

Body Mass Index and Pediatric Asthma Outcomes

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Objective: The purpose of this study was to determine the association between body mass index (BMI), a measure of obesity, with emergency department admission rate in children with asthma.

Methods: This was a prospective study in a tertiary care, urban pediatric emergency department. Treating physicians and academic associates enrolled subjects during June 2005 to April 2008. Eligible subjects with documented weight and height were between ages 6 and 18 years with chief complaint of wheezing. We compared admission rates between overweight children (BMI, $\geq 85\%$ percentile) and nonoverweight children (BMI, $< 85\%$ percentile). Data were expressed as mean (SD). Group comparisons were made by Student *t* test or Fisher exact test, as appropriate. All tests were 2-tailed with an α set at 0.05.

Result: We studied 183 children, where 108 children were classified overweight. Demographic differences (mean age, male sex, and African-American race) between overweight and nonoverweight children were not statistically significant. In addition, changes in asthma outcome measures (inpatient admissions during the previous year, asthma visits in the last 30 days, and missed school days in the last 30 days) were not statistically significant. Only household tobacco use approached statistical significance ($P = 0.07$). The admission rate for nonoverweight children was 9.3% (95% confidence interval [CI], 4.3–18.3) compared with the 10.2% (95% CI, 5.6–17.5) for overweight children; a $P = 1.0$ was equivalent.

Conclusions: Body mass index, a method to quantify overweight children, failed to predict admission of children with ambulatory asthma who presented to the pediatric emergency department.

Key Words: asthma, obesity, hospitalization

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Obesity and asthma have emerged as chronic health problems among the pediatric population.¹ The prevalence of obesity has increased from 1999 to 2004 according to the National Health and Nutritional Examination Survey. During 1999 to 2000, the obesity prevalence rate for all children aged 2 to 19 years was 13.9%. It was 17.1% from year 2003 to 2004.² A similar trend has been noted in rates of pediatric emergency department (ED) visit due to asthma. The visit rate in patients younger than 18 years has increased from 96.4 per 10,000

visits in 1992 to 103.5 per 10,000 visits in 2004.³ Among patients with current disease of asthma, the pediatric attack rate of 11.2 per 100 is higher compared with the 7.8 per 100 in adults.³ There seems to be an epidemiological association between increasing rates of obesity and the prevalence of pediatric asthma.

There is good evidence for an association between the prevalence and severity of asthma and obesity.^{4–6} Beuther and Sutherland⁷ performed a meta-analysis, showing a dose-response rate between obesity (body mass index [BMI], > 25) and the prevalence of asthma in adults. The odds ratio was 1.51 or a 50% increase in the association to develop asthma when one is overweight.⁷ Chinn and Rona⁸ found a similar association between increased weight and asthma prevalence among British children participating in the National Study of Health and Growth from 1982 to 1994.

Asthma severity, defined by clinical symptoms and hospitalization rate, is closely linked to obesity in an adult population.^{9,10} Rodrigo and Plaza¹⁰ found that there is an increase in hospital admission rate in adult patients with obesity, with a 13.7% admission rate in patients with obesity compared with the 6.8% admission rate in normal-weight patients. A similar association exists between obesity and asthma severity in children. Belamarich et al¹¹ showed in children aged 4 to 9 years that obesity is associated with decreased peak expiratory flow rates, increased asthma symptoms, and increased health service use. Carroll et al¹² found that pediatric patients with obesity, defined as a percentile higher than 95%, had a longer stay of 9.8 days in the pediatric intensive care unit compared with 6.5 days for nonobese patients in the pediatric intensive care. Carroll et al¹³ found an association between asthma admission rate and obesity from a retrospective chart review. Patients with obesity, defined as a percentile higher than 95%, had a higher admission rate. The odds ratio is 1.76.

We planned a prospective study of overweight and nonoverweight ED pediatric patients with asthma. We conducted a prospective study, examining asthma admission rates between overweight and nonoverweight ambulatory children who presented to the pediatric ED.

METHODS

Study Design

This was a prospective study examining the rate of pediatric asthma admission using a convenience sample of patients stratified on BMI. This study was approved by the institutional review board of the State University of New York–Downstate and Kings County Hospital Corporation.

