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RESEARCH ARTICLE

Association between dietary patterns and body composition in normal-weight subjects with metabolic syndrome

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Abstract

Background and aims The development of metabolic syndrome (MetS) has been proposed to be related to dietary pattern and body compostion indexes. Diet is one of the most important lifestyle-related factors which may regulate the inflammatory process. Numerous individual foods and dietary patterns can have a valuable health effect that is associated with their anti-inflammatory properties. Here we aimed to investigate the association between body composition indexes and dietary patterns in individuals with metabolic syndrome who were nnormal for weight.

Methods and materials Normal weight subjects with MetS were recruited as part of Survey of Ultraviolet Intake by Nutritional Approach (SUVINA). A validated food frequency questionnaire (FFQ) was used to determine dietary patterns that were: low-, or high in antioxidant; dietary inflammation index (DII) and health eating index (HEI) were also determined. Body composition indexes including basal metabolic rate (BMR), body free fat mass (BFFM), body fat mass (BFM), body fat percentage (BFP), trunk fat and total body water (TBW) were measured using a InBody body composition analyser. A P value <0.05 was considered significant.

Results A total 77 individuals including 29 males and 48 females were recruited into the study. A high-antioxidant dietary pattern was significantly correlated with BMR ($p=0.002$), BFFM ($p=0.007$) and TBW ($p=0.002$). There was no significant relationship between body compostion with a low-antioxidant dietary pattern, DII and HEI. After adjusting for age and sex, our findings showed that a high-antioxidant dietary pattern were independently associated with BMR, BFFM and TBW.

Conclusion A high-antioxidant dietary pattern was independently associated with decreased BMR, BFFM and TBW, while no association was found between body composition indexes and DII and HEI in normal weight paticipants with MetS.

Keywords Metabolic syndrome · Body composition · High-antioxidant pattern · Low-antioxidant pattern · Dietary inflammatory index · Healthy eating index

Introduction

Metabolic syndrome (MetS) is a multi-factorial disorder characterised by abdominal obesity, insulin resistance, dysglycemia, hypertension, and dyslipidemia [1, 2]. MetS is commonly seen in obese individuals. However, features of MetS can also be identified in normal-weight individuals, who are referred to as metabolically obese but normal weight (MONW) individuals [3]. The prevalence of MONW varies from 5% - 59% in different populations based on the age, gender, ethnicity, geographic location, and the criteria used for the MONW diagnosis [3, 4]. The dietary inflammatory index (DII) has been designed to quantify the potential inflammatory properties [5] and the relationships between DII and MetS and cardiovascular disease (CVD) have been studied in several countries [6]. Besides the DII, the other indices used to show diet quality and effectiveness are the Healthy Eating Index (HEI), in which demonstrates diets with high HEI scores are associated with higher public health status [7].

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Anthropometrical parameters such as fat mass, waist circumference, abdominal diameter, and corporal weight can be indicators of nutritional status, and changes in these parameters have been shown to improve overall health in MetS patients [8–10]. Body composition is a commonly used method to evaluate body fat percentage (BFP), body fat mass (BFM), body free fat mass (BFFM) trunk fat, total body water (TBW), basal metabolic rate (BMR) [11, 12]. It has been shown that multidisciplinary interventions resulted in greater changes in body composition in patients with MetS. These changes were especially obtained by the combinations of dietary interventions and physical exercise [8].

Several studies have shown dietary patterns to significantly impact MetS development, especially in individuals with MONW. However, dietary patterns to prevent and treat MetS remain undetermined beyond weight and total calorie control [2]. Dietary patterns describe the overall diet and recognize the combination of foods and nutrients consumed together, making it a superior method compared to examining foods and nutrients individually. Principal components analysis (PCA) is a method for assessing dietary patterns by analyzing the correlation between foods and giving scores to evaluate different dietary patterns, to differentiate individuals with high and low intakes [13, 14]. Two meta-analyses of dietary pattern analysis reported that a healthy (prudent) dietary pattern is negativley associated with MetS, whereas an unhealthy (western) is associated with an elevatd risk for MetS [2, 15]. Although dietary patterns have been shown to affect MetS development and influence the overall health in these individuals, the relation between dietary patterns and metabolic indexes in MONW individuals is not fully investigated. This cross-sectional study aimed to explore the association between dietary patterns and body composition indexes in normal-weight individuals with metabolic syndrome.

