Cognitive Functioning in Well-Controlled Asthma

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Cognitive Functioning in Well-Controlled Asthma

A Dissertation Presented to the Faculty of the Department of Psychology

West Chester University

West Chester, Pennsylvania

In Partial Fulfillment of the Requirements for the

Degree of

Doctor of Psychology in Clinical Psychology

By

Erin R. Walsh, M.S.

February 2024

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Abstract

Asthma is a common lung disease that impacts lung functioning through inflammatory based mechanisms. Past research suggests that decreased blood oxygenation due to asthma attacks may impair cognitive capabilities (Irani et al., 2017). Moreover, the observed differences in cognition between those with and without asthma may be associated with disease severity or asthma control respectively in asthma populations. The current study explored differences in cognitive functioning between college students with and without self-reported asthma. Sociodemographic data, self-reported asthma severity, and measures of asthma control were collected. The current study did not find significant differences in measures of cognitive efficiency between those with and without asthma. Within asthma groups, neither asthma control nor asthma severity were significantly associated with cognitive efficiency variables. These results do not support the hypothesis that individuals with well-controlled moderate asthma have significantly different cognitive functioning in comparison to those without asthma. Clinical directions and future directions are discussed.
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Chapter 1: Introduction

Asthma is a chronic condition that affects lung and brain functionality, and cognitive processes through insufficient oxygenation and inflammation-based mechanisms (Irani et al., 2017). There are significant differences in the prevalence of asthma among racial/ethnic groups with Black and Native populations having the highest rates of asthma in comparison to Asian, Non-Hispanic Whites, and Hispanics (National Health Survey Interview, 2021). Due to inflammation causing the airways to narrow, this chronic lung disease is characterized by obstructed airflow and periods of wheezing, chest tightness, and shortness of breath. Moreover, during an asthma attack, oxygen saturation levels may dip significantly and may lead to neurological complications (Brown et al., 2004). Past research suggests that decreased blood oxygenation may impair cognitive capabilities (Irani et al., 2017; Moss, Franks, Briggs, Kennedy, & Scholey, 2003).

Cortical areas with high metabolic demands that are not receiving adequate oxygenated blood supply because of intermittent hypoxia may result in cognitive abnormalities. More specifically, researchers have found cell injury and impacts on the blood brain barrier due to disrupted mechanisms involved in chronic inflammation associated with asthma (Wang, Mou, Wang, Song, Wei, Ren & Song, 2023). Other noted anatomical differences between those with and without asthma include significantly smaller hippocampal volume in those with asthma compared to controls. (Carlson et al. 2016). This of course has cognitive implications including differences in memory integration and spatial abilities. Moreover, oral corticosteroid use for symptom management negatively impacts limbic system structures including hippocampal integrity and amygdala volume (Kroll & Ritz, 2023). Importantly structural abnormalities differ when evaluating age and disease variables such as severity and asthma control.
Though past literature has continued to explore cognitive functioning and memory in children, adults, and older adults with asthma, little is known of the impact on young adults with asthma. As such, there is scant literature that examines the effect of asthma on global intellectual functioning, processing speed, language, and other neurocognitive areas in young adults.
Chapter 2: Literature Review

Impact of Asthma Control

Differences in cognition among those with asthma may be related to asthma control and asthma severity. Among other variables, asthma control is measured by medication compliance, experiences of shortness of breath, number of hospitalizations, and sleep disturbance (Nathan et al., 2004). Those with better controlled asthma and thus, better management of symptoms, are less likely to experience asthma attacks.

A series of variables should be considered when assessing asthma control such as symptom severity, school absences, and sleep disturbances. Past research suggests that children have worse asthma control even when controlling for age related differences (Kuehini and Frey, 2002). That is, if a child has poorly controlled asthma, they are more likely to require hospitalizations, leading to missed school days. Senter et al. (2020) found that students with poorly controlled asthma have significantly more absences than their peers, missing close to two weeks of school per year. This study found asthma to be associated with worse Measures of Academic Progress (MAP) and standardized test performance as measured by the Partnership for Assessment of Readiness of College and Careers (PARCC). In this way, cumulative disadvantage may occur if early detection interventions are not implemented to support academic achievement growth.

Predictors of cognitive performance within asthma populations may include the individual’s perceived control of their asthma as measured by self-report questionnaires. Comparatively, other studies have used more subjective measures of asthma control such as the Asthma Control Test and the Asthma Control Questionnaire. Researchers using the Asthma Control Questionnaire, a measure of control of symptoms in the past week, have found
inconsistent results, with asthma control negatively correlated with scores on a measure of global cognitive functioning, but this finding loses significance when controlling for age in both young adults (Ray et al., 2015) and elderly populations (Kroll et al. 2018). Whereas studies that elected to utilize the Asthma Control Test, a measure of control of symptoms in the past month, suggest children with poorly controlled asthma have worse executive functioning abilities in comparison to healthy controls (Sonney & Insel, 2018). To further understand the relationship between asthma control and cognition, the current study will explore the association between self-reported scores on the Asthma Control Test and measures of executive functioning in asthma participants.

Researchers have considered pathophysiological variables such as forced expiratory volume (Chung et al. 2014) in determining asthma control. Forced expiratory volume (FEV), is associated with tasks of executive functioning and is a common measure of respiratory function utilized as a measure of asthma control. Across asthma participants and those with COPD, FEV was negatively correlated with all measures of cognitive functioning in that worse airway obstruction was associated with worse cognitive functioning (Ray et al., 2015). Results suggest that individuals with asthma have poorer executive functioning in comparison to healthy controls when using FEV (objective measurement) as a measure of asthma control but not when using the Asthma Control Questionnaire (self-report measurement). Additionally, measures of asthma control, such as FEV, provide more nuanced comparison in respiratory functioning among asthma in comparison self-report participants.