Study Setting and Population

Subjects were enrolled at a tertiary care, urban pediatric ED located in Brooklyn, NY. The pediatric ED is part of a teaching municipal hospital with 25,000 annual patient visits. Trained research associates enrolled patients from 7:00 AM to 11:00 PM for 2 to 3 days per week, whereas the medical staff enrolled eligible subjects at any time and day of the week. The

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TABLE 1. Baseline Characteristics by the Pediatric Asthma Group (Overweight Vs Nonoverweight Patients)

	Overweight	Nonoverweight	P
n	108	75	
Age, mean (SD), yr	10.41 (3.40)	10.23 (3.07)	0.71
Sex, male, %	61	64	0.76
Race, African American, %	86.1	93.3	0.15
Household smoker, %	10.7	21.3	0.07

research associates and medical staff enrolled subjects between ages 6 and 18 years, presenting with chief complaints of wheezing, shortness of breath, or respiratory distress. The research associates and medical staff enrolled subjects with self-report history of asthma or reactive airway disease or who have been treated with nebulized albuterol for wheezing. Subjects were excluded if they had known cardiac disease or nonasthma pulmonary disease. Subjects were enrolled from June 2005 to April 2008.

Study Protocol

Patients were enrolled as a convenience sample. Informed consent was obtained from the parent or guardians of the subjects. In addition, assent was obtained from subjects aged 7 to 12 years. Both consent and assent forms stated that the study investigated the role of height and weight to predict asthmatic admissions. Weights and heights were measured for all patients who were able to stand at the time of presentation. Those patients who were unable to stand because of moderate to severe asthma symptoms were not enrolled in the study because the research associates and medical staff were not able to measure their heights and weights during the ED presentation. Weight was measured on a Detecto Scale (model 6439 Digital Exe-Level Physician Scale; Detecto Scale, Webb City, Mo). Height was measured from a wall-mounted vertical ruler. The treating physicians were aware of this study's hypothesis, but they were blinded to the calculation of BMI and weight classification. The physicians systematically treated the patients in accordance with an asthma flow sheet that was modeled on the treatment protocol from the *Guidelines for the Diagnosis and Management of Asthma, Expert Panel Report 2*, of the National Institutes of Health¹⁴ and from its 2003 supplement.¹⁵ Subjects were treated with 3 doses of nebulized albuterol every 20 minutes and 1 dose of corticosteroids. At this point, the treating physician made a decision regarding the disposition of the patient, whether to be admitted or discharged. While awaiting transfer to the inpatient bed from the ED, admitted children continued to receive additional albuterol treatments and asthma care.

Measurements

Baseline characteristics were age, sex, race, and household tobacco smoking. These baseline characteristics were self-reported by the family and patient. The outcome variable, admission with the index ED visit, was determined at the time of enrollment in the study. Additional asthma outcome measures, asthma admission in the past year, ED visits in the last 30 days, and missed school days in the past 30 days, were self-reported by the family and the patients. The data were collected and entered onto an Excel spreadsheet (Microsoft Office Excel 2003; Microsoft Corporation, Seattle, Wash). Body mass index was a calculated value of weight (kilogram)/height (meter)². Patients with a BMI lower than the 85% percentile were classified as with nonoverweight BMI. Patients with a BMI of 85% or higher were classified as with overweight BMI. We used the BMI growth

charts for boys and girls aged 2 to 20 years of the Centers for Disease Control to categorize patients as with nonoverweight BMI or with overweight BMI.¹⁶

Data Analysis

Data were expressed as mean (SD). The reference group comprised patients with a BMI lower than the 85% percentile based on age and sex (nonoverweight BMI). The comparison group comprised patients with a BMI of 85% or higher (overweight BMI). Three variables, asthma inpatient admission in the past year, ED asthma visits in the last 30 days, and missed school days in the past 30 days, were dichotomized as either "no/none event" or "1 or more events." The outcome measure, the patient's final disposition in the index ED visit, was dichotomized as "admission to the hospital" or "discharged home." Group data were analyzed with the statistical software package SPSS version 8 (SPSS Inc, Chicago, Ill). Comparisons were made by Student *t* test or Fisher exact test, as appropriate. All tests were 2-tailed with the α set at 0.05. The proposed study required 300 subjects to achieve an α of 0.05 based on a power of 80% and on a difference of 30% in admission rate between the nonoverweight BMI patients and the overweight BMI patients.

RESULTS

The study enrolled 183 pediatric patients with a mean (SD) age of 10.3 (3.3) years (range, 6–18 years) and 62.3% males. One hundred eight patients (59%) were overweight ($\geq 85\%$ by BMI), and 75 (41%) were the nonoverweight ($< 85\%$ by BMI) controls. Table 1 compares the baseline characteristics between overweight and nonoverweight pediatric patients with asthma. For age ($P = 0.71$) and sex ($P = 0.76$), there was no significant difference between overweight and nonoverweight children enrolled in this study. In addition, there was no difference in race between overweight and nonoverweight patients. There was a trend toward a higher rate of household smoking in overweight (21.3%) versus nonoverweight children (10.7%); however, this difference was not significant ($P = 0.07$). When the study sample was stratified by BMI between a percentile lower than 85% and a percentile of 85% or higher and smoking, the admission rates between the overweight and nonoverweight children was statistically nonsignificant. We found no statistically significant difference (Fisher exact test, $P = 0.58$) in the admission rates between asthmatic children with obesity (15%; 95% confidence interval [CI], 4%–37%) and asthmatic children without obesity (25%; 95% CI, 6%–59%).