Method and materials

Study design and study population

This present cross-sectional study was performed as part of the Survey of Ultraviolet Intake by Nutritional Approach (SUVINA study) [16]. Among screening data of SUVINA study, We enrolled 77 participants between 30 and 50 years old (women 48, men 29). These individuals were recruited from staff and students at Mashhad University of Medical Science, who attended the Ghaem Hospital. We include participants with a reported energy intake <4200 kcal/d and > 800 kcal /d, and those who completed a FFQ (food frequency questionnaire) [17]. Participant with previous special diet, like vegan, smoking or drinking alcohol, participants with history of abnormal waist circumference were included from our study.

We informed all of our study cases about the methods and goals of our analytical study. Then they completed a written consent form to confirm their willingness for participating. Our study was approved by the Research Ethics Committee of the Iran National Institute for Medical Research Development (NIMAD) approved written consent. (Protocol ID: IR.NIMAD.REC.1396.027).

Data collection

We collected all demographic data of individuals by using a questionnaire at baseline by health care professionals and a nurse interview. The applied FFQ, validated by 5 dietitian experts of Mashhad University of Medical Science which consists 65 different dietary items [17]. We determined height, and weight of participants using standard approaches (Cm and Kg respectively) and by using standard tapes and scales. The BMI (body mass index) was computed using height^2/weight formula. The hip circumference (HC) and waist circumference (WC) were measured by flexible scales.

Blood samples of all participants were collected in plain Vacutainer tubes after 12-hours of overnight fasting. They were then centrifuged at 5000 g for 15 min at 4 °C to separate the serum, and aliquots of serum were kept frozen at −80 °C for future analysis. We determined Basal metabolic rate (BMR), Fat free mass (FFM), body free fat mass (BFFM), body fat percentage (BFP), trunk fat and total body water (TBW) using an InBody body composition analyser All of this approaches were validated by experts.

Assessment of dietary patterns

We used factor analysis to assess dietary patterns based on 22 food groups. We orthogonally rotated factors. The screening test and interpretability of each component with an eigenvalue>1, were assessed in determining the factor retains. The factor outcomes were evaluated for each pattern by adding consumption of the food groups. Based on the 3 specified dietary patterns an individuals score was computed.

Statistical analysis

We used mean + SD (standard deviation) for quantitative variables and frequency and percentage for discrete data. The Shapiro-Wilk and Kolmogorov Smirnov test is performed to determine the normality of the distribution of variables. We used 16th version of SPSS (statistical package for social science) for analyzing the data from validated answers of questionnaire. We present T-test for

normalized data and Mann Whitney U for non parametric data. We performed a Fisher or Chi-square test for categorical data. The correlations between FFQ and anti-oxidant patterns, DII and HEI are presented as a graph with the Pearson correlation and they are also shown in the Tables. We considered P value less than 0.05 as significant.

Results

The study included 77 young adults: 48 (62.3%) women and 29 (37.7%) men (mean age 43.81 ± 8.36 years). Based on the BMI classification, all of the subjects were of normal weight subject with MetS Table 1.

Antropometric measurements categorised according to tertiles of high-antioxidant pattern, low-antioxidant pattern, DII and HEI in normal weight participants with metabolic syndrome are shown in Table 2.

Correlation analysis indicated that only high-antioxidant pattern was negatively correlated with BMR (r = −0.397, $p = 0.002$), FFM (r = −0.346, $p = 0.007$) and TBW (r = −0.391, $p = 0.002$), while others were not significantly correlated with high-antioxidant pattern. Moreover, low-antioxidant dietary pattern, DII and HEI were not correlated with body composition (Table 3).

