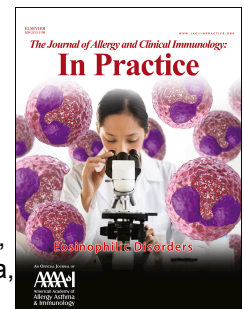


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Multivariate Association of Child Depression and Anxiety with Asthma Outcomes

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Multivariate Association of Child Depression and Anxiety with Asthma Outcomes

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MULTIVARITE ASSOCIATION OF CHILD

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1. What is already known about this topic? Depression and anxiety are common among children with asthma. Sex differences may exist in asthma outcomes between boys and girls.
2. What does this article add to our knowledge? Large effect size (37.2%) present in the relationship between depressive and anxiety symptoms and asthma outcomes. Girls may overperceive asthma symptoms compared to boys despite no differences in lung function measures.
3. How does this study impact current management guidelines? Consider incorporating questions about psychiatric symptoms as part of routine asthma management with a focus on perception of asthma symptoms between boys and girls.

Highlights

Keywords: asthma, depression, anxiety, pediatric, multivariate

Acronyms/Abbreviations

ACT – Asthma Control Test

CASI – Composite Asthma Severity Index

CCA – Canonical Correlation Analysis

CDC – The Centers for Disease Control

CDI – Child Depression Inventory

GINA – Global Initiative for Asthma

ICS – Inhaled corticosteroids

LABA – Long-acting β_2 agonist

PAQOL – The Pediatric Asthma Quality of Life

SCARED – Screen for Child Anxiety Related Disorders (SCARED)

Abstract

Background: Pediatric asthma is associated with increased health services utilization, missed school days and diminished quality of life. Children with asthma also report more frequent depressive and anxiety symptoms than non-asthmatic children, which may further worsen asthma outcomes.

Objective: The current study investigated the relationship between depressive and anxiety symptoms and four asthma outcomes (asthma control, asthma severity, lung function, and asthma-related quality of life) in children ($N = 205$) with moderate-to-severe persistent asthma.

Methods: The data were analyzed using a canonical correlation analysis (CCA), a multivariate framework that allows examination of all variables of interest in the same model.

Results: We found a statistically significant relationship between symptoms of depression and anxiety and asthma outcomes ($1 - \Lambda = .372, p < .001$). A large effect size suggests that 37.2% of variance is shared between depression and anxiety symptoms and four asthma outcomes (particularly asthma control and asthma-related quality of life) in the overall sample. Among girls (vs. boys), asthma control (measured by ACT) emerged as a stronger contributor to asthma outcomes compared to boys.

Conclusions: These results suggest that psychiatric symptoms, especially anxiety, are associated with poor asthma-related quality of life, and more negative perception of asthma control in girls compared to boys (with no observed sex difference in physiological lung function). Clinicians should consider incorporating questions about psychiatric symptoms as part of routine asthma management, and focus patient education on unique differences in which boys and girls perceive their asthma symptoms.

Introduction

In 2016, The Centers for Disease Control (CDC) reported that asthma is the most common chronic medical condition among children under the age of 18 in the United States, affecting approximately 8.3% of the child population (1). Child asthma also represents a significant public health burden that includes missed school days and unscheduled service utilization, such as the asthma-related emergency room visits and hospitalizations (1). Epidemiologic research suggests there are sex differences in asthma severity, prevalence, and healthcare utilization and these differences may be driven by different environmental influences among children (2-5). However, the causes or specific mechanisms that may contribute to differences in asthma outcomes among pediatric populations are not well understood (6).

Psychiatric comorbidities, such as depression and anxiety, further increase healthcare utilization (e.g., emergency department use) and associated public health costs among pediatric populations with various medical conditions (7, 8), including asthma (9). In general, children with asthma may be at higher risk for psychiatric problems, including depression and anxiety disorders, that may negatively affect the disease management (e.g., medication adherence) (10, 11). Children with asthma age 11-17 years with a history of at least one depressive episode report greater frequency of daytime asthma symptoms compared to those with no psychiatric history (12). Depressive and anxiety disorders are almost twice as prevalent in asthmatics (16.3%) vs controls (8.6%) (13), and depressive symptom severity in children with asthma correlates negatively with degree of asthma control (14). Children with depressive and anxiety symptoms report greater frequency of emergency department (ED) visits and asthma symptoms compared to those without psychiatric symptoms (9), and the depressive and anxiety symptoms are common in children even with well-controlled asthma (15). These results suggest that it may

be important to consider both depressive and anxiety symptoms when assessing both pediatric asthma control and severity.

