Original Article

The effects of obesity on pulmonary function in adults with asthma

Ümüş Özbey[1], Aslı Uçar[1], Aliye Gamze Çalış[2]

[1]Department of Nutrition and Diet, Health Science Faculty, Ankara University, Ankara, Turkey, [2]Department of Chest Disease, Medicine Faculty, Akdeniz University, Antalya, Turkey

ABSTRACT

Objective: While the effects of obesity on asthma are unclear, an increased body mass index (BMI) is known to enhance the symptoms and severity of asthma and to impair asthma control. The present study evaluates the effects of nutritional habits and obesity on pulmonary function and asthma control in individuals with asthma. **Methods:** This cross-sectional study included 60 obese respondents and 60 respondents with normal body weight, who were referred to pulmonology clinics over a period of 2 months. The anthropometric measurements and macro–micro nutrient consumption records of the patients in both groups were obtained, and the two groups were compared in terms of pulmonary function and asthma control test (ACT) scores. **Results:** The mean age of the normal weight and obese respondents was 39.55 ± 11.0 and 45.1 ± 10.3 years, respectively. The ACT scores of the respondents decreased significantly with increasing BMI, waist circumference (WC), and waist–hip ratio (WHR) measurements ($P < 0.05$). The obese respondents had a lower mean forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), midexpiratory flow (MEF) between 25% and 75% of the maximal expiration ($MEF_{25–75}$), MEF_{75}, MEF_{50}, MEF_{25}, and FEV_1/FVC values when compared to the respondents with normal weight ($P < 0.05$). The total energy and carbohydrate intake was higher in the obese respondents, while their total protein intake was lower when compared to the normal weight respondents ($P < 0.05$), and a significant positive correlation was found between the omega 3 intake and ACT scores of the respondents ($P < 0.05$). **Conclusions:** Pulmonary functions and ACT scores decrease with increasing BMI, WC, and WHR. Obese respondents with asthma should be referred to diet clinics to improve their asthma symptoms.

KEY WORDS: Asthma, asthma control test, nutrition, obesity, pulmonary function test

Address for correspondence: Dr. Aslı Uçar, Department of Nutrition and Diet, Health Science Faculty, Ankara University, Sükrüye Mahallesi, Aktas Kavsagi, 06000 Altindag/Ankara, Turkey. E-mail: aucar@ankara.edu.tr

INTRODUCTION

For more than two decades, the prevalence of both obesity and asthma in the developed western populations has been increasing in parallel.[1] According to data from the American National Health and Nutrition Study (NHANES), the prevalence of obesity increased by 30.5% between 1999 and 2000, and by 37.9% between 2013 and 2014.[2] Similarly, the number of asthmatic people in America, which was reported to be 14 million in 2001, increased by 33.5% to reach 18.7 million in 2012.[3] Such increases in the prevalence of both diseases indicated a potential relationship between the two conditions and led the issue to be investigated in further studies.[4,5] Although the fundamental factors involved in the relationship between asthma and obesity are still unclear, the factors that have been suggested to play a role include the mechanical pressure of obesity on the lungs, increased inflammatory response within the immune system, and hormonal changes caused by obesity.[6,7] Not only total

Access this article online	
Quick Response Code:	Website: www.lungindia.com
	DOI: 10.4103/lungindia.lungindia_16_19

How to cite this article: Özbey Ü, Uçar A, Çaliş AG. The effects of obesity on pulmonary function in adults with asthma. Lung India 2019;36:404-10.

body weight or body mass index (BMI) but also body composition and body fat distribution are believed to have certain effects on asthma symptoms.[7] Studies have shown that a fattening of the thorax along with abdominal obesity decreases asthma control and pulmonary function, particularly in adults.[8,9]

Changes in lifestyle can also be associated with a rapid increase in the prevalence of asthma. Several diet hypothesis associated with asthma has been suggested in the recent years, and researchers have argued that changes in dietary content have been one of the most important environmental factors increasing the prevalence of asthma.[10] The transformation of a conventional diet to a modern diet and food processing practices have reduced the total antioxidant amount taken on a diet.[11] Moreover, it has been suggested that the increasing consumption of fast-food weighted diets has exasperated the symptoms of asthma by increasing the amount of saturated fats taken through the diet.[12] While inflammatory omega 6 fatty acids are consumed in larger amounts, there has been a decrease in the consumption of anti-inflammatory omega 3 fatty acids, and this increased omega 6/omega 3 ratio resulting from changes in dietary habits has also been suggested as a factor with a negative effect on asthma.[10,12] That said, the exact effect of any specific macronutrient or micronutrient on asthma is still unclear, and previous studies have reported conflicting results.[13,14]

Based on the above-mentioned information, the present study aimed to investigate the relationship between obesity and macro–micro nutrient intake as a dietary variable with pulmonary functions and asthma control in adult asthmatics.

