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Citation

Deal, T. (2020). Effects of Asthma on Lung Function, Aerobic Fitness, and Physical Activity Levels in Young Adults. *Health, Human Performance and Recreation Undergraduate Honors Theses* Retrieved from <https://scholarworks.uark.edu/hhpruht/89>

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Effects of Asthma on Lung Function, Aerobic Fitness, and Physical Activity Levels in Young
Adults

University of Arkansas

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Introduction

Asthma, defined by the National Heart, Lung, and Blood Institute as a chronic lung disease that inflames and narrows the airways, is one of the most commonly diagnosed medical conditions in the United States (NHLBI, 2018). There are currently an estimated twenty-five million individuals in the U.S. living with asthma, with seven million being children (NHLBI, 2018). Some of the most common symptoms experienced include recurrent periods of wheezing, chest tightness, shortness of breath, and coughing. Asthma is idiopathic, meaning that an exact cause has not been determined, although it is widely believed there is a potential environmental or genetic link. Individuals may be at a higher risk for asthma if they suffer from atopy, have parents who have asthma, had respiratory infections during childhood, or were exposed to certain viral infections while their immune system was still developing (NHLBI, 2018). Furthermore, during childhood, boys are more likely to be diagnosed with asthma than girls, but the exact opposite is true in adulthood (NHLBI, 2018). Studies have also shown that asthma rates are higher in more urban communities, and with the percentage of individuals living in urban communities expected to increase to 59% by the year 2025, it is projected that there will be 100 million new cases of asthma by then (Bousquet, Bousquet, Godard, & Daures, 2005). Beyond the physical health implications, asthma can also be a financial burden, costing the average person anywhere between \$300 and \$1300 per year (Braman, 2006). Asthma can serve as a potential barrier to physical activity, and physical inactivity can have additional negative health implications, particularly regarding fitness and lung function.

Current research shows that individuals with asthma typically participate in less physical activity than individuals without the condition, and therefore have decreased levels of fitness and lung function. In the Netherlands, a cross-sectional study was conducted to measure and compare

physical activity levels in a group of adult patients with bronchial asthma to a group of apparently healthy individuals (Hul et al., 2016). All participants in the study were asked to answer questions regarding asthma control and quality of life with the Asthma Control Questionnaire and the Asthma Quality of Life Questionnaire, respectively. In addition, they were asked to take a spirometry test to assess lung function and wear a DynaPort MoveMonitor activity monitor for seven consecutive days to measure free-living physical activity. The results found that physical activity levels were significantly lower in adults with bronchial asthma compared to the healthy group. On average, the participants with bronchial asthma took 1200 less steps per day and spent 11 less minutes at a vigorous exercise intensity per day. Furthermore, based on physical activity level, as high as 70 percent of the bronchial asthma group could be classified as ‘predominantly sedentary,’ with another 19 percent classified as ‘very inactive.’ However, this study failed to collect data from participants on presence or lack of exercise-induced bronchoconstriction, time of onset of asthma, and medication regime at the time of referral to a pulmonologist, all of which are factors that may skew results and findings. In our study, this information will be gathered when participants answer survey questions regarding history with asthma.

Asthma may decrease levels of physical activity through direct complications from exercise-induced bronchoconstriction, abbreviated EIB, which is an obstruction to the airways brought on by physical activity. Many different physicians and researchers have come up with theories to attempt to explain the cause of EIB. One popular theory suggests that during exercise, rapid breathing occurs, causing heat and water loss that is compounded by breathing cold, dry air (Asthma and Allergy Foundation of America, 2015). In turn, the airway cooling would cause reflex bronchoconstriction, and vasodilation would take place at the end of the exercise, leading

to mucosal edema and narrowing of the airways. A second theory states that airway drying as a result of hyperventilation would lead to the release of mediators that would cause bronchoconstriction (Hughes, 2014).

What is known for certain is that approximately 90% of individuals diagnosed with asthma will experience EIB at some point in time while performing exercise, making it the most common cause of asthma symptoms in teenagers and young adults (Asthma and Allergy Foundation of America, 2015). Typically, symptoms, of which coughing is the most commonly experienced, begin at the onset of exercise, but actually worsen approximately 5-10 minutes after stopping the exercise and persist for another 20-30 minutes. In severe cases, a second round of symptoms may occur anywhere between 4 and 12 hours after completing the exercise. While the physical activity alone is enough to cause symptoms of EIB to appear, there are certain potential triggers that can make an episode worse, including high levels of pollution, high pollen counts, exposure to irritants such as smoke or fumes, or a recent cold or asthma episode. It is highly recommended that individuals participate in exercise in conditions where the air is warm and humid rather than cold and dry (Asthma and Allergy Foundation of America, 2015).