Although there is evidence suggesting a univariate relationship between depressive and anxiety symptoms and asthma outcomes in children, to our knowledge, only adult studies to date have examined the multiple psychiatric symptoms and asthma outcomes simultaneously as part of the same model (i.e., multivariate relationship) (16, 17). Furthermore, to our knowledge, sex differences in the relationship between psychiatric symptoms and childhood asthma outcomes have not been examined previously. However, a study of adult men (mean age 42.0) and women (mean age of 42.3) with asthma suggests greater anxiety symptomatology and insomnia in women compared to men and emphasizes the importance of sex differences when considering asthma management strategies (18).

The current study investigated the shared multivariate relationship between symptoms of depression and anxiety (simultaneously), and four asthma outcome variables (simultaneously) using the canonical correlation analysis (CCA) and examined the sex differences in this relationship. Two critical advantages of a multivariate analysis like CCA is reducing the likelihood of familywise error rate (Type I error anywhere within the study associated with performing multiple separate hypotheses tests), as well as honoring the complex nature of experimental variables that frequently interact together (e.g., depression symptoms are often comorbid with anxiety symptoms) (19).

Methods

Participants

Data for this study were collected as part of an ongoing multi-site longitudinal clinical research study at UT Southwestern Medical Center and University at Buffalo evaluating the

relationship between caregiver depression and childhood asthma outcomes. Cross-sectional baseline data were used for the current study. The protocol was approved by both the UT Southwestern and University at Buffalo Institutional Review Boards (IRB), and all the participants signed an informed consent form prior to their participation. Children under 12 years of age provided their assent to participate in research, which was corroborated by their parent or legal guardian. The participants were primarily recruited from outpatient private asthma clinics in the area, hospital-affiliated child asthma clinics, and the emergency departments affiliated with children's hospitals (children who presented with an asthma exacerbations and consented to being contacted for research). The recruitment methods were similar between two sites.

The current study included children between 7 and 17 years of age who met diagnostic criteria for moderate-to-severe persistent asthma based on impairment and risk criteria of the National Asthma Education and Prevention Program, or those requiring at least Step 3 therapy (20). The study excluded potential participants with severe cognitive impairment; those at high risk of suicide defined by more than two suicide attempts in the past year, any attempt in the past month, or any current suicidal ideations with a plan or intent; those with severe or life-threatening medical illness, such as other serious cardiopulmonary conditions (e.g., congenital heart disease, cystic fibrosis, alpha-1-antitrypsin disease) or cancer; and those with severe psychiatric illness, such as autism, bipolar disorder, schizophrenia or current alcohol or drug use disorder.

Asthma Outcomes Variable Set

Four asthma-related variables were used as outcomes in the study. The Asthma Control Test (ACT) is a validated 5-item self-report survey of asthma control, with total scores ranging from 5 to 25 ($\alpha = .84$) for use in children age 12 and above (21). The child version of the ACT (cACT) is a 7-item scale of asthma control administered to children under the age of 12, with the

total scores ranging from 0 to 27 ($\alpha = .79$) (22). The ACT and the cACT assess daytime and nighttime asthma symptoms, the need for rescue medication, interference with daily functioning due to asthma, and overall self-reported asthma control. Higher scores on ACT and cACT indicate better control.

The Pediatric Asthma Quality of Life (PAQOL) was the second asthma outcome variable included in the analysis. PAQOL is a 23-item, validated self-report instrument of child asthma quality of life with items rated on a 7-point Likert scale. The questions on PAQOL represent the physical, emotional and social problems that are most burdensome for children with asthma, and a higher total score indicates better quality of life and less burdensome asthma symptoms (23). The total PAQOL score (sum of all items) was included in the analysis.

The Composite Asthma Severity Index (CASI) was the third asthma outcome measure used in the study. CASI is a 5-domain measure of asthma severity, including daytime and nighttime asthma symptoms in the past 14 days, lung function measure based on the predicted percentage of forced expiratory volume in 1 second, controller medication treatment, and asthma exacerbations (prednisone bursts and hospitalizations in the past 2 months), with a total score ranging from 0 to 20 (24). A higher CASI score is associated with greater asthma severity. Forced expiratory volume in one second (FEV₁%) predicted was included as the fourth asthma outcome as a continuous outcome variable.

