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The Relationship Between Body-Mass Index, Central Obesity and Asthma in Children

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ABSTRACT

Objective: We hypothesized that, compared with body mass index (BMI) alone, central obesity would provide added information regarding types of asthma (allergic, nonallergic) and asthma severity.

Materials and Methods: A total of 150 children aged between 7-17 years with 50 allergic asthma, 50 nonallergic asthma and 50 controls were included in the study. Height, weight, waist and hip circumferences of the groups were measured. Waist-to-hip ratio and BMI were calculated. Pulmonary function test results were recorded. The relation between anthropometric measurements, asthma, atopy, obesity and each other was analyzed.

Results: Obesity according to BMI was higher in the group with allergic asthma than nonallergic asthma and the control group (p: 0.014). A positive correlation was found between asthma and BMI percentile, BMI z score and waist-to-hip ratio (p: 0.002; 0.003; 0.040, respectively). Children with obesity according to waist circumference were more frequent in the groups with allergic and nonallergic asthma compared to the control group (p: 0.048). There was a significant relationship between asthma severity and central obesity (p: 0.048). FEV1 / FVC and FEF25-75 were lower in the asthmatic groups compared to the control group (p: 0.028; 0.012, respectively).

Conclusion: This study showed that central obesity was associated with asthma and asthma severity, but not with atopy. More investigation is needed to clarify how central obesity in children affects the control of asthma and the response to asthma medication.

Keywords: Childhood asthma, central obesity, waist-to-hip ratio, body mass index

INTRODUCTION

Childhood asthma and obesity are two major public health concerns for which the prevalence has been rapidly increasing over the recent years (1). Previous epidemiological studies have demonstrated that both asthma and obesity are now 'endemics' in developed countries and 'epidemics' in developing countries (2). The parallel increase in the prevalence of asthma and obesity has necessitated the investigation of the relationship between these two diseases and their etiopathogenesis (3).

The relationship between childhood asthma and atopy with central obesity remains unclear, although various results have been reported (4, 5). In a study by Papoutsakis et al. that included 514 children aged 5-11 years, i.e. 217 children with asthma and 294 healthy children, it was found that children with asthma had a higher prevalence of central obesity and higher mean body mass index (BMI) than healthy children (6). Furthermore, the percentages of children who were overweight and obese according to BMI were higher in children with asthma (6). Musaad et al. reported that increased BMI and waist circumference (WC) positively correlated with the severity of asthma and negatively correlated with atopy (7). Although some studies showed that obesity was associated with asthma, a relationship between obesity, and atopy and eosinophilia was not defined (8, 9).

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On the other hand, there are also some studies that have shown different results (10-15). Leung et al. could not determine a relationship between obesity and asthma, allergic rhinitis and eczema (11). Moreover, it was shown that atopy was not associated with BMI, WC, serum lipid profile and fasting blood glucose levels (11). In a study by Schachter et al. that included 5,993 children aged 7-12, it was reported that a high BMI was not a risk factor for asthma or bronchial hyperreactivity, but it was associated with increased atopy only in girls (12). Chinn and Rona concluded that the increased prevalence of asthma could not be attributed to the increased BMI in children (13). Another study also reported that a correlation between BMI and allergic respiratory tract symptoms, eczema and rhinoconjunctivitis could not be documented (15).

Asthma is a multifactorial syndrome that affects the health of children. BMI and central obesity might be potential risk factors but the evidence is unclear. Therefore, we aimed to investigate the relationship between asthma and atopy, and central obesity in children.

MATERIALS and METHODS

Study Population and Study Design

This was a prospective, single-centered, observational, case-control study between 2017 and 2019. This study included the children with allergic asthma (n=50) and non-allergic asthma (n=50) who had been followed for at least one year at the Pediatric Immunology and Allergy Department. The patients who had genetic disorders, primary immune deficiencies, a history of prematurity, and other systemic illnesses were excluded from this study. Controls (n=50) were children with no past medical history of an allergic disease, immune deficiency or chronic diseases. Exclusion criteria were any disease known to affect growth (cystic fibrosis, Kleinfelter syndrome, Turner syndrome, endocrine, systemic and skeletal disease).

