Journal of Urban Health: Bulletin of the New York Academy of Medicine, Vol. 83, No. 3
doi:10.1007/s11524-006-9050-9
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Childhood Asthma and Extreme Values of Body Mass Index: The Harlem Children's Zone Asthma Initiative

Helen L. Kwon, Benjamin Ortiz, Rachel Swaner, Katherine Shoemaker, Betina Jean-Louis, Mary E. Northridge, Roger D. Vaughan, Terry Marx, Andrew Goodman, Luisa N. Borrell, and Stephen W. Nicholas, for the Harlem Children's Zone Asthma Initiative

ABSTRACT *To examine the association between body mass index (BMI) percentile and asthma in children 2–11 years of age, we performed a cross-sectional analysis of 853 Black and Hispanic children from a community-based sample of 2- to 11-year olds with measured heights and weights screened for asthma by the Harlem Children's Zone Asthma Initiative. Current asthma was defined as parent/guardian-reported diagnosis of asthma and asthma-related symptoms or emergency care in the previous 12 months. Among girls, asthma prevalence increased approximately linearly with increasing body mass index (BMI) percentile, from a low of 12.0% among underweight girls (BMI ≤5th percentile) to a high of 33.3% among girls at risk for overweight (BMI 85th–94th percentile). Among boys, asthma prevalence was associated in a U-shaped curve with the extremes of BMI percentile, that is, 36.4% among underweight boys, 19.1% among normal weight boys (BMI 6th–84th percentile), and 34.8% among overweight boys (>95th percentile). After adjusting for age, race/ethnicity, and household smoking, among girls, having asthma was associated with being at risk for overweight (odds ratio [OR], 2.6; 95% confidence interval [CI], 1.4–5.0) and being overweight (OR, 2.1; 95% CI, 1.2–3.8) compared to normal weight; among boys, having asthma was associated both with overweight (OR, 2.4; 95% CI, 1.4–4.3) and with underweight (OR, 2.9; 95% CI, 1.1–7.7). Large, prospective studies that include very young children are needed to further explore the observed association between underweight and asthma among boys. Early interventions that concomitantly address asthma and weight gain are needed among pre-school and school-aged children.*

KEYWORDS *Asthma, Children, Epidemiology, Gender, Obesity.*

Kwon and Ortiz share co-first authorship. Ortiz and Nicholas are with the Department of Pediatrics, Harlem Hospital Center/Columbia University, New York, NY, USA; Kwon and Borrell are with the Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, NY 10032, USA; Swaner, Shoemaker, and Jean-Louis are with the Harlem Children's Zone, Inc., New York, NY; Northridge and Vaughan are with the Harlem Health Promotion Center, Mailman School of Public Health, Columbia University, New York, NY, USA; Northridge is with the Department of Sociomedical Sciences, Mailman School of Public Health, Columbia University, New York, NY, USA; Vaughan is with the Department of Biostatistics, Mailman School of Public Health, Columbia University, New York, NY, USA; Marx is with the Department of Education, New York City, NY, USA; Goodman is with the East and Central Harlem District Public Health Office, New York City Department of Health and Mental Hygiene, New York, NY, USA.

Correspondence: Helen L. Kwon, PhD, MPH, Department of Epidemiology, Mailman School of Public Health, Columbia University, 722 W. 168th Street, 7th Floor, New York, NY 10032, USA. (E-mail: helen.kwon@aya.yale.edu)

INTRODUCTION

Asthma and overweight are chronic conditions that have increased substantially among U.S. children during the past several decades.[1,2] Poor communities and communities of color may be at increased risk for these conditions. Pediatric asthma is the primary cause of hospitalizations in U.S. children and the chronic condition most commonly associated with school absences.[1] In 2001, children 14 years and younger in Central Harlem were twice as likely as other New York City children to be hospitalized for asthma.[3] In the United States, 23% of 2–5 year olds and 31% of 6–11 year old children are now considered overweight or at risk for overweight.[2] Among New York City public elementary school children, 43% are overweight or at risk for overweight.[4]

A growing body of literature has reported a relationship between asthma and obesity among adults.[5,6] Studies conducted among children,[7–21] however, have produced conflicting results thus far, and further elucidation is necessary of how an association between asthma and body mass index (BMI) may differ by population characteristics, such as age, gender, and race/ethnicity. In addition, many studies among children have failed to assess the potential effect across the full range of BMI percentiles, including those who are underweight.