Linear regression analysis adjusted for age and sex has been shown that BMR, FFM and TBW was independently associated with high-antioxidant pattern (indicated in Table 4). In a way that by 116.22 unit decrease in high-antioxidant pattern, BMR increases 1 unit. Moreover, by 4.64 unit decreae in high-antioxidant pattern, FFM increases 1 unit. And by 3.20 unit decrease in high-antioxidant pattern, TBW incearses 1 unit.

Discussion

This study was designed to determine the possible associations between dietary patterns and body composition in normal weight subjects with MetS applying cross-sectional and prospective models. A dietary pattern, defined by higher frequency of consumption of antioxidant vitamins and minerals ('high antioxidant') was associated with decreased BMR and BFFM compared with a dietary pattern poor in antioxidant vitamins and minerals ('low antioxidant'). In contrast, no significant association was observed for DII and body composition, recommending that an inflammatory dietary pattern may not play a notable role in body composition of normal weight subjects with MetS.

Table 1 Baseline characteristics of the study poulation

Age (y)		43.83 ± 8.37
Weight (Kg)		72.57 ± 7.83
Waist circumference (cm)		92.41 ± 7.15
Hip circumference (cm)		102.88 ± 4.62
BMI (Kg/m^2)		22.06 ± 1.80
Sex (n%)	Male	29 (37.7%)
	Female	48 (62.3%)

Metabolic syndrome (MetS) is associated with central obesity and insulin resistance. The associations between DII and metabolic syndrome are inconsistent in cross-sectional studies [18]. No correlation between the DII and MetS was discovered in a study from Luxembourg, nor was a linking observed in a study from Spain [19, 20]. In the Luxembourg study, the DII was associated only with the dyslipidemic component of MetS [19].

It should be noted that both the Luxembourg and BCOPS studies (Metabolic Occupational Police Stress and Buffalo Employer Stress Study) were cross-sectional, while the study from Spain was prospective. In addition, pro-inflammatory diets were more associated with lowering HDL cholesterol and raising blood pressure and triglycerides [21]. However, caution is needed when comparing our results with these other studies, as the population characgteristics differ from country to country.

There is a poor correlation between dietary patterns and changes in adipose mass in mid-childhood [11]. In another study, a significant relationship was found between dietary patterns and total and central fat indices, but not BMI [22]. Although we did not find a significant association between DII and body composition in our study, others have. The study proposes that diet's inflammatory potential, measured using the DII, is associated with obesity-related parameters such as BFFM and weight [23]. The relationship between the dietary pattern and DII with BMR, BFM, BFFM and the percent fat have not previously been investigated [18]. By considering these measurements, in addition to traditional parameters such as weight and BMI, we have provided more accurate information about obesity-related traits by distinguishing adipose tissue from body lean mass. Furthermore, this inconsistency may be due to different subgroup of MetS which were normal weight in the current study.

Body composition is related to various physiological and pathological states.

Previous studies using BMI to estimate total body weight have not been an ideal predictor of the risk of atherosclerosis [24, 25]. An obese individual might have a normal metabolic profile with no additional signs of cardiovascular disease, whereas an only moderately overweight person may have severe cardiovascular disease with various comorbidities [26].

Analysis of body composition, different in terms of quantity and location of adipose tissue, has shown that

Table 2 Descreptive data on antropometric measurements according to high-antioxidant pattern, Low-antioxidant, HEI and DII tertiles in normal weight subjects with MetS

