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Sex Differences in the Relationship Between Fitness and Obesity on Risk for Asthma in Adolescents

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Abstract

Objective—To evaluate the relationship of fitness and obesity on asthma risk in adolescent girls and boys.

Study design—A cross-sectional assessment of participants 12–19 years of age was conducted using data from the 1999–2004 National Health and Nutrition Examination Survey (NHANES). Participants completed cardiorespiratory fitness testing, body composition measurements, and respiratory questionnaires.

Results—A total of 4828 participants were included. Overweight/obesity was associated with increased odds of history of asthma (aOR 1.64, 95% CI 1.16, 2.31), current asthma (aOR 1.77, 95% CI 1.15, 2.72), and wheezing (aOR 1.40, 95 % CI 1.01, 1.95) in girls. Overweight/obesity was also associated with increased odds of asthma attacks (aOR 2.78, 95% CI 1.59, 4.86) and wheezing related to exercise (aOR 1.64, 95% CI 1.09, 2.46) in girls. High fitness was associated with lower odds of asthma-related ED visits (aOR 0.24, 95% CI 0.07, 0.88), wheezing-related medical visits (aOR 0.31, 95% CI 0.13, 0.75), wheezing-related missed days (aOR 0.14, 95% CI 0.06, 0.33), and wheezing related to exercise (aOR 0.43, 95% CI 0.24, 0.76) in boys.

Conclusion—Overweight/obesity is associated with increased asthma prevalence and morbidity in girls but not in boys, independent of fitness. High fitness is associated with decreased rates of asthma morbidity in boys but not in girls, independent of weight status. Obesity and fitness may each influence asthma onset and severity in different ways for boys versus girls.

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Keywords

asthma; obesity; fitness; adolescents

Asthma is one of the most common chronic illnesses of childhood and prevalence rates increased in the United States over the past few decades despite advances in management, therapies, and knowledge (1). During this same time period, the prevalence of obesity and overweight has almost tripled, with an estimated 17% of children affected (2). A growing body of literature suggests that there is an association between these two disorders with obesity negatively influencing asthma risk and health (3–6). However, the mechanism(s) are unknown, hindering our ability to treat these patients. Recent literature suggests that obesity-related asthma may represent a distinct phenotype and is becoming a major public health issue in the United States (7–9).

The relationship between sex and asthma depends on age, with boys being more affected with asthma during childhood and girls being more affected with asthma during adolescence and adulthood (10–13). A few investigators have examined whether the asthma-obesity association differs between sexes; however, the results have been mixed (14–16).

Significant reductions in physical activity leading to decreased aerobic fitness have occurred during the same period in which rates of obesity and asthma have dramatically increased (17;18). There are also significant sex differences in fitness, particularly during adolescence (19). Decreased aerobic fitness and physical activity are known to be associated with obesity and asthma separately (17;20–23). The combination of obesity and reduced physical activity, each of which can stimulate inflammation, can lead to a vicious cycle in the obese asthmatic child. However, few studies have tried to adequately evaluate how fitness influences the relationship between obesity and asthma risk and morbidity (24).

The objective of this study was to evaluate the relationship of obesity and fitness on asthma risk in adolescent girls and boys using a nationwide sample in the United States. Understanding the role of fitness in the link between obesity and asthma prevalence and morbidity, particularly in pediatric populations, provides valuable knowledge that could translate into specific interventions.

METHODS

The National Health and Nutrition Examination Survey (NHANES) is an ongoing nationally representative survey conducted to assess the health and nutritional status of adults and children in the U.S. NHANES uses a stratified multistage probability sample design.

The NHANES is comprised of household interview and mobile examination center (MEC) tests. Detailed description of the study design and methodology for NHANES can be found on the NHANES website (25). The NHANES over samples adolescents, age 12–19, low-income, African-American and Mexican American populations. The study protocols were approved by the National Health Statistics institutional review board. All participants (or their parents/guardians) gave written informed consent.

This report used NHANES datasets from 1999–2000, 2001–2002, and 2003–2004. Cardiorespiratory fitness testing was completed in participants 12 years and older (n=4997) during the MEC examinations. We included participants who had complete data on asthma prevalence, body composition, and cardiorespiratory fitness testing (n=4828). Underweight participants were excluded from analyses involving models as they were too few in number (n=135).

