or urgent care visit for asthma symptoms in the past 6 months. According to the Asthma Control Test (ACT; Nathan et al.

2004), most participants reported poorly controlled asthma ($M = 15.98$, SD 4.54).

Measures

Expired Carbon Monoxide

We biochemically verified that participants were non-smokers by carbon monoxide (CO) analysis using a Bedfont Micro 4 Smokerlyzer CO Monitor (Model EC50; coVita, Haddonfield, NJ). Based on previous research (Perkins et al. 2013), participants with a CO value less than 5 ppm were identified as non-smokers.

Asthma Screening Questionnaire (ASQ)

The ASQ (Shin et al. 2010) is a six-item questionnaire that screens for the presence of asthma symptoms (cough, chest tightness, wheeze, and dyspnea) in four situations that commonly elicit asthma symptoms (laughing, exercise, lie down to sleep, talking). Research indicates that a score of ≥ 4 on the ASQ reliably discriminates between those with and without asthma (96% sensitivity, 100% specificity; Shin et al. 2010).

Anxiety Sensitivity Index-3 (ASI-3)

The ASI-3 (Taylor et al. 2007) evaluates the extent to which individuals fear their own anxiety symptoms. The ASI-3 is comprised of one global anxiety sensitivity factor and three lower-order facets of physical, cognitive, and social concerns (Taylor et al. 2007). The ASI-3 has demonstrated good psychometric properties (Taylor et al. 2007). For the present study, only the physical concerns subscale (AS-PC) was used. Internal consistency for AS-PC was good ($\alpha = 0.84$).

Asthma Control Test (ACT)

The ACT (Nathan et al. 2004) is a 5-item self-report measures that evaluates one's perceived control of asthma symptoms. The ACT assesses how often asthma symptoms have occurred and how much the individual's life has been negatively impacted by these symptoms over the past month, with higher scores indicating better asthma control. The ACT has demonstrated good reliability and can differentiate between patients with differing levels of asthma control (Nathan et al. 2004). Cronbach's alpha for the ACT in the study sample was good ($\alpha = 0.86$).

Asthma Quality of Life Questionnaire (AQLQ)

The AQLQ (Juniper et al. 1992) is a 32-item self-report measure assessing asthma-related quality of life. Participants rate, on a 7-point Likert-type scale (1 = *totally limited* to 7 = *not limited at all)*, the degree to which common activities have been limited over the past 2 weeks due to asthma symptoms. The AQLQ assesses four dimensions of impairment associated with asthma: (1) activity limitations (e.g., exercising); (2) asthma symptoms (e.g., chest tightness); (3) emotional functioning (e.g., frustration due to asthma condition); and (4) environmental stimuli (e.g., feeling bothered by or avoiding going outside because of weather conditions). The AQLQ has exhibited good reliability and validity (Juniper et al. 1993). Cronbach's alpha for the AQLQ in the current sample was excellent for the total score, activity limitations subscale, and symptoms subscale (range 0.92–0.97), good for the emotional functioning subscale ($\alpha = 0.86$), and acceptable for the environmental stimuli subscale ($\alpha = 0.79$).

Lung Function

Lung function was measured using forced expiratory volume in 1 s (FEV_1) using a KoKo Legend portable office spirometer (nSpire Health, Inc., Longmont, CO). Participants' actual FEV_1 score was compared to a predicted score based on reference values taking gender, age, height, and race into account to calculate a percent predicted score. This measure of lung function was chosen, because it is the most reliable and commonly used in clinical practice (O'Byrne 2014). Moreover, it is used to help determine asthma severity and guide treatment decisions using a stepwise approach (National Heart Lung and Blood Institute 2007).

Discomfort Intolerance Scale-Revised (DIS-R)

The DIS-R (McLeish et al. 2018) is a revised version of the original Discomfort Intolerance Scale (DIS; Schmidt et al. 2006) and assesses the perceived inability to tolerate physical discomfort, beliefs about physical discomfort, and responses to feelings of physical discomfort. The DIS-R consists of nine items (e.g., "I can't handle feeling physical discomfort") rated on a 7-point Likert-type scale (0 = *not at all like me* to 6 = *extremely like me*) with higher scores indicating greater discomfort intolerance. Confirmatory factor analysis revealed that the revised 9-item version was a good fit to the data and demonstrated good construct validity in both symptomatic (i.e., clinically-elevated levels of depression or anxiety) and non-symptomatic samples (McLeish et al. 2018). The DIS-R demonstrated excellent internal consistency ($\alpha = 0.93$).

