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Effects of dietary intervention on diet inflammatory index and asthma characteristics in obese asthmatic individuals: Randomized controlled trial

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Abstract:

BACKGROUND AND AIM: Inflammatory factors are very important in the emergence of asthma. In recent years, the inflammatory response caused by diet has also been associated with asthma. In this study, we evaluated the association between the Dietary Inflammatory Index (DII®), weight loss, and asthma characteristics.

METHODS: Obese asthmatic individuals ($n = 55$) were randomized into the diet ($n = 29$) or control groups ($n = 26$) for 10 weeks. The anthropometric measurements, nutrition consumption records (past 24 h), pulmonary function tests DII® were recorded and compared between groups.

RESULTS: After intervention, the DII changes of the individuals in the diet group showed a negative correlation with the changes in forced expiratory volume in 1 s (FEV_1), forced vital capacity (FVC), mean expiratory flow rate ($MEF_{25–75}$), asthma control (ACT) and asthma quality of life questionnaire (AQLQ) scores (all $P < 0.05$). DII changes in the diet group showed a positive significant partial correlations (i.e. controlling for important confounders) with changes in body weight ($r = 0.527$; 95% confidence interval [CI]: 0.211, 0.725), FEV_1, ($r = -0.486$; 95% CI: −0.695, −0.249), and FVC ($r = -0.459$; 95% CI: −0.688, −0.162). FEV_1, peak expiratory flow (PEF), $MEF_{25–75}$, MEF_{25} and ACT scores decreased with increasing DII from tertile 1 to tertile 3 (P <0.05).

CONCLUSIONS: Weight loss through diet intervention and decrease in the inflammatory load of diet increase pulmonary function and improve asthma control.

Keywords:

Asthma control, diet, dietary inflammatory index, weight loss

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Introduction

Asthma is an inflammatory and chronic disease that causes damage to the airways and makes breathing difficult.[1] Although there are many factors in its emergence; it is known that oxidative stress and inflammatory response are important factors in asthma pathophysiology. Especially, inflammatory response caused by oxidative stress has many deleterious effects on respiratory functions and hyperresponsiveness.[2]

The decrease in antioxidant intake as a result of changes in diet over the last two decades also is associated with an increase in asthma prevalence.[3] The transition from traditional diets to modern diets along with changes in eating habits increased asthma symptoms by reducing antioxidant, vitamin, and mineral intake.[4] In particular, the increased uptake of pro-inflammatory food products. Such as ultra-processed food and decreased uptake of anti-inflammatory nutrients such as Vitamins A, C, E represent significant indicators of these changes.[5]

In addition to changes in lifestyle factors, including diet, obesity has been frequently associated with asthma.[6] Excessive accumulation of fat tissue, which is known to be pro-inflammatory, leads to reduction in lung volume. Fat tissue can increase systemic and local inflammation, thus increasing the severity of asthma and negatively affects pulmonary functions.[7,8] Therefore, weight loss through diet is recommended for obese asthmatic individuals.[9]

Although it is well documented that nutritional habits affect the inflammatory response, the responsible nutrients or nutrient groups and their level of impact have not been well clarified. For this purpose, Shivappa *et al*. developed the Dietary Inflammatory Index (DII®) for the assessment of the inflammatory load of a diet. Accordingly, a higher DII load shows a more inflammatory diet.[10] It has also been shown in various studies in Western countries that an increased DII score is associated with increased asthma characteristics.[11,12] Therefore, this study was planned to evaluate the effects of dietary intervention and weight loss on DII and asthma characteristics.

Methods

Subjects and study design

This study was conducted with patients in the Department of Immunology and Allergy. Participants were randomized between January 2017 and May 2017 to 10-week dietary intervention group or control group [Figure 1]. Random number-generating software program was used for randomization (Microsoft Excel 2010). Obese asthmatic patients (determined by doctor's diagnosis) between the ages of 20 and 65 years were included in the study. Pregnant or breastfeeding women, patients with acute asthma exacerbation or those using corticosteroids were excluded. Informed consent form signed by all participants [Figure 1].