In addition to executive functioning, past literature has focused on cognitive processing globally rather than focusing on executive functioning exclusively. Using the Montreal Cognitive Assessment (MoCA), a test used to assess mild cognitive impairment, Caldera-Alvarado et al.’s
(2013) research team explored differences in cognitive impairment among those with and without asthma. Variables related to asthma control (FEV, corticosteroid use) were not associated with neuropsychological outcome variables. After controlling for demographic characteristics (e.g., age, gender), inhaled corticosteroid use, self-reported health status, and FEV were associated with a 78% increased risk of cognitive impairment. This finding necessitates further research into the degree to which asthma control impacts cognitive ability. Rather than utilizing FEV as a measure of asthma control, self-reported measures of asthma control will be collected.

Taken together, further research is needed to evaluate the extent to which asthma control is associated with measures of executive functioning in young adult populations. To provide a more comprehensive measure of asthma control, the current study aims to examine this gap by shedding light on cognitive difference in young adults with and without asthma by using the Asthma Control Test as a measure of asthma control.

**Impact of Asthma Severity**

Asthma disease severity may be categorized by the medical intervention needed to alleviate symptoms. Those with severe asthma necessitate frequent high dosage corticosteroids use in comparison to those with mild or moderate asthma (Chung et al., 2014). This group may also include those who are unresponsive to medical interventions or unable to access treatment (Blackman & Gurka, 2007). Additionally, those with poor control of their symptoms necessitate more medical intervention and in turn, experience severe asthma. Overall, those with severe asthma require more frequent use of medical intervention to control symptoms, experience more asthma attacks, and have more intermittent hypoxic events (Irani, Barbone, Beausoleil, & Gerard, 2017).
Cognitive Weakness in Children and Adolescents with Asthma

Research findings suggest children are vulnerable to asthma-related cognitive deficits (Fryt et al., 2013). Specifically, children with asthma struggle with set-shifting and attention (Fryt et al., 2013). Illness variables such as asthma control suggest worse asthma control may result in more errors and slow response rates on cognitive tasks (Fryt et al., 2013). Additionally, the cognitive deficits emphasized are consistent in clinical presentations of ADHD. However, further investigation is needed to see if the same findings exist among young adult populations.

In addition to set shifting and attentional deficits, children with asthma have worse processing speed in comparison to healthy controls. When comparing global cognitive functioning of children who had sustained an ischemic stroke, children with asthma, and controls, children with asthma did not demonstrate significantly different cognitive capabilities in comparison to children who had sustained ischemic strokes. Specifically, the Weschler Intelligence Scale for Children’s (WISC) general IQ composite and processing speed index scores of children with asthma were significantly worse than normative controls in domains of inhibitory control, sustained attention, and processing speed. Importantly, these areas of higher-order functioning are associated with executive functions within the prefrontal cortex, a cortical region with a high metabolic demand. Though findings suggest deficits in executive functioning exist among children with asthma, this finding is limited by its inability to provide a measure of asthma control. To address these limitations, the current study will capture the mediating effect of asthma severity within the young adult population.

Despite literature supporting cognitive differences between children with and without asthma, there is still some degree of inconsistency. A past meta-analysis found no significant differences in cognitive performance between children with and without asthma (Milton,
Whitehead, Holland & Hamilton, 2004; Annet et al., 2000). Further research is needed to observe differences between those with and without asthma.

**Cognitive Weakness in Adult Asthma Populations**

There is a well-established literature supporting the relationship between cognitive processing in adults with and without asthma (Rhoyu & Nam, 20201; Irani, Barbone, Beausoleil, &Gerard, 2017). When comparing global cognitive impairment as assessed by the MoCA in those with and without asthma, there was a significant negative correlation between global cognitive impairment, disease severity asthma duration, and a significant positive correlation between global cognitive impairment and lung functioning (Rhoyu & Nam, 2021). Severe asthma was defined as 3 or more asthma attacks necessitates corticosteroid intervention. Looking at these findings more closely, cognitive variables were not significantly differently according to asthma severity (severe vs non-severe asthma. Further exploration is needed to understand the relationship between cognitive functioning, asthma control, and asthma severity in asthma populations given inconclusive findings of the impact of disease variables.

Regarding specific cognitive domains, individuals with asthma struggle with set-shifting, worse inhibition abilities, and worse attentional performance in comparison to healthy controls (Rajabi et al.,2018). The Wisconsin Sorting Task, Stroop and the Continuous Performance Test are common tasks for assessing executive functioning capabilities. Individuals with asthma demonstrated significantly more perseverative errors and inability to adapt to new test principles within the Wisconsin task (Rajabi et al., 2018). These results suggest people with asthma have worse set-shifting skills in comparison to healthy controls. Similarly, individuals with asthma committed more errors and had slower reaction times on the Stroop task, suggesting worse inhibition abilities in comparison to healthy controls (Rajabi et al., 2018). Moreover, individuals
with asthma demonstrated significantly worse performance on the CPT, committed more commission errors and demonstrated worse attentional performance over all (Rajabi et al., 2018). This study sets an important foundation for the justification of selecting these tests to serve as a measure of executive functioning in young adult asthma populations.