The diagnosis of asthma was made in accordance with the Global Initiative for Asthma (GINA) Guidelines. Asthma severity was evaluated as mild, moderate and severe (16). Demographic data such as age, gender, age of asthma diagnosis, follow-up time, severity of asthma, and skin prick test results were recorded. Pulmonary function tests were performed in the patient and control groups. Weight, height, WC and hip circumference were measured in all three groups. The waist-to-hip ratio and body mass index were calculated.

This research was approved by the Selcuk University Ethics Board (2017/279). Written informed consent was obtained from the parents of all the child participants. Research and publication ethical standards were complied with.

Spirometric Measurements

Respiratory function parameters were measured with Jaeger Masterscreen IOS spirometry. Subjects rested for 15 mins before measurements and were informed about the procedure. After appropriate placement of the mouth piece and nose clip, a powerful, quick, forced expiration challenge was conducted just after maximum forced inhalation. After performing at least three technically appropriate measurements, the highest value was accepted as the basal value. Forced vital capacity (FVC) and forced expiratory volume in one second (FEV1), FEV1/FVC (%), peak expiratory flow (PEF), and 25-75% of vital capacity (FEF25-75) were recorded. A FEV1, FVC and FEV1/FVC ratio higher than 80% of the predicted value and a FEF25-75 value higher than 70% of the predicted value were considered normal (17).

Skin Prick Test

Skin prick tests were performed as standard in children with a set of allergens containing the following: Dermatophagoides farinae, Dermatophagoides pteronyssinus, Alternaria, Cladosporium, a mixture of 3 trees (alnus, betula, corylus), a mixture of 4 cereals (avena, hordeum, triticum, secale), a mixture of 6 herbs (dactylis, festuca, lolium, phleum, poa, avena), Ambrosia artemisifolia, Urticadiocia and latex (ALK, Madrid). Histamine phosphate (10 mg/ml) and physiological saline were used as positive and negative controls. The results were evaluated 15 minutes later. Three mm and bigger induration mean diameters were accepted as positive. Asthma with a positive skin test was defined as allergic asthma and atopy.

Anthropometric Measurements

Height while standing, without shoes and with the child in an upright position was measured by a stadiometer with a sensitivity of 1 mm, measuring 80-200 cm. During the measurement, the most protruding part of the back of the head, scapulas, gluteal region, the back of the legs, and the heels were touching the measuring board.

Body weight; 100 grams of digital precision, calibrated with quick-to-measure weighing shoes and jackets, such as clothing was measured by taking off.

Waist circumference; This value was measured from the exposed WC at the level of the umbilicus with a non-flexing tape measure at slight expiration (immediately after exhalation). WC evaluation; Hatipoglu et al. evaluated 4770 school children between the ages of 7-17 (18). All measurements for WC were made by using reference curves and central obesity was defined as 90th percentile and above of WC (18).

The hip circumference was measured from the widest part of the hip with a non-stretching tape measure.

Body mass index (BMI), BMI percentile, BMI z value; this was calculated with the help of the WHO AnthroPlus Anthropometric Calculator, which used BMI reference values that vary according to age and gender. Patients were classified as obese if BMI > +2 SD (equal to 30 kg/m^2 for 19 years) according to the WHO criteria for the age of 5-19 (19).

There is no national or international standard data related to waist-to-hip ratio and hip circumference in children. Therefore, the waist-to-hip ratio results were evaluated by comparing between groups.

Statistical Analysis

Statistical analysis was performed with the SPSS 21.0 package program. The Kolmogorov-Smirnov normality test was used to determine whether the test was parametric or non-parametric test and the Levene test was used to evaluate the homogeneity of variances. The Independent Two Sample T test or Mann Whitney U test was used to evaluate the difference between the two groups. ANOVA or the Kruskal-Wallis H test was used to evaluate the difference between more than two groups. The Tukey test or Mann-Whitney U test were used in pairs in order to compare the difference between groups. The chi-square test was used to examine the relationship between variables. $p < 0.05$ was considered statistically significant.

RESULTS

Demographic and Clinical Data

Of the 150 children included in the study, 60 were boys and 90 were girls. The mean age of the 150 children included in the study was 11.85 ± 2.924 (min-max; 7-17.92). There was no significant difference between the groups in terms of gender and age distribution (p: 0.920 and p: 0.145, respectively) (Table I).