We explored in our study sample whether increased BMI would be associated with increased risk of asthma, and whether the association between increased BMI percentile and increased risk of asthma would be stronger among girls than boys and among Hispanic children compared with Black children. In contrast with many previous studies, we explored the risk of asthma across all ranges of BMI percentiles, among Black and Hispanic children who reside in an urban community in the United States, where risk for the two conditions may be elevated overall.[8] In addition, we sought to address the unresolved issue of whether gender modifies the association between BMI and asthma. The association between current asthma and obesity was assessed among 853 children ages 2–11 years who were screened for asthma and had height and weight measurements recorded by the Harlem Children's Zone Asthma Initiative between 2002 and 2004.

METHODS

Setting and Participants

The Harlem Children's Zone Asthma Initiative (HCZAI) is an urban, community-based collaboration that was established in 2001 to address the high asthma-related morbidity observed among children 0–12 years of age living within a 24-block (expanded in 2004 to a 60-block) area of Central Harlem, New York City, known as the Harlem Children's Zone (see http://www.hcz.org). The partnership between Harlem Children's Zone, Inc. (HCZ) and the Department of Pediatrics at Harlem Hospital Center aims to intervene by offering medical, educational, home-based environmental, social, and legal interventions as part of HCZ's larger community-building initiative. The HCZAI has been previously described in detail.[22,23]

In order to assess asthma prevalence, an asthma screening questionnaire was distributed to the parents/guardians of children aged 0–12 years who lived or attended school in the Harlem Children's Zone or participated in any HCZ programs, including those geared towards early childhood development and parenting (Baby College) and pre-kindergarten children (Harlem Gems) as well as after-school programs. Children were also recruited by reviewing Harlem Hospital

Center inpatient, emergency room and clinic records and through community events and other outreach activities. In addition to completing a written screening survey, parents/guardians were asked for their permission to have a physician or nurse from the pediatric asthma team conduct a brief physical examination of their children that included stethoscopic chest examinations, peak expiratory flow rates for children 6 years and older, and height and weight measurements.[22] Standing heights and weights were measured using portable scales and wall-mounted tape measures. Because of resource limitations, not all school-aged children were physically screened after 2002 even when parent/guardian permissions were granted.

The study sample used in the current analysis consisted of the 853 children aged 2–11 years screened for asthma between April 2002 and November 2004 for whom information on asthma status was available and for whom body mass index (BMI) percentile could be calculated as described below. Approval for the screening and the physical examinations with parent/guardian permission was received from the Institutional Review Boards (IRB) of Harlem Hospital Center and the New York City Department of Education.

Definition of Asthma

The definition of current asthma used for the analysis was a parent/guardian-reported diagnosis of asthma and evidence of asthma-like symptoms or asthma-related emergency care use during the past year, as recorded on the asthma screening survey. Specifically, having asthma was defined as an answer of "yes" to the question, "Has your child ever been told by a doctor or nurse that she or he has asthma?" and at least one of the following four self-reported symptoms of asthma: 1) "In the last 12 months, has your child had wheezing or whistling in the chest?"; 2) "In the last 12 months, has your child wheezed or coughed during or after exercise when he or she did not have a cold?"; 3) "In the last 12 months, has your child made an emergency room visit to a doctor's office or hospital emergency room because of asthma or other breathing problems?"; or 4) "In the past 12 months, has your child's sleep been disturbed due to a dry cough at night, apart from a cough associated with a cold or a chest infection?"

Measurement of BMI Percentile

BMI was defined as weight (in kilograms) divided by the square of height (in meters). BMI percentiles were calculated from measured heights and weights using the Centers for Disease Control and Prevention (CDC) age- and gender-specific BMI growth charts for children 2 years of age and older by six-month age intervals[24,25] and a SAS program provided online by the CDC (http://www.cdc.gov/nccdphp/dnpa/growthcharts/sas.htm). CDC-defined cutoffs for age- and gender-specific BMI were used to define underweight (less than or equal to the fifth percentile), normal weight (sixth percentile to less than 85th percentile), at risk for overweight (85th percentile to less than 95th percentile), and overweight (greater than or equal to 95th percentile).