**Cognitive Weakness in Older Adult Asthma Populations**

In addition to duration of asthma and disease severity, increased age poses an additional risk factor for cognitive deficits. Previous literature has demonstrated that the disease burden associated with asthma may lead to cognitive deficits in older adults. Past research indicates a more prominent relationship between airway obstruction and cognitive variables than asthma control and cognitive variables among older adults. However, these cognitive differences were no longer statistically significant when adjusting for age, sex, race and ethnicity, education, income, English proficiency, and current depression. Researchers assessed working memory (Wechsler Adult Intelligence Scale III (WAIS), Letter- Number sequencing), processing speed (Trail Making Test A (TMT-A), executive function (Trail Making Test B (TMT-B), word fluency (animal naming), and delayed recall (Wechsler Memory Scale Story A (WMS- Logical Memory))(Ray et al. 2015). Results indicated that 48% of the sample had poor asthma control as measured by the Asthma Control Questionnaire (ASQ) and higher rates of airway obstruction or spirometry FEV (Ray et al. 2015). Moreover, differences in scores with respect to FEV suggested worse cognitive performance for processing speed, attention and working memory, and global cognition among older adults with asthma.

**Current Study Rationale and Aims**

Though there is literature supporting the relationship between asthma and cognition in older adults (Ray, 2015) and younger children (Hajek et al., 2014), there is limited literature
observing asthma sequelae on young adults. Most recently, Irani, Barbone, Beausoleil, & Gerard, 2017 (2017) sought to bridge the gap in this literature. A meta-analysis found that in a demographic that was largely White (54.15%) women (52%) with a mean age of 25 years, there was a significant effect size (-.36) for age in individuals with asthma and cognitive deficits. That is, as age increased, cognitive deficits decreased with younger individuals showing the worst cognitive deficits. Sex related differences indicated males had worse cognitive outcomes. Strongest effect size (medium-sized) was for global cognitive functioning and included academic achievement, executive functioning, processing speed, attention, visuospatial functioning, language, learning and memory. Most importantly, several demographic moderators were examined. Young males from low annual household incomes that identified as African American, Hispanic or of another racial/ethnic minority had greater cognitive burden (medium effect size) compared to those with mild to moderate asthma.

In addition to cognitive variables, young adults with asthma may have deficits in subcortical structures associated with cognitive functioning such as the hippocampus, situated in the medial temporal lobe (Kroll et al, 2018). Individuals with asthma had lower levels of metabolites in these regions, however, there were no statistically significant group differences in hippocampal volume (p > .05) or mild cognitive impairment as measured by the Montreal Cognitive Assessment (MoCA) (Kroll et al., 2018). When examining cognitive scores and metabolites and controlling for hippocampal volume in both groups, those with higher levels of glutamate performed better on global cognitive function measures (Kroll et al., 2018). However, this trend did not reach statistical significance for asthma participants alone.

Despite the literature that has accumulated related to asthma and global cognitive functioning, further research is needed. Taken together, past studies conducted by various
Researchers support the assertion that asthma can impact an individual’s physical and cognitive functioning. To further understand how asthma control affects executive functioning, the current study seeks to explore the association between asthma and cognitive domains including sustained visual attention, executive functioning, and working memory. The current study aims to provide further evidence on how asthma impacts cognitive resources in young adults with asthma.

Aim I: To examine differences in cognitive functioning between those with and without asthma.

Hypothesis 1: There will be differences in performance on tasks of cognitive functioning between young adults without asthma and young adults with asthma.

Aim 2: To examine the association between asthma symptomology and measures of executive functioning.

Hypothesis 1: Scores on the Asthma Control Test will be associated with efficiency on tests of cognitive functioning.

Hypothesis 2: Asthma participants’ self-reported severity (mild, moderate, severe) will be associated with efficiency on tests of cognitive functioning.
Chapter 3: Methods

The current study is a secondary exploratory analysis of research conducted in 2018.

Participants

All participants were recruited from West Chester University’s SONA system. Participants were excluded from data analysis based on a history of respiratory illness other than asthma, other comorbid illness such as epilepsy, traumatic brain injury, or active psychosis. Prior to participation, all participants provided written consent. All participants who completed the research trial were granted course credit. Inclusion criterion for asthma participants was a self-reported asthma diagnosis as well as written consent to participant in the study. Prior to in-person participation, participants were asked to complete an online screening form to assess exclusion/inclusion criterion.

Measures:

Neuropsychological Testing

The University of Pennsylvania’s Computerized Neurocognitive Batter (CNB) measures a series of neuropsychological domains including abstraction and mental flexibility, attention, working memory, episodic memory, face memory, spatial memory, language reasoning, spatial processing, sensorimotor processing speed, motor speed, and emotion identification. Comprehensive analysis of the battery suggests that the CNB effectively captures these neuropsychological domains (Moore et al., 2015). Research by Gur et al. (2010) demonstrated good reliability and internal consistency with Cronbach alphas for each of the subtests within the Penn CNB ranging from moderate (0.77) to strong (0.95) for measures of accuracy and moderate (0.77) to strong (0.97) for response time.
To evaluate cognitive performance, the CNB was administered by trained research staff on the lab’s laptop. This comprehensive battery assessed a number of cognitive domains such as attention, mental flexibility, emotion recognition, and facial memory. The current study will utilize the following tasks of executive function, attention and working memory. The following descriptions of the selected tests are consistent with the descriptions of the Neuropsychiatry Department’s Penn CNB Test Descriptions Master List (Gur, 2015):

**Executive functioning**

**PCET: Penn Conditional Exclusion Task**

Penn’s Conditional Exclusion Test is a test of executive function that measures abstract thinking and mental flexibility. Similar to the Wisconsin Card Sorting Test (WCST), this computerized test asks participants to select the item in a pattern that does not belong. Once the test begins, four items are displayed in the center of the screen in a straight line. The participant is asked to click on the item that does not belong. There are three criteria for exclusion which change once the participant has achieved 10 consecutive correct answers. The principles include line thickness, shape, and size. The participant has 48 trials to get 10 consecutive answers correct for each principle. Though the participant is not told the principle, the participant must derive the principle by receiving feedback from each correct response. If the participant does not receive 10 consecutively correct answers within the 48 trials, the test ends.