METHODS

Study population and design

This cross-sectional study was carried out in the Pulmonology Department of the Kırsehir Ahi Evran Training and Research Hospital in Turkey. The study included all patients who referred to the clinics over a 2 months' period in the spring (March 15–May 15, 2017) who were aged between 20 and 65 years, who had been diagnosed with asthma at least 1 year earlier and who agreed voluntarily to take part in the study. In the and, 120 patients were enrolled in the study [Figure 1]. The diagnosis of asthma was made by a specialist doctor and documented based on the patient's airway hyperresponsiveness history. All patients met the reversibility criteria at the beginning of the study. According to reversibility criteria, test of bronchodilation was performed (using a salbutamol metered dose of 400 mcg) by clinician and reversibility was considered if an increase of at least 12% of FEV_1 from baseline was achieved.[15] Pregnant or lactating women were excluded from the study, so as to eliminate the potential effects on body weight and changes in nutritional habits. Patients using systemic corticosteroid medications were also excluded from the study, as these drugs increased food intake and sodium retention.[16] In addition, patients experiencing asthma exacerbation were also excluded from the study as they were mostly using systemic corticosteroids during these events and experienced a greater than normal decline in pulmonary functions. Before initiating the study, the necessary permissions were obtained from the Kırsehir Ahi Evran Training and Research Hospital, and approval was obtained from the Ankara University Medical Faculty Science Ethics Committee.

Anthropometric measurements

The body weight measurements of the patients were recorded using a Tanita BC 601 scale in the morning while in a fasted state. Height and waist and hip circumference measurements were obtained using an inflexible measuring tape and according to standard methods (without shoes and wearing thin clothes). All measurements were recorded only once. BMI was calculated by dividing body weight in kilograms by the square of height in meters (kg/m^2), and the classification was made according to the World Health Organization (WHO) data. Based on their BMI results, the patients were divided into two groups, as normal weight (18.5–24.9 kg/m^2) and obese ($\geq$30.0 kg/m^2).[17] A waist circumference (WC) of 80 cm and above was considered to be indicative of "at risk," while 88 cm and above was considered to indicate "at high risk" in women. A WC of 94 cm and above was considered to be indicative of "at risk," while 102 cm and above was considered to indicate "at high risk" in men. The waist–hip ratio (WHR) was calculated based on the waist and hip circumference measurements and classified according to WHO criteria. A WHR above 0.85 in women and 0.90 in men was considered to be indicative of "at risk."[18]

Pulmonary function tests

The pulmonary function test measurements of the patients were obtained by a responsible nurse using a Cosmed Quark Spiro device. Measurements were obtained while the patients were sitting on a flat surface, with measurements repeated three times, and the best mean values considered. Forced expiratory volume in 1 s (FEV_1), forced vital capacity (FVC), peak expiratory flow (PEF), and mid-expiratory flow (MEF) values were measured. The patients' age, gender, and height were recorded on the measurement device before the measurements were taken, and the values were evaluated after respiratory maneuvers.[19]

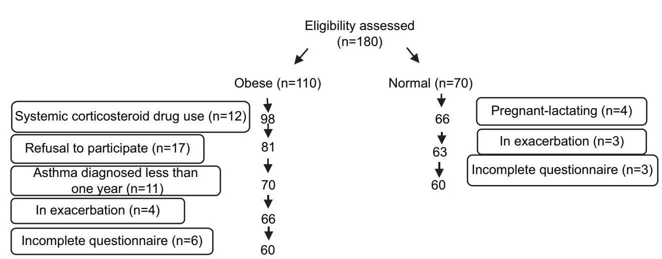

Figure 1: Flowchart of study participants

Asthma control test

The asthma control test (ACT) consists of five questions that inquire the level of influence of asthma symptoms on daily activities, and each question is scored on a scale of 1–5. The total score that can be obtained from ACT is in a range of 5–25, with a high score indicating better asthma control.[20] In the present study, ACT was applied to the patients by a specialist physician for the assessment of asthma control.

Assessment of nutrition consumption records

The nutrition consumption records of the participants were recorded retrospectively for 1 weekday using the 24-h recall method. A nutrition photograph catalog was used to determine the measures and amounts during recordings.[9] All consumed nutrients were recorded in detail, and the collected data were evaluated using the Turkey-Specific Nutrition Guide and a computer-supported nutrition program (BeBIS).[21]

Statistical analysis of data

The SPSS (SPSS Statistics for Windows, Version 22.0; IBM Corp, Armonk, NY, USA). software package was used for the evaluation of the data collected in the study. Normally distributed parameters were compared between the two groups using a Student's *t*-test, and mean and standard deviation values were presented. A Mann–Whitney U-test was used to compare nonnormally distributed parameters between the two groups, and medians and interquartile range (Q1–Q3) values were presented. A Kruskal–Wallis H-test was used to compare more than two nonnormally distributed variables, and a *post hoc* (Tukey) correction was applied to find the source of significant differences. Pearson correlation test was used to evaluate the power and direction of linear relations between two continuous quantitative variables. All statistical analyses were performed within 95.0% confidence interval, and $P < 0.05$ was considered as statistically significant.