Table 2 compares the asthma outcome measures of admission rate for the index ED visit, asthma admissions in the previous year, previous number of ED visits, and school days missed. The admission rate for the index ED visit was not significantly ($P = 1.00$) different between the overweight

TABLE 2. Comparisons of Asthma Outcomes Between Pediatric Asthma Groups (Overweight Vs Nonoverweight Patients)

	Overweight	Nonoverweight	P
Admission rate and index ED visit, %	10.2	9.3	1.00
≥ 1 inpatient admission during the past year, %	35	31	0.63
≥ 1 ED asthma visits during the past 30 d, %	27	28	0.87
≥ 1 missed school days during the past 30 d, %	51	40	0.18

(10.2%; 95% CI, 5.6–17.5) and nonoverweight children (9.3%; 95% CI, 4.3–18.3). Asthma-related admission rates over the past year were also not significantly ($P = 0.63$) different between the 2 study groups. There was no significant difference in the percentage of children who had 1 or more asthma-related ED visits in the past 30 days ($P = 0.87$) or school days missed secondary to asthma in the previous 30 days ($P = 0.18$).

DISCUSSION

Our study showed no association between overweight children, as measured by BMI, and pediatric asthma outcomes. Our primary, prospectively measured outcome variable, index visit and admission rate, was not significantly ($P = 1.00$) different between overweight (10.2%) and nonoverweight children with ambulatory asthma (9.3%) presenting to the ED. Our result was discordant with that of Carroll et al¹³ who showed higher admission rates in children with obesity (>95% weight-for-age percentile) versus asthmatic children with normal weight ($\leq 95\%$ weight-for-age percentile).

Our study had methodological differences from that of Carroll et al.¹³ Our study prospectively enrolled children presenting to the ED, whereas Carroll et al¹³ retrospectively enrolled children from a medical chart review. In addition, our study measured height and weight to calculate the BMI for each child with asthma, whereas Carroll et al¹³ used weight for height and sex-specific reference data from the National Center for Health Statistics. Each study's cutoff for a significant increased weight is different and is measured differently.

Our prospective methodology also allowed for the collection of other generally accepted surrogate measures of asthma outcome, such as admissions over the previous year, ED visits during the preceding 30 days, and the number of school days missed in the last 30 days. Our surrogate asthma outcome measures supported our hypothesis that BMI was not associated with asthma severity. We found no clinically significant differences in admission in the previous year, ED visits for 30 days, and the number of missed school days in the last 30 days between overweight and nonoverweight children with asthma.

LIMITATIONS

We did not achieve our projected enrollment of 300 patients. Because of our smaller study sample of 183 patients, this study may be underpowered to detect a 30% difference in asthma admission rate or effect size. However, we believe that because the absolute difference in asthma admission rates was only 0.9% and the 95% CIs nearly entirely overlap, there was no important difference in asthma admission rates between these 2 patient populations.

Our study population was a convenience sample of enrolled ambulatory patients. The ED staff was able to obtain the height and the weight of these patients because these children were able to stand for these measurements. Enrolling these children introduced the possibility of spectrum bias, where healthier patients with asthma were selected for our study.

However, children with severe asthmatic symptoms, that is, tachypnea, dyspnea, retractions, hypoxia, and so on, were self-selected for exclusion in our study. Because of their severe symptoms, these children were unable to have their height and weight measured. These children had their disposition to admission based upon their poor pulmonary reserves and respiratory symptoms rather than on their BMI. Thus, BMI does not and should not be the primary predictive variable in these patients with severe symptoms.

Another limitation is the lack of objective measures for asthma severity at the time of disposition. Many children were

unable to exhale forcefully into a peak flow meter to measure their peak flow rate. Surrogate measures of asthma severity such as wheeze, work of breathing, air entry, prolonged expiration, and mental status were measured. However, these measures were subject to interpretation by the medical staff and research associates. Ultimately, we did not have any consistent measure of asthma severity. Despite lacking measurements of asthma severity, we felt that our physicians treated patients with asthma in a systematic fashion because they followed an asthma flow sheet when treating the patients with asthma.

CONCLUSIONS

Body mass index, a method to quantify overweight children, failed to predict admission of children with ambulatory asthma who present to the pediatric ED.

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