Covariates and Effect Modifiers

Potential confounders were obtained from the screening survey and included the child's gender, age, race/ethnicity, nativity, health insurance status, and household smoking exposure. Potential effect modifiers were identified from the literature and included age, gender, and race/ethnicity. Self-reported race/ethnicity was catego-

rized here as (1) Hispanic, any race and (2) Black, non-Hispanic (which includes Black, no Hispanic ethnicity noted).

TABLE 1. Characteristics of the population by asthma status—children screened by Harlem Children's Zone Asthma Initiative*, 2002–2004 (n = 853)

	Total		No asthma		Yes asthma	
	Number[†]	%	Number	%	Number	%
Body mass index percentile[‡,§]						
≤5 (underweight)	47	5.5	36	5.5	11	5.7
6–84 (normal)	479	56.2	394	59.8	85	43.8
85–94 (at risk of overweight)	139	16.3	99	15.0	40	20.6
≥95 (overweight)	188	22.0	130	19.7	58	29.9
Asthma**						
Yes	194	22.7				
No	659	77.3				
Gender						
Male	422	49.5	320	48.6	102	52.6
Female	431	50.5	339	51.4	92	47.4
Age, years						
2–5	253	29.7	193	29.3	60	30.9
6–11	600	70.3	466	70.7	134	69.1
Race/ethnicity						
Black[††]	685	80.3	533	80.9	152	78.4
Hispanic[‡‡]	168	19.7	126	19.1	42	21.6
Nativity						
Foreign-born	33	3.9	27	4.1	6	3.1
U.S.-born	815	96.1	628	95.9	187	96.9
Health insurance						
Yes	745	92.4	573	92.4	172	92.5
No	61	7.6	47	7.6	14	7.5
Household smoking[§,§§]						
Yes	195	24.2	131	21.1	64	34.4
No	612	75.8	490	78.9	122	65.6

*Children screened by Harlem Children's Zone Asthma Initiative (Ages 2–11), 2002–2004, with complete information on asthma and for calculating BMI percentile.

[†]Totals may differ due to missing values.

[‡]Sex-specific BMI percentile categories of the 2000 Centers for Disease Control and Prevention BMI-for-age growth charts.

[§]Chi-square $p < 0.001$.

**Asthma is an answer of "yes" to "Has your child ever been told by a doctor or nurse that she or he has asthma?" and an answer of yes to at least one of the following: "In the last 12 months, has your child had wheezing or whistling in the chest?", "In the last 12 months, has your child wheezed or coughed during or after exercise when he or she did not have a cold?", "In the last 12 months, has your child made an emergency room visit to the doctor's office or hospital emergency room because of asthma or other breathing problems?", "In the past 12 months, has your child's sleep been disturbed due to a dry cough at night, apart from a cough associated with a cold or a chest infection?"

[††]Black non-Hispanic (includes Black no Hispanic ethnicity noted).

[‡‡]Hispanic, any race.

[§§]Presence of household smoking is defined as the answer "yes" to "Do you or anyone who lives in your home smoke cigarettes now?"

Statistical Analyses

Children aged 2–11 years were assessed for comparability with national age groupings relative to BMI percentile and previous studies of pre-adolescent children. The prevalence of asthma by BMI percentile category was calculated for girls and boys separately; chi-square tests were used to assess evidence of an association. To test for the possibility of linear trend, the Cochran–Armitage test for trend was also utilized. Differences in asthma prevalence by BMI percentile category were considered by age group (2–5 and 6–11 years) and race/ethnicity (Hispanic, any race and Black, non-Hispanic). Age groups were chosen based on prior literature and national reports of overweight among children.[2,4]

To further explore the relationship between BMI percentile and asthma (yes or no) with adjustment for appropriate covariates and examination of interactions,

TABLE 2. Prevalence of asthma* by age and gender—children screened by Harlem Children's Zone Asthma Initiative†, 2002–2004

