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Association of neck circumference and pulmonary function in children

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A B S T R A C T

Background: Childhood obesity leads to many complications including impaired respiratory function. There are various anthropometric parameters related to obesity.
Objective: To investigate the correlation between anthropometric indices and pulmonary function test results in children without asthma.
Methods: Children without any respiratory disorders were enrolled in this study. Anthropometric measurements, such as height, weight, neck circumference (NC), and waist circumference, were obtained from the enrollees and body mass index was calculated. Afterward, pulmonary function tests were performed using spirometry.
Results: A total of 178 children (106 boys, 59.5%) with a mean age of 9.7 years were included the study. NC was above the 90th percentile in 65 children. Importantly, pulmonary parameters, such as forced expiratory volume during the first second (FEV_1) and the ratio of FEV_1 to forced vital capacity (FVC), were lower in subjects with a large NC. Similarly, waist circumference was above the 90th percentile in 67 children, and FEV_1/FVC was significantly lower in children with a large waist circumference. Moreover, there was a statistically significant negative correlation among FEV_1, FEV_1/FVC, and body mass index SD score. Also, multivariable linear regression analysis showed that an NC above the 90th percentile was associated with lower FEV_1 and FEV_1/FVC values.
Conclusion: We identified NC as a novel anthropometric index that is strongly correlated with respiratory functions in children. Therefore, close monitoring of respiratory symptoms, particularly in children with obesity and a large NC, could help with early and prompt determination of respiratory complications of obesity.

Introduction

Childhood obesity is a growing health problem that can lead to impairment of organ functions, including the respiratory system.[1] Respiratory impairments are mostly related to obstructive sleep apnea and obesity hypoventilation syndrome. In fact, numerous studies have reported a clear association of obesity with asthma in children.[2–4]

Body mass index (BMI) is the most commonly used parameter to define obesity. However, BMI does not provide information on the body fat distribution that is particularly associated with obesity-related respiratory complications.[5,6] Therefore, anthropometric measurements that identify upper body obesity better than BMI are needed. Several studies have reported an association between waist circumference (WC) and pulmonary functions.[7,8] Neck circumference (NC) is a new measurement to determine body fat distribution in children and adults.[9,10] Previous studies have shown that NC is associated with respiratory disorders, such as obstructive sleep apnea, respiratory endurance, and perioperative adverse events.[11–13] More recent studies have identified an association between NC and severity of asthma.[14,15] Nevertheless, more clarity is required on the mechanisms that help explain the strong association between obesity and pulmonary function.

The present study investigated the correlation between anthropometric indices and pulmonary function test results in children without asthma.

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Methods

One hundred seventy-eight children 5 to 15 years old who were admitted to pediatric allergy outpatient department for various symptoms from 2013 through 2015 were enrolled in this study. Patients with asthma, other lung diseases, and/or chronic systemic disorders were excluded from the study. Consent forms were obtained from the enrolled children and their parents. The institutional review board approved the study.

Different anthropometric indices such as weight, height, WC, and NC were measured under postabsorptive conditions by a physician. Height was measured to the nearest 0.5 cm on a standard height board, and weight (with no clothes or shoes on, except for underwear) was measured to the nearest 0.1 kg. Subsequently, BMI was calculated as weight (kilograms) divided by height (meters) squared. WC was measured at the end of normal expiration using a flexible tape at the circumference equidistant between the superior border of the iliac crest and the lowest rib margin. Hip circumference was measured at the level yielding the maximum circumference between the trochanters. NC was measured at the level of the cricothyroid cartilage. All measurements were performed by the same researcher. Obesity was defined as BMI above the 95th percentile for Turkish children. BMI *z*-scores, WC, and NC percentiles were calculated.[16] Patients were graded according to WC and NC. Values above the 90th percentile were defined as “high.”[17,18]

Pulmonary function tests were recorded in the sitting position by a physician using a spirometer (Zan 100, Nspire Health, Oberthulba, Germany) according to recommendations of the European Respiratory Society. Parameters, such as forced vital capacity (FVC), forced expiratory volume during the first second (FEV_1), FEV_1/FVC ratio, and forced expiratory flow between 25% and 75% (FEF_{25-75}), were measured and the predicted values were calculated. During the measurement, volume and flow curves were closely monitored to detect artifacts and to confirm enough effort was rendered by the participants. Overall, 3 appropriate measurements were recorded and the highest value was considered the basal value. All values were represented as percentages according to age, sex, weight, and height.