Procedure

We recruited participants via advertisements posted in public areas, physician office waiting rooms, and community-oriented websites. We then screened interested individuals

for eligibility over the phone (i.e., age, smoking status, physician-diagnosed asthma, Asthma Screening Questionnaire). Those who were deemed potentially eligible were then scheduled for an individual study session. Upon arrival to the study session, participants first gave written, informed consent. We then verified eligibility (i.e., non-smoking status) using CO analysis. Those who were confirmed to be non-smokers then completed spirometry to assess lung function, followed by the self-report measures. Participants were paid $25 for completing the study. Institutional Review Board approval for the study was obtained prior to data collection.

Data Analytic Plan

First, zero-order correlations were computed to explore associations between all study variables. Next, hierarchical multiple regression analyses (Cohen et al. 2003) were performed to assess the unique associations between discomfort intolerance (DIS-R) and terms of lung function (FEV_1), asthma control (ACT), and asthma-related quality of life (AQLQ). We created separate regression models for each outcome variable. Because previous research has demonstrated relatively specific associations between the physical concerns domain of anxiety sensitivity and not the other domains of anxiety sensitivity (McLeish et al. 2011, 2016), anxiety sensitivity-physical concerns was entered as a covariate at step one of each model. Discomfort intolerance was entered at step two of each model to determine how much unique variance it accounted for. For the secondary analyses, if model for the AQLQ total score was significant, additional models for the four AQLQ subscales would be examined using the same approach.

Results

See Table 1 for associations among all study variables. Greater discomfort intolerance was significantly correlated with worse lung function, asthma control, and asthma-related quality of life at the zero-order level. See Table 2 for results of the regression analyses. For lung function, anxiety sensitivity-physical concerns accounted for 0.4% of the variance at step one, and discomfort intolerance accounted for an additional 9.5% unique variance at step two. For asthma control, anxiety sensitivity-physical concerns accounted for 25.6% unique variance at step one, and discomfort intolerance accounted for an additional 9.9% unique variance at step two. In terms of overall asthma-related quality of life, anxiety sensitivity- physical concerns accounted for 33.1% of the variance at step one, and discomfort intolerance accounted for an additional 11.7% of the variance at step two. For the secondary analyses, greater anxiety sensitivity-physical concerns was significantly associated with poorer asthma-related quality of life across each of the four domains, accounting for 16.7–33.2% of unique variance at step one. Greater discomfort intolerance accounted for an additional 12.6% of unique variance for activity limitations, 6.8% unique variance for asthma symptoms, 4.7% unique variance for emotional functioning, and 4.2% unique variance for environmental stimuli.

Discussion

The present study explored the role of discomfort intolerance in relation to important indices of disease management among those with asthma (i.e., lung function, asthma

Table 1 Descriptive statistics and intercorrelations among predictor and criterion variables

	1	2	3	4	5	6	7	8	9	M	SD	Range
1. AS-PC	–	0.51**	−0.05	−0.47**	−0.54**	−0.53**	−0.41**	−0.51**	−0.40**	9.86	5.99	0–21
2. DIS-R	–	–	−0.29*	−0.51**	−0.58**	−0.58**	−0.45**	−0.44**	−0.37**	22.32	13.65	1–54
3. FEV_1	–	–	–	0.38**	0.18	0.23	0.11	0.25	0.12	85.97	23.73	43–179
4. ACT	–	–	–	–	0.85**	0.80**	0.85**	0.78**	0.59**	15.98	4.54	6–25
5. AQLQ-total	–	–	–	–	–	0.96**	0.96**	0.90**	0.80**	4.50	1.30	1.28–6.97
6. AQLQ-activity	–	–	–	–	–	–	0.86**	0.82**	0.81**	4.74	1.30	1.64–7.00
7. AQLQ-symptoms	–	–	–	–	–	–	–	0.85**	0.66**	4.33	1.42	1.08–7.00
8. AQLQ-emotions	–	–	–	–	–	–	–	–	0.62**	4.35	1.51	1.00–7.00
9. AQLQ-environment	–	–	–	–	–	–	–	–	–	3.88	1.41	1.25–6.75

AS-PC Anxiety Sensitivity Index-3 Physical Concerns Subscale (Taylor et al. 2007), *DIS-R* Discomfort Intolerance Scale-Revised (McLeish et al. 2018), *FEV_1* lung function, *ACT* Asthma Control Test (Nathan et al. 2004), *AQLQ-total* Asthma Quality of Life Questionnaire-Total Score (Juniper et al. 1992); AQLQ-activity: Asthma Quality of Life Questionnaire-Activity Limitations subscale (Juniper et al. 1992), *AQLQ-symptoms* Asthma Quality of Life Questionnaire-Symptoms subscale (Juniper et al. 1992), *AQLQ-emotions* Asthma Quality of Life Questionnaire-Emotional Functioning subscale (Juniper et al. 1992), *AQLQ-environment* Asthma Quality of Life Questionnaire-Environmental Stimuli subscale

*$p < 0.05$, **$p < 0.01$

Table 2 Discomfort intolerance predicting lung function, asthma control, and quality of life