Depression and Anxiety Predictor Variable Set

The Child Depression Inventory (CDI) assessed child depressive symptom severity. The CDI is a self-report scale consisting of 27 items, each rated from 0 (*no depressive symptoms*) to 2 (*clear presence of depressive symptoms*), with a total score ranging from 0 to 54. The total score

was then converted to a *T*-score, adjusting for age and sex. The CDI has been validated in different populations, with the average internal consistency coefficient of $\alpha = .80$ (25).

The Screen for Child Anxiety Related Disorders (SCARED) was used as a predictor of child anxiety symptoms. This validated self-report scale consists of 41 items ($\alpha = .74$) each rated on a Likert scale from 0 (*not true or hardly ever true*) to 2 (*very true or often true*), yielding a total possible score of 0-123, with higher scores indicative of a possible anxiety disorder (26).

Statistical Analysis

All analyses were conducted using IBM SPSS Statistics, Version 26.0, with statistical significance level set at $p < .05$. Differences between groups on categorical demographic variables were compared using χ^2 test. The distribution of continuous variables was examined for normality and extreme values. Prior to the analysis, the total scores on ACT were linearly transformed to the cACT score range to produce total scores with a minimum score of zero. A similar linear transformation approach of age-specific ACT measures to the range of cACT was recently employed by (27). Both the ACT and the cACT have the same cut-off point for asthma control (i.e., the score of 19 or below is indicative of uncontrolled asthma) and proven to be good predictors of the asthma control guidelines established by the Global Initiative for Asthma (GINA) guidelines (28).

For the primary analysis, The Canonical Correlation Analysis (CCA) (19, 29) was used to evaluate a multivariate relationship between a set of *Psychiatric Symptoms* predictors and a set of *Asthma Outcomes*. Under this framework, we defined the *Psychiatric Symptoms* predictor set to consist of CDI and SCARED total scores and the *Asthma Outcomes* set to consist of ACT, CASI, PAQOL, and FEV1% scores (Figure I). The goal of the study was to identify whether a multivariate relationship exists between the *Psychiatric Symptoms* and the *Asthma Outcomes* sets

in children, determine specific variables within each set that contribute to the strength of this relationship, and assess whether the relationship between sets may vary by sex.

The full CCA model (Figure I) was evaluated for statistical significance, followed by the evaluation of *individual* psychiatric symptoms (i.e., depressive and anxiety symptoms) and asthma outcome variables to examine which *individual* variables drive the relationship between child depressive and anxiety symptoms and asthma outcomes.

Past research suggests sex differences in childhood asthma outcomes, particularly higher prevalence of asthma among boys than girls before puberty, however, the trend appears to reverse after the girls reach the puberty age (30, 31). To investigate the sex differences in the relationship between childhood psychiatric symptoms and asthma variables, a secondary CCA was conducted separately in boys ($n = 94$) and girls ($n = 111$) and the descriptive differences in results were compared between the subsamples.

Results

Demographic and Clinical Characteristics

The final sample ($N = 205$) had an average age of 11.31 ($SD = 2.89$) and consisted of slightly more girls (54.1%) compared to boys (45.9%). African Americans made up over half of the overall study sample (56.6%), followed by White (34.6%) participants. There was also a substantial proportion of Hispanic participants included in the study (31.7%). The demographics of the sample reflected the local population and the recruitment pool (primarily African American and a large portion of Hispanic patients). At baseline, asthma was managed primarily by daily inhaled corticosteroids (ICS, 45.4%), including 25.4% of children on a high-dose ICS medication, or by a combination of long-acting β_2 agonist (LABA)/ICS (39.0%) (Table II). There were also 15 children (7.3%) on more than one ICS or ICS/LABA at baseline. Furthermore,

42.4% of children were taking an antileukotriene, such as montelukast. Four children were being treated with daily steroid therapy (prednisone), one child was on an anticholinergic tiotropium, 6 children received omalizumab, and one child received mepolizumab. Full demographic and clinical characteristics of the sample are presented in Tables I and II.