Those who did not complete cardiorespiratory fitness testing were excluded (n=1198). Participants at increased risk for complications from exercise or with conditions that might affect the tests results were excluded from fitness testing, including participants with asthma with 12 or more wheezing episodes per year or any wheezing episodes associated with speech limitations.

Asthma Outcomes

All participants were asked (by proxy if under 16 years) whether a doctor or other health professional had ever said they had asthma. Those who answered "yes" were asked a series of additional questions, including whether they currently have asthma, whether they had experienced an asthma attack in the past year, and whether they had been to the emergency department (ED) for asthma in the past year. The primary outcomes for these analyses are a report of history of asthma and current asthma. Additional questions related to asthma attacks and asthma-related ED visits in the past 12 months were asked.

A separate set of questions were asked about wheezing. Wheeze outcomes used in these analyses include a report of wheeze in the past year (yes/no), medical visit for wheeze in the past year (yes/no), missing school or work due to wheeze in the past year (yes/no), and wheezing related to exercise (yes/no).

Weight Measurements

Participants had their weight and height measured following a standard protocol. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Sex-specific BMI percentile-for-age was calculated using the Centers for Disease Control and Prevention 2000 reference standards (26). Children between the 5^{th} and 85^{th} percentiles of BMI-for-age were considered to be normal weight, those between the 85^{th} and 95^{th} percentiles were considered overweight, and those at or above the 95^{th} percentile were considered obese.

Cardiorespiratory Fitness Testing

Cardiorespiratory fitness was assessed by a submaximal treadmill exercise test. Participants were assigned to 1 of 8 treadmill test protocols on the basis of their expected VO_2 max, which was predicted from sex, age, BMI, and self-reported level of physical activity by using the formula developed by Jackson et al (27). Each protocol included a 2-minute warm-up, two 3-minute exercise stages, and a 2-minute cool-down period. The goal of each protocol was to elicit a heart rate that was approximately 75% of the age-predicted maximum (220 − age) by the end of the second exercise stage.

The heart rate was monitored continuously via 4 electrodes connected to the trunk and the abdomen of the participant and was recorded at the end of warm-up, each exercise stage, and each minute of recovery. Blood pressure was measured at the end of each stage by using an STBP-780 automated sphygmomanometer (Colin Medical Instruments Corporation). $\dot{V}O_2$ max (mL/kg per min) was estimated by extrapolation to an expected age-specific maximal heart rate by using measured heart rate responses to the two 3-minute exercise stages. This assumes that the relationship between heart rate and oxygen consumption is linear during treadmill exercise. Cardiorespiratory fitness levels were grouped into tertiles by sex.

Statistical Analyses

Participant characteristics were compared between sexes using independent sample t-tests for continuous variables and Pearson's chi squared test for categorical variables. The sex-specific associations of BMI and fitness with asthma prevalence and morbidity were examined in a series of logistic regression models, stratified by sex. Asthma prevalence and morbidity were first compared across BMI categories and fitness tertiles in bivariate analyses. In final models, BMI and fitness were combined to allow for comparisons between overweight/obese versus normal-weight groups and low-to-moderate versus high-fitness groups. Multivariate models were adjusted for age, survey year, poverty index ratio, second hand smoke exposure, and race/ethnicity. Models using fitness as the dependent variable were also adjusted for BMI categories. Models using BMI as the dependent variable were also adjusted for fitness. Sex by BMI and sex by fitness interactions were tested for each outcome. BMI by fitness interactions were also tested for each outcome. Cardiorespiratory fitness was also examined as a continuous variable (z-score) for boys and girls. The sex-specific associations of fitness as a continuous variable with asthma prevalence and morbidity were examined in a series of logistic regression models, stratified by sex. Adjustments for multiple comparisons (8 outcomes) were made by controlling for the false discovery rate using the Benjamini-Hochberg procedure (28). All analyses accounted for weighted data design of NHANES and were performed with SAS (version 9.4, Cary, NC). A p value < 0.05 was considered statistically significant for main effects and <0.10 for interactions.