RESULTS

The study population consisted of 60 normal weight and 60 obese respondents; the majority of whom were women. The mean age of the normal weight and obese respondents was 39.55 ± 11.0 and 45.1 ± 10.3, respectively. A high proportion of the respondents in the normal weight group were high school graduates (45.0%), while the majority of obese respondents were primary school graduates (60.0%). The majority of the respondents in both groups were living in urban areas and were nonsmokers (≥80.0%). More than half of the respondents had asthma for >10 years. Of the obese respondents, 38.3% reported increased body weight and 46.7% reported increased appetite after starting on antiasthma medication. These increases were milder in the normal weight respondents when compared to the obese ones. The most common comorbidity was reflux (8.3%) in the normal weight group and diabetes and reflux (11.7%) in the obese group. The mean ACT scores of the obese and normal weight respondents were 17.9 ± 3.7 and 20.6 ± 2.3, respectively. The mean BMI, WC, and WHR of the respondents in the normal weight group were 22.6 ± 1.7 kg/m², 75.5 ± 9.2 cm, and 0.90 ± 0.1, respectively. The mean BMI, WC, and WHR of the obese respondents were 34.6 ± 5.4 kg/m², 96.4 ± 5.6 cm, and 1.4 ± 0.3, respectively [Table 1].

Table 1: Demographic and anthropometric characteristics of the respondents according to body mass index classification

	Normal (*n*=60)	Obese (*n*=60)
Age (mean±SD)	39.55±11.0	45.1±10.3
Gender, *n* (%)		
Male	12 (20.0)	8 (13.3)
Female	48 (80.0)	52 (86.7)
Level of education, *n* (%)		
Primary school graduate	22 (36.7)	48 (60.0)
High school graduate	27 (45.0)	9 (35.0)
University graduate+	11 (18.3)	3 (5.0)
Residential area, *n* (%)		
Rural	7 (11.7)	12 (20.0)
Urban	53 (88.3)	48 (80.0)
Smoking, *n* (%)		
Nonsmoker/ex-smoker	55 (91.7)	54 (90.0)
Active smoker	5 (8.3)	6 (10.0)
Duration of asthma, *n* (%)		
1-10 years	38 (63.4)	33 (55.0)
10+ years	22 (36.6)	27 (45.0)
The effect of asthma medication on body weight, *n* (%)		
No change	40 (66.7)	32 (53.4)
Increased body weight	14 (23.3)	23 (38.3)
Decreased body weight	6 (10.0)	5 (8.3)
The effect of asthma medication on appetite, *n* (%)		
No change	38 (63.4)	29 (48.3)
Increased appetite	16 (26.6)	28 (46.7)
Decreased appetite	6 (10.0)	3 (5.0)
Comorbidities, *n* (%)		
Diabetes	-	7 (11.7)
Hypertension	1 (1.7)	4 (6.7)
Allergic rhinitis	3 (5.0)	4 (6.7)
Reflux	5 (8.3)	7 (11.7)
ACT score (mean±SD)	20.6±2.3	17.9±3.7
BMI (kg/m²) (mean±SD)	22.6±1.7	34.6±5.4
WC (cm) (mean±SD)	75.5±9.2	96.4±5.6
WHR (mean±SD)	0.90±0.1	1.4±0.3

Data was presented as, *n* (%) or mean±SD. SD: Standard deviation, ACT: Asthma control test, BMI: Body mass index, WC: Waist circumference, WHR: Waist-hip ratio

The effects of obesity on pulmonary functions

When the pulmonary functions of the respondents were compared based on their BMI classification, all parameters other than the PEF value were found to be significantly different between the two groups ($P < 0.05$). All of the pulmonary function parameters of the respondents with normal BMI values were higher than in the obese respondents [Table 2].

When the pulmonary function of the respondents was compared according to their WC classification, the FEV_1, MEF_{25-75}, MEF_{75}, MEF_{50}, MEF_{25}, and FEV_1/FVC values in the respondents with normal WC were found to be higher than in the respondents at risk and at high risk ($P < 0.05$). Pulmonary function decreased with increasing WC [Table 3].

When the pulmonary functions of the respondents were compared according to the WHR classification, the FEV_1, MEF_{25-75}, MEF_{50}, MEF_{25}, and FEV_1/FVC values in the respondents with normal WHR values were found to be higher than those recorded in the respondents who were at risk ($P < 0.05$) [Table 4].

Figure 2 presents the ACT scores of the respondents according to their WC, WHR, and BMI values. The asthma control scores decreased with increasing WC, and this decrease was more pronounced between the respondents with normal WC and the high-risk respondents ($P < 0.01$). Similarly, the ACT scores of the respondents with normal WHR (20.2 ± 2.5) were significantly higher than the at-risk respondents (18.3 ± 3.8) ($P < 0.01$). When the relationship between ACT score and BMI was analyzed, an increasing BMI was found to be inversely related to ACT scores which decreased significantly with an increasing severity of obesity ($P < 0.01$).