	Body mass index percentile categories				
	Underweight ≤5	Normal 6–84	At risk for overweight 85–94	Overweight ≥95	*p* value‡
All Ages					
Girls (*n* = 431)					0.005
n/N§	3/25	39/238	23/69	27/99	
Prevalence, %	12.0	16.4	33.3	27.3	
Boys (*n* = 422)					0.014
n/N	8/22	46/241	17/70	31/89	
Prevalence, %	36.4	19.1	24.3	34.8	
2 to 5 year olds					
Girls (*n* = 124)					0.820
n/N	2/13	14/70	2/11	8/30	
Prevalence, %	15.4	20.0	18.2	26.7	
Boys (*n* = 129)					0.179
n/N	5/11	14/72	5/17	10/29	
Prevalence, %	45.5	19.4	29.4	34.5	
6 to 11 year olds					
Girls (*n* = 307)					0.002
n/N	1/12	25/168	21/58	19/69	
Prevalence, %	8.3	14.9	36.2	27.5	
Boys (*n* = 293)					0.089
n/N	3/11	32/169	12/53	21/60	
Prevalence, %	27.3	18.9	22.6	35.0	

*Asthma is an answer of "yes" to "Has your child ever been told by a doctor or nurse that she or he has asthma?" and an answer of yes to at least one of the following: "In the last 12 months, has your child had wheezing or whistling in the chest?", "In the last 12 months, has your child wheezed or coughed during or after exercise when he or she did not have a cold?", "In the last 12 months, has your child made an emergency room visit to the doctor's office or hospital emergency room because of asthma or other breathing problems?", "In the past 12 months, has your child's sleep been disturbed due to a dry cough at night, apart from a cough associated with a cold or a chest infection?"

†Children screened by Harlem Children's Zone Asthma Initiative (Ages 2–11), 2002–2004, with complete information on asthma and for calculating BMI percentile.

‡*p* for chi-square test.

§Totals may differ due to missing values.

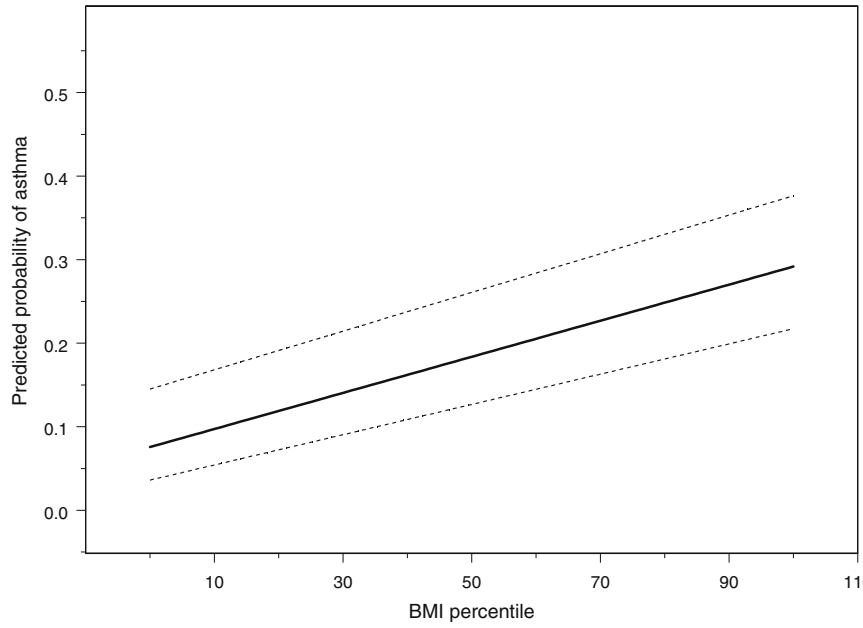

FIGURE 1. Body mass index percentile by risk of asthma* among girls in Central Harlem, adjusting for age, race/ethnicity, and household smoking.

multivariate logistic models were fit for girls and boys separately, with BMI percentile (1) categorized as described previously and (2) considered as a continuous variable. To explore potential bias related to lower rates of physical examinations for 6–11 year olds after 2002 due to resource constraints, a sensitivity analysis was performed including only children screened in 2002. Statistical tests were two-sided with a significance level of 0.05. All analyses were conducted in SAS Version 9.1 (SAS Institute, Cary, NC). Figures were created using S-Plus Version 6.2 (Insightful Corp., Seattle, WA).