All participants (55 total) were randomly assigned to diet group or control group. All anthropometric measurements and diet sessions were done in separate rooms to prevent any communication between groups. Detailed body analysis and 24-h food consumptions of all participants were recorded at the 1st day and at the last day of the study. Consent form was obtained from the individuals who participated in the study. The study was approved by the Faculty of Medicine Science Ethics Committee with approval number 19-96716.

Anthropometric measurements

Participants' body weight, fat percentage (%), muscle mass, and abdominal fat degree measurements were recorded using Tanita BC 601(Tartı Medical, https://www.tarti.com/) in the morning while fasting. Height, waist, and hip circumference measurements were obtained using a measuring tape (without shoes and wearing thin clothing). Body mass index (BMI) was calculated according to the WHO criteria. Participants with a BMI over 30 kg/m^2 were considered obese.[13]

Diet intervention

For overweight and obese individuals aproximately 5%–10% weight loss is recommended as moderate weight loss.[14] According to researches, 10 weeks is enough to achieve this weight loss.[15,16] Therefore, we decided to continue our research for 10 weeks.

Food consumptions were recorded retrospectively at the beginning and at the end of the study using the 24-h recall method. Data were entered by a dietician and analyzed using BEBIS software (BEBIS).[17] Weekly phone calls were made to keep the diet group's motivation high throughout the study. The diet program was prepared by nutritionists according to the individual characteristics (age, gender, physical activity) and general nutritional habits.

Physical activity level (PAL) of the participants in the last 24 h and their basal metabolic rate (BMR) were calculated according to the Schofield equation. The total energy requirement was obtained by multiplying BMR with PAL values.[18] A diet consisting of 10%–20% protein, 45%–60% carbohydrate, and 25%–30% fat was planned according to the energy requirement.[19] The content and application of the diet were explained to the individuals in the diet group. However, no dietary recommendations were given to the participants in the control group.

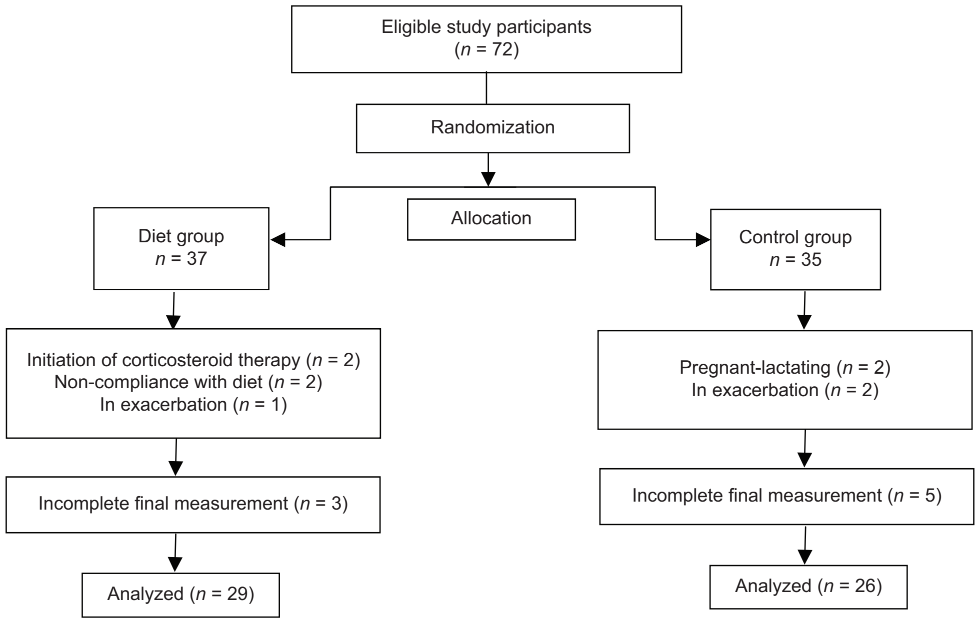

Figure 1: Flowchart of study participants

The Dietary Inflammatory Index®

The DII was identified and scored to derive the component-specific inflammatory effect scores for 45 dietary factors (i.e. components of DII). For the current study, E DII scores were calculated using 24 dietary parameters which were available for all three cohorts (energy, protein, carbohydrate, Mg, iron, zinc, beta carotene, Vitamin: D, C, E, A, B6, B12, thiamin, riboflavin, niacin, folic acid, fiber, SFA (saturated fatty acids), MUFA (mono-unsaturated fatty acids), PUFA (polyunsaturated fatty acids), omega 6, omega 3 and cholesterol). [10]