While the analysis of macro–micro nutrient intake did not reveal any difference in saturated fatty acid, omega 6, total fat, monounsaturated fatty acid, or polyunsaturated fatty acid intake, the energy (1710.4 ± 336.3; 1558.3 ± 326.2 kcal) and carbohydrate (187.9 ± 46.8; 165.3 ± 44.8 g) intakes were found to be higher in the obese group than in the normal weight group. Protein intake was lower in the obese group than in the normal weight group (48.9; 60.8 g) ($P < 0.05$) [Table 5].

When the anthropometric measurements of the respondents and their ACT scores were compared, negative correlations were found between ACT scores and WHR ($r = -0.262$; $P < 0.05$), WC ($r = -0.356$; $P < 0.01$), and BMI ($r = -0.353$; $P < 0.01$) measurements. When the ACT scores and macronutrients were analyzed, the ACT scores were found to be negatively correlated with total energy ($r = -0.302$; $P < 0.01$) and carbohydrate intake ($r = -0.238$; $P < 0.01$), while protein ($r = 0.214$; $P < 0.05$) and omega 3 ($r = 0.209$; $P < 0.05$) intake were positively correlated with ACT scores [Figure 3].

Table 2: Pulmonary functions according to body mass index classification

	Normal (s=60)	Obese (s=60)	P
FVC (%)	92.4±16.2	84.6±19.1	0.018*
FEV_1 (%)	91.7-19.6	79.2±21.6	0.001**
PEF (%)	68.7±19.9	61.7±22.6	0.075
MEF_{25-75} (%)	81.8±31.3	58.4±22.5	0.003**
MEF_{75} (%)	73.6±22.6	61.5±24.5	0.006**
MEF_{50} (%)	82.6±31.9	57.8±23.0	0.000**
MEF_{25} (%)	79.6 (20.9-245.9)	56.2 (24.2-256.6)	0.001**
FEV_1/FVC	103.6 (69.7-126.9)	99.3 (69.1-130.2)	0.016*

*$P<0.05$, **$P<0.01$. Normally distributed data was presented as mean±SD, while nonnormally distributed data was presented as median (Q3-Q1). FEV_1: Forced expiratory volume in 1 s, FVC: Forced vital capacity, PEF: Peak expiratory flow, MEF: Mid-expiratory flow, SD: Standard deviation

Table 3: Pulmonary function according to waist circumference classification

	Normal (s=50)	At risk + At high risk (s=70)	P
FVC (%)	91.5±18.1	86.3±17.9	0.125
FEV_1 (%)	93.8±22.7	79.5±18.1	0.010*
PEF (%)	69.1±21.4	62.5±21.3	0.094
MEF_{25-75} (%)	84.5±31.6	59.8±23.2	0.000**
MEF_{75} (%)	74.0±24.3	62.9±23.3	0.014*
MEF_{50} (%)	85.0±31.5	59.6±24.7	0.000**
MEF_{25} (%)	83.0 (23.1-245.9)	59.0 (20.9-256.6)	0.001**
FEV_1/FVC	104.9 (69.7-126.9)	98.7 (69.1-130.2)	0.016*

*$P<0.05$, **$P<0.01$. Normally distributed data was presented as mean±SD, while nonnormally distributed data were presented as median (Q3-Q1). FEV_1: Forced expiratory volume in 1 s, FVC: Forced vital capacity, PEF: Peak expiratory flow, MEF: Mid-expiratory flow, SD: Standard deviation

Table 4: Pulmonary function according to waist-hip ratio classification

	Normal (s=60)	At risk (s=60)	P
FVC (%)	90.2±17.9	86.8±18.2	0.299
FEV_1 (%)	90.1±20.7	80.9±21.0	0.018*
PEF (%)	66.1±20.9	64.4±22.2	0.683
MEF_{25-75} (%)	80.1±31.0	60.1±24.5	0.000**
MEF_{75} (%)	70.1±23.9	64.9±24.6	0.244
MEF_{50} (%)	80.4±31.3	60.1±25.9	0.000**
MEF_{25} (%)	81.2 (23.1-245.9)	57.3 (20.9-256.6)	0.007**
FEV_1/FVC	103.6 (69.7-129.8)	99.3 (69.1-130.2)	0.000**

*$P<0.05$, **$P<0.01$. Normally distributed data was presented as mean±SD, while nonnormally distributed data were presented as median (Q3-Q1). FEV_1: Forced expiratory volume in 1 s, FVC: Forced vital capacity, PEF: Peak expiratory flow, MEF: Mid-expiratory flow, SD: Standard deviation

DISCUSSION

Pulmonary functions decrease due to fatty thorax and the associated decrease in diaphragm motility in obese patients. The systemic and local inflammation caused by fat tissue further enhances these effects and complicates asthma control in obese respondents.[22] In the present study, the FVC, FEV_1, PEF, MEF_{25-75}, MEF_{75}, MEF_{50}, MEF_{25}, and FVC/FEV_1 values of obese respondents were found to be significantly lower than in the respondents with normal BMIs ($P < 0.05$). In a cross-sectional study carried out by Leone *et al.* involving 121,965 patients who referred to their clinics between 1999 and 2006, a significant decrease was noted in pulmonary function as BMI values increased.[23] In another study, Bruno *et al.*[24] reported that FEV_1, FVC, and FEV_1/FVC values decreased as BMI increased, and people with normal BMIs recorded the highest pulmonary function values. In line with the above findings, Steier *et al.* found that the FEV_1, FVC, and FEV_1/FVC values of obese people were significantly lower than those recorded in people with normal BMI values ($P < 0.05$).[25]

The decrease in pulmonary function related to asthma also manifests through increasing abdominal obesity.