Primary Analysis

The CCA was conducted to evaluate the multivariate shared relationship between the predictor set *Psychiatric Symptoms* (CDI, SCARED) and the *Asthma Outcomes* set (ACT, CASI, FEV1%, PAQOL). The full model was statistically significant (Λ [variance unexplained] = .628, $F(40, 366) = 12.004, p < .001$). The effect size ($1 - \Lambda$) for the full model was .372, suggesting that a substantial 37.2% of variance was shared between the *Psychiatric Symptoms* and *Outcomes* variable sets in the model. The influence of child sex, age, and race on the relationship between psychiatric symptoms and asthma outcomes was also explored by adding these variables as covariates in the model. The full model remained statistically significant ($\Lambda = .578, p < .001$), suggesting that 42.2% of variance was shared between the *Psychiatric Symptoms* and *Asthma Outcomes* variable sets, after adding covariates to the model.

We subsequently evaluated the individual variables (CDI, SCARED in the *Psychiatric Symptoms* set and ACT, CASI, FEV1, and PAQOL in the *Asthma Outcomes* set) to identify which variables are contributing to the relationship between the variable sets (Table III). As indicated by the structure coefficients (r_s) and squared structure coefficients (r_s^2), SCARED was the primary contributor to the relationship between psychiatric symptoms and asthma outcomes, followed by a slightly smaller CDI contribution. Among the asthma variables, PAQOL and ACT were the primary drivers of the relationship between psychiatric symptoms and asthma outcomes, while CASI and FEV1% predicted did not contribute significantly to this relationship

(Table III). More specifically, SCARED and CDI were negatively related to the asthma outcome variables, ACT and PAQOL, suggesting that greater anxiety and depression were associated with poorer asthma control and asthma-related quality of life (Table III).

We also evaluated the individual covariates in a subsequent model (child sex, age, and race) to determine whether the addition of these covariates influenced the relationship between the *Psychiatric Symptoms* and *Asthma Outcomes* variable sets. PAQOL ($r_s = .96$; $r_s^2 = .92$) and ACT ($r_s = .52$; $r_s^2 = .27$) remained the primary influences on the relationship between psychiatric symptoms and asthma outcomes, while CASI ($r_s = .04$; $r_s^2 = .001$) and FEV1% predicted ($r_s = -.13$; $r_s^2 = .02$) did not contribute significantly to this relationship. Among the psychiatric predictors and covariates, CDI ($r_s = -.29$; $r_s^2 = .08$) and SCARED ($r_s = -.80$; $r_s^2 = .64$) were negatively related to asthma outcomes, with the anxiety variable (SCARED) being the strongest predictor in the overall model. None of the demographic variables were strongly related to the Asthma Outcomes variable set (sex, $r_s = .14$; age, $r_s = -.08$; race, $r_s = .01$).

Secondary Analysis

The full canonical model was statistically significant for both girls ($p < .001$; $1 - \Lambda = .370$) and boys ($p < .001$; $1 - \Lambda = .388$). Wilks's Λ represents the variance *unexplained* by each model, suggesting that 37.0% of the variance was shared between the depression/anxiety symptom set and the asthma outcomes variable set among girls and 38.8% among boys.

We further isolated variables that were the most relevant to each variable set for both girls and boys (Figure 2). We examined structure coefficients (r_s) to identify that, among girls, PAQOL was the primary contributor to the asthma variable set ($r_s = .96$), followed by the ACT score ($r_s = .57$). CASI ($r_s = .05$) and FEV1% ($r_s = -.09$) did not provide substantial contribution to the asthma variable set. On the predictor side, SCARED (anxiety symptoms) was a stronger

contributor ($r_s = -.95$) to the psychiatric symptoms variable set compared to CDI (depressive symptoms), ($r_s = -.69$). Both anxiety and depression structure coefficients were directionally opposed compared to PAQOL and ACT, suggesting an inverse relationship between these variables, such that greater anxiety and depressive symptom severity are associated with lower asthma-related quality of life and poorer asthma control.

Among boys, PAQOL was also the strongest contributor to the asthma outcomes set ($r_s = .96$), followed by ACT ($r_s = .26$) (Figure 2). However, squared structure coefficients (r_s^2) suggest that ACT explained 32.5% of variance in asthma outcomes among girls ($r_s^2 = .325$) compared to only 6.8% among boys ($r_s = .26$; $r_s^2 = .068$). These results suggest that asthma control may be a more relevant variable to asthma outcomes among girls compared to boys. On the predictor side, in boys, SCARED was a slightly stronger contributor ($r_s = -.96$) to the psychiatric variable set compared to CDI ($r_s = -.77$), and both were negatively related to PAQOL and ACT. These results are consistent with those observed in the girl subsample (Figure 2).

