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Every Breath You Take: A Study Linking the Relative Efficacies of the Asthma Control Test and the Child Asthma Severity Tool with the Pulmonary Function Test

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Abstract

Eighty nine children were recruited for the study during the child's routine asthma clinic visit by their provider. Everyone between 7 and 13 years of age were eligible. Those children and parents who agreed to participate were introduced to the study team waiting in a conference room where the study occurred. *Pulmonary Function Tests* were collected to provide the biological function of the child's lungs. In return, the child would receive a $10 Amazon gift card. The child completed the first activity by replicating the Asthma Control Test and the second activity by filling out the new survey tool, the Child Asthma Severity Tool. Results showed that the Asthma Control Test is significantly correlated with aspects of the Pulmonary Function Test but more importantly, it showed that the Child Asthma Severity Tool is significantly correlated with the Pulmonary Function Test.

Keywords: Asthma, Pulmonary function test, Asthma control test, Child asthma severity tool

1. Introduction

Asthma is a condition characterized by narrow airways and circumstances of wheezing, tightness, and coughing quite often. While this condition can impact a variety of ages, my research focused on children aged 7-13. Pulmonary Function Tests (PFT) were also collected to provide the biological function of the child's lungs. This test was then correlated with both the Asthma Control Test (ACT), a tool already used by providers and previously found to be moderately correlated (r_s=0.2758), and a new questionnaire, the Child Asthma Severity Tool (CAST), to determine its efficacy and accuracy against a PFT. It is important to understand previous literature about asthma symptoms, control, and management. Many factors influence the severity of asthma and asthma episodes in children. These include environmental surroundings, genetics, social determinants of health, asthma management etc.

When speaking about asthma, smoking tobacco products often come into conversation. While being a victim of second-hand smoke does not determine a diagnosis of asthma, "exposure to second-hand smoke (SHS) has repeatedly been shown to be associated with asthma development in both children and adults…there is sufficient evidence for a casual relationship between exposure to SHS and asthma prevalence in school-aged children." which was concluded in a Surgeon General's report (2006).

It was not until recently with the advancements of genomics that scientists could investigate how certain gene expressions relate to asthma. In fact, in 2021, Johansson *et al.* sought to link the NFE2L2 genotype with second-hand smoke exposure to see if both of these factors in children increased their risk of asthma. Data proved that when the genotype NFE2L2 interacted with second-hand smoke, the risk of asthma symptoms and severity were significantly increased. This impacts my research because it provides insight into why some children experience more severe

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asthma and hospitalization. Johansson (2021) further points out that, "household incomes were slightly higher for non-asthmatic children than for asthmatic children, [but] this difference was not statistically significant (p=.67)". This remains important because household income or zipcode is a factor for the possibility of future research of my study, but knowing that income did not remain significant may predict how it will impact my research.

Scotney *et al*. (2021) discussed recent advances in the management of different factors of pediatric asthma. These factors were also defined as "poor inhaler technique, inappropriate device selection, failure to collect medications, poor adherence to medications, and poor parental understanding of the disease." (Bracken *et al.,* 2009). Clearly a number of factors contribute to asthma severity and episode onset. The widespread introduction of the CAST questionnaire and the mobile health application would allow these factors to be better understood and controlled by parents and children. This could ultimately allow for improvement of severity and symptoms of asthma: "the most common chronic disease of childhood" (Lovinsky-Desir & Ramsey *et al*., 2019). A number of scholars have used the Pulmonary Function Test (PFT) to develop their research, and therefore supported the method I employed. In 2011, Zhang *et al*. found that Pulmonary Function Tests are important because they "can objectively and effectively reflect the actual lung conditions and functional indicators of children and are of high value for the definitive diagnosis, observation of the course of the disease and determination of its efficacy". This suggests that PFT's are important to provide information about the biological lung function of asthmatic patients, but in this case, children. This study had a somewhat similar method in that PFT results, such as Forced Expiratory Volume (FEV1), were also recorded. FEV1 is a measure of the amount of air one exhales in the first second of a Pulmonary Function Test. In a study done by Li *et al.* (2022) collecting the PFT results was used to determine the differences in results between pediatric asthma and cough variant asthma because "in the diagnosis of pediatric asthma and cough variant asthma, the clinical symptoms are mainly chronic cough, while pulmonary function tests can effectively differentiate the diagnosis and distinguish it from lung infections".