RESULTS

Sociodemographic and clinical characteristics by sex of the study population were examined (Table I). Girls were younger than boys with a mean age of 15.3 years compared with 15.5 years of age (p=0.02). There was no difference between race/ethnicity between boys and girls. Girls were more likely to have a current diagnosis of asthma, 8.5% compared with 6.4% of boys (p=0.04), but no difference was seen in history of asthma or wheezing. There was no difference in asthma-related morbidity between sexes except for wheezing related to exercise; 5.9% of girls reported wheezing related to exercise compared with 3.8% of boys (p=0.04). There was no difference between BMI groups by sex. Girls had a significantly lower mean estimated VO_2 max of 38.4 ml/kg/min compared with 46.2 ml/kg/min in boys (p<0.001). We also examined clinical characteristics between participants included and excluded from our study (due to no fitness testing completed). Excluded participants had higher prevalence of asthma and asthma-related morbidity as well as increased BMI (data not shown).

Obesity and Asthma Risk

Overall, there was a significant relationship between overweight/obesity and increased asthma prevalence among girls but not boys (Table II). There was a significant association between overweight/obesity and history of asthma in girls (adjusted OR 1.63, 95% CI 1.16, 2.30) but not boys (adjusted OR 0.96, 95% CI 0.68, 1.35; test for interaction, p=0.06). There was also a significant association between overweight/obesity and current asthma among girls (adjusted OR 1.73, 95% CI 1.13, 2.64) but not boys (adjusted OR 0.90, 95% CI 0.59, 1.38; test for interaction, p =0.11). The association between overweight/obesity and increased odds of wheezing was significant among boys in unadjusted models (OR 1.37, 95% CI 1.00, 1.89), but not significant after adjusting for covariates (adjusted OR 1.25, 95% CI 0.85, 1.86). There was also a significant relationship between overweight/obesity and wheezing among girls (adjusted OR 1.40, 95% CI 1.03, 1.91), but not boys (adjusted OR 1.25, 95% CI 0.85, 1.86; test for interaction p=0.87).

When examining asthma-related morbidity outcomes, there were significant associations between overweight/obesity and increased odds of asthma attacks and wheezing related to exercise among girls but not boys (Table III). For example, overweight/obese girls had increased odds of asthma attacks compared with their normal-weight counterparts (adjusted OR 2.69, 95% CI 1.56, 4.65). Overweight/obese females also had increased odds of wheezing related to exercise (adjusted OR 1.60, 95% CI 1.07, 2.38). There were no significant sex by BMI interactions for asthma morbidity.

Fitness and Asthma Risk

We also examined relationships between fitness levels and asthma prevalence. There was a significant association between high fitness and decreased odds of wheezing among boys in unadjusted models (OR 0.59, 95% CI 0.39, 0.89), but not significant after adjusting for covariates (adjusted OR 0.61, 95% CI 0.37, 1.01).

When examining asthma-related morbidity, overall, we found significant associations between high fitness and decreased odds of asthma morbidity among boys but not girls. For example, the high fit boys had a significantly lower odds of asthma-related ED visits (adjusted OR 0.24, 95% CI 0.07, 0.88) compared with the low/moderately fit boys but not girls (adjusted OR 0.61, 95% CI 0.37, 1.01; test for interaction p=0.53).

High fit boys also had a decreased odds of wheezing-related medical visits (adjusted OR 0.31, 95% CI 0.13, 0.75) compared with low and moderately fit boys but not girls (adjusted OR 1.57, 95% CI 0.85, 2.93; test for interaction p =0.07). There was also a significant association between high fitness and decreased odds of wheezing-related missed days in boys (adjusted OR 0.14, 95% CI 0.06, 0.33) but not girls (adjusted OR 1.90, 95% CI 0.80, 4.52; interaction p value=0.06). Lastly, there was a significant association between high fitness and decreased odds of wheezing related to exercise (adjusted OR 0.43, 95% CI 0.24, 0.76) compared with low and moderately fit boys but not girls (adjusted OR 1.50, 95% CI

0.91, 2.49; test for interaction $p<0.01$). For all outcomes, BMI by fitness interactions were examined for both sexes and none were found to be significant.

DISCUSSION

In this cross-sectional analysis of adolescents from NHANES, we found, in sex-stratified models, significant associations between overweight/obesity and three measures of asthma prevalence, specifically history of asthma, current asthma, and wheezing in girls but not boys, independent of fitness. We also found an association between overweight/obesity and increased asthma morbidity in girls but not boys. We found that higher fitness was associated with lower rates of wheezing among boys but not girls, independent of BMI with a significant sex by fitness interaction. Higher fitness was also significantly associated with lower rates of asthma-related morbidity including asthma-related ED visits, wheezing-related medical visits, wheezing-related missed days, and wheezing related to exercise in boys but not girls, independent of BMI, with significant sex by fitness interaction.