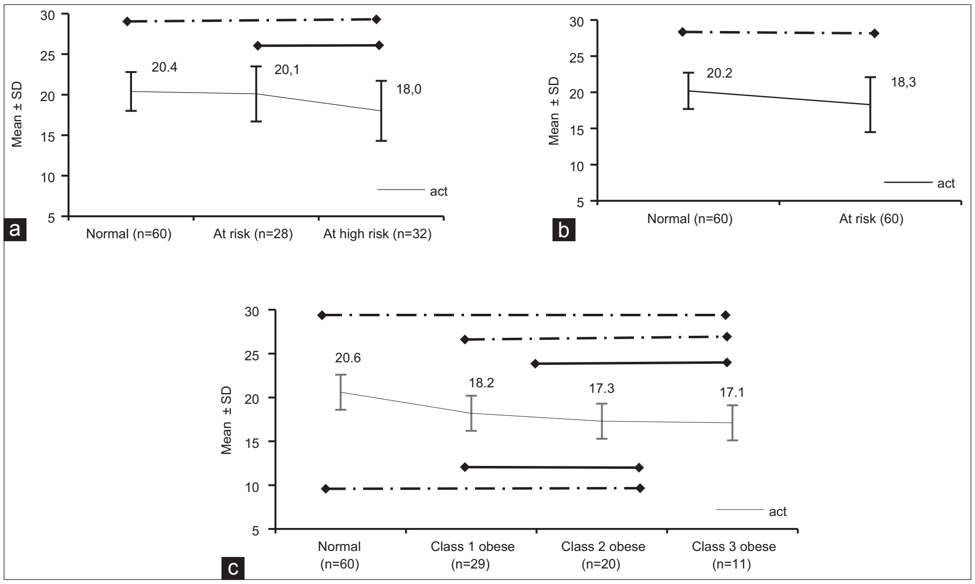

Figure 2: The asthma control test scores according to waist circumference classification (a) waist–hip ratio classification (b) and body mass index classification (c) ♦ Indicates differences between groups. ▬*P* <0.05, ▬ ▬*P* <0.01

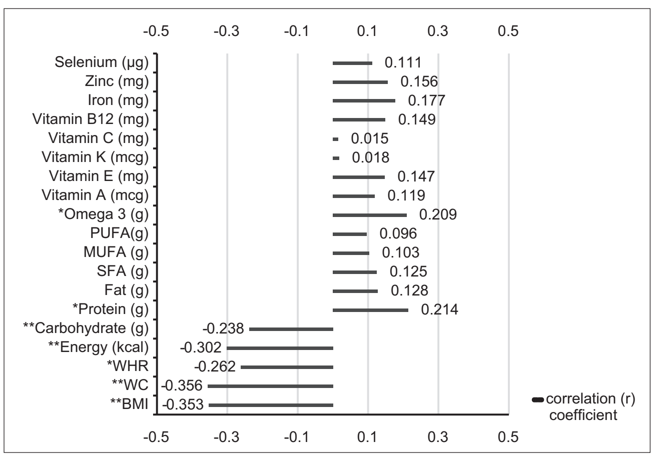

Figure 3: Correlations of asthma control test scores with macro–micro nutrient uptakes and anthropometric measurements. **P* < 0.05, ***P* < 0.01. MUFA: Monounsaturated fatty acid; PUFA: Polyunsaturated fatty acid; SFA: Saturated fatty acid; WHR: Waist–hip ratio; WC: Waist circumference; BMI: Body mass index

Respiratory capacity decreases and sufferers become incapable of complete respiration, particularly in the presence of increased fat tissue in the WC and elevated WHR.[26] Furthermore, respiratory maneuvers become shorter, more frequent, and limiting than in normal individuals.[24] In a study by Baruah *et al*., the FEV_1 and FVC values of the respondents classified as at risk and at high risk based on their WC were found to be lower than in the respondents with a normal WC ($P < 0.05$).[26] In a cross-sectional study involving 1674 participants carried out by Chen *et al*. investigating the relationship between WC and pulmonary function, increased WC measurements were found to be associated with decreased pulmonary function. Based on their results, a mean WC increase of 1 cm was found to cause a 13 ml decrease in FVC and an 11 ml decrease in FEV_1.[27] Similar to the abovementioned

