



Association of wider neck circumference and asthma in obese children



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ABSTRACT

Background: Obesity is a well-established risk factor for asthma. Previous studies have reported that central obesity is associated with asthma.

Objective: To investigate the association between fat distribution, which is determined by anthropometric measures, including neck circumference (NC), and asthma in school-aged children.

Methods: Children diagnosed as having asthma were enrolled along with controls who were admitted to our outpatient department with allergic symptoms, such as rhinitis, urticaria and atopic dermatitis. Anthropometric measures, including height, weight, NC, waist circumference, and hip circumference, were obtained. Skin prick tests, blood eosinophil counts, and serum total IgE level measurements were performed.

Results: A total of 196 children (92 male [46.9%]) were included. Asthma was present in 102 patients (52.1%). Ninety-one of the patients (46.4%) were overweight, and 45 patients (22.9%) were obese. The NC of children with asthma was significantly higher than that of children in the control group. Grades defined according to NC percentiles were also significantly different between groups. In children with asthma, the prevalence of children with an NC higher than the 90th percentile (grade 6) was more frequent when compared with controls. The median NC of obese-overweight children with asthma was significantly higher compared with obese-overweight controls without asthma. Results of multivariable logistic regression analysis revealed that the presence of an NC in the greater than 90th percentile was associated with asthma in obese-overweight children.

Conclusion: This study found that NC, which is a simple anthropometric measure, is associated with asthma in obese children.

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Introduction

Obesity and asthma are increasing health problems in children. During recent decades, childhood obesity has reached an epidemic prevalence.^{1,2} The association between obesity and asthma has been well established.^{3,4}

Obesity is usually defined by body mass index (BMI; a measure of weight in kilograms divided by square of height in meters). However, BMI indicates only the total amount of fat, and it is reported that fat distribution plays a more important role in the development of complications.⁵ Upper body obesity is particularly associated with obesity-related chronic disease. Notwithstanding that there are advanced devices that assess body fat distribution,⁶ the use of anthropometric indexes is cheaper and easier to apply. Waist circumference (WC) is widely used and identifies central obesity better than BMI.⁷ Neck circumference (NC) has been

suggested as a new parameter to determine upper obesity in children and adults.^{8,9} NC is correlated with obstructive sleep apnea and metabolic syndrome in adults and children.^{4,7,10}

It was recently found that a large NC was associated with asthma severity.¹¹ However, the association between asthma and NC has not been previously evaluated in children or adult populations. In this study, we aimed to investigate the association between anthropometric measurements, particularly NC, as an indicator of body fat distribution and the presence of asthma in children.

Methods

Patients

A total of 196 children 6 years or older followed up between 2012 and 2015 in an allergy outpatient clinic were consecutively recruited during a 3-year period for this study. Children diagnosed as having asthma were enrolled along with controls who were admitted to our outpatient unit with various symptoms of rhinitis, urticaria, and atopic dermatitis. All control children had normal

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lung function test results with no airflow obstruction and no reversibility. Children with asthma included in this study were followed up by our outpatient clinic for at least 1 year. Patients with recent exacerbation at the time of enrollment, additional or coexisting chronic lung disease, and/or other chronic diseases were excluded. All patients and parents signed informed consent forms, and the institutional review board of GATA Military School of Medicine approved the study.

Diagnosis of Asthma and Other Allergic Diseases

Asthma diagnosis was made in the presence of reversible airway obstruction as defined by at least a 12% improvement in forced expiratory volume in 1 second after bronchodilator administration or an improvement in asthma symptoms after oral or inhaled corticosteroid therapy.¹²

Study Measurements

Anthropometric measures

Height, weight, NC, WC, and hip circumference (HC) were measured in postabsorptive conditions and with an empty bladder. Height was measured to the nearest 0.5 cm on a standard height board, and weight was determined to the nearest 0.1 kg on a standard physician's beam scale with the individual dressed only in light underwear and no shoes. The WC was measured 3 times at the end of gentle expiration using a flexible tape, midway between the lowest rib and the superior border of the iliac crest. The HC was measured at the level of the widest portion of the trochanters. The NC was measured at the level of the cricothyroid cartilage in the Frankfort horizontal plane. Obesity was defined as a BMI in greater than the 95th percentile, and overweight was defined as a BMI in greater than the 85th percentile for Turkish children. BMI z scores and WC and NC percentiles were also calculated.¹³ Both WC and NC were defined to be high with a value above the 90th percentile for our population.^{14,15} Furthermore, we graded patients according to NCs and WCs. We defined patients whose NC and WC were in the less than the 10th percentile as having grade 1 asthma, between the 10th and 90th percentiles as grade 2, and greater than the 90th percentile as grade 3.