Analysis compared healthy controls and asthma participants on several outcome measures. Second level analysis examined the association between asthma control and the outcomes measures that include number of correct responses as well median response time. Additional error analysis scores are available such number of errors and perseverative errors or
when the participant makes an incorrect response following 3 incorrect responses based on a previous criterion.

**SPCT: Short Penn Continuous Performance Test**

The Short Penn Continuous Performance Test (SPCPT) is a test of visual attention and executive function. This test is similar to the Conner’s Continuous Performance Test as it offers a measure of attention and vigilance. The SPCPT consists of two conditions, letters, and numbers. In the letter condition, the participant is asked to press the spacebar whenever the flashing lines form a complete letter. Similarly, in the number condition, the participant is asked to press the spacebar whenever the flashing lines form a complete number.

Analysis compared healthy controls and asthma participants on several outcome measures. Second level analysis examined the association between asthma control and the following outcomes measures. The SPCPT is based on several correct responses as well median response time. Specifically, the SPCPT provides measures of true positive, true negative, false positive, and false negative responses. Efficiency scores are also calculated by dividing the sum of true positive response by the median response time for true positive responses.

**SLNB: Short Letter N Back Test**

The Short Letter-N-Back task is a test of attention and working memory. In this test, participants are asked to attend to letters presented on the computer screen. The participants are asked to comply with three different principal conditions: the 0-back, the 1-back, and the 2-back. During the 0-back, the participant is asked to press the space bar whenever the letter “X” is presented. During the 1-back, the participant must press the space bar whenever the letter presented is the same as the previous letter. For example, if the letters presented are A, E, E, the participants will press the spacebar the second time E is presented. During the 2-back, the
participant will press the space bar when the presented letter is the same as the letter presented before the previous letter. For example, if the letters presented are E F E, the participant must press the space bar when the E is presented for the second time.

Several outcome measures were included in the analysis. True positive and true negative variables are calculated by summing the number of correct responses. Efficiency scores are also calculated by dividing the sum of true positive responses for both the 1-back and the 2-back divided by the median response time for true positive responses for both the 1-back and the 2-back.

**Differentiation Between Asthma and Control**

The Asthma Control Test (ACT; Appendix A), a publicly accessible five item questionnaire, was given to all participants. This questionnaire provided a measure of how well managed asthma symptoms were in the past 4 weeks. Items included “how much of the time did your asthma keep you from getting as much done at work, school or home” and “how often have you had shortness of breath.” The scores ranged from 5 (poor controlled) to 25 (well controlled). All participants were given the ACT regardless of their asthma status so that future analysis could examine the impact of symptoms of shortness of breath and other pulmonary symptoms on cognition. This questionnaire demonstrates overall good internal consistency reliability ($a = 0.84$) (Nathan et al., 2004). More specifically, the ACT demonstrates strong internal consistency reliability in individuals with poorly controlled asthma ($a = 0.83$) and individuals with well controlled asthma ($a = 0.79$) (Nathan et al., 2004).

**Sociodemographic Measures**

Participants completed a sociodemographic form prior to completing the CNB. This form captured age, race/ethnicity, gender, estimated household income, sexual orientation, and
disability status. This form also gathered important information regarding corticosteroid usage as well as comorbid medical and psychological conditions.

**Procedure**

*Informed Consent and Confidentiality*

All research procedures were conducted by the trained research assistants (RA) within Dr. Farzin Irani’s research lab space in Wayne Hall from 2014-2018. Prior to participation, the RA was given a physical copy to read over. The RA reminded the participant that their participation is voluntary, and they may elect to discontinue participation without penalty at any point during the study. The RA answered any questions the participant had before obtaining their signature. If informed consent had been obtained, the RA continued to the next portion of the study. If the participant refused to consent, the participant was thanked for their time and allowed to leave. After informed consent had been obtained, participants complete the sociodemographic forms, the asthma control test (ACT), and UPenn’s CNB. All data collected from participants was deidentified to ensure the participant’s privacy and confidentiality. Participants were provided with the SONA credit regardless of completion of testing.

*Debriefing*

The debriefing procedure proceeded after completion of all testing or if the individual elected to discontinue participation at any point in the study. Following completion of the battery, the participant was debriefed by a research assistant and thanked for their participation. The RA shared that the aim of the study was to examine the relationship between asthma and cognitive functioning. The research assistant answered any of the participants’ questions. The participant was provided with a printed copy of the debriefing statement including the WCU
Counseling Center’s contact information along with the primary investigators contact information should the individual have any outstanding questions.
Chapter 4: Results

Data Analytic Strategy

Prior to running any analyses, the data was checked to ensure that data had been entered correctly and that no data were missing. Before conducting analyses, the researcher reviewed behavioral observations gathered during data collection (e.g. environmental integrity, compromised computerized administration, etc.) Shapiro-Wilk normality tests and visual inspection of histograms failed to demonstrate normality (p < 0.05) for both groups. There were significant outliers (> two standard deviations) as determined by inspection of boxplots for all cognitive tests. As such, a total of 19 significant outliers for each group were removed. Additionally, within each individual cognitive test, there was additional missing data due to administrative errors or poor data quality.