RESULTS

A total of 1,219 children aged 0–12 years were physically screened by the HCZAI between April 2002 and November 2004. After excluding children who were less than 2 years of age and older than 11 years of age (n = 201), those who were missing data on race/ethnicity (n = 51), or, because of small numbers, who were White or Other Race (n = 15), or who were missing data on asthma (n = 7) or BMI percentile (n = 92), the current analysis was limited to the 853 children aged 2–11 years for whom complete data on BMI percentile and asthma were available. The median age of the children was 7.4 years (mean = 7.5 years, standard deviation = 2.5). Calculated BMI values ranged from 11.3 to 51.0. The self-reported measure for asthma was associated with absolute peak expiratory flow rate among children 6–11 years of age (t-test p = 0.02). Table 1 provides general characteristics of the population by asthma status. Overall, 5.5% of the children were underweight, 56.2% were normal weight, 16.3% were at risk for overweight, and 22.0% were

*_Dashed lines_ represent 95% confidence limits

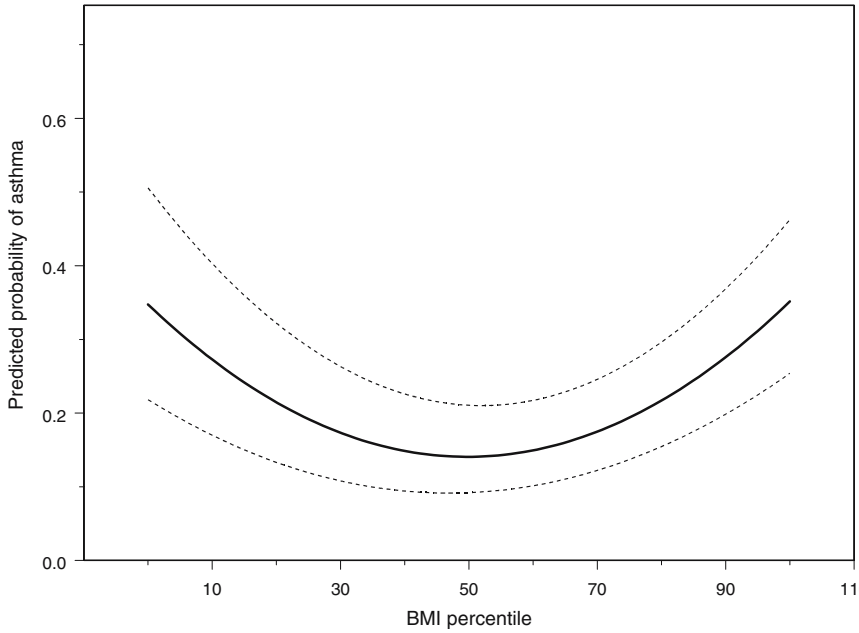

FIGURE 2. Body mass index percentile by risk of asthma* among boys in Central Harlem, adjusting for age, race/ethnicity, and household smoking.

overweight. Among children 2–5 years of age, 9.5% were underweight. Approximately 23% of the children overall had current asthma. None of the characteristics presented in Table 1 differed significantly by gender. Asthma status was significantly related to BMI percentile category and to household smoking (chi-square $p < 0.001$) (Table 1).

Asthma prevalence differed by BMI percentile category (Table 2). Among girls overall, there was evidence of a linear increase in asthma prevalence with increasing BMI percentile (p for association = 0.005, p for linear trend = 0.001). Asthma prevalence at the lowest BMI percentile category (underweight) was 36.4% among boys compared to 12.0% among girls. The elevated asthma prevalence among underweight boys combined with the relatively lower asthma prevalence among boys in the normal range of BMI (19.1%) and increased asthma prevalence among at risk for overweight (24.3%) boys and overweight (34.8%) boys suggested a curvilinear trend among boys. When the data were further examined by age group in addition to gender, the increased risk of asthma observed among underweight boys was especially pronounced among 2–5 year old boys (45.5%) compared to 6–11 year old boys (27.3%). Among girls, an increased risk of asthma among those at risk for overweight compared to normal weight was found in 6–11 year old girls (36.2 vs. 14.9%) but not in 2–5 year old girls (18.2 vs. 20.0%). Further exploration of the data revealed some differences by race/ethnicity, including a trend among 6–11 year olds towards an increased risk of asthma among overweight Hispanic boys (57.1%) and Hispanic girls who were at risk for overweight (56.3%) (data not shown).