Pandit *et al.* (2013) also effectively used the Pulmonary Lung Function Test in order to measure Forced expiratory volume (FEV1) to determine "the role of yoga therapy in the treatment of bronchial asthma as an adjunct to conventional drug therapy". This study, too, used PFT results, specifically the FEV1 number. Pandit *et al*. employed this test before and after the yoga therapy in order to determine the changes in pulmonary function tests, determining that yoga therapy "resulted in decreased frequency of attacks of asthma, thereby decreasing compromising of the pulmonary function tests over the period".

The Asthma Control Test (ACT) is a widely used tool, found throughout previous literature. Created by Nathan *et al*. in 2004 as "a patient-based tool for identifying patients with poorly controlled asthma", it is validated and highly respected. Sağmen *et al.* (2020) determined that if physicians fill out the ACT, the results often indicate a greater level of asthma control. Another interesting finding by Greenblatt *et al.* (2010) was that although Sağmen's study found that gender did directly correlate with ACT results, "a significant difference was found between men and women according to the results of ACT applied by patients…however, any gender difference was not detected in the assessments made by physicians". Yanamadala *et al*. (2021) found correlations between the FEV1 of a Pulmonary Function Test and the ACT (r_s=0.2758). This demonstrates that the ACT is an accurate tool for provider use. Therefore, the Child Asthma Severity Tool (CAST) was tested for several reasons: 1) The Asthma Control Test questions are copyrighted and not to be integrated into products. 2) ACT requires parents to answer the last three questions. One goal of the creation of CAST was for the child to be able to manage his/her/their own asthma with the medical care team. The central reasons for developing CAST and testing was so that it can be integrated into a program designed to help children self manage their asthma. It is hypothesized that 1.) The Pulmonary Function Test results will be moderately correlated (r=0.5-0.7) with Child-Asthma Control Test (ACT) Scores (2. The Pulmonary Function Test results will be moderately correlated (r=0.5-0.7) with the the CAST Scores.

2. Procedure

Although collecting data for the original study generally began in late March of 2022, personal data collection did not begin until July 11, 2022, in Knoxville, Tennessee. Prior to collecting data at the East Tennessee Children's Hospital, certification was completed in two Collaborative Institutional Training Initiative courses: Biomedical

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Research- Basic/Refresher and Data & Safety Monitoring in Human Subjects Research. In addition, approval by the UTK Institutional Review Board was acquired. On the days of data collection with Dr. Tami Wyatt of the College of Nursing at the University of Tennessee-Knoxville, it took place in a conference room on the Pulmonary floor, waiting for children volunteers. The sample was strictly limited to asthmatic patients aged 7-13. When a child was present for their appointment and fit the study criteria, the child and parent were asked if they were willing to participate in a 10-15 minute survey. In return, they would receive a $10 Amazon gift card.

The parent provided an intake form with the child's initials, their Asthma Control Test (Nathan, 2004) total score that they had completed in the clinic room, and their Pulmonary Function Test (PFT) results, which had been taken by the respiratory therapist. The reasoning and purpose of the survey were outlined, consent/assent forms were thoroughly read over, and any questions were answered. Immediately thereafter, the child completed the first activity by replicating the ACT. If the child was over 12, they completed a tool specific to them with fewer items. Sometimes, children who were 12 still used the 4-11 tool with their provider based on comprehension. In this case, a decision was made to consistently have the child use the tool he/she/they previously used. On some occasions, the child's ACT total score changed depending on how similar their responses were to the one they filled out moments prior. This did not occur often, but if it did, both values were still recorded and accounted for. This would not impact the data significantly because the scores were usually very close in value.