The mean ages for the diagnosis of allergic and nonallergic asthma were 7.92 ± 3.544 (min / max; 2-16)

Table I: Demographic and clinical characteristics of all participants

		Frequency	Min-max	Test statistics	p
Sex n (male/female)	Allergic Asthma	21/29		0.167[1]	0.920
	Nonallergic Asthma	19/31			
	Control	20/30			
Age (year) (mean ± SD)	Allergic Asthma	11.355 ± 2.986	7-17.92	1.954[2]	0.145
	Nonallergic Asthma	11.715 ± 3.118	7-17.33		
	Control	12.48 ± 2.586	7.92-17.42		
The age of diagnosis year (mean ± SD)	Allergic Asthma	7.92 ± 3.544	2-16	-1.186[3]	0.239
	Nonallergic Asthma	8.740 ± 3.367	2-16		
Follow-up period month (mean ± SD)	Allergic Asthma	23.62 ± 23.181	1-84	903.500[4]	0.016
	Nonallergic Asthma	30.6 ± 19.911	3-83		
Asthma severity n (%)	Allergic Asthma	mild moderate	33 (66) 17 (34)	0.386[1]	0.534
	Nonallergic Asthma	mild moderate	30 (60) 20 (40)		

1: Chi-square test, **2:** One-way variance analysis (ANOVA) test, **3:** Two independent samples t test, **4:** Mann- Whitney U test

and 8.740 ± 3.367 (min / max; 2-16), respectively, showing no statistically significant difference (p: 0.239) (Table I). The follow-up period of nonallergic asthmatic patients was longer than in the allergic ones (30.6 ± 19.911; 23.62 ± 23.181 months, respectively) (Table I). Sixty-three children had mild and 37 had moderate asthma. There were no patients with severe asthma. There was no difference between the two groups in terms of asthma severity (Chi-Square: 0.386 p: 0.534) (Table I).

When the skin prick test results in the allergic asthma group were evaluated, allergic sensitivity was present in 20 patients (40%) to pollen, in 9 (18%) to mite, in 1 (2%) to mold, in 8 (16%) to pollen and mold, in 8 (16%) to mite and pollen, in 1 (2%) to mite and mold, and in 3 (6%) to mite, pollen and mold.

Anthropometric Measurements

Weight, height, BMI, WC, hip circumference and the waist/hip ratio in all groups are presented in Table II. While there was no statistically significant differences between the groups in terms of weight, height, WC and hip circumference; BMI percentiles, BMI z score, and waist-to-hip ratio were significantly different. The allergic asthma group had a higher BMI percentile, BMI z score and waist-to-hip ratio than the control group (p: 0.002, p: 0.001 and p: 0.04) (Table II, Figure 1A-C).

In terms of general and central obesity, there was a significant difference between the groups. While the ratio of children with general obesity was higher in the group with allergic asthma (p: 0.014), the ratio of children with central obesity was higher in the groups with allergic and

Table II: The comparison of anthropometric measurements between groups

		n	mean ± SD	Test statistics	p
Weight (kg)	Allergic Asthma	50	46.478 ± 16.472	0.748[2]	0.688
	Nonallergic Asthma	50	43.422 ± 13.045		
	Control	50	45.266 ± 13.430		
Height (cm)	Allergic Asthma	50	147.600 ± 15.911	0.847[1]	0.431
	Nonallergic Asthma	50	147.280 ± 14.255		
	Control	50	150.800 ± 14.659		
BMI (kg/m²)	Allergic Asthma	50	20.546 ± 3.712	1.670[1]	0.192
	Nonallergic Asthma	50	19.544 ± 3.367		
	Control	50	19.358 ± 3.397		
BMI percentile	Allergic Asthma	50	76.648 ± 24.415	13.043[2]	**0.002**
	Nonallergic Asthma	50	65.032 ± 29.444		
	Control	50	56.478 ± 28.926		
BMI z score	Allergic Asthma	50	0.975 ± 0.969	5.941[1]	**0.003**
	Nonallergic Asthma	50	0.559 ± 1.116		
	Control	50	0.257 ± 1.043		
Waist circumference (WC) (cm)	Allergic Asthma	50	72. 00 ± 12.295	0.786[1]	0.458
	Nonallergic Asthma	50	71.100 ± 10.431		
	Control	50	69.660 ± 9.933		
Hip circumference (HC) (cm)	Allergic Asthma	50	84.560 ± 13.384	0.035[1]	0.966
	Nonallergic Asthma	50	84.100 ± 11.181		
	Control	50	84.720 ± 11.925		
Waist-to-hip ratio	Allergic Asthma	50	0.853 ± 0.061	3.280[1]	**0.040**
	Nonallergic Asthma	50	0.843 ± 0.052		
	Control	50	0.825 ± 0.054		