A multivariate logistic model considering BMI percentile as a continuous variable and adjusting for age, race/ethnicity, and household smoking supported

*_Dashed lines_ represent 95% confidence limits

TABLE 3. Adjusted* association between asthma† and body mass index percentile—screened by Harlem Children's Zone Asthma Initiative‡, 2002–2004

	Girls (n = 431)		Boys (n = 422)	
	OR	95% CI	OR	95% CI
Body mass index percentile				
≤5 (underweight)	0.7	0.2 to 2.6	2.9	1.1 to 7.7
6–84 (normal weight)	1.0		1.0	
85–94 (at risk for overweight)	2.6	1.4 to 5.0	1.5	0.8 to 2.8
≥95 (overweight)	2.1	1.2 to 3.8	2.4	1.4 to 4.3
Age, years				
2–5	1.0		1.0	
6–11	1.0	0.6 to 1.7	0.8	0.5 to 1.4
Race/ethnicity				
Black§	1.0		1.0	
Hispanic**	1.3	0.7 to 2.4	0.9	0.5 to 1.7
Household smoking††				
Yes	1.7	1.0 to 2.9	2.1	1.2 to 3.5
No				

*Each variable was adjusted for every other variable listed in the model.

†Asthma is an answer of "yes" to "Has your child ever been told by a doctor or nurse that she or he has asthma?" and an answer of yes to at least one of the following: "In the last 12 months, has your child had wheezing or whistling in the chest?", "In the last 12 months, has your child wheezed or coughed during or after exercise when he or she did not have a cold?", "In the last 12 months, has your child made an emergency room visit to the doctor's office or hospital emergency room because of asthma or other breathing problems?", "In the past 12 months, has your child's sleep been disturbed due to a dry cough at night, apart from a cough associated with a cold or a chest infection?"

‡Children screened by Harlem Children's Zone Asthma Initiative (Ages 2–11), 2002–2004, with complete information on asthma and for calculating BMI percentile.

§Black, non-Hispanic (includes Black, no Hispanic ethnicity noted)

**Hispanic, any race.

††Presence of household smoking is defined as the answer "yes" to "Do you or anyone who lives in your home smoke cigarettes now?"

linear and quadratic BMI interaction terms by gender (linear interaction p = 0.0004, quadratic interaction p = 0.0021). Figures 1 and 2 reflect the monotonic, linear trend observed for girls and the quadratic model of asthma by BMI percentile among boys, respectively.

In models considering BMI percentile categorically as per the CDC-defined cut points for underweight, normal weight, at risk for overweight, and overweight,[24] adjusted for age, race/ethnicity, and household smoking, among girls, being at risk for overweight was associated with an odds ratio (OR) for having asthma of 2.6 (95% confidence interval [CI], 1.4–5.0) and an OR of 2.1 (95% CI, 1.2–3.8) for overweight as compared to being normal weight (Table 3). No increased risk for asthma was observed among underweight girls (OR, 0.7; 95% CI, 0.2–2.6). On the other hand, among boys, those who were underweight were 2.9 times as likely to have asthma (95% CI, 1.1–7.7) compared with those who were normal weight. Boys who were at risk for overweight had a trend towards increased risk of asthma (OR, 1.5; 95% CI, 0.8–2.8). Boys who were classified as overweight were 2.4 times as likely to have asthma (95% CI, 1.4–4.3) as normal weight boys. The sensitivity analysis conducted among children screened in 2002 with measured weights and heights revealed similar results to those obtained for all children screened between

2002 and 2004 with measured weights and heights and presented here (data not shown). Since clinicians may be reluctant to attribute a diagnosis of asthma to young children who may have early transient wheezing,[26] we assessed our definition of asthma statistically to see whether it appeared to be robust among younger children in our study. We did not find a significant association between asthma diagnosis and age less than 6 years or between asthma-like symptoms and age less than 6 years (data not shown).