During childhood, decreased levels of physical activity in individuals with asthma may also be attributed to parents being overprotective and having negative perceptions and beliefs concerning their child's ability to participate in physical activity with this condition. In one cross-sectional study, the parents of children between the ages of six and twelve who had made a visit to either a local pediatric clinic or emergency room in an urban area and received a diagnosis of asthma were interviewed by telephone about their child's condition and physical activity levels (Lang, Butz, Duggan, & Serwint, 2004). To be considered physically active, a child must have participated in at least 30 minutes of physical activity per day or at least 3 days

of physical activity per week. The study found that urban school-aged children with asthma were less active than their peers, and that more than 20% of the children in the study meeting the goal of normal physical activity. Furthermore, the severity of the asthma and the health beliefs of the parents had a significant influence on the physical activity levels of their children. Twenty percent of parents interviewed stated that they believed exercise is dangerous for children with asthma, and 25% were afraid their child would get sick if they exercised. There was also a strong belief that exercise would make the child upset or uncomfortable, and all of these misconceptions contributed to parents discouraging their children with asthma from participating in exercise. Most parents who were interviewed admitted to living within walking distance of a park, playground, or recreation center, and their children not taking advantage of these facilities/amenities. However, it is not currently known if these childhood experiences with asthma may result in differences in physical activity behavior into young adulthood.

Airway inflammation is a widely known complication of asthma, but oxidant/antioxidant imbalance is another major health implication of asthma that is not discussed as much. Asthma can trigger oxidative stress, during which time activated inflammatory cells can release reactive oxygen species, which have toxic effects and can be harmful to all individuals, especially those with asthma. High levels of reactive oxygen species in the body have been linked to increased lipid peroxidation, increased airway reactivity and secretions, increased production of chemoattractants, and increased vascular permeability (Barnes, 1990). In 2010, a study was conducted to determine the effects of an exercise training program on antioxidant status in children with asthma (Onur et al., 2010). All participants in the study started by receiving a daily dose of 250 micrograms of Fluticazone. In addition to the medication, half of the participants were assigned to an exercise training program where they were required to cycle twice a week

for an hour at a time for 8 weeks, with the first 15 minutes being a warm-up phase followed by 45 minutes of cycling at their target heart rate. Following completion of the exercise program, participants in the training group saw a significant improvement in their nitric oxide levels, as well as in their lung function. Results also show that while strenuous exercise can cause oxidative stress, an exercise program tailored to the individual, which was centered around target heart rate in this study, can aid in regulating antioxidant enzyme activity and increase oxidative capacity (Liu et al., 2000). Because asthma is a chronic condition, treatment, in this case aerobic training, should be continuous, which can be difficult if the individual does not truly enjoy exercising. For some, the fear of negative consequences is enough to continue, but in most cases, including children, putting the effort in to see better performance and greater energy expenditure requires some internal source of motivation (Gao, Podlog, & Huang, 2013).

Physical training, specifically aerobic training, has been studied extensively to determine its benefits and effectiveness as a potential treatment option for managing asthma and its symptoms. In one study, participants ages 25 to 65 in one group went through a 6-week exercise training program in addition to the standard medical care that all participants were receiving (Refaat & Gawish, 2015). As part of the training program, participants started with a 10-minute warm-up and stretching period, followed by 20 minutes of cycle ergometry training, step ups, wall squats, and upper limb endurance training for 2 weeks, then 30 minutes of the same exercises in weeks 3 through 6. The results from the data collected showed that participants in the 6-week training program saw a significant improvement in physical limitations, frequency of asthma symptoms, and emotional domains of the Asthma Quality of Life Questionnaire compared to the control group. Participants in the training group also saw increases in their forced vital capacity, as well as their forced expiratory volume in one second, abbreviated FVC