1: One way variance analysis (ANOVA) test, **2:** Kruskal Wallis H test

nonallergic asthma compared to the control group (p: 0.048) (Table III).

When the obesity values according to BMI and WC were compared with each other, significant differences were found in all participants (p: 0.000). Seventy-three per cent of the children (46 of 63) who were defined as obese according to WC were not obese according to BMI while 34.6% (46 of 133) of children who were obese according to WC were defined as normal weight according to BMI (Table IV).

A significant relationship was found between obesity according to WC and asthma severity. The prevalence of moderate asthma was higher in those who were obese according to WC. This result showed that central obesity was associated with increased asthma severity (Table V). There was no significant difference between obesity

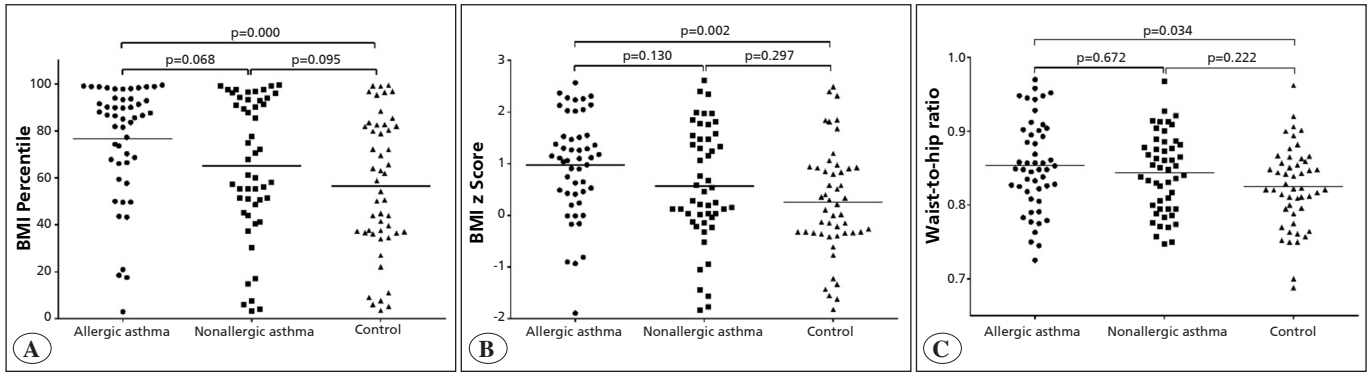

Figure 1. Comparison of body mass index (BMI) percentile **(A)** BMI z score **(B)** and waist-to-hip ratio **(C)** values between groups.

Table III: The distribution of obesity defined by BMI value and waist circumference (WC) in all groups

			Allergic Asthma	Nonallergic Asthma	Control	Total
General Obesity according to BMI [1]	**yes**	n (%)	11 (22)	3 (6)	3 (6)	17 (11.3)
	no	n (%)	39 (78)	47 (94)	47 (94)	133 (88.7)
Central Obesity according to WC [2]	**yes**	n (%)	25 (50)	24 (48)	14 (28)	63 (42)
	no	n (%)	25 (50)	26 (52)	36 (72)	87 (58)

1: p:0.014, 2: p: 0.048

Table IV: The relationship between general and central obesity

			Central Obesity according to WC		Total
			yes	no	
General Obesity according to BMI	**yes**	n (%)	17 (100)	0 (0)	17 (11.3)
	no	n (%)	46 (34.6)	87 (65.4)	133 (88.7)
Total		n (%)	63 (42)	87 (58)	150 (100)

Chi Square test: 26.477, p-value: 0.000

Table V. The relationship between central obesity and asthma severity

		Obesity according to WC		Total
		yes	no	
Mild asthma	n (%)	26 (41.3)	37 (58.7)	63 (100)
Moderate asthma	n (%)	23 (62.2)	14 (37.8)	37 (100)
Total	n (%)	49 (49.0)	51 (51.0)	100 (100)

Chi Square test:4.071, p value: 0.044

according to BMI and age at the time of diagnosis of asthma, follow-up time and asthma severity (p: 0.829; 0.209; 0.277, respectively).