Asthma characteristics

The respiratory functions of the participants were measured using a device branded ZAN 100 (Germany). All measurements were repeated three times while the individual was sitting on a flat surface and the best mean values were recorded.[20]

The asthma control test (ACT) is a five-question scale that evaluates the effect of asthma symptoms. The total score that can be obtained from the scale is between 5 and 25.[21] In this study, the validated Turkish version was used to evaluate the ACT.[22]

The asthma quality of life questionnaire (AQLQ) was used to assess the quality of life. The questionnaire consists of 32 questions. A higher AQLQ score indicates a better quality of life. The current Turkish version is used in this study.[23]

Statistical analysis

Data were analyzed using the SPSS-20 software. Descriptive statistics were presented as mean ± standard deviation, median (interquartile range, Q3–Q1) or number of cases and percentages (%). Normality of data was assessed by using Shapiro Wilk's test. When data were normally distributed between two groups Student's *t*-test was used. When data were not normally distributed between two groups Mann–Whitney U-test was used.

For dependent groups, within-group changes were analyzed by a Wilcoxon Signed-Rank test. Partial correlation (controlling for baseline marker) test was used to evaluate the relations between quantitative variables. The study population was divided into three subgroups according to the E-DII (difference) score. Kruskal–Wallis H-test was used to test the differences between DII tertiles for more than two nonnormally distributed data. All analyses were performed within a confidence interval (CI) of 95.0%.

Results

Baseline information

The study was completed with a total of 55 participants (29 diets and 26 controls). The percentage of women participating in the study is higher than that of men [Figure 1]. When the baseline data were compared, there was no difference between the groups in terms of gender, age, anthropometric measurements, asthma characteristics, education level, smoking status, and DII score [Table 1].

At the end of the 10 weeks, all respiratory functions increased in the diet group except forced expiratory volume in 1 s (FEV_1)/forced vital capacity (FVC) and peak expiratory flow (PEF). The same values decreased in the control group ($P < 0.05$). Similar to respiratory functions, AQLQ and ACT scores also increased in the diet group ($P < 0.01$) [Table 2]. After the intervention, DII score of the diet group decreased significantly ($P < 0.01$) [Figure 2]. Total DII changes in the diet group were significantly negatively correlated with changes in FEV_1, FVC, mean expiratory flow rate ($MEF_{25–75}$), ACT, and AQLQ scores ($P < 0.05$). As the inflammation score of the diet decreased, individuals' respiratory capacity increased. In the control group, there was no difference compared to baseline ($P > 0.05$) [Table 2].

Following the dietary intervention, all anthropometric measurements decreased in the diet group ($P < 0.01$). However, no change was observed in the control group. DII changes in the diet group after the intervention showed a positive significant correlation with changes in body weight, BMI, waist circumference (WC), Waist to hip ratio (WHR) ($P < 0.05$). The inflammatory score of the diet decreased with a decrease in body composition [Table 3].

In terms of pulmonary functions, FEV_1, PEF, $MEF_{25–75}$ decreased with increasing DII from tertile 1 to tertile 3 ($P < 0.05$). In parallel with pulmonary functions, the ACT score also differed between tertiles and decreased with increasing DII values ($P < 0.01$) [Table 4].