and FEV1, respectively. This finding was confirmed in another study, in which researchers hypothesized that the diaphragm was at a mechanical advantage after aerobic training, increasing the inspiratory force and decreasing airway obstruction (Shaw, Shaw, & Brown, 2003). Similarly, another study saw participants complete a 3-month aerobic exercise training program, this time to determine the program's effects on airway inflammation (Mendes et al., 2011). Throughout the duration of the program, 34 participants in the training group were asked to walk on an indoor treadmill for 30 minutes at a time twice a week. For the first two weeks, the intensity was set at 60% VO₂max, and then increased to 70% VO₂max. After the study was completed, only those who were in the training group saw a reduction in their eosinophil and total cell counts, as well as nitric oxide [FeNO] levels in their body. During the study, these same participants also reported a lower number of emergency room visits and asthma exacerbations. On the opposite end of the spectrum, the training group saw an increase in the number of days they went without experiencing asthma symptoms after 30 days, 60 days, and 90 days of aerobic training. Finally, only members of the training group saw an increase in VO₂max, with 24 participants seeing an improvement of 10% or greater in this measurement. All of the studies mentioned are comprised of participants who are older adults, while our study will focus on undergraduate college students in the age range 18 to 25.

Purpose

The purpose of this study was to determine if physical activity differs between those with asthma and those without, and to determine if fitness or physical activity is associated with FVC/FEV1 measures. We hypothesized that participants with asthma will have lower levels of physical activity compared to those without the condition, and that physical activity will have a correlation with FVC/FEV1.

Methods

Participants. University of Arkansas students, ranging from ages 18 to 25, were recruited to participate in the study through Exercise is Medicine. Participants first completed the International Physical Activity Questionnaire, then a subset of the participants completed the Exercise is Medicine fitness assessment, as well as a standardized spirometry test. Descriptions of the measures used for data collection are listed below.

Physical Activity and Sleep. Actigraph GT9x accelerometers were worn on the non-dominant wrist for one week to track physical activity. Data collected was used to find counts per minute and steps per day.

Cardiorespiratory Fitness. Participants completed a maximal treadmill test using the Bruce protocol. At two minute intervals, the speed and grade of the treadmill were increased until the participant could no longer continue the test. Data collected from the Bruce protocol was used to find VO₂max.

Lung Function and Physical Activity. Prior to beginning their fitness assessment, individuals who agreed to participate in the asthma sub-study had their lung function measured and assessed through a standardized spirometry test. The participant was asked to deeply inhale, then exhale as strongly as possible into the spirometer to measure their Forced Vital Capacity and Forced Expiratory Volume 1.

Statistical Analysis. Physical activity between participants with asthma and participants without the condition was compared using a Wilcoxon Rank Sum test. Associations between fitness and physical activity were made using Spearman Correlations.

Results

	No Asthma (n=759)	Asthma (n=140)	p-value
Vigorous mins/day	44.8 (68.5)	36.8 (65.5)	.068
Moderate Mins/day	96.6 (114.0)	99.4 (131.6)	.464
Walking mins/day	100.0 (104.6)	93.5 (116.3)	.164
Total METMIN/Week	4850.3 (4917.4)	4513.0 (6037.7)	.059

Table 1- Comparing physical activity from IPAQ between those with and without asthma, mean (SD)

	Males	Females
Age	21.4 (1.17)	21.1 (0.9)
VO2max	42.66 (6.46)	36.76 (4.17)
FVC	4.51 (0.57)	3.24 (0.83)
FEV1	3.56 (0.86)	2.71 (0.76)
Accelerometer Counts per minute	1922.57 (437.28)	1870.30 (374.17)
Accelerometer Steps per day	12899.61 (2098.95)	11629.85 (2489.87)

Table 2- Description of participants who completed fitness assessment, mean (SD)

	FVC		FEV1	
	Spearman Rho	p-value	Spearman Rho	p-value
VO2max	.35	.11	.10	.665
Accelerometer counts per min	.08	.73	-.02	.923
Accelerometer steps per day	.18	.43	.24	.28

Table 3- Spearman correlation associations between spirometry and fitness/physical activity, n=22

A total of 899 participants (40.2% female) completed the IPAQ survey, with 759 participants reporting no asthma and 140 participants reporting having asthma. Participants without asthma reported, on average, 100.0 mins/day walking (SD-104.6), 96.6 mins/day of moderate PA (SD-114.0), and 44.8 mins/day of vigorous PA (SD-68.5), resulting in an average of 4850.3 Total MET min/week (SD-4917.4). In the same categories, the asthma participants averaged 93.5 mins/day (SD-116.3), 99.4 mins/day (SD-131.6), 36.8 mins/day (SD-65.5), and 4513.0 MET min/week (SD-6037.7). There was no statistically significant difference between the groups for any of these categories, as the p-values are .068, .464, .164, and .059, respectively.