The groups were evaluated in terms of the association between gender and obesity defined according to BMI and WC. In allergic asthmatics, there was a significant relationship between gender and obesity according to BMI. In the allergic asthma group, the frequency of obesity according to BMI was higher in boys (p: 0.019). In the nonallergic asthma and control groups, there was no significant relationship between gender and obesity according to BMI (p: 0.864; 0.331, respectively). There was no significant relationship between gender and obesity according to WC in all groups (p: 0.152; 0.944; 0.700, respectively). No significant difference was found between obesity, and mono and poly-sensitization in the allergic asthma group.

Pulmonary Function Test Results

The evaluation of pulmonary function test results showed no significant difference in FVC, FEV1 and PEF between groups (p: 0.685; 0.102; 0.554, respectively).

In the allergic and nonallergic asthma groups, FEV1 / FVC and FEF25-75 were lower than in the control group (p: 0.008; 0.009). There was no significant difference between the allergic and nonallergic asthma groups.

The FVC value was higher in those who were obese according to WC compared to those who were not obese (p: 0.029). No significant association was found with other pulmonary function test parameters. There was no difference between the pulmonary function test parameters between those who were obese according to BMI and those who were not.

DISCUSSION

The body mass index is commonly used as a marker of obesity in epidemiological studies concerning asthma. However, it is not exactly known whether other methods for adipose tissue measurement provide additional or different phenotypic information compared to BMI in childhood asthma. This study evaluated the relationship between WC, hip circumference and waist-to-hip ratio as well as BMI with allergic asthma, non-allergic asthma, respiratory functions, severity of asthma and allergen sensitivity. The BMI, waist-to-hip ratio and waist circumference were found to be related to asthma. Interestingly, obesity defined according to BMI (general obesity) was associated with atopy.

There are various studies that have investigated the relationship between asthma and adiposity. In a study by Forno et al. that included 8,886 children and 12,795 adults, dual-energy X-ray absorptiometry was used to determine the total, trunk and leg percent fat; BMI; body fat percentage; WC and waist-to-height ratio to investigate the relationship of these variables with asthma (20). They found that the percentage of children with obesity according to BMI (general obesity, 19.47%) was higher than the percentage of children with obesity according to WC (central obesity, 8.94%). Furthermore, 9.86% of the children had asthma; general obesity and central obesity were more prevalent in children with asthma. Considering the relationship between obesity and atopy, general obesity was more prevalent in the non-allergic asthma group than in the allergic asthma group. However, there was no relationship between asthma and central obesity in children with allergies (20). Similarly, in our study, central and general obesity were found to be associated with asthma. Conversely, general obesity was found to be increased in the allergic asthma group. These results showed that fat distribution in obesity and its relationship with atopy vary depending on the population.

In our study, the prevalence of obesity according to WC was 42%, which is similar to the prevalence of central obesity reported by Benedetti et al. (36.7% according to WC) (4). We found that the prevalence of obesity according to BMI was 11.3%. In a study by Leung et al. the same value was reported to be 7.4% (11). Although previous studies have shown a positive correlation between BMI and WC, most of the children who were obese according to their WC were classified as normal weight according to their BMI (4, 6).