Table 1: Baseline informations of the participants

	Diet (*n*=29)	Control (*n*=26)	*P*
Age	50.4±10.4	50.3±10.0	0.93
Gender (percentage women)	93.1	100	0.16
BMI (kg/m^2)	37.5 (7.8)	35.7 (5.0)	0.65
Asthma duration	10 (13.5)	10 (15)	0.99
Level of education (%)			
Primary school	69.0	68.0	0.33
Secondary-high school	17.2	24.0	0.20
University+	13.8	8.0	0.75
Somker (%)	6.9	8.3	0.60
Comorbid diseases (%)			
Diabetes mellitus	17.4	11.5	0.81
Hypertension	27.2	26.7	0.78
Hypercholesterolemia	13.7	-	0.72
Reflux	13.7	3.8	0.63
DII score	0.55 (1.2)	0.38 (1.4)	0.12

Data was presented as median (IQR) or percentage. Student's *t*-test (normal distribution) and Mann-Whitney U test (nonnormal distribution) was used. DII: Dietary inflammatory index, BMI: Body mass index, IQR: İnterquartile range

Discussion

In the last 15 years, various dietary hypotheses related to asthma have been proposed and it has been stated that changing dietary content is one of the leading environmental factors in the development of asthma.[5] In particular, diets rich in antioxidant vitamins and minerals such as the Mediterranean diet are known to reduce asthma symptoms.[24] Processed foods with high-fat content, on the other hand, are known to exacerbate the symptoms of asthma.[5] The relationship between the DII, as a novel and relatively recent concept reflecting the inflammatory degree of a diet with asthma characteristics, has not been clarified totally. The first study into this topic reported that an increased DII

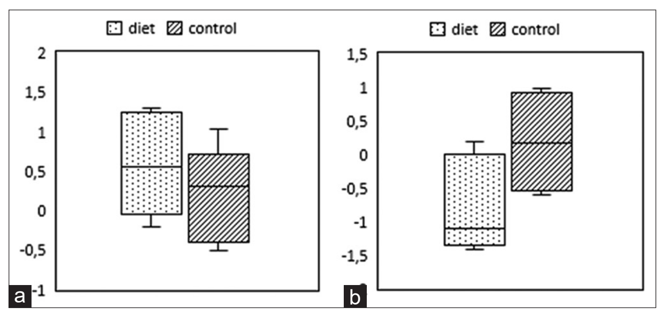

Figure 2: (a) Comparison of the baseline Dietary Inflammatory Index scores of the participants; (b) Comparison of the 10 weeks Dietary Inflammatory Index scores of the participants. $^{**}P < 0.01$

Table 2: Correlation between individuals' dietary inflammatory index changes and asthma characteristics changes

	Diet group (*n*=29)				Control group (*n*=26)			
	Baseline	Change	Correlation with change in DII score^a		Baseline	Change	Correlation with change in DII score^a	
FEV_1	79.0 (29.5)	5.0 (10.5)ǂ	−0.486**	−0.695-−0.249	88.0 (23.5)	−3.0 (9.5)ǂ	−0.374	−0.633-−0.086
FVC	96.0 (25.0)	3.0 (12)ǂ	−0.459**	−0.688-−0.162	96.0 (20.7)	−2.0 (10.7)#	−0.367	−0.637-−0.071
FEV_1/FVC	98.0 (17.0)	0 (65)	−0.206	−0.450-0.020	96.0 (11.7)	−2.0 (4.5)	−0.054	−0.473-−0.340
PEF	80.0 (27.0)	3.0 (10.0)	−0.194	−0.444-0.185	80.5 (25.0)	−3.0 (15.7)	−0.252	−0.548-0.073
MEF_{25-75}	52.0 (31.5)	6.0 (15.5)#	−0.224*	−0.442-−0.038	51.0 (38.7)	−1.5 (9.0)	−0.047	−0.423-0.369
MEF_{75}	81.0 (44.0)	6.0 (18.0)#	−0.295	−0.513-−0.055	79.0 (39.5)	−4.0 (9.5)	−0.398	−0.642-−0.166
MEF_{50}	60.0 (38.5)	6.0 (9.0)ǂ	−0.268	−0.504-−0.084	64.0 (43.5)	−4.0 (9.5)#	−0.098	−0.510-0.413
MEF_{25}	38.0 (23.5)	5.0 (11.5)#	−0.165	−0.429-−0.041	38.0 (26.0)	0 (8.7)	0.001	−0.300-0.283
ACT (score)	21.0 (2)	2.0 (2.0)ǂ	−0.443**	−0.661-−0.206	21.0 (2.5)	0 (1.7)	0.189	−0.261-0.515
AQLQ (score)	5.5 (0.9)	0.1 (0.8)ǂ	−0.517**	−0.714-−0.262	5.7 (0.8)	−0.06 (0.2)	0.021	−0.387-0.422