Data was collected from 271 participants. The research team divided participants into two groups based on their self-reported asthma status. Those who endorsed asthma diagnoses were grouped into the asthma group (n = 109) whereas those who did not endorse a current or past diagnosis of asthma were grouped into the control group (n= 162). Three unspecified participants were excluded from the analysis. Regarding age, asthma participants were 19.22 years old (+/- 1.68), and control participants were 19.14 years old (+/- 2.01). For more specific demographics by group, see Table 1.

Asthma control status was measured from all participants. An independent sample-test was run comparing asthma participants and control participants asthma control test scores. Homogeneity of variance was not assumed as assessed by Leven’s test for Equality of Variances (p <.05) There was a statistically significant difference between asthma and control participants on measures of asthma control. Specifically, asthma participants had lower scores of asthma
control (M = 20.68, SD=3.58) than healthy controls (M = 24.70, SD=0.82), with a difference of -4.02 (95% CI) (t (1, 112.68) = 11.194, p <0.001. Notably, asthma control scores within the range of 20-25 are still indicative of well-controlled asthma (Nathan et al., 2006).

The Penn CNB battery provided measures of efficiency scores (accuracy/log Median Response Time for Correct Responses) for group comparison of cognitive variables. Independent sample t-tests were conducted comparing efficiency scores between asthma and control participants to address the first aim and hypothesis of examining differences in cognitive functioning between those with and without asthma. Differences in efficiency scores between asthma and control participants on measures of cognitive functioning were not significant. Homogeneity of variance was assumed as assessed by Leven’s test for Equality of Variances (p >0.05) for all cognitive measures except the PCET. Therefore, independent t-tests were run on the data with a 95% confidence interval for the mean difference. The asthma group’s efficiency scores (M= 0.23, SD =0.08) were lower in comparison to the control group (M = 0.24, SD = 0.07), (t (192.18) = -1.84, p = 0.07, with a difference of -0.02 (95% CI) on the PCET. On the SLNB the asthma group’s efficiency scores (M = 3.06, SD =0.20) were lower in comparison to the control group (M = 3.07, SD = 0.18), (t (242) = -0.54, p = 0.59 with a difference of -0.01 (95% CI). On the SPCPT, the asthma group’s efficiency scores (M= 8.99, SD= 0.95) were higher in comparison to the control group (M= 8.86, SD = 0.77), t (242) = -0.536, p = 0.59 with a difference of -0.01 (95% CI).
Table 1

Demographics for Asthma and Control Groups

<table>
<thead>
<tr>
<th>Measure</th>
<th>Asthma Group</th>
<th></th>
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</tr>
<tr>
<td>Unspecified</td>
<td>8</td>
<td>7.4</td>
<td>8</td>
<td>4.9</td>
</tr>
<tr>
<td>Current Academic Year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman</td>
<td>63</td>
<td>58.3</td>
<td>119</td>
<td>73.5</td>
</tr>
<tr>
<td>Sophomore</td>
<td>25</td>
<td>23.1</td>
<td>24</td>
<td>14.8</td>
</tr>
<tr>
<td>Junior</td>
<td>15</td>
<td>13.9</td>
<td>8</td>
<td>4.9</td>
</tr>
<tr>
<td>Senior</td>
<td>3</td>
<td>2.8</td>
<td>9</td>
<td>5.6</td>
</tr>
<tr>
<td>Non-Degree</td>
<td>1</td>
<td>0.9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unspecified</td>
<td>1</td>
<td>0.9</td>
<td>2</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Table 2

Results of Independent T-Test Comparing Cognitive Measures of Efficiency Between Groups

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Asthma M</th>
<th>SD</th>
<th>Control M</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLNB</td>
<td>3.06</td>
<td>0.20</td>
<td>3.07</td>
<td>0.18</td>
<td>-0.54</td>
<td>242</td>
<td>0.59</td>
<td>0.19</td>
</tr>
<tr>
<td>SPCPT</td>
<td>8.99</td>
<td>0.96</td>
<td>8.86</td>
<td>0.77</td>
<td>1.21</td>
<td>242</td>
<td>0.22</td>
<td>0.85</td>
</tr>
<tr>
<td>PCET</td>
<td>0.23</td>
<td>0.08</td>
<td>0.24</td>
<td>0.07</td>
<td>-1.84</td>
<td>192.18</td>
<td>0.06</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Correlations

Correlations were run to address aim 2 and examine the association between asthma symptomology and measures of cognitive functioning in asthma participants. Specifically, two correlations were run. The first correlation, to address hypothesis 3, was run to identify associations between asthma control test scores and efficiency on tests of cognitive functioning. There was no significant correlation between efficiency scores on the PCET and asthma control scores $r(96)=0.08, p=0$. There was no significant correlation between efficiency scores on the SLNB and asthma control scores $r(92)=0.06, p=0.58$. There was no significant correlation between efficiency scores on the SCPT and asthma control scores $r(98)=-0.01, p=0$. These results are represented in Table 3.