Of the participants who completed the fitness assessment ($n=28$, 50% female), the average age was 21.4 years (SD-1.1) and 21.1 (SD-0.9), VO₂max 42.7 (SD-6.8) and 36.02 (SD-4.3), FVC 4.5 (SD-0.5) and 3.24 (SD-0.8), FEV₁ 3.5 (SD-0.8) and 2.7 (SD-0.7), counts/minute 2080.4 (SD-457.1) and 1922.1 (SD-388.9), and steps/day was 11494.5 (SD-3635.3) and 11846.1 (SD-2359.0) for males and females, respectively. The Spearman correlation association values for FVC were .35 ($p=.11$) for VO₂max, .08 ($p=.73$) for counts/min, and .18 ($p=.43$) for steps/day, indicating a slightly positive, but not statistically significant correlation between FEV and all three variables. For FEV₁, the correlation was .10 ($p=.665$) for VO₂max, -.02 ($p=.923$) for counts/min, and .24 ($p=.28$) for steps/day, resulting in slightly positive correlations for FEV₁ with VO₂max and steps/day, and a slightly negative correlation with counts/min. Again, there is no statistically significant difference for any of the variables.

Discussion

After analyzing our data, we see no statistically significant difference in self-reported physical activity levels between participants with asthma and those without. In addition, there is no association between fitness/physical activity and spirometry measures. These findings do not support either one of our hypotheses. The findings of our study contradict the study conducted in the Netherlands, which found participants with asthma to be significantly less active than the participants in the other group (Hul et al., 2016). However, our study was limited by a small number of fitness assessment participants that had asthma. Additionally, our study focused on young adults, while the study in the Netherlands had participants with a larger age range. It is possible that this skewed the data, as young adults could be more physically active than older adults, regardless of whether the individual has asthma or not.

The results of our study also differed from those in the urban school-aged children study, which found the children with asthma to be less active than those without the condition (Lang, Butz, Duggan, & Serwint, 2004). That study went a step further, finding that children with asthma were typically less physically active than their peers if their parents believed exercise was dangerous for children with asthma. This could potentially explain the difference in findings, as school-aged children with asthma have parents who could hold them out of physical activity. Our study consisted of college-aged students, who are more free to participate in physical activity as often as they would like. Furthermore, the study on urban school-aged children found a strong association between low physical activity and reported symptom frequency. Our study did not take into account how frequently the participant experienced asthma symptoms.

Similarly, the study on fitness, daily activity, and body composition in children with newly diagnosed, untreated asthma found that the children with asthma were less fit than their peers, and spent less time participating in vigorous activity (Vahlkvist & Pedersen, 2009). Our study did not collect data on how recent participants' asthma diagnosis was, or if their condition was managed or not. It is likely that participants who have their asthma under control are better equipped to handle physical activity, and thus be more fit.

The study conducted on the effect of physical training on health-related quality of life in patients with asthma found that physical training can increase the spirometry measures FVC and FEV1 (Refaat & Gawish, 2015). This directly opposes our finding that there is no association between physical activity and fitness and spirometry measures. However, Refaat and Gawish's study only contained participants with moderate or severe bronchial asthma, while our study did not gather information on the severity of our participants' asthma. In addition, their study measured FVC and FEV1 before and after a specific six-week physical training period, while our

study only collected data on these measures before the fitness assessment, with no physical training performed.

With such a small sample size and very few participants with asthma, it is hard to draw conclusions that could apply to a whole population. There are also several factors that our study did not take into consideration, such as date of diagnosis, severity of asthma, and frequency of symptoms, that could significantly change our findings. Further, more in-depth research is needed to expand our knowledge on this topic. If the findings of our study are true, and there is no difference in physical activity levels between participants with asthma and those without or association between fitness/physical activity and FVC/FEV1 measures, college-aged students should not have any reservations about participating in physical activity if they suffer from asthma. This finding could allow for further promotion of physical activity on college campuses, which if successful, would improve individuals' fitness and overall health and quality of life.

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