In a study by Papoutsakis et al. children who had central obesity and who were classified as obese or overweight according to BMI had a higher risk of developing asthma (6). It was concluded that each 10 cm increase in WC increased the risk of developing asthma by 40% (6). Similarly, Musaad et al. showed that each unit increase in WC resulted in a nearly three-fold increase in the odds ratio for asthma (7). In a study by Benedetti et al. the risk of developing asthma was found to be 1.24-fold higher in adolescents who had central obesity (4). Moreover, the

risk of severe asthma was three-fold higher in those with severe obesity according to BMI z-score (4). Although the mechanisms of the relationship between central obesity and asthma are largely unclear, the positive association of central body fat distribution (high WC) and asthma indicates that there may be mechanical effects such as reduced functional residual capacity that contribute to the development of asthma symptoms. At the same time, central obesity is an independent predictor of insulin resistance in children. Insulin resistance and dyslipidemia were found to be associated with airway inflammation (21). In our study, there was a significant relationship between the severity of asthma and central obesity.

In a study by Lucas et al. that aimed to investigate the relationship between high BMI and severity of asthma, allergen sensitivity and polysensitisation in 125 children with asthma aged between 1 and 16 years, it was found that the prevalence of allergen sensitivity and polysensitisation was lower in overweight and obese children, and there was a negative correlation between BMI and atopy (22). In the other study, it was reported that BMI, body fat percentage and WC were associated with the severity/management of asthma and atopy and that atopy could have a mediating role in the obese-asthma phenotype in children aged 6-14 years (5). There was no significant relationship between the severity of asthma and high BMI. In our study, the prevalence of obesity according to BMI was higher in the allergic asthma group than in the non-allergic and control groups. In addition, when the allergic asthma group was divided into monosensitised and polysensitised subgroups according to the results of the skin prick test, no significant difference was found between these two subgroups.

In a study by Akın et al. conducted with 196 children who presented to an outpatient clinic, i.e. 102 children with asthma and 94 children with other causes such as allergic rhinitis and urticaria, comparison of BMI, WC, hip circumference, prevalence of overweight/obesity, prevalence of atopy, total IgE and eosinophil count between the two groups did not show any significant difference (23). Only neck circumference was higher in the asthma group than in the other group. There were no significant differences in terms of age, gender, birth weight and atopy between obese/overweight patients and others. In conclusion, WC, hip circumference and BMI values were considered insufficient to explain the relationship between asthma and obesity in children, unlike our study (23).

Some studies have reported significant results only according to gender. In a study investigating the relationship between asthma and obesity in 1,362 students aged 10-19 years, the prevalence of obesity according to BMI, WC and waist-to-height ratio was high in girls, although the difference was not statistically significant. In addition, the prevalence of asthma and severe asthma was high in girls (4). In our study, the prevalence of obesity according to BMI was high in boys in the allergic asthma group.

Previous studies have shown a positive correlation between BMI and FVC, FEV1 and PEF and a negative correlation between BMI and FEV1/FVC (5, 10). In a study by Forno et al. , it was found that BMI was associated with higher FEV1; BMI, WC and waist-to-hip ratio were all associated with higher FVC, and WC was associated with lower FEV1/FVC (5). One of the studies conducted on this topic in Turkey was the study by Ulger et al. conducted in 2006 (24). The study showed lower FVC, FEV1, PEF and FEV 25-75 values in the obese group than in the control group, whereas there was no difference between the two groups in terms of the FEV1/FVC value. They found that obese children had increased incidence of exercise-induced bronchospasm and airway hyperresponsiveness (24). In obese children, a mismatch in the growth of the airway and lung parenchyma and obstructive airway stenosis lead to high or normal FEV1 and FVC as well as decreased FEV1/FVC, unlike in obese adults (10). As expected, our study showed that the mean FEF25-75 and FEV1/FVC were lower in the asthma groups than in the control group. We found that the FVC value was higher in those who were obese according to WC than those who were not. On the other hand, we did not observe a relationship between obesity with respiratory function test parameters.

One of the limitations of our study was that there are no reference curves for the waist-to-hip ratio and hip circumference variables according to age and gender for the Turkish population. The lifestyle and physical activity of the children were not evaluated. In addition, we could not evaluate the relationship between severe asthma and obesity as none of the patients in our sample had severe asthma.

CONCLUSIONS

This study showed that it is essential to evaluate central obesity as well as general obesity in children with asthma. Therefore, we recommend waist and hip circumference measurements to be included in addition to other measurements in the routine examinations of asthmatic children. It is also important to study the confounding factors that affect the relationship between asthma and obesity in future research.

Disclosure Statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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