Discussion

We investigated a cross-sectional sample of children (7-17 years) with moderate to severe asthma in order to assess the multivariate relationship between psychiatric symptoms and asthma outcomes, as well as the sex differences in the relationship between anxiety and depressive symptoms and asthma outcomes. We found that anxiety and depressive symptoms are negatively related to asthma outcomes, particularly to asthma control and asthma-related quality of life. Of note, these measures are more subjective in nature compared to the other asthma outcomes (CASI and FEV1% predicted). The current results suggest that the subjective emotional nature of a child's experience as a result of his or her asthma may be due to heightened anxiety and depression (particularly anxiety). In adults, contrasting self-reported asthma control based on

ACT with lung function measures suggests that over 60% of patients tend to under- or overperceive their asthma status, with asthma-specific anxiety contributing the most to the enhanced perception of asthma-symptoms (32). It is possible that our model may have captured a theoretical construct consistent with “subjective emotional asthma experiences”, however it was not as effective at identifying a construct consistent with physiological asthma changes.

Asthma is a complex disease characterized by multiple clinical dimensions (e.g., daytime symptoms, controller use, etc.), that can challenge the reliable assessment of disease endpoints (24, 33). In our model, we observed substantial contributions of PAQOL (a quality of life measure) and ACT (a disease control measure) to the relationship between mental health predictors and asthma outcomes, but were unable to capture significant contribution of CASI and FEV1% predicted in the model. This is consistent with other studies that suggest FEV1 does not consistently correlate with other asthma outcome measures (34, 35). The CASI, an instrument developed to assess asthma severity rather than control, takes into account both objective and subjective measures of control, as well as the controller medication requirements to achieve that control, and asthma exacerbation frequency. Therefore, CASI score may not correlate as strongly with a more subjective asthma outcome, such as patient perception of asthma control as measured by ACT.

Limited cross-sectional evidence suggests that adult females may have worse asthma control than males based on the ACT score (but no clinically significant differences in asthma control based on physiological measures of lung function), as well as higher asthma-related anxiety compared to males (34). Adult women accounted for 75% of asthma overperceivers compared to men and reported less asthma control than men despite comparable level of lung function (32), thus it is possible that girls may have a heightened emotional response in response

to asthma symptoms compared to boys. Adult women with asthma also tend to report worse asthma control and poorer quality of life compared to affected men (36), and self-report changes in asthma control among women appear to be more variable than changes in lung function measures when compared to men (35). This could be reflected in the higher percentage of variance explained by the ACT scores among girls compared to boys. We also found that anxiety symptom severity may have a slightly stronger association with asthma outcomes compared to depression. Consistent with our findings, adult females with severe allergic asthma had a worse perception of their asthma (including perception of a more symptomatic disease) and had poorer quality of life due to asthma compared to males (37). Our findings extend these results in adults to a children with moderate-to-severe persistent asthma and suggest that clinicians may need to evaluate depressive and anxiety symptoms in children at routine asthma management visits, as well as personalize this process to individual differences in which boys and girls perceive their asthma.

There are several limitations associated with the study. The observation regarding sex differences should be interpreted with caution, as the CCA was conducted separately in each subgroup, thus we were unable to perform a statistical significance test between the subgroups (i.e., the groups were compared using descriptive statistics). Another potential consideration is that the current CCA model does not explicitly control for inhaled corticosteroid use as a separate asthma variable. It is possible that the patients receiving chronic inhaled steroid therapy or systemic steroids may shower greater depressive and anxiety symptoms (38). We examined the differences in SCARED and CDI total scores based on the level of asthma treatment (albuterol only, leukotriene modifiers or low-dose ICS, low-dose ICS+LABA or medium-dose ICS, medium-dose ICS+LABA, or high-dose ICS). However, there were no statistically

significant differences in CDI ($F = 1.06, p = .386$) or SCARED ($F = 1.15, p = .333$) between patients in each treatment group (i.e., there was no significant effect of the type of asthma medication use on psychiatric symptoms in children). Furthermore, although the study included children with at least moderate persistent asthma, the average CASI and FEV1% predicted scores appeared to reflect an adequate level of control. Children with severe or poorly controlled asthma were not purposefully excluded from the study. Thus, it is possible that we were unable to observe the relationship between mental health and physiological asthma severity in those with severe and poorly controlled cases.