To address aim 4, bivariate correlations were run to explore the association between asthma severity and cognitive efficiency measures in asthma participants. There was no significant correlation between asthma severity and efficiency scores on the PCET $r(98)=-.09, p=0.36$. There was no significant correlation between asthma severity and efficiency scores on the SLNB $r(93)= -0.05, p=0.64$. There was no significant correlation between asthma severity and efficiency scores on the SCPT $r(99)=-0.06, p=0.56$. These results are represented in Table 3. Notably, Caldera-Alvarado (2021) found asthma severity was associated with cognitive...
impairment but did not find severe asthma was associated with cognitive impairment. As such, it is possible because the given sample is representative of a well-controlled moderate severity asthma population, that is why there is no association between asthma severity and cognitive outcomes.

**Post Hoc Analysis**

Past literature has differed in the definition of asthma disease severity and asthma control. Correlations were run to explore whether asthma severity and asthma control are related variables. (Table 3). There was a significant negative moderate correlation between asthma control and asthma severity \( (r(102) = -0.39, p < .001) \). This relationship suggests that as asthma control decreases, asthma severity increases.

Results from the a-priori analytic plan did not yield statistically significant results. However, results comparing cognitive efficiency between asthma and control participants were approaching statistical significance \( p = .07 \). To further explore this relationship assuming the directional hypothesis that asthma populations would demonstrate worse performance, one-tailed independent sample t-tailed tests were run to compare cognitive efficiency measures between those with and without asthma. Homogeneity of variance was not assumed as assessed by Leven’s test for Equality of Variances \( p < .05 \). Findings support asthma participants \( (n = 100) \) were less efficient \( (0.22, SD=0.08) \) than healthy controls \( (n = 152) \) \( (0.24, SD=0.24) \) \( t (192.18) = -1.84, p = .03 \).

Previous research has found on similar tasks such as the Wisconsin Sorting Tasks, individuals with asthma are more likely to commit perseverative errors in comparison to their healthy peers (Taha, 2017; Rajabi et al., 2018). An independent sample t-test was conducted to
explore whether there was a difference in perseverative errors between asthma and control participants. The cognitive battery codes perseverate errors or a participant’s given response based on the previous ruling criterion despite continued negative feedback. This component measures cognitive flexibility or the ability to adapt to a new governing principle. Homogeneity of variance was not assumed as assessed by Leven’s test for Equality of Variances (p < .05).

Findings support asthma participants (n = 100) demonstrated significantly more (15 +/- 9.25) perseverative errors than their healthy peers (n = 152) (12.42, SD=.7) t (184.74) = 2.66, p = .004. This finding is consistent with Rajabi et al.’s (2018) research that supports the idea that young adults with asthma, even when well-controlled, are more likely to commit perseverative errors.
Chapter 5: Discussion and Clinical Implications

The current study aimed to fill a gap in the literature on the functional effects of asthma on executive functioning in young adult populations. The existing literature suggests that individuals with poorly controlled asthma are more likely to experience worse symptoms and more frequent exacerbations. As such, those with worse control are likely to experience more severe asthma. The neurocognitive consequences of poor respiratory functioning among individuals with asthma suggest intermittent hypoxic events can negatively impact the amount of oxygenated blood in the brain and, in turn, cognitive processes (Kroll et al., 2018). Research has demonstrated that this association between asthma and cognition differs by age (Ray, 2015), asthma control (Chung et al., 2014), and asthma severity (Irani et al., 2017).

First, the current study examined if there were any differences in executive functioning at the group level. No significant differences were found between groups regarding executive functioning skills as measured by efficiency measures on Penn’s CNB. Second, the research team explored whether asthma control or severity would predict cognitive performance for asthma participants. However, neither of these variables was significantly associated with executive functioning variables. One reason for this may be the subjective nature of these measures. As mentioned, the Asthma Control Test is a self-report measure that asks the participant to rate their symptoms in the past four weeks. Other studies have found success correlating asthma control with cognitive measures that use more objective momentary measurements of asthma symptomology, such as FEV (Ray et al., 2015). Another reason may be the overall well-controlled and mild severity of the sample.

Overall, the gathered sample included young adult asthma participants with mild and well-controlled asthma. Within this context, there were no significant differences in efficiency
across the different cognitive measures. Performance on one measure of mental flexibility, Penn’s Conditional Exclusion Task, approached statistical significance with marginal differences between groups. Given that previous research has demonstrated a significant relationship with asthma participants underperforming in comparison to controls, a one-tailed t-test was run. This difference was statistically different when taking a less conservative approach in comparison using a one-tailed t-test. Moreover, asthma participants committed more perseverative errors within this task than control participants. This difficulty with setting shifting is established in the literature and may have become more apparent had participants been more symptomatic (Rajabi et al., 2018).

Clinical Implications

Despite retaining the null hypothesis, the current study provides further evidence that young adult populations with well-controlled asthma group do not demonstrate significantly different executive functioning capabilities compared to healthy controls. These results suggest the importance of thorough assessment, medication adherence, and symptom management. Those with well-controlled asthma necessitate longer-term corticosteroid use and are still susceptible to exacerbations (Reddel, Ware, Marks, Salome, Jenkins, and Woolcock (1999, & Chan and Lipworth, 2022.) However, as represented by the findings of this study, well-controlled asthma is not associated with significant cognitive burden. With respect to integrative care, physicians and psychologists should be mindful of the impact asthma can have on cognitive functioning when symptoms are severe asthma. As such, clinicians should be mindful of thorough differential diagnostic assessment in understanding organic and/or environmental perpetuants.
Differences in cognition have also been found in adult populations on tasks assessing for mild cognitive impairments, but this result was most prevalent in older adults (Rhoyu, 2021; Caldera-Alvarado, 2013). When comparing this study’s findings to others that looked explicitly at executive functioning, it seems significant differences were found in child populations where asthma was poorly controlled, and executive function was measured using no-go tasks, card sorting, and a Stroop (Cutuli, 2010). Though there are similarities between card sorting tasks and CNB subtests such as the PCET, insignificant findings may underscore the importance of gaining asthma control.