	ΔR^2	*t*	β	*B*	sr^2	95% CI	*p*
Criterion variable: FEV_1							
Step 1	0.00						0.64
AS-PC		−0.47	−0.06	−0.25	0.00	−1.33 to 0.82	0.64
Step 2	0.10						0.02*
DIS-R		−2.38	−0.36	−0.62	0.09	−1.14 to −0.10	0.02*
Criterion variable: ACT							
Step 1	0.26						0.00**
AS-PC		−4.36	−0.51	−0.38	0.26	−0.55 to −0.20	0.00**
Step 2	0.10						0.006**
DIS-R		−2.87	−0.36	−0.12	0.10	−0.20 to −0.04	0.006**
Criterion variable: AQLQ-total							
Step 1	0.33						0.00**
AS-PC		−4.82	−0.58	−0.12	0.33	−0.18 to −0.07	0.00**
Step 2	0.12						0.00**
DIS-R		−3.13	−0.40	−0.04	0.12	−0.06 to −0.01	0.00**
Criterion variable: AQLQ-activity							
Step 1	0.33						0.00**
AS-PC		−4.88	−0.58	−0.12	0.33	−0.17 to −0.07	0.00**
Step 2	0.13						0.00**
DIS-R		−3.30	−0.40	−0.04	0.13	−0.06 to −0.02	0.00**
Criterion variable: AQLQ-symptoms							
Step 1	0.21						0.00**
AS-PC		−3.62	−0.45	−0.11	0.20	−0.17 to −0.05	0.00**
Step 2	0.07						0.04*
DIS-R		−2.16	−0.30	−0.03	0.07	−0.06 to −0.002	0.04*
Criterion variable: AQLQ-emotions							
Step 1	0.27						0.00**
AS-PC		−4.47	−0.52	−0.13	0.27	−0.19 to −0.07	0.00**
Step 2	0.05						0.06
DIS-R		−1.91	−0.24	−0.03	0.05	−0.06 to 0.001	0.06
Criterion variable: AQLQ-environment							
Step 1	0.17						0.00**
AS-PC		−3.29	−0.41	−0.10	0.17	−0.16 to −0.04	0.00**
Step 2	0.04						0.10
DIS-R		−1.68	−0.24	−0.02	0.04	−0.05 to 0.005	0.10

β standardized beta weight, *B* unstandardized beta weight, sr^2 squared semi-partial correlation, *95% CI* 95% confidence interval for B, *AS-PC* Anxiety Sensitivity Index-3 Physical Concerns Subscale (Taylor et al. 2007), *DIS-R* Discomfort Intolerance Scale-Revised (McLeish et al. 2018), FEV_1 lung function, *ACT* Asthma Control Test (Nathan et al. 2004), *AQLQ-total* Asthma Quality of Life Questionnaire-Total Score (Juniper et al. 1992), *AQLQ-activity* Asthma Quality of Life Questionnaire-Activity Limitations subscale (Juniper et al. 1992), *AQLQ-symptoms* Asthma Quality of Life Questionnaire-Symptoms subscale (Juniper et al. 1992), *AQLQ-emotions* Asthma Quality of Life Questionnaire-Emotional Functioning subscale (Juniper et al. 1992), *AQLQ-environment* Asthma Quality of Life Questionnaire-Environmental Stimuli subscale

*$p < 0.05$, **$p < 0.01$

control, quality of life). As hypothesized, greater discomfort intolerance was significantly associated with poorer lung function, asthma control, and overall asthma-related quality of life as well as the specific domains of activity limitations and asthma symptoms. Importantly, these significant effects were found after accounting for the effects of the physical concerns domain of anxiety sensitivity. These findings indicate that individuals with asthma who cannot tolerate physical discomfort have greater difficulty managing their asthma and experience greater functional impairment, particularly related to activity limitations and their asthma symptoms.

The present findings are in line with earlier work (e.g., Bernstein et al. 2009) and demonstrate that discomfort

intolerance, while conceptually related to anxiety sensitivity, is a distinct construct. Indeed, in the current study, these two constructs only shared 25.8% of the variance, suggesting that discomfort intolerance offers unique explanatory value in understanding how anxiety-related cognitive risk factors impact asthma outcomes. Indeed, Bernstein et al. (2009) postulate that anxiety sensitivity reflects the ability to withstand affective distress, whereas discomfort intolerance reflects the ability to tolerate physical distress. Incorporating the current findings with previous research on anxiety sensitivity and asthma (Avallone et al. 2012; McLeish et al. 2011, 2016), it appears that the ability to tolerate both affective and physical distress play important roles in asthma. In fact, in the current study, discomfort intolerance, but not anxiety sensitivity- physical concerns, was associated with poorer lung function. This finding is in contrast with the McLeish et al. (2016) study that did find a significant association between anxiety sensitivity- physical concerns and lung function. However, in that study, lung function was only assessed after a straw breathing task, and reactivity to this task by individuals with high anxiety sensitivity- physical concerns likely influenced this measurement. Thus, discomfort intolerance and anxiety sensitivity- physical concerns may be differentially related to asthma outcomes, and it will be important for future research to examine tolerance for both affective distress and physical distress in asthma.