In summary, the study suggests that anxiety and depressive symptoms may be associated with worsened asthma outcomes, particularly asthma control and quality of life. Anxiety emerged as the strongest predictor of poor asthma outcomes, particularly asthma-related quality of life and asthma control. This finding was stronger among girls than boys, suggesting that girls may perceive asthma more negatively compared to boys and be more anxious about the disease. This may subsequently affect day-to-day quality of life, further worsening the perception of asthma symptoms and increasing the emotional burden associated with asthma. These findings suggest that it may be important to screen children for depressive and anxiety symptoms, as well as assess asthma-related quality of life in a structured format, as part of the routine asthma management visits. PAQOL is a brief structured self-report questionnaire that is fairly quick to complete and could provide an abundance of information to the clinician regarding the issues perceived by the child as the most concerning. Although the current paper does not directly address this concern, it is possible that if the psychiatric symptoms remain unidentified or untreated, the long-term effectiveness of asthma treatment may suffer. Furthermore, clinicians may need to be aware of unique differences between boys and girls in terms of the perceived

341 emotional distress associated with asthma and personalize patient education based on these
342 differences. Future studies should attempt to parse out the differences between the subjective
343 asthma experiences and physiological asthma outcomes to determine the mechanism that drives
344 the relationship between mental health and asthma in children.

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Table I*Descriptive Statistics for the Baseline Characteristics of Child Participants*

Demographic Variables	N	Mean	SD
Age (years)	205	11.31	2.89
cACT	205	17.37	5.59
CASI	205	5.74	3.23
FEV1% predicted	197	97.64	17.69
PAQOL	205	5.10	1.39
CDI T-score	197	49.32	8.87
SCARED	205	26.09	13.60
<i>Sex</i>	<i>N</i>	<i>%</i>	
Male	94	45.9	
Female	111	54.1	
<i>Race</i>	<i>N</i>	<i>%</i>	
African American	116	56.59	
White	71	34.63	
More than 1 race	12	5.85	
American Indian	2	0.98	
Asian	1	0.49	
Missing/Unknown	3	1.46	
<i>Ethnicity</i>	<i>N</i>	<i>%</i>	
Non-Hispanic	132	64.39	
Hispanic	65	31.71	
Other	8	3.90	

Note. CDI – Child Depression Inventory; SCARED – The Screen for Child Anxiety Related Disorders; ACT – Asthma Control Test; PAQOL – Pediatric Asthma Quality of Life; CASI – Composite Asthma Severity Index; FEV1 – Forced Expiratory Volume in one second.

Table II*Participant Asthma Medications at Baseline (N = 205)*

ICS	N	%
fluticasone	59	28.8
beclomethasone	32	15.6
mometasone	2	1
ICS/LABA		
fluticasone/salmeterol	51	25.3
budesonide/formoterol	15	7.3
mometasone/formoterol	10	4.9
fluticasone/vilanterol	3	1.5
Anticholinergics		
tiotropium	1	0.5
Antileukotrienes		
montelukast	87	42.4
Oral Steroids		
prednisone	4	2.0
Injections		
omalizumab	6	2.9
mepolizumab	1	0.5

Note. ICS – Inhaled Corticosteroids; LABA – long-acting β_2 agonist. The total does not add up to 100% because some participants were on multiple medications simultaneously (e.g., ICS + antileukotriene).

Table III

Canonical Solution for the Psychiatric Symptom Set (Predictors in the Model) and the Asthma Outcomes Set (Outcomes in the Model)

Variables	Full Model		
	Coef	r_s	r_s^2 (%)
Outcomes (Asthma Set)			
ACT	-.237	<u>.471</u>	22.18 %
PAQOL	1.146	<u>.951</u>	90.44 %
CASI	.152	.055	0.30 %
FEV1	-.130	-.111	1.23 %
Predictors (Psychiatric Symptoms Set)			
CDI	-.298	<u>-.701</u>	49.14 %
SCARED	-.816	<u>-.964</u>	92.93%
R_c^2			36.3 %