**Limitations and Future Directions**

There are several limitations to consider within the current study. Due to recruitment occurring on a state college campus, participants were primarily White middle-class young adults with self-reported well controlled asthma. Literature supports that the current asthma population is consistent of BIPOC individuals and perhaps this studies’ sample has fallen short in accurately representing this population, thus sacrificing external validity. As such, future directions could include examination of larger, more diverse community samples and more in depth analysis of clinical and pharmacological data including medication dosage and frequency to provide a more nuanced understanding of asthma control. More research is needed in understanding the impact of underlying intermittent hypoxia on brain networks. Previous researchers have used functional near-infrared spectroscopy to get an instant read of hemodynamic status to areas of high cognitive demand (Pinti, Hamilton, Hirsch, Aichelburg, Gilbert, & Burgess, 2020). Future studies may consider utilizing this technology to compare asthma and control populations’ levels of oxygenated blood to the prefrontal cortex, a brain area associated with executive functioning tasks.
References


Chan, R. & Lipworth, B. (2022) Determinants of asthma control and exacerbations in moderate to severe asthma, *Journal of Allergy Clinical Immunology Practice*, 11 (10), pgs. 2758-2760.


National Health Interview Survey (NHIS), (2019), Most Recent National Asthma Data, CDC, https://www.cdc.gov/asthma/most_recent_national_asthma_data.html


Appendix A: IRB Approval Letter

Thesis/Doctoral Culminating Project - Registration and Research Compliance Form

This form is required and should be completed by all students working on a master’s thesis or doctoral culminating project. The form registers your project with the Graduate School and confirms the faculty advisor. Advising and research mentoring are the responsibility of the student’s Faculty Advisor and/or Committee Members.

WCUPA complies with federal regulations regarding the use of human subjects in research. Research sponsored, supported, or conducted by its faculty, staff, or students must not expose people who participate as subjects to unreasonable risk to their health, general well-being, or privacy. Student research projects that involve human beings as subjects must be conducted according to the university policy for the protection of human subjects.

It is the faculty advisor’s responsibility to ensure that students and their research are conducted in accordance with WCUPA University policies, and have a research protocol approved by the Institutional Review Board for the Protection of Human Subjects (IRB) for research with human subjects and the IACUC for research with animals. Students apply for IRB review by completing a protocol form that can be downloaded at https://www.wcupa.edu/_admin/research/irb.aspx and submitting it for review and routing to the IRB Committee for consideration. If you have any questions regarding the IRB, please email irb@wcupa.edu.

To be completed by the student:

Name: Erin Walsh

Phone Number: 7327789660

Student ID# 0829545

WCU Email: EW829545@wcupa.edu

Check one:

☐ Master’s Thesis  ☐ DPA Dissertation  ☐ EdD Dissertation  ☐ DNP Project  ☐ PsyD Dissertation

Degree: Clinical Psychology, PsyD

Chairperson: Geeta Shivde, PhD

Anticipated Title of Study: Cognitive Functioning in Well-Controlled Asthma Populations

Anticipated Graduation: Spring 2024

If your project involves human or animal subjects, please provide protocol number and date of approval from the IRB/IACUC:

IRB-FY2022-174  2/11/2022

Faculty Advisor/Committee
Signature of Student: Eri R Walsh

Signature of Faculty Advisor/Committee Chairperson: Geeta Shivde

Faculty Advisor/Committee Chairperson Contact Information: Geeta Shivde  gshivde@wcupa.edu

Date: 10/16/2023
Appendix B: Consent Form
Consent for Research Participation

Project Title: Neuropsychological Effects of Asthma
Investigator: Farzin Irani, Ph.D. Department of Psychology, firani@wcupa.edu 610-436-2271

You are being asked to participate in a research project conducted through West Chester University of PA. The University requires that you give your signed agreement to participate in this project. The investigator or her representative will explain to you in detail the purpose of the project, the procedures to be used, the expected duration or frequency of your participation, and the potential benefits and possible risks of participation. You may ask her any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have.

If you decide to participate in the project, please sign on the last page of this form in the presence of the person who explained the project to you. You will be given a copy of this form to keep.

Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

Purpose: To examine the effects of having asthma and not having asthma on cognitive task performance.

Procedures: You will be asked to complete paper questionnaires and then sit in front of a computer to complete thinking tests. The procedure will last approximately 1.5-2 hours.

Discomfort & Risks: There are no known risks to this study except fatigue. You will be provided opportunities to take breaks as needed.

Benefits: There are no direct benefits to you for participation, but you will learn more about the psychological research process and cognitive testing. The results will also help improve our understanding of cognition in asthma.

Compensation: You can receive course credit for your Introductory Psychology course by participating in the PSY100 SONA systems pool.

Confidentiality: Your participation in this research will be kept anonymous since your data will be identified with a number. Any identifying information (e.g. consent form) will be stored in a secure cabinet that will be accessed only by the researcher and her assigned assistants.

Withdrawal: Your participation is completely voluntary. You may withdraw your consent and discontinue participation at any time without penalty.