Table 5: Mean energy and macronutrient uptake

	Obese (s=60)	Normal (s=60)	*P*
Energy (kcal)	1710.4±336.3	1558.3±326.2	0.013*
Carbohydrate (g)	187.9±46.8	165.3±44.8	0.008**
Saturated fatty acids (g)	25.3±7.4	23.6±8.1	0.225
Omega 6 (g)	17.8±9.3	18.7±10.5	0.604
Protein (g)	48.9 (23.8-144.6)	60.8 (31.6-118.2)	0.003**
Fats (g)	74.7 (31.0-154.3)	73.4 (172.0-34.3)	0.493
MUFA (g)	23.5 (9.3-64.9)	23.4 (11.4-60.6)	0.569
PUFA (g)	19.7 (3.3-58.3)	19.0 (4.5-56.9)	0.813
Ω 3 (g)	1.1 (0.25-10.9)	1.1 (0.51-24.1)	0.265

**P*<0.05 ***P*<0.01. Normally distributed data was presented as mean±SD, while nonnormally distributed data were presented as median (Q3-Q1). MUFA: Monounsaturated fatty acid, PUFA: Polyunsaturated fatty acid, SD: Standard deviation

studies, a study investigating the relationship between body fat distribution and pulmonary function reported an inverse relationship between WC and WHR, and FEV_1 and FVC values.[28] In the present study, the FEV_1, $MEF_{25–75}$, MEF_{75}, MEF_{50}, MEF_{25}, and FEV_1/FVC values of those in the at risk and at high-risk groups based on their WC measurements were found to be significantly lower than in those with a normal WC ($P < 0.05$). This finding is consistent with literature. Similar to WC, an increase in WHR has also been found to be inversely correlated with pulmonary functions (except for MEF_{75}).

When the ACT scores of the respondents were analyzed based on their WC and WHR classification, those in that risk or high-risk groups were found to be lower than in the normal group ($P < 0.05$). In a randomized controlled trial performed by Lv *et al*. involving 90 asthmatic patients, an increase in WC was found to decrease asthma control, which is consistent with the findings of the present study ($P < 0.05$).[29] Another study investigating the effects of adipose tissue on asthma control in adolescents showed that an increase in the amount of adipose tissue decreased asthma control ($P < 0.05$).[1] In another study, involving 38 obese asthmatic patients, Scott *et al*. found that decreasing WC improved asthma control ($P < 0.05$).[30]

Along with prolonged disease duration, an increase in the amount of medication used (particularly systemic corticosteroids) may result in increased appetite, and therefore, a higher food intake.[31] Of the respondents in the present study, 30.8% reported increased body weight and 20.8% reported increased appetite after starting to use antiasthma medications. The number of respondents reporting increased body weight and appetite was higher in the obese group than in the normal weight group. The fact that those in the obese group in particular reported increased body weight and appetite after starting asthma medications can be attributed them reflecting their overeating behaviors to another cause. Obese people may circumvent the responsibility of their inability to control the eating instinct by attributing the problem to another cause.[32]

Considering that people with asthma tend to live sedentary lifestyles due to their respiratory problems, they may be more prone to obesity. In addition to insufficient physical activity, the overconsumption of energy and carbohydrates further trigger tendencies to obesity and effect people with asthma in a vicious cycle.[22] In the present study, the total energy and carbohydrate intakes of the obese respondents were found to be higher than those with normal body weight ($P < 0.05$). Moreover, a negative correlation was noted between ACT scores and total energy and carbohydrate intake ($P < 0.01$). Previous studies investigating this subject have also reported decreased asthma control with high levels of energy and carbohydrate intake and showed improvements in ACT scores with energy and carbohydrate-limiting diets.[30,33] Unlike energy and carbohydrate intake, protein intake was found to be lower in obese people than in those of normal weight and was positively correlated with ACT scores ($P < 0.05$). An increase in protein intake is known to increase respiratory smooth muscle and contractile number and to allow stronger respiration.[34] Similarly, in the study of Barros *et al*., the protein intake of those whose asthma was under control was found to be higher than in those with uncontrolled asthma.[35]

Several diet hypothesis has been put forward over the last 15 years in relation to asthma, and changing dietary content has been stated as one of the leading environmental factors in the development of asthma.[10] In particular, diets that are rich in omega 3 and antioxidant vitamins–minerals, such as the Mediterranean diet, are known to decrease symptoms of asthma.[33] In the present study, a positive significant correlation was identified between omega 3 intake and ACT score ($P < 0.05$), and there have been previous studies reporting that a high omega 3 intake alleviates asthma symptoms, while also providing further protection from the development of symptoms.[31,36] In contrast, ACT scores would appear to be unaffected by vitamin–mineral intake, which may be attributed to the fact that both the obese and normal weight groups consumed insufficient amounts of fruit and vegetables. Although high fruit and vegetable consumption is believed to decrease asthma symptoms, there have been previous studies reporting conflicting findings on this matter.[37,38]