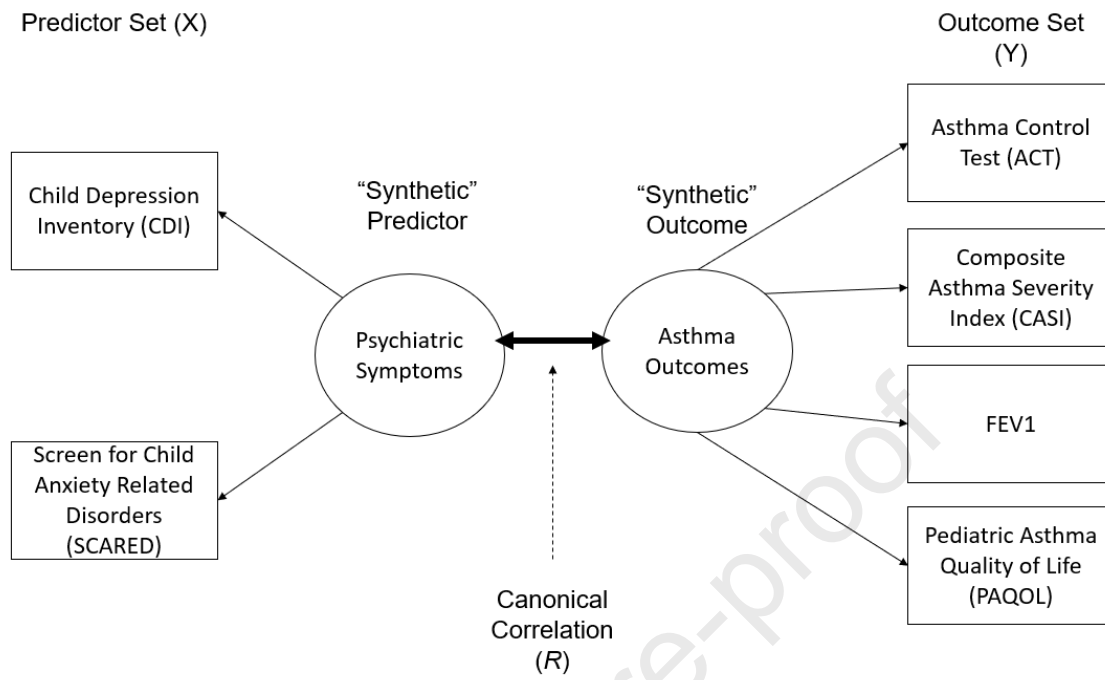
Note. CDI – Child Depression Inventory; SCARED – The Screen for Child Anxiety Related Disorders; ACT – Asthma Control Test; PAQOL – Pediatric Asthma Quality of Life; CASI – Composite Asthma Severity Index; FEV1 – Forced Expiratory Volume in one second. Coef = standardized canonical function coefficient; r_s – structure coefficient; r_s^2 = squared structure coefficient – percent of variance shared between the individual variable and the variable set. Structure coefficients (r_s) > than |.45| are underlined (37). Higher absolute values are associated with stronger relationship between each variable and the overall variable set.

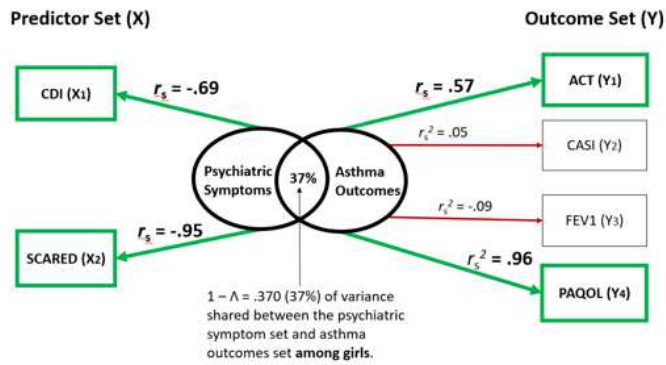
462 **Figure 1.** Hypothesized multivariate relationship between the psychiatric predictors and asthma
463 outcomes using the Canonical Correlation framework.

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Figure II. Multivariate relationship between the psychiatric predictors and asthma outcomes among boys vs. girls.

Legend. The r_s values represent structure coefficients. The bolded variables contribute to the “synthetic” predictor and outcome variables. CDI – Child Depression Inventory; SCARED – The Screen for Child Anxiety Related Disorders; ACT – Asthma Control Test; PAQOL – Pediatric Asthma Quality of Life; CASI – Composite Asthma Severity Index; FEV1 – Forced Expiratory Volume in one second.



Results of The CCA Model: Girls ($N = 111$)Results of The CCA Model: Boys ($N = 94$)