DISCUSSION

Our results suggest strong associations that differ by gender between BMI percentile and current asthma among Black and Hispanic children 2–11 years of age in Central Harlem. More specifically, a U-shaped curve was observed for boys and a linear trend was observed for girls when examining BMI percentile versus the probability of having asthma. There also appear to be smaller differences in these observed associations by age group and race/ethnicity. Among girls, the increased risk of asthma with greater BMI percentile was found among 6–11 year olds but not among 2–5 year olds. Among 6–11 year old children, Hispanic girls accounted for a greater proportion of the asthma cases among those at risk for overweight than Black, non-Hispanic girls, while Hispanic boys accounted for a greater proportion of the asthma cases among those who were overweight than Black, non-Hispanic boys. However, these sub-group analyses by age and race/ethnicity involved small numbers and should be interpreted with caution. Additionally, in order to gain a better understanding of the impact of race/ethnicity in our study, we would need more complete information on other factors such as barriers to health care access and quality of care, language spoken at home, and discrimination based on skin color.

Although recent studies of asthma and BMI percentiles among children have tended to focus solely on the upper range of BMI percentile, our findings are consistent with reports of a U-shaped association between asthma and BMI among men and a less dramatic (J-shaped) or linear association observed among women.[27–29] A similar pattern has been observed among children 6–14 years of age.[18] In addition, our analyses presented here utilized both a continuous measure of BMI percentile, which strengthened our statistical analysis, and the CDC-defined categories for underweight, normal weight, at risk for overweight, and overweight, which facilitated interpretation of our results. We observed a two-fold risk of asthma among overweight boys and girls and a three-fold increased risk of asthma among underweight boys compared with children of normal weight.

Previous investigations have found associations between underweight and asthma in adults and adolescents.[30,31] A prospective study of children recruited during 1974–1979 in six U.S. cities demonstrated an increased risk of developing asthma among the leanest boys; however, their analysis did not include children younger than 6 years of age.[18] Our analyses of a more recent cohort of children assessed in 2002–2004 reveal that an association between underweight and asthma appears to occur early on in the life course, and was even stronger among 2–5 year old boys than among 6–11 year old boys. Furthermore, studies such as those demonstrating a U-shaped association between ponderal index at birth (birth weight divided by length cubed) and adult asthma and atopy[32] and increased risk of asthma among low-normal gestational age boys [33] point to the role of perinatal and early life factors in the development of asthma and atopy. It is possible that among

some of the children in our sample, nutritional and growth restriction occurring during these periods could have contributed to abnormal lung growth and asthma. The gender difference in risk associated with underweight that we observed may reflect, in part, smaller airways for lung size in boys who are more susceptible to asthma at early ages compared to girls.[34,35] The U-shaped association between asthma and BMI among boys may be due to different mechanisms underlying the relationship among underweight boys and overweight boys. Further research is needed to elucidate these potential pathways.

We found an increased risk of asthma associated with being at risk for overweight among 6–11 year old girls but not among younger girls or among boys. The importance of intervening among pre-adolescent girls who are at risk for overweight was also suggested by a longitudinal study of children in the Tucson Children's Respiratory Study, which demonstrated that girls, but not boys, with BMIs greater than or equal to the 85th percentile at age 11 were more likely to experience wheezing at 11 and 13 years of age than those with BMIs less than the 85th percentile.[11] In addition, girls in the Tucson study who became overweight or at risk for overweight between ages 6–11 years were seven times more likely to develop new asthma symptoms at 11 or 13 years of age than girls who did not become overweight or at risk for overweight during this period of development.