Though the findings in other studies on sex differences in contributors to asthma are mixed, the majority of studies in children support a more consistent relationship between obesity and asthma development in girls consistent with our findings (14;29;30). In the Tucson Children's Respiratory Study, a longitudinal birth cohort followed for several decades, girls who became overweight or obese between ages 6 and 11 years (OR 6.8 95% CI 2.4, 19.4 and OR 5.5 95% CI 1.3, 23.3) were more likely to develop wheezing compared with those who were normal weight (14). This relationship was not seen in boys. Few studies have specifically examined the relationship between obesity and asthma risk in adolescents (30;31). Ho et al evaluated over 4,000 participants between 13–15 years of age and found that girls who were overweight had an increased odds of physician-diagnosed asthma (OR 1.75 95% CI 1.18–2.61) compared with those who were normal weight (31). No significant relationship between weight status and asthma was seen in boys (31). Tollefsen et al examined over 2,300 adolescents in Norway and found increased odds (OR 2.4 95% CI 1.3, 4.6) of stable current wheeze in overweight compared with normal-weight girls only (30).

A systematic review and meta-analysis examining sex differences of childhood overweight/ obesity in predicting risk of incident asthma found that obese boys had a significantly larger asthma risk (RR 2.47 95% CI 1.57, 3.87) compared with obese girls (RR 1.25 95% CI 0.51, 3.03)(15). However, they included pediatric studies with age ranges from 5 to 18 years. In a study of over 3,500 adolescents in Taiwan, Lee et al. found that overweight boys had RR 1.74 (95% CI 1.35, 2.26) compared with normal-weight boys and no relationship was seen in girls (32).

Few studies have examined fitness in the relationship between obesity and asthma. Consistent with our findings, Kilpelainen et al examined BMI and physical activity in relationship to asthma in young adults and found that increased moderate physical activity was associated with a lower risk of asthma in male but not among females (33).

In contrast to our findings, Tollefsen found that low physical activity was not seen to be associated with an increased risk of wheezing in boys or girls (30). Visness et al examined levels of subjective measures of physical activity and screen-time on asthma risk using NHANES and found no significant differences on current asthma or medical visits for wheezing related to physical activity or sedentary time (34). There was an association between overweight/obesity and asthma outcomes after adjusting for levels of physical activity. Jones et al examined relationships between asthma, overweight, and physical activity among high school students in the U.S. and found that significantly more students with asthma were overweight compared with those without asthma (OR 1.4 95% CI 1.1, 1.6), both boys and girls (35). No relationships between vigorous or moderate physical activity and asthma status were seen. All of these studies used subjective measures of physical activity or sedentary behavior which are known to correlate poorly with objective measures and may explain why these findings were different from ours.

Chen et al have used objective measures of fitness to examine the interrelations between central obesity, physical fitness level, sedentary time, and asthma (24). In a group of over 2,700 school children from Taiwan, they found that central obesity most accurately predicts asthma. Furthermore, low fitness increased the risk of central obesity but did not appear to be a link in the relationship between obesity and asthma. However, fitness was assessed using an 800-meter sprint, a field test that relies on technique and motivation, and therefore the results may not accurately reflect cardiorespiratory fitness. While they adjusted for sex in their models, the authors did not examine the outcomes separately by sex. This may mask any effect of fitness in the relationship between obesity and asthma as we saw a possible effect of fitness in boys only.

We speculate that one possibility for our observation that high fitness is associated with decreased asthma morbidity in boys and not girls may be due to the fact that adolescent boys are known to be more physically active and, consequently, more fit compared with adolescent girls (36;37). Possible mechanisms for the relationship between high fitness and improved asthma may include down-regulation of inflammation contributing to asthma (38), ability of higher fit individuals to adapt or develop tolerance of asthma-related symptoms (39).

Limitations

NHANES is a series of cross-sectional studies and thus we are unable to establish temporal relationships between observed variables or determine the directionality of the relationships between obesity, fitness, and asthma outcomes. Although significant BMI-by-sex and fitness-by-sex interactions were observed for several of the study outcomes, for some of the outcomes, the models reported did not have significant interaction terms. For these outcomes, there is insufficient evidence to rule out the possibility that the differences in effect sizes for BMI or fitness reported in the sex-stratified models were due to chance rather than a true difference. For those models, larger samples will be required to determine if the associations between BMI or fitness and asthma prevalence/morbidity differ significantly between sexes. Taken together, however, the pattern of findings in the models presented is consistent with sex differences in these associations.