Skin prick tests

All participants underwent skin prick testing for house dust mites (*Dermatophagoides farinae* and *Dermatophagoides pteronyssinus*), pollens (grass, tree and weed), molds (*Penicillium*, *Cladosporium*, *Aspergillus*, and *Alternaria*), animal dander (horse, dog, and cat), and histamine (10 mg/mL of histamine phosphate) as positive controls and 0.9% sodium chloride solution as negative controls. The volar surfaces of both forearms were used for application. Test results were recorded 15 minutes after application, and a mean wheal diameter of 3 mm or greater compared with the negative control was determined as a positive result. A positive skin prick test result to at least one allergen was defined as atopy.

Blood eosinophil counts and serum total IgE levels

Blood eosinophil counts were determined from Coulter Counter (Beckman Coulter, Fullerton, California) leukocyte measurements. Serum total IgE levels were measured with the ImmunoCAP system (Phadia AB, Uppsala, Sweden).

Statistical Analysis

SPSS statistical software, version 21.0 (SPSS Inc), was used for all calculations. Descriptive data for categorical variables were expressed as frequencies. The distributions of all numerical variables, including age, laboratory data, and anthropometric measures, were skewed; thus, results were summarized as medians and interquartile ranges (IQRs). Group comparisons were established

using Mann-Whitney tests for medians (and ranges) and the χ^2 test for categorical variables.

The association between demographic and anthropometric parameters and asthma presence in overweight-obese children was analyzed using logistic regression modeling. Anthropometric measures along with atopy and sex were used for multivariate analysis. The strength of the association between the presence of asthma and risk factors was measured using the odds ratios (ORs) and 95% confidence intervals (CIs). $P < .05$ was considered significant.

The OpenEpi software, version 3.0 (Emory University, Atlanta, Georgia), open source calculator was used for power analysis, and the power of the study was calculated as 67.6% for the whole group and 96.5% for the overweight-obese group.

Results

A total of 196 children (92 male [46.9%]) with a median age of 9.3 years (range, 7.3–11.6 years) were included. The median follow-up duration of the study group was 20 months (range, 12–35 months). Atopy was present in 109 patients (55.6%). Ninety-one patients (46.4%) in the study population were overweight, and 45 (22.9%) were obese (Table 1). There were 102 (52%) who met the diagnostic criteria for asthma, 71 (69.6%) by at least 12% improvement in forced expiratory volume in 1 second and 31 (30.4%) by symptom improvement with oral or inhaled corticosteroid therapy.

No significant differences were found between the 2 groups in terms of age, sex, birth weight, obesity-overweight prevalence, BMIs, WC, WC grade, and HC (Table 2). Atopy prevalence, eosinophil count, eosinophil percentage, and total IgE level were also not different between the groups. However, the median NC of children with asthma (median, 29.0 cm; IQR, 23.5–38.5 cm) was significantly higher than children in the control group (median, 28.5 cm; IQR, 26.9–30.0) ($P = .04$). Grades defined according to NC percentiles were also significantly different between groups ($P = .04$). In children with asthma, the ratio of children with NC in the higher than the 90th percentile (grade 6) was greater than for nonasthmatic controls ($P = .02$) (Table 2).

In obese-overweight patients, no significant difference was found between groups according to age, sex, birth weight, atopy, obesity-overweight prevalence, total IgE level, eosinophil count, eosinophil percentage, BMIs, WC, WC grade, and HC. The median NC of obese-overweight children with asthma (median, 32 cm; IQR, 29.3–33.0) was significantly higher than nonasthmatic obese-overweight controls (median, 30 cm; IQR, 28.0–32.0) ($P = .01$). There was a statistically significant difference between groups in terms of NC grade ($P = .01$). The difference was more significant for patients in the NC grade 6 group in those with and without asthma ($P \leq .01$) (Table 3).

Results of multivariable logistic regression analysis revealed that the presence of an NC in the greater than 90th percentile was

Table 1
Demographic Characteristics of the Study Population

Characteristic	Finding ^a (N = 196)
Male sex	92 (46.9)
Age, y	9.3 (7.3–11.6)
Atopy	112 (57.1)
Asthma	102 (52)
BMI	19.7 (16.7–23.1)
BMI z score	1.04 (0.02–1.84)
Overweight	91 (46.4)
Obese	45 (22.9)

Abbreviation: BMI, body mass index (a measure of weight in kilograms divided by the square of height in meters).