This study has some limitations. First of all, the results of the study cannot be extrapolated to the entire population, as it study was conducted at a single center. In addition, due to limited research period, the study was conducted only during the spring months and may reflect results specific to this season. There was no bias in the subject selection, and all of those who were eligible for inclusion who referred to the clinics over a 2-month period were included in the study. In addition, there were a lot more women included in the study than men, although this difference in the prevalence of asthma between genders is a global fact. As a result of the effects of sex hormones after puberty, asthma is more commonly seen among women than men.[39]

Despite all these limitations, the comparison of the characteristics of asthma with both anthropometric measurements and the uptake of nutrients has increased the strength of the study. By making a comparison of the characteristics of asthma according to the WC and WHR classification in addition to BMI has revealed not only the effect of total obesity but also the effects of abdominal obesity on asthma. Furthermore, the investigation of the relationship between the ACT score and macronutrients and vitamins–minerals has served to highlight the effects of nutritional habits on asthma control.

CONCLUSIONS

The results of this study have shown that ACT scores and pulmonary functions decreased with increasing BMI, WC, and WHR values in adults with asthma. Data on the food intake of the respondents suggested a correlation between that some micro–macro nutrients and ACT scores. Considering that the prevalence of obesity has been increasing day by day and that today's nutritional habits are based mostly on processed foods rather than antioxidant-rich fruit and vegetables, the results of this study are consistent with each other. Based on the findings of this study, it would seem to be appropriate to refer obese asthmatic people to nutrition and diet outpatient clinics for correct diet recommendations, as decreased body weight will be effective in reducing the symptoms of asthma and in improving quality of life.

Acknowledgment
The authors would like to thank Mehtap Akçil Ok for her statistical support.