The child then completed the second activity by filling out the new survey tool, the Child Asthma Severity Tool (Odom, 2016). The child might receive minor assistance if they had trouble comprehending a specific question, but each question had an answer done independently by the child. After completion of both activities, the child received a $10 Amazon gift card for their participation, and their information was recorded in an anonymous spreadsheet. Upon returning from Knoxville, a series of correlations were done on the data in order to determine the efficacy of the CAST questionnaire against the child's PFT results to test the accuracy and utility of the new survey tool. In order to demonstrate significance beyond 95% confidence level, the p value must be less than 0.5.

2.1 Participants

The sample consisted of young boys and girls, aged 7-13, all from or around Knoxville, Tennessee. These children were standard patients at the East Tennessee Children's Hospital Pulmonology clinic as asthma patients. Although a number of demographics may contribute to the cause and severity of one's asthma, the only factor collected for this study was age. This is because the ACT survey the children initially completed was dependent on how old they were, so it was important that the surveys were matched to their age range. In future research, demographic information such as race, gender, ethnicity, and zip code/census tract could provide new perspectives and new hypotheses. The proportion of ages can be seen in the pie chart below:

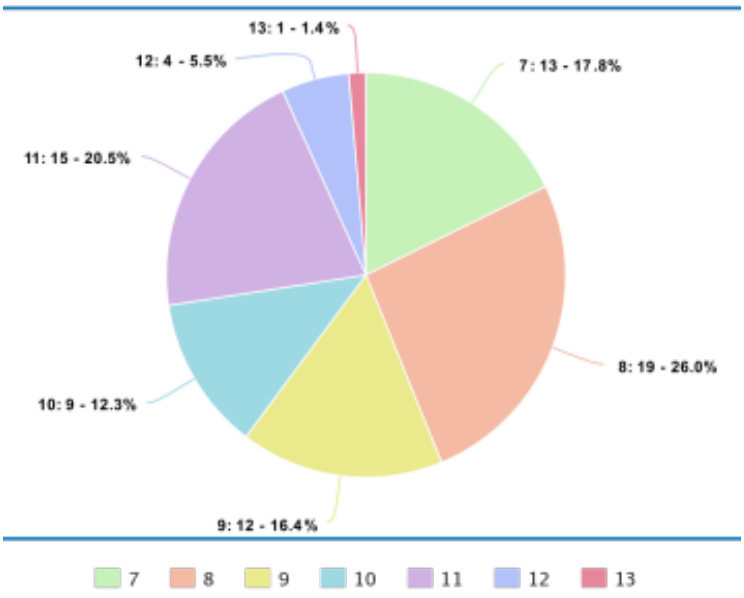

Figure 1: Demographics

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Table 1. Instruments

Title/Author	Author (s)/ Date Purpose/Sample questions
Asthma Control Test (ACT)	Nathan, R.A., et al. 2004 To determine whether your asthma is being properly controlled 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? 2. During the past 4 weeks, how often have you had shortness of breath? 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?
Child Asthma Severity Tool (CAST)	Odom, L. & Christenbery, T., 2016 To determine your daily asthma symptoms/control, for future use on a mobile application 1. Check all the symptoms you had today ___ coughing ___ wheezing or making a funny sound when you breathe ___ feeling tight in your chest, like something is pushing on your chest ___ having a hard time breathing or shortness of breath. Think about every day between today and last week that matched the same day as today (A calendar with the last 7 days highlighted will appear) 2. How many times during those days did you take your rescue medicine? a. None or only 1 time b. Between 2 and 6 times c. At least 7 times d. More than 7 times
Note: *Pulmonary Function Test, created by John Hutchinson in 1846, was also used.*	

3. Results

After all data was collected, a series of correlations were done between the ACT and CAST total scores, and also each aspect of the PFT was correlated with each aspect of both the ACT and CAST scores.