^aData are presented as frequency (percentage) or median (interquartile range).

Table 2
Comparison of Study Groups According to Asthma

Variable	Group with asthma ^a (n = 102)	Group without asthma ^a (n = 94)	P value
Male sex	54 (52.9)	38 (40.4)	.08
Age, y	9.2 (7.2–11.5)	9.3 (7.3–11.6)	.99
Atopy	64 (62.7)	48 (51.1)	.10
Birth weight, g	3120 (2880–3290)	3160 (2910–3330)	.90
Total IgE, kU/L	44 (14–113)	38 (11–144)	.80
Eosinophil counts, /mm ³	230 (140–375)	210 (110–305)	.30
Eosinophil percentage, %	3.0 (1.7–5.4)	2.8 (1.7–5.3)	.88
Overweight	46 (50.5)	45 (49.5)	.69
Obese	24 (23.5)	21 (56.4)	.84
Height, cm	136.3 (126.9–150.0)	137.0 (126.8–150.6)	.77
Body weight, kg	36.2 (28.0–48.0)	39.5 (28.4–50.3)	.24
BMI	19.6 (16.5–22.8)	20.0 (17.3–24.2)	.18
BMI z score	0.88 (0.03–1.81)	1.30 (0.05–1.98)	.17
NC, cm	29.0 (27.0–32.0)	28.5 (26.9–30.0)	.04
NC grade			.02
I (<10th percentile)	1 (1.0)	5 (5.3)	
II (10th–90th percentile)	56 (54.9)	63 (67.0)	
III (>90th percentile)	45 (44.1)	26 (27.7)	
NC >90th percentile	45 (44.1)	26 (27.7)	.02
WC, cm	65.3 (57.0–78.0)	69.0 (60.5–79.6)	.14
WC >90th percentile	39 (53.4)	34 (46.6)	.76
HC, cm	76.5 (67.0–86.0)	80.0 (70.0–90.0)	.10

Abbreviations: BMI, body mass index (a measure of weight in kilograms divided by the square of height in meters); HC, hip circumference; NC, neck circumference; WC, waist circumference.

^aData are presented as frequency (percentage) or median (interquartile range).

associated with the presence of asthma in obese-overweight children (OR, 3.67; 95% CI, 1.25–8.21; *P* = .001) (Table 4).

Discussion

In this cross-sectional study, we found that a larger NC may be a superior predictor of asthma in particularly obese children and may serve better than WC and HC in determining the association between obesity and asthma in children. Several studies have revealed the association between asthma and obesity. Peak expiratory flow, maximum expiratory flow, and mean forced expiratory

Table 3
Comparison of Study Groups According to Asthma

Variable	Group with asthma ^a (n = 46)	Group without asthma ^a (n = 45)	P value
Male sex	30 (65.2)	23 (51.1)	.17
Age, y	9.5 (7.2–11.2)	9.5 (7.4–11.8)	.88
Atopy	24 (52.2)	20 (44.84)	.35
Birth weight, g	3200 (3040–3380)	3240 (3060–3410)	.89
Total IgE, kU/L	37 (11–90)	29 (10–130)	.93
Eosinophil counts, /mm ³	210 (140–480)	195 (108–280)	.22
Eosinophil percentage, %	2.9 (1.8–5.4)	2.5 (1.7–3.6)	.31
Obese	24 (53.3)	21 (46.7)	.60
Height, cm	139.0 (129.8–151.6)	140.0 (129.0–152.0)	.67
Body weight, kg	36.2 (28.0–48.0)	36.5 (28.5–51.2)	.87
BMI	23.0 (20.4–25.9)	23.1 (20.3–27.4)	.44
BMI z score	1.83 (1.51–2.20)	1.88 (1.60–2.25)	.38
NC, cm	32.0 (29.3–33.0)	30.0 (28.0–32.0)	.01
NC grade			<.001
II (10th–90th percentile)	6 (13.0)	22 (48.9)	
III (>90th percentile)	40 (87.0)	23 (51.1)	
NC >90th percentile	40 (87.0)	23 (51.1)	<.001
WC, cm	78.0 (66.6–84.0)	78.5 (71.8–89.0)	.37
HC, cm	84.5 (75.8–92.5)	85.0 (81.0–96.0)	.42

Abbreviations: BMI, body mass index (a measure of weight in kilograms divided by the square of height in meters); HC, hip circumference; NC, neck circumference; WC, waist circumference.