Financial support and sponsorship
Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Backer V, Baines KJ, Powell H, Porsbjerg C, Gibson PG. Increased asthma and adipose tissue inflammatory gene expression with obesity and Inuit migration to a western country. Respir Med 2016;111:8-15.
2. National Center for Health Statistics. National Health Interview Survey; 2013-2014. https://www.cdc.gov/nchs/data/hestat/obesity_adult_13_14/obesity_adult_13_14.htm. [Last accessed on 2017 Oct 21].
3. National Center for Health Statistics. National Health Interview Survey; 2012. Available from: https://www.cdc.gov/nchs/data/databriefs/db219.pdf. [Last accessed on 2017 Oct 21].
4. Rabec C, de Lucas Ramos P, Veale D. Respiratory complications of obesity. Arch Bronconeumol 2011;47:252-61.
5. Khalid F, Holguin F. A review of obesity and asthma across the life span. J Asthma 2018;55:1286-300.
6. Zhang X, Zheng J, Zhang L, Liu Y, Chen GP, Zhang HP, *et al*. Systemic inflammation mediates the detrimental effects of obesity on asthma control. Allergy Asthma Proc 2018;39:43-50.
7. Bianco A, Nigro E, Monaco ML, Matera MG, Scudiero O, Mazzarella G, *et al*. The burden of obesity in asthma and COPD: Role of adiponectin. Pulm Pharmacol Ther 2017;43:20-5.
8. Kattan M, Kumar R, Bloomberg GR, Mitchell HE, Calatroni A, Gergen PJ, *et al*. Asthma control, adiposity, and adipokines among inner-city adolescents. J Allergy Clin Immunol 2010;125:584-92.
9. Rakıcıoğlu N, Acar N, Ayaz A, Pekcan G. Food and Nutrition Photo Catalog. Ankara, Turkey: Ata Offset Press; 2012.
10. Allan K, Devereux G. Diet and asthma: Nutrition implications from prevention to treatment. J Am Diet Assoc 2011;111:258-68.
11. Cepeda AM, Del Giacco SR, Villalba S, Tapias E, Jaller R, Segura AM, *et al*. A traditional diet is associated with a reduced risk of eczema and wheeze in Colombian children. Nutrients 2015;7:5098-110.
12. Li Q, Scott HA, Berthon BS, Gibson PG, Baines KA, Wood LG. Saturated fatty acids, but not N-6 polyunsaturated fatty acids or carbohydrates, increase airway inflammation in non-obese asthmatics. Am J Respir Crit Care Med 2017;195:A7467.
13. Greenough A, Shaheen SO, Shennan A, Seed PT, Poston L. Respiratory outcomes in early childhood following antenatal Vitamin C and E supplementation. Thorax 2010;65:998-1003.
14. Nakamura K, Wada K, Sahashi Y, Tamai Y, Tsuji M, Watanabe K, *et al*. Associations of intake of antioxidant vitamins and fatty acids with asthma in pre-school children. Public Health Nutr 2013;16:2040-5.
15. El-Shafey BI, El-Deib AE. Effect of weight reduction on obese patients with COPD and bronchial asthma. Egypt J Chest Dis Tuberc 2015;64:773-8.
16. Moxley RT 3rd, Pandya S, Ciafaloni E, Fox DJ, Campbell K. Change in natural history of duchenne muscular dystrophy with long-term corticosteroid treatment: Implications for management. J Child Neurol 2010;25:1116-29.
17. World Health Organization. 10 Facts on Obesity. World Health Organization; 2016. Available from: http://www.who.int/features/factfiles/obesity/facts/en/. [Last accessed on 2017 Nov 22].
18. World Health Organization. Waist Circumference and Waist-Hip Ratio: Report of a WHO Expert Consultation. Geneva, Switzerland: WHO Press; 2011.
19. Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi R, *et al*. Interpretative strategies for lung function tests. Eur Respir J 2005;26:948-68.
20. Uysal MA, Mungan D, Yorgancioglu A, Yildiz F, Akgun M, Gemicioglu B. The validation of the Turkish version of asthma control test. Qual Life Res 2013;22:1773-9.
21. Nutrition Knowledge Package Program (BEBIS). Ebispro for Windows, Stutgart, Germany; Turkish version BEB_IS; Data Bases: Bundeslebenmittel schlussell, 11.3. Germany.
22. Boulet LP. Asthma and obesity. Clin Exp Allergy 2013;43:8-21.
23. Leone N, Courbon D, Thomas F, Bean K, Jégo B, Leynaert B, *et al*. Lung function impairment and metabolic syndrome: The critical role of abdominal obesity. Am J Respir Crit Care Med 2009;179:509-16.
24. Bruno A, Pace E, Cibella F, Chanez P. Body mass index and comorbidities in adult severe asthmatics. Biomed Res Int 2014;2014:607192.
25. Steier J, Lunt A, Hart N, Polkey M, Moxham J. Observational study of the effect of obesity on lung volumes. Thorax2014; 69:752-759.
26. Baruah K, Dutta BC, Sarkar R, Kumar V. Association of waist circumference with pulmonary function in obesity. Int J Physiol 2016;4:27-32.
27. Chen Y, Rennie D, Cormier YF, Dosman J. Waist circumference is associated with pulmonary function in normal-weight, overweight, and obese subjects. Am J Clin Nutr 2007;85:35-9.
28. Wannamethee SG, Shaper AG, Whincup PH. Body fat distribution, body composition, and respiratory function in elderly men. Am J Clin Nutr 2005;82:996-1003.
29. Lv N, Xiao L, Camargo CA Jr., Wilson SR, Buist AS, Strub P, *et al*. Abdominal and general adiposity and level of asthma control in adults with uncontrolled asthma. Ann Am Thorac Soc 2014;11:1218-24.
30. Scott HA, Gibson PG, Garg ML, Pretto JJ, Morgan PJ, Callister R, *et al*. Dietary restriction and exercise improve airway inflammation and clinical outcomes in overweight and obese asthma: A randomized trial. Clin Exp Allergy 2013;43:36-49.
31. Liu D, Ahmet A, Ward L, Krishnamoorthy P, Mandelcorn ED, Leigh R, *et al*. A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. Allergy Asthma Clin Immunol 2013;9:30.
32. Dalen J, Smith BW, Shelley BM, Sloan AL, Leahigh L, Begay D. Pilot study: Mindful eating and living (MEAL): Weight, eating behavior, and psychological outcomes associated with a mindfulness-based intervention for people with obesity. Complement Ther Med 2010;18:260-4.
33. Barros R, Moreira A, Fonseca J, de Oliveira JF, Delgado L, Castel-Branco MG, *et al*. Adherence to the Mediterranean diet and fresh fruit intake are associated with improved asthma control. Allergy 2008;63:917-23.
34. Slats AM, Janssen K, van Schadewijk A, van der Plas DT, Schot R, van den Aardweg JG, *et al*. Expression of smooth muscle and extracellular matrix proteins in relation to airway function in asthma. J Allergy Clin Immunol 2008;121:1196-202.
35. Barros R, Moreira A, Fonseca J, Delgado L, Castel-Branco MG, Haahtela T, *et al*. Dietary intake of α-linolenic acid and low ratio of n-6:n-3 PUFA are associated with decreased exhaled NO and improved asthma control. Br J Nutr 2011;106:441-50.
36. Kompauer I, Demmelmair H, Koletzko B, Bolte G, Linseisen J, Heinrich J. Association of fatty acids in serum phospholipids with lung function and bronchial hyperresponsiveness in adults. Eur J Epidemiol 2008;23:175-90.
37. Garcia-Larsen V, Arthur R, Potts JF, Howarth PH, Ahlström M, Haahtela T, *et al*. Is fruit and vegetable intake associated with asthma or chronic rhino-sinusitis in European adults? Results from the global allergy and asthma network of excellence (GA2LEN) survey. Clin Transl Allergy 2017;7:3.
38. Rosenlund H, Kull I, Pershagen G, Wolk A, Wickman M, Bergström A. Fruit and vegetable consumption in relation to allergy: Disease-related modification of consumption? J Allergy Clin Immunol 2011;127:1219-25.
39. Zein JG, Erzurum SC. Asthma is different in women. Curr Allergy Asthma Rep 2015;15:28.