Contact Information: If you would like more information about this study, a summary of the result or if you incur any physical injury during your participation, please contact: Farzin Irani, Ph.D., People’s Building room 46, 610-436-2271

If you would like us to contact you for future research please provide your contact information: _________________________

If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Institutional Review Board through the OSR, 610-436-3357.

I have read this form and I understand it. I understand that if at any time I become uncomfortable with this project I am free to stop my participation. I understand also that it is not possible to identify all potential risks in an experimental procedure, and I believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

Participant Signature ___________________________ Date ____________

Witness Signature ___________________________ Date ____________
Appendix C: Asthma Control Test

**FOR PATIENTS:**

**Take the Asthma Control Test™ (ACT) for people 12 yrs and older.**

Know your score. Share your results with your doctor.

1. **Step 1** Write the number of each answer in the score box provided.
2. **Step 2** Add the score boxes for your total.
3. **Step 3** Take the test to the doctor to talk about your score.

<table>
<thead>
<tr>
<th>Question</th>
<th>Score</th>
<th>Score</th>
<th>Score</th>
<th>Score</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. In the past 4 weeks, how much of the time did your asthma keep you from getting as much done at work, school or at home?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All of the time</td>
<td>1</td>
<td>Most of the time</td>
<td>2</td>
<td>Some of the time</td>
<td>3</td>
</tr>
<tr>
<td>2. During the past 4 weeks, how often have you had shortness of breath?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than once a day</td>
<td>1</td>
<td>Once a day</td>
<td>2</td>
<td>3 to 6 times a week</td>
<td>3</td>
</tr>
<tr>
<td>3. During the past 4 weeks, how often did your asthma symptoms (wheezing, coughing, shortness of breath, chest tightness or pain) wake you up at night or earlier than usual in the morning?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 or more nights a week</td>
<td>1</td>
<td>2 or 3 nights a week</td>
<td>2</td>
<td>Once a week</td>
<td>3</td>
</tr>
<tr>
<td>4. During the past 4 weeks, how often have you used your rescue inhaler or nebulizer medication (such as albuterol)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 or more times per day</td>
<td>1</td>
<td>1 or 2 times per day</td>
<td>2</td>
<td>2 or 3 times per week</td>
<td>3</td>
</tr>
<tr>
<td>5. How would you rate your asthma control during the past 4 weeks?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not controlled at all</td>
<td>1</td>
<td>Poorly controlled</td>
<td>2</td>
<td>Somewhat controlled</td>
<td>3</td>
</tr>
<tr>
<td>Well controlled</td>
<td>4</td>
<td>Completely controlled</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Copyright 2002, by QualityMetric Incorporated.

Asthma Control Test is a trademark of QualityMetric Incorporated.
If your score is 19 or less, your asthma may not be controlled as well as it could be. Talk to your doctor.

FOR PHYSICIANS:

The ACT is:

- A simple, 5-question tool that is self-administered by the patient
- Clinically validated by specialist assessment and spirometry\(^1\)
- Recognized by the National Institutes of Health
Appendix D: Demographics Questionnaire

History Form

Participant ID Number: __________
Date____________

Please fill in the blanks or circle the best choice

Demographics:
Age:_____  Sex: M / F  Height:_____  Weight:_____  Handedness: Right / Left / Ambidextrous

Race/Ethnicity: Caucasian / African American / Hispanic / Asian / Other
_________________________

Current Academic Year: Freshman/Sophomore/Junior/Senior

Family History:
Household Income: <$15K / $15k-$29K / $30K-$49K / $50k+

What is your mother’s highest level of education?  Less than High School / High School Diploma / Associates Degree/ Bachelor’s Degree/ Masters Degree / Doctorate Degree

What is your father’s highest level of education?  Less than High School /High School Diploma /Associates Degree/Bachelor’s Degree /Masters Degree/ Doctorate Degree

Do you have a family history of asthma?  Yes/No.  If yes, indicate who:

________________________________________

Medical History:
Please list any non-asthma medications you have taken, including Dosage, and Frequency if known
(Past Year):
________________________________________

(Lifetime):
________________________________________

Do you have any medical conditions?  Yes/No:  If yes, please list:

________________________________________
Have you been treated for addictive substances within the past 6 months? Yes/No.

Have you participated in electroconvulsive therapy within the past 6 months? Yes/No

Have you been diagnosed with any neurological, psychiatric, or medical diseases? Yes/No. If so, list:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Asthma: Have you been diagnosed with Asthma? Yes/No. IF YES, PLEASE FILL OUT SECTION BELOW.

Age of onset of these asthma symptoms:_______
# school days missed due to asthma flares (Past year):_______________
(Lifetime):_______________
Number of hospitalizations due to asthma (Past Year):_______________
(Lifetime):_______________
Please list your asthma medications, dosage, and frequency
(Past Year):________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
(Lifetime):________________________________________________________________________
________________________________________________________________________

How severe is your asthma? Mild Moderate Severe

Do you have any allergies? Yes/No Specify: ________________
Appendix E: Screening Form

Screening Form

Please check if you have a history of any of the following conditions?

☐ Asthma

☐ History of any neurological condition

☐ History of treatment for a psychiatric or psychological condition

☐ History of a medical condition (e.g. heart disease, diabetes, head injury)

☐ Substance dependence or abuse that is not in remission for past 6 months

☐ Electroconvulsive therapy

Please provide your contact information so we can follow up with you about your eligibility for the study.

Name: ___________________________________________

Email: ___________________________________________

Phone #: _______________________________________