Our report has a number of important limitations. The cross-sectional nature of our data precludes our ability to draw conclusions about causation or the directionality of the BMI-asthma association or to distinguish age from cohort effects in our study sample. Sub-group analyses by age and race/ethnicity involved relatively small numbers of children, as did our analyses of underweight children. While resource limitations influenced the eventual number of children we were able to screen for heights and weights, the sensitivity analysis we conducted demonstrated that lower rates of physical screening in more recent years does not seem to have biased our overall results. In addition, while BMI percentile was assessed from objectively measured heights and weights, our assessment of asthma was based upon parent/guardian-reported asthma diagnosis and asthma-related symptoms or emergency care in the previous 12 months, although self-reported asthma was associated with objective measures of lung function in our study. We cannot exclude the possibility of bias associated with differential diagnosis of asthma or contact with the health care system with overweight or underweight status. Our analysis relies upon baseline data that did not include a measure of asthma severity, clinical management, or symptom control. During follow up, children enrolled in the asthma intervention are being assessed for asthma management, including inhaled corticosteroid use.[22,36] We did not find a significant difference in prevalence of asthma diagnosis or symptoms with younger age; however, it is still possible that differential diagnosis by age could have influenced our findings by age group. Finally, our method of recruitment was intended for reaching as many diagnosed and undiagnosed asthmatic children as possible within the 60-block area of the HCZ and was not designed to achieve a representative sample. Nonetheless, the proportion of Black and Hispanic children in our study reflects the racial and ethnic profile of Central Harlem from the 2000 U.S. Census, and the high rates of current asthma and overweight observed in our dataset are similar to those in published reports of other less affluent, urban communities in New York City.[4,37,38] In short, our results are consistent with findings from other cross-sectional and prospective studies in children and adults[18,27–31] and address the unresolved issue of whether gender modifies the putative association between obesity and asthma.[39] On the

basis of our findings, we are in the process of implementing an intervention for overweight and at risk for overweight children with asthma enrolled in the HCZAI, which will include physical activity and nutrition sessions and an asthma educational intervention.

In summary, we were able to demonstrate an association between BMI percentile and asthma among children 2–11 years in Central Harlem. Different shapes of the curves were observed by gender for this association along the entire range of the BMI percentile, including an increased risk of asthma among underweight boys and overweight boys and girls. Pediatricians should be aware of a gender difference in the relationship between BMI percentile and the probability of asthma. The association we observed between underweight and asthma among boys needs to be further explored with a large, prospective study, which utilizes both continuous and categorical measures of BMI and includes assessments of gestational age and weight at birth along with a substantial number of very young children. Finally, interventions that aim to prevent excessive weight gain in the pre-school and elementary school years are especially important to healthy development and may also help to reduce asthma- and obesity-related morbidity in school-aged children, adolescents, and adults.

ACKNOWLEDGEMENTS

Financial and ongoing program support for the Harlem Children's Zone Asthma Initiative is provided by the Robin Hood Foundation (grant RHF CU516688), the Anne E. Dyson Community Pediatrics Training Initiative, the National Institute of Environmental Health Sciences (grant 5 R25 ES012574-02), the American Legacy Foundation (grant 5052), the Centers for Disease Control and Prevention through the Harlem Health Promotion Center (grant U48/CCU209663-08), and the Kellogg Scholars in Health Disparities Program.

Past and present participants in the Harlem Children's Zone Asthma Initiative include the named authors on this article, as well as (in alphabetical order) T. Berry Brazelton, Geoffrey Canada, Jason Corburn, Jazmine Credell, Linda Cushman, Lisa Desrochers, Daouda Diarrassouba, Shannon Farley, Lee Farrow, Keith Faulkner, Jacqueline Fox-Pascal, Regina Garrett, Cynthia Golembeski, Katrina Gonzalez, Roger Hayes, Vincent Hutchinson, Marilyn Joseph, Daniel Kass, Renuka Kher, Sandra Klihr-Beall, Lucille Lebovitz, Rasuli Lewis, Marty Lipp, Cara McAteer, Brian McClendon, Robert Mellins, Dennis Mitchell, Carolyn Nash, Eric Polley, Yvonne Pradier, Doris Prester, Miriam Ramos, David Saltzman, Gwendolyn Scott, Carron Sherry, Donna Shelley, Caressa Singleton, Joshua Sparrow, Seth Spielman, Gabriel Stover, Denise Sutton, Dawn Sykes, Michael Weinstein, Mizetta Wilson, and Candace Young.

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