One possible explanation for the current findings is that discomfort intolerance may amplify the experience of physical discomfort and could lead to the inflexible use of strategies to reduce this discomfort. Therefore, these findings provide preliminary evidence that it may be helpful to reduce discomfort intolerance in asthma patients in order to improve management of asthma. Interoceptive exposure-based approaches that elicit physical discomfort may be particularly helpful as it would target both affective and physical distress tolerance (i.e., anxiety sensitivity and discomfort intolerance). Moreover, discomfort intolerance likely interferes with accurate symptom perception, leading to greater attentional biases towards physical symptoms, which could result in inappropriate responding to such symptoms (e.g., overuse of SABAs). Thus, psychoeducation on the nature of physical symptoms experienced during an asthma exacerbation and what symptoms need to be tolerated versus treated would be an important addition to any intervention targeting discomfort intolerance. Such an approach would not only help to ensure accurate symptom perception, but also the use of more appropriate behavioral responses to physical symptoms (e.g., waiting a brief period of time to see if symptoms improve before using SABAs). It will also be important to determine which specific asthma symptoms are most aversive to individuals who are high in discomfort intolerance as well as which ones they tend to over-respond to.

In terms of the quality of life findings, it may be that an individual with asthma who has difficulty tolerating physical distress would be more likely to notice their asthma symptoms and experience them as more intrusive in their daily lives as well as limit their activities for fear of potentially exacerbating asthma symptoms. Experiencing poorer quality of life in these domains is likely to be especially problematic as it may lead to the perception of greater asthma severity than would be expected based on objective indices, which could result in a vicious cycle of increasingly greater medication use and activity limitations to protect against asthma exacerbations. Thus, these findings are supportive of the proposed theoretical model of the role of discomfort intolerance in asthma.

There is also some indication the greater discomfort intolerance could also be associated with poorer quality of life due to emotional reactions to having asthma, although this finding needs to be replicated as it did not meet traditional significance cut-off values in the current sample. Individuals who are unable to tolerate physical distress yet are diagnosed with a condition that involves a number of physiological symptoms are likely going to be more distressed and upset by these symptoms if they have a low tolerance for them. However, the negative impact of asthma symptoms and their resulting activity limitations (or the perceived need for activity limitations) may make these aspects of quality of life more salient than the emotional distress they experience, because discomfort intolerance is more focused on physical rather than affective symptoms.

Interestingly, lung function, as assessed by FEV_1, was not significantly correlated with asthma-related quality of life. These findings are consistent with extant research that indicates quality of life and lung function may represent distinct aspects of disease severity (Wijnhoven et al. 2001). However, as the values of the correlations were not inconsequential (range 0.11–0.25), these non-significant findings could also be due to the small sample size being somewhat underpowered to detect small effect sizes.

This study has a number of strengths and limitations that are worth noting. In terms of strengths, participants in the present study were predominantly African American (55%), which is particularly notable as asthma is more common among minority populations (Akinabi et al. 2012). Further, this study is the first to examine the construct of discomfort intolerance in asthma outcomes, which helps inform theoretical models of the role of cognitive-affective risk factors in asthma. At the same time, there are also limitations that should be noted. First, asthma diagnosis was not objectively verified. While we attempted to verify the asthma diagnosis for individuals self-reporting a physician diagnosis of asthma using a validated asthma screening measure (Shin et al. 2010), it will, nonetheless, be essential for future studies to objectively verify asthma diagnoses

in order to ensure that all study participants have a current diagnosis. Second, outside of measurements of lung function, the current study relied on self-report assessment toold, which increases the chance for shared method variance and reporting errors. Future work will benefit from using a multimethod approach to behaviorally assess or experimentally manipulate discomfort intolerance.

Finally, the cross-sectional design employed in the current study does not allow for any tests of causality. Longitudinal studies will be helpful to understand how discomfort intolerance affects asthma as well as how these variables interact with one another over time. Notwithstanding these limitations, the current study underlines the significance of discomfort intolerance in asthma outcomes and the potential ability to improve asthma management through interventions that decrease discomfort intolerance.

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Data Availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Compliance with Ethical Standards

Conflict of Interest Alison C. McLeish, Kristen M. Kraemer and Emily M. O'Bryan declare that they have no conflicts of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institution and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Animal Rights This article does not contain any studies with animals performed by any of the authors.

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