Calculations were performed using SPSS Statistics 21.0 (IBM, Armonk, New York). Descriptive data for categorical variables were expressed as frequencies. Grouped variables were compared using the Student *t* test for numerical values and the Pearson χ^2 test for categorical variables. Pearson correlations were calculated to analyze the relation between BMI SD score (SDS) and lung function test results. Normality of the variable distributions was evaluated by the Kolmogorov-Smirnov test. Multiple linear regression analysis used anthropometric parameters as predictors, and significant variables in the Student *t* test and Pearson correlation test were included as dependent variables. Significantly associated variables were determined by the backward elimination procedure. A *P* value less than .05 was set as the cutoff for statistical significance.

Results

A total of 178 children (106 boys, 59.5%) with a mean age of 9.7 years were included. Atopy was present in 73 patients (41%). Forty-one patients (23%) in the study population were obese and 73 (41%) were overweight (Table 1). NC was above the 90th percentile in 65 children. There was no significant difference in NC by age, sex, birthweight, atopy prevalence, FVC, peak expiratory flow (PEF), and FEF_{25-75}. However, FEV_1 and FEV_1/FVC were higher in subjects with a large NC ($P = .04$ and .01, respectively; Table 2). Similarly, WC was above the 90th percentile in 67 children. Atopy prevalence, birthweight, age, sex, FVC, FEV_1, PEF, and FEF_{25-75} were not significantly different between children with a large or small WC. Only FEV_1/FVC was significantly high in children with a WC higher than the 90th percentile ($P = .01$; Table 3). There was a statistically significant negative correlation among FEV_1, FEV_1/FVC, and BMI SDS. There were no significant correlations between other pulmonary function test parameters and BMI SDS.

Table 1
Demographic Features of Study Population (N = 178)[a]

Boys	106 (59.5)
Age (y)	9.7 ± 2.6
Atopy	73 (41.0)
BMI *z*-score	0.94 ± 1.2
Obese	41 (23)
Overweight	73 (41)

Abbreviation: BMI, body mass index.
[a]Data are presented as frequency (percentage) or mean ± SD.

Multiple linear regression analysis used pulmonary function test parameters, such as FEV_1 and FEV_1/FVC, as dependent variables that were significantly associated with obesity indices. Independent variables were determined as anthropometric parameters, such as NC, WC, and BMI SDS. The results showed a significant association among FEV_1, FEV_1/FVC, and NC.

Discussion

In the present study, we found an association between the pulmonary function variable FEV_1 and anthropometric indices of obesity. NC, a novel anthropometric measurement of obesity, was strongly associated with FEV_1 and FEV_1/FVC.

Many studies have shown an association between obesity using BMI as an index and respiratory functions. For instance, FEV_1/FVC was negatively associated with BMI in obese and overweight adults.[8] In another adult study, a decrease in midexpiratory flow rate and FEV_1/FVC was shown in patients with morbid obesity.[19] Similar findings were observed in cross-sectional studies performed in children with or without asthma.[20,21] A different study showed that FEV_1 and FEV_1/FVC were significantly lower in children with obesity compared with those without obesity, whereas FVC did not differ by obesity status.[22] In the present study, we found that FEV_1 and FEV_1/FVC were negatively correlated with BMI SDS. However, when the comparison was adjusted for other indices of obesity, BMI SDS was not related to FEV_1 and FEV_1/FVC. The regression model showed only the association between pulmonary functions and NC.

Various mechanisms have been suggested to explain the association between obesity and pulmonary functions. Mechanical changes due to fat deposition on the abdomen, chest wall, and upper airway have been implicated in changes in lung volumes,[23] leading to decreases in FVC and FEV_1.[24–26] Conversely, other pediatric studies, including the present study, found no association between FVC and BMI and/or other obesity indices.[22] Therefore, we suggest that, in addition to mechanical pressure, airway resistance

Table 2
Respiratory Function Test Results of Groups According to Neck Circumference[a]

	<90th percentile (n = 113)	>90th percentile (n = 65)	*P* value
Boys	66 (58.4)	40 (61.5)	.28
Age (y)	9.5 ± 2.6	9.8 ± 2.4	.59
Atopy	48 (42.5)	25 (38.5)	.63
Birthweight (g)	3,050 ± 100	3,130 ± 110	.84
FVC (%)	97.5 ± 11.0	95.8 ± 11.3	.35
FEV_1 (%)	100.9 ± 12.0	96.9 ± 11.3	.04
FEV_1/FVC	91.0 ± 5.7	87.0 ± 8.3	.01
PEF (%)	88.3 ± 15.3	87.8 ± 18.3	.35
FEF_{25-75} (%)	97.9 ± 21.7	98.1 ± 18.3	.94

Abbreviations: FEF_{25-75}, forced expiratory flow between 25% and 75%; FEV_1, forced expiratory volume during first second; FVC, forced vital capacity; PEF, peak expiratory flow.
[a]Data are presented as frequency (percentage) or mean ± SD.