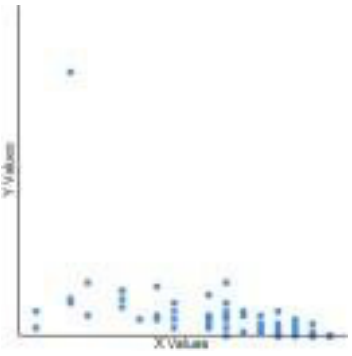

Figure 3. ACT total * CAST total **R= -.488, p<.001, n=80 [significant]**; This significant correlation determines that the CAST questionnaire is an effective tool when compared to an already published tool, the Asthma Control Test (ACT).

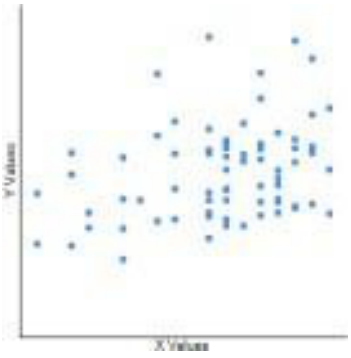

Figure 4. ACT total * FEv1 actual **R .330, p=.003, n=80 [significant]**; This significant correlation determines that the total score of the ACT is accurate when compared to the FEV1 value of a Pulmonary Function Test. This proves that the ACT total score gives an accurate biological representation of the amount of air the child can exhale in one second.

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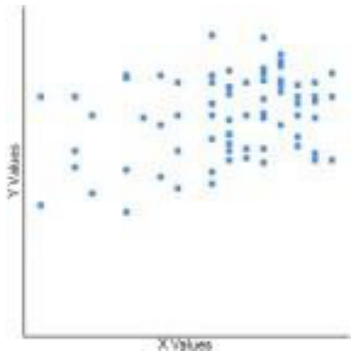

Figure 5. ACT total * FEv1 predicted **R= .304, p=.006, n=79 [significant]**; This significant correlation determines that the total score of the ACT is accurate when compared to the predicted FEV1 value of a Pulmonary Function Test. The predicted value is based on age, height, weight, race, and gender of the child taking the test.

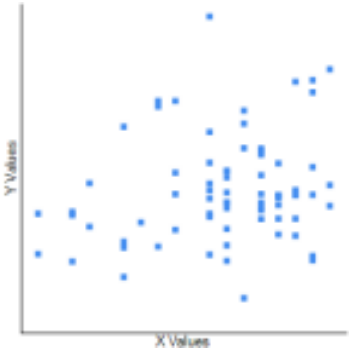

Figure 6. ACT total * FEF max actual **R= .217, p=.053, n=80 [non-significant]**; This illustrates that the ACT total score does not have any significant correlation with the actual FEF max value. The FEF max value is the maximum amount of air exhaled during the entirety of the PFT. This value did not have a significant correlation with the questionnaire, which is worthy of additional study since the FEV1 as well as the predicted value of FEF max were both significant.

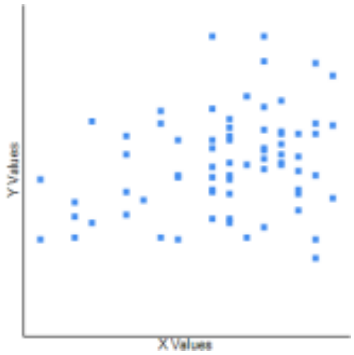

Figure 7. ACT total * FEF max predicted **R= .010, p<.05 n=80 [significant]**;This significant correlation determines that the total score of the ACT is accurate when compared to the predicted FEF value of a Pulmonary Function Test.

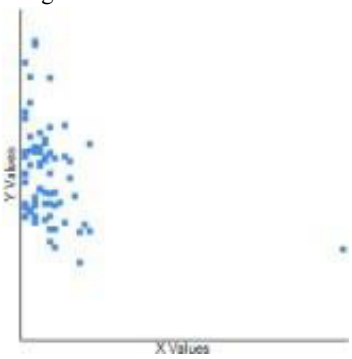

Figure 8. CAST total * FEv1 actual **R= -.296, p=.008, n=80 [significant]**; This significant correlation determines that the total score of the newer questionnaire, the CAST, is an effective and accurate tool when compared to the actual FEV1 value of the Pulmonary Function Test.