During the NHANES survey years of our sample population, data regarding asthma diagnoses or morbidity was subjectively based on questionnaires and, unfortunately, no objective measures of asthma were captured, including pulmonary function testing and broncho-provocation testing. Several studies have shown the effects of obesity on lung function particularly airway obstruction (40;41). It would be important to evaluate for associations between pulmonary function testing, weight status and fitness levels.

There were several limitations related to the fitness testing performed in NHANES. Fitness testing excluded subjects with specified medical conditions like more severe asthma or respiratory conditions. We did find statistically significant increased rates of asthma diagnoses and morbidity in the excluded sample compared with our included sample, potentially introducing selection bias (data not shown). Additionally, there were more overweight and obese participants in the excluded sample population. It is possible that our study may have underestimated the relationship between fitness, obesity on asthma due to the exclusion criteria.

The extrapolation of submaximal HR data from a submaximal test to an estimation of peak $\dot{V}O2$ could easily introduce systematic bias for both sexes and confound the data because a maximal test was not actually performed. Also, predicted VO_2 max levels were scaled to body weight in this study, which may not accurately reflect metabolically active muscle mass. Studies show that normalizing fitness to lean body mass is a more specific measure because skeletal muscle and not body fat is mainly responsible for oxygen uptake during exercise (42). Furthermore, there are significant differences in body composition particularly body fat between boys and girls during adolescence (43). These limitations highlight the difficulty in quantifying cardiorespiratory fitness in children.

Our study emphasizes the importance of examining girls and boys separately when evaluating the relationships between obesity, fitness, and asthma. Future prospective studies need to elucidate the role of fitness in the relationship between obesity and asthma outcomes using more objective measures including cardiorespiratory fitness testing and spirometry in a pediatric asthmatic population.

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List of Abbreviations

BMI	Body mass index
CI	Confidence interval
ED	Emergency department
MEC	Mobile examination center
NHANES	National Health and Nutrition Examination Survey
OR	Odds ratio
VO_2 max	Maximal oxygen consumption

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Table I

Sociodemographic and Clinical Characteristics

	Boys N=2465	Girls N=2363	*p* value
Age, mean (SE)	15.5 (0.07)	15.3 (0.09)	0.02
Race and ethnicity, %			0.25
White	62.1	58.6	
Black	13.6	15.1	
Hispanic	18.0	19.2	
Other	6.3	7.1	
Family income to poverty threshold Ratio, mean (SE)	2.6 (0.07)	2.5 (0.07)	0.06
Asthma Prevalence and Morbidity % (SE)			
History of asthma	14.4 (1.0)	15.7 (0.8)	0.38
Current asthma	6.5 (0.7)	8.5 (0.6)	0.04
Wheezing/whistling	9.3 (0.7)	10.7 (1.0)	0.25
Asthma attack	2.8 (0.4)	4.3 (0.6)	0.10
Asthma-related ED visit	0.7 (0.2)	0.7 (0.2)	0.86
Wheezing-related medical visit	2.9 (0.5)	4.2 (0.6)	0.09
Wheezing-related missed days	2.2 (0.5)	2.9 (0.6)	0.32
Wheezing related to exercise	3.8 (0.6)	5.9 (0.8)	0.04
BMI and Fitness			
BMI category, %			0.84
Normal weight	67.8	68.9	
Overweight	16.1	15.5	
Obese	16.1	15.6	
Estimated VO_2 max, mean (SE)	46.2 (0.37)	38.4 (0.27)	<0.001
Fitness tertiles, mean estimated VO_2 max(range)			0.09
Tertile 1	37.0 (24.2, 41.7)	30.9 (20.1, 34.6)	
Tertile 2	45.1 (41.7, 48.9)	37.5 (34.6, 40.5)	
Tertile 3	56.6 (48.9, 76)	48.1 (40.5, 76)	

p value generated from chi square for differences (Pearson) in dichotomous or categorical outcomes.
p value generated from t test for differences in means for continuous outcomes.