#P<0.05, ǂP<0.01, *P<0.05, **P<0.01, ^{a}Partial correlations between change in asthma characterisitcs and change in DII score, controlling for baseline marker value. Data was presented as median (IQR).Within-group changes were analyzed by a Wilcoxon signed-rank test presented as partial (r) coefficient and 95% CI. FEV_1: Forced expiratory volume in 1 s, FVC: Forced vital capacity, MEF: Mean expiratory flow rate, ACT: Asthma control, AQLQ: Asthma quality of life questionnaire, PEF: Peak expiratory flow, DII: Dietary inflammatory index, IQR: İnterquartile range

Table 3: Correlation between individuals' dietary inflammatory index changes and body composition changes

	Diet group (*n*=29)				Control group (*n*=26)			
	Baseline	Change	Correlation with change in DII score[a]		Baseline	Change	Correlation with change in DII score[a]	
Body weight±kg	85.1 (19.7)	−5.2 (4.5)ǂ	0.527**	0.211-0.725	89.0 (14.6)	−0.1 (1.3)	0.317	−0.212-0.670
BMI (kg/m²)	37.5 (7.8)	−2 (1.7)ǂ	0.381*	−0.057-0.691	35.7 (5.0)	0 (0.6)	0.052	−0.348-0.442
WC (cm)	105.0 (17.0)	−5.0 (5.0)ǂ	0.518**	0.122-0.787	105.0 (9.5)	−0.2 (1.0)	0.150	−0.313-0.487
WHR	0.87 (0.06)	−0.05 (0.04)ǂ	0.413*	0.068-0.656	0.9 (0.14)	0.01 (0.01)	0.189	−0.244-0.537
Total body fat (%)	44.3 (6.7)	−1.8 (2.8)ǂ	−0.052	−0.481-0.386	43.3 (4.6)	0.4 (1.6)	−0.119	−0.634-0.620
Muscle mass (kg)	45.7 (8.1)	−1.1 (1.5)ǂ	0.286	−0.229-0.664	47.1 (6.6)	0.1 (1.2)	0.193	−0.338-0.631
Abdominal fat	13.0 (5.5)	−1 (1)ǂ	0.149	−0.398-0.558	11.0 (3.5)	0 (0.5)	0.274	−0.634-0.148

ǂ*P*<0.01, **P*<0.05, ***P*<0.01, [a]Partial correlations between change in body composition and change in DII score, controlling for baseline marker value. Presented as partial (*r*) coefficient and 95% CI (lower and upper level). Data was presented as median (IQR). Within-group changes were analyzed by a Wilcoxon signed-rank test. WHR: Waist to hip ratio, DII: Dietary inflammatory index, IQR: İnterquartile range, BMI: Body mass index, WC: Waist circumference, CI: Confidence interval

Table 4: Asthma characteristics at 10-week by tertiles of 10-week change in dietary inflammatory index score

	Tertile 1	Tertile 2	Tertile 3	*P*
FEV_1 (%)	91.0 (27.0)	88.0 (22.5)	75.0 (33.0)	0.02
FVC (%)	96.5 (21.0)	98.0 (24.0)	97.0 (22.0)	0.23
FEV_1/FVC	98.5 (17.25)	95.0 (8.5)	93.0 (12.0)	0.05
PEF (%)	82.5 (31.5)	88.0 (21.0)	72.0 (32.0)	0.04
MEF 25-75 (%)	62.0 (20.0)	57.0 (21.5)	56.0 (20.0)	0.04
MEF 75 (%)	80.0 (33.75)	85.5 (32.75)	82.0 (36.0)	0.16
MEF 50 (%)	58.0 (33.75)	61.0 (37.0)	63.0 (24.0)	0.27
MEF 25 (%)	47.0 (26.0)	44.5 (21.25)	48.0 (23.0)	0.07
ACT (score)	23.0 (2.0)	22.0 (2.75)	20.0 (4.0)	0.001
AQLQ (score)	5.5 (0.5)	5.8 (0.9)	5.5 (0.8)	0.58