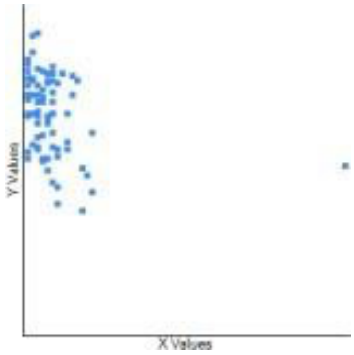

Figure 9. CAST total * FEv1 predicted **R= -.309, p=.006, n=79 [significant]**; This significant correlation determines that the CAST total score is also an effective and accurate tool when correlated with the predicted FEV1 value of the Pulmonary Function Test.

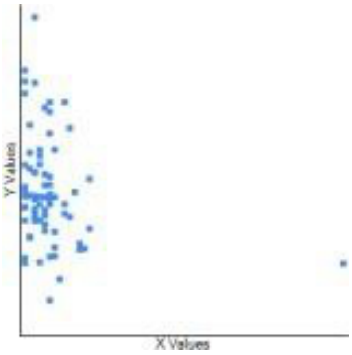

Figure 10. CAST total * FEF max actual **R= -.240, p<.05 n=80 [significant]**; This significant correlation determines that the CAST total score is also an effective and accurate tool when correlated with the actual FEF max value of the Pulmonary Function Test.

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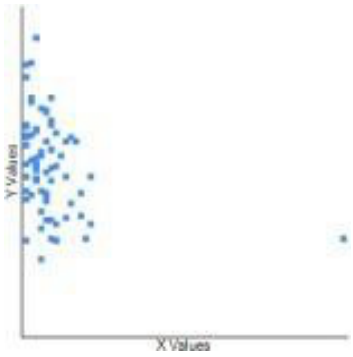

Figure 11. CAST total * FEF max predicted **R= -.310, p=005, n=80 [significant]**; This significant correlation determines that the CAST total score is an accurate value when looked at against the predicted FEF max value of the Pulmonary Function Test.

4. Discussion

This research, which is a part of the larger research project of Dr. Tami Wyatt (University of Tennessee-Knoxville, College of Nursing), can bring an important impact to the world. The results showed that the hypotheses were supported. The Asthma Control Test was significantly correlated with the values of the Pulmonary Function Test. Significantly, the Child Asthma Severity Tool (CAST) was also significantly correlated with the Pulmonary Function Test. Although the graphs illustrated what looks like a negative correlation, this is due to the CAST being reverse scored relative to the ACT. The results may inform asthma and public health researchers that Odom's CAST survey (2016) can be effectively employed to determine the severity of childhood asthma. These significant values will allow for the CAST questionnaire to be a useful tool in replace of the Asthma Control Test, but also in the situation that a hospital might not have machinery like the Pulmonary Function Test. In lower income or ill-equipped hospitals, the patients and providers can still receive an accurate illustration of the biological lung function of the child, even if a PFT is not in reach.

5. Conclusion

Both the ACT and the new CAST questionnaire have been found to be significantly correlated with the values of the Pulmonary Function Test. In view of these results, it is evident that providers can now use this CAST questionnaire to provide an accurate reading on a child's biological lung function, if the PFT machine is not available, or just as another measure. In the future, there is room for expansion of my research. One of the study's main limitations is that subject zip code was not a part of the data collected. The area of Tennessee that the children live in would be important to know because it would give insight on the impact that their environment has on their asthma, perhaps aligning with the Surgeon General's Report (2006) of second hand spoke exposure. In low-income communities, asthma is more frequently seen and more severe due to air pollution, higher population density, and greater levels of rodent and insect animal feces. It would be interesting to see how this impacts children's survey answers. Additionally, only one 13-year-old volunteered for the study. The lack of 13-year-olds caused an unfair picture of the sample population. Future researchers would do well to consider these limitations when replicating or extending my study.

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