Table II

Association Between Overweight/Obesity and Asthma Diagnosis/Morbidity

	Unadjusted model		Adjusted model	
Outcome	**Overweight/obese vs. normal weight OR (95% CI)**	**Sex by BMI interaction (*p*)**	**Overweight/obese vs. normal weight aOR (95% CI)**	**Sex by BMI interaction (*p*)**
History of asthma				
Boys	1.09 (0.82, 1.45)	0.18	0.96 (0.68, 1.35)	0.06
Girls	**1.46 (1.08, 1.99)**		**1.63 (1.16, 2.30)**	
Current asthma				
Boys	1.08 (0.70, 1.67)	0.28	0.90 (0.59, 1.38)	0.11
Girls	1.51 (0.99, 2.29)		**1.73 (1.13, 2.64)**	
Wheezing				
Boys	1.37 (1.00, 1.89)	0.70	1.25 (0.85, 1.86)	0.88
Girls	1.25 (0.90, 1.75)		1.40 (1.03, 1.91)	
Asthma attack				
Boys	1.69 (0.92, 3.08)	0.41	1.29 (0.71, 2.35)	0.14
Girls	**2.31 (1.32, 4.07)**		**2.69 (1.56, 4.65)**	
Asthma-related ED visit				
Boys	2.21 (0.61, 8.01)	0.50	1.49 (0.45, 4.95)	0.50
Girls	3.56 (0.89, 14.16)		3.50 (0.71, 17.24)	
Wheezing-related medical visit				
Boys	1.75 (0.84, 3.64)	0.99	1.20 (0.54, 2.63)	0.86
Girls	1.74 (0.97, 3.13)		1.57 (0.85, 2.93)	
Wheezing-related missed days				
Boys	1.65 (0.86, 3.16)	0.93	0.97 (0.45, 2.08)	0.37
Girls	1.58 (0.74, 3.35)		1.90 (0.80, 4.52)	
Wheezing related to exercise				
Boys	1.26 (0.77, 2.07)	0.83	1.06 (0.62, 1.81)	0.61
Girls	1.36 (0.95, 1.95)		**1.60 (1.07, 2.38)**	

Models adjusted for age, survey year, poverty index ratio, second hand smoke exposure, race/ethnicity, and fitness groups.
Bolded OR indicate p<0.05 controlled for multiple comparisons.

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Table III

Association Between Fitness and Asthma Diagnoses/Morbidity

	Unadjusted model		Adjusted model	
Outcome	**High fit vs. low/moderately fit (OR (95% CI)**	**Sex by fitness interaction (*p*)**	**High fit vs. low/moderately fit (aOR (95% CI)**	**Sex by fitness interaction (*p*)**
History of asthma				
Boys	0.84 (0.61, 1.14)	0.30	0.84 (0.60, 1.19)	0.89
Girls	1.08 (0.77, 1.51)		1.13 (0.81, 1.57)	
Current Asthma				
Boys	0.71 (0.41, 1.20)	0.08	0.69 (0.39, 1.22)	0.38
Girls	1.32 (0.86, 2.05)		1.24 (0.80, 1.91)	
Wheezing				
Boys	**0.59 (0.39, 0.89)**	0.10	0.61 (0.37, 1.01)	0.08
Girls	1.08 (0.63, 1.87)		1.21 (0.69, 2.10)	
Asthma attack				
Boys	0.79 (0.35, 1.81)	0.26	0.85 (0.36, 1.99)	0.29
Girls	1.41 (0.76, 2.61)		1.62 (0.90, 2.92)	
Asthma-related ED visit				
Boys	**0.18 (0.05, 0.63)**	0.39	**0.24 (0.07, 0.89)**	0.55
Girls	0.51 (0.11, 1.56)		0.46, (0.11, 1.82)	
Wheezing-related medical visit				
Boys	**0.33 (0.15, 0.72)**	**0.02**	**0.31 (0.13, 0.75)**	0.07
Girls	0.94 (0.50, 1.76)		0.91 (0.46, 1.79)	
Wheezing-related missed days				
Boys	**0.21 (0.08, 0.52)**	**0.02**	**0.14 (0.06, 0.33)**	0.06
Girls	0.62 (0.23, 1.66)		0.66 (0.25, 1.74)	
Wheezing related to exercise				
Boys	**0.51 (0.29, 0.88)**	**0.03**	**0.43 (0.24, 0.76)**	**<0.01**
Girls	1.20 (0.74, 1.93)		1.50 (0.91, 2.49)	

Models adjusted for age, survey year, poverty index ratio, second hand smoke exposure, race/ethnicity, and BMI categories.
Bolded OR indicate p<0.05 controlled for multiple comparisons.