Data were presented as median (IQR). Kruskal-Wallis H test was used to test the differences between DII tertiles. Tertile 1; ≤−1.528, tertile 2; −1.528-0.728, tertile 3; ≥−0.728. FEV_1: Forced expiratory volume in 1 s, FVC: Forced vital capacity, MEF: Mean expiratory flow rate, ACT: Asthma control, AQLQ: Asthma quality of life questionnaire, PEF: Peak expiratory flow, IQR: İnterquartile range, DII: Dietary inflammatory index

was associated with decreases in FEV_1 and FVC, as measures of pulmonary function (P < 0,05).[25] Another study similarly reported that increased DII exacerbated dyspnea as a symptom of impaired respiration and decreased FVC values.[26] In another study in the US, higher DII (a pro-inflammatory diet) was associated with wheeze among adults (odds ratio = 1.41, CI = 1.17–1.70; P trend < 0.001).[11] In the present study, a negative correlation was found between change in DII score and change in FEV_1, FVC, and $MEF_{25–75}$ values ($P < 0.05$). FEV_1, PEF and $MEF_{25–75}$ values also decreased with increasing DII tertiles ($P < 0.05$).

The most important goals in the asthma treatment process are to control asthma and to increase the quality of life. For this purpose, the importance of nonpharmacological treatment approaches has been emphasized in recent years.[21] In the studies of Dixon *et al*., it was found that ACT and AQLQ values increased as a result of the decrease in inflammatory cytokines.[27] Similarly, in another study, ACT and AQLQ values increased with the decrease in C-reactive protein (CRP), adiponectin and leptin levels.[28] In this study, the changes in DII score and ACT-AQLQ scores showed a significant negative correlation. ACT value decreased with the increase of DII, which is an inflammatory indicator, between tertiles.

Visceral adipose tissue formed as a result of the increase in body weight limits the movements of the diaphragm by applying pressure to the chest Wall.[29] Especially in obese individuals, total lung capacity decreases due to the accumulation of adipose tissue.[30] The general opinion on this matter is that an increased BMI aggravates inflammatory response in asthmatic individuals. Previous studies have reported increased blood levels of tumor necrosis factor, CRP, and interleukin-6 with increased BMI in asthmatic individuals.[31,32] In a study by Wood *et al*. the DII in asthmatic individuals increased with increasing BMI.[25] In another study, Vasudevan *et al*. reported decreases in body weight and the level of chemokin that causes bronchial inflammation in asthmatic individuals after following a diet program.[33] In this study, the change in body weight and BMI and the change in DII showed a significant positive correlation. As the bodyweight decreased, the inflammatory score also decreased ($P < 0.05$).

As markers of abdominal obesity, WC and WHR, also cause an inflammation.[34] In the studies, an increase in the WC of asthmatic individuals was positively correlated with an increase in high-sensitivity-CRP levels ($P < 0.05$).[16,31] In this study, the changes in WC and WHR were found to be positively correlated with the DII score change.

This study has some limitations. The effects of diet on inflammatory cytokines could not be observed due to the lack of blood findings. Much more women than men were included in the study; however, the gender difference in asthma prevalence is a global consequence. Because after puberty, with the effect of hormones, asthma is more common in women than in men.[3]

The total sample size is small, but this is an inevitable result due to the long dietary follow-up period of the study. In other studies, examining the relationship between asthma and weight loss, the sample size was also found to be similar to our study.[14,35]

Despite these limitations, this study also has its strengths. First, it is a randomized trial. Second, the comparisons made between DII and the characteristics of asthma shed some light on the relationship between asthma and nutrition. Third, this study also included high-quality anthropometric measurements, in addition to pulmonary functions and ACT scores.

Conclusions

Weight loss through diet intervention and decrease in the inflammatory load of diet increase pulmonary function and improve asthma control.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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