^aData are presented as frequency (percentage) or median (interquartile range).

Table 4
Multivariable Logistic Regression Analysis for Asthma in Overweight-Obese Children

Variable	OR (95% CI)	P value
Male sex	2.15 (0.83–5.61)	.12
NC >90th percentile	3.67 (1.25–8.21)	.001
WC	0.98 (0.89–1.02)	.84
HC	1.05 (0.90–1.18)	.10
Atopy	1.16 (0.68–2.35)	.99

Abbreviations: CI, confidence interval; HC, hip circumference; NC, neck circumference; OR, odds ratio; WC, waist circumference.

flow values were found to be lower in obese individuals. These data suggest that upper airway flow is affected by obesity.^{16,17} Inflammation and fatty infiltration of muscles directly narrowing the airway are possible pathophysiologic mechanisms of this effect.¹⁸ Increased airway reactivity and interruption of the autonomic nervous system mediated by leptin were also suggested as reasons.¹⁹

Central obesity and deposition of fat, particularly in the upper body, are suggested to be related to obesity complications, such as hypertension, diabetes mellitus, obstructive sleep apnea, and cardiovascular disease.^{20–23} An association between upper or central obesity and airway hyperresponsiveness was also found in an adult study.²³ In our study, NC and NC grade, new markers of central obesity, were significantly different between patients with and without asthma. However, this difference was much more distinctive in obese individuals. Moreover, the power of the study was 67.6% for the whole group, whereas it was 96.5% for the overweight-obese group. It may be suggested that NC is an indicator of the association between asthma and obesity.

WC is a widely used measure to define central obesity. NC may be an alternative measurement of upper body subcutaneous fat²⁴ for determining central obesity. NC was found to be strongly correlated with BMI in both adults and children. NC is also correlated with other indexes of obesity.^{8,25} In our study, other obesity indicators, such as BMI, WC, and HC, were not different between the asthmatic and nonasthmatic groups in obese patients. In other words, NC may be the best indicator of an asthma obesity association. On the other hand, in contrast to the values of WC, NC values do not vary within the day, and the results do not change because of the anatomical region of the measurement.²⁶ The neck is a steadier region for measurement than the waist or hip. Therefore, NC provides consistency between results of different researchers and false results from physicians or patients decrease.²⁵ In addition, the measurement of NC is more tolerable, especially for adolescents.

In obese children, tidal volume and functional residual capacity of the lungs are reduced as a result of decreased elasticity of the chest wall. Therefore, strain on airway smooth muscles may be reduced.¹⁸ Neck adipose tissue may also contribute to pressure on airways. The neck is anatomically related to the respiratory airways; thus, NC may reflect the adverse effects of obesity on pulmonary functions better than other anthropometric measures, such as HC or WC. NC was found to play a role in the pathophysiology of obstructive sleep apnea syndrome in adolescents, whereas WC was not defined as a major contributor to obstructive sleep apnea syndrome.²⁷ NC was found to be associated with sleep disordered breathing risk in children.²⁸ Another study reported that NC in the greater than 90th percentile is associated with asthma, obstructive sleep apnea, loud snoring, and perioperative adverse respiratory events in children.²⁹ The thickness of subcutaneous tissue in the neck region can be supposed to be associated with respiratory disorders. We also found asthma prevalence to be highest in patients whose NC was in the greater than 90th percentile. A recent study found that NC in the greater than 90th percentile was significantly related to asthma severity.¹¹ It can be

suggested that asthma risk and severity is highest in obese patients whose NC is in the greater than 90th percentile.

There were limitations to our study. First, this is a cross-sectional study. Studies with longer follow-up may better reveal the predictability of asthma using NC. Second, the frequency of obese-overweight children in our study group is slightly higher than the obesity-overweight prevalence in all children because of our tertiary institutional structure. However, the power of our study was prominently better in the overweight-obese group when compared with the whole study population. We enrolled children with allergic symptoms, such as urticaria, rhinitis, and atopic dermatitis, as the control group. Therefore, the atopy prevalence was high in both groups, and there was no statistically significant difference between groups.

To our knowledge, this is the first study investigating the association of NC and asthma in children. NC, which is a simple tool of anthropometric measurement, is associated with asthma, especially in obese children. We suggest that NC is a good indicator of the presence of asthma in atopic obese patients. Close monitoring of obese patients with wide NCs may help with an earlier diagnosis of asthma and prompt initiation of therapeutic interventions. Longitudinal studies may clarify the role of NC follow-up of asthmatic patients in predicting better asthma control in children.

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