High-antioxidant pattern tertiles			
	Ter 1 (<−0.45)	Ter 2 [−0.45_-0.13]	Ter 3 (>0.13)
Weight (Kg)	75.47 ± 11.97	75.29 ± 14.23	79.04 ± 12.27
Waist circumference (cm)	92.84 ± 8.33	94.02 ± 8.13	94.56 ± 8.84
Hip circumference (cm)	105.47 ± 8.4	104.63 ± 8.09	105.46 ± 7.74
BMI (Kg/m^2)	23.38 ± 3.35	23.2 ± 4.15	24.06 ± 2.98
BMR (kcal)	1722.47 ± 315	1532 ± 245	1394 ± 208
BFFM (Kg)	55.65 ± 13.25	44.79 ± 13.26	40.42 ± 12.96
BFM (Kg)	20.33 ± 8.11	24.11 ± 7.75	23.54 ± 4.77
BFP (%)	26.64 ± 8.17	31.62 ± 8.15	32.28 ± 2.51
Trunk fat (Kg)	13.62 ± 5.63	15.47 ± 6.59	14.39 ± 1.1
TBW (L)	42.83 ± 8.37	38.08 ± 7.04	33.86 ± 1.45
Low-antioxidant pattern tertiles			
	Ter 1 (<−0.53)	Ter 2 [−0.53_-0.16]	Ter 3 (>0.16)
Weight (Kg)	76.66 ± 13.09	73.32 ± 11.2	78.1 ± 13.44
Waist circumference (cm)	92.48 ± 8.24	90.68 ± 8.34	96.17 ± 7.88
Hip circumference (cm)	106.48 ± 8.4	104.06 ± 8.16	105.1 ± 7.8
BMI (Kg/m^2)	23.99 ± 4.01	22.7 ± 3.1	23.73 ± 3.45
BMR (kcal)	1575.19 ± 249	1628.42 ± 290	1480.92 ± 302
BFFM (Kg)	51.53 ± 11.06	51.44 ± 15.21	40.54 ± 13.63
BFM (Kg)	21.49 ± 5.39	24.65 ± 8.19	22.3 ± 7.488
BFP (%)	29.09 ± 7.02	31.26 ± 9.99	30.11 ± 9.41
Trunk fat (Kg)	12.38 ± 3.63	13.97 ± 4.82	16.47 ± 6.95
TBW (L)	38.81 ± 6.92	40.07 ± 8.09	36.80 ± 8.43
DII tertiles			
	Ter 1 (<−0.25)	Ter 2 [−0.25_1]	Ter 3 (>1)
Weight (Kg)	76.91 ± 11.58	76.46 ± 12.89	74.35 ± 11.73
Waist circumference (cm)	94.28 ± 7.98	93.93 ± 7.99	92.1 ± 8.15
Hip circumference (cm)	106.2 ± 7.04	104.55 ± 8.31	105.32 ± 7.39
BMI (Kg/m^2)	23.64 ± 2.98	23.41 ± 3.44	22.79 ± 3.26
BMR (kcal)	1529.56 ± 226	1563.33 ± 324	1521.93 ± 269
BFFM (Kg)	47.59 ± 13.15	47.91 ± 15.77	46.08 ± 13.24
BFM (Kg)	23.17 ± 4.90	21.76 ± 6.13	25.82 ± 8.18
BFP (%)	31.22 ± 6.85	28.61 ± 9.95	33.55 ± 7.24
Trunk fat (Kg)	13.44 ± 4.78	14.16 ± 5.10	14.79 ± 5.31
TBW (L)	37.82 ± 6.56	38.57 ± 8.59	37.09 ± 7.34
HEI tertiles			
	Ter 1 (<62)	Ter 2 [62–68]	Ter 3 (>68)
Weight (Kg)	80.24 ± 13.08	77.81 ± 12.57	71.54 ± 9.15
Waist circumference (cm)	95.06 ± 8.91	94.32 ± 8.37	91.79 ± 6.82
Hip circumference (cm)	107.07 ± 6.19	105.2 ± 8.1	104.5 ± 7.8
BMI (Kg/m^2)	24.25 ± 3.16	23.53 ± 3.53	22.49 ± 2.76
BMR (kcal)	1575.52 ± 333	1589.56 ± 273	1475.86 ± 229
BFFM (Kg)	49.57 ± 14.82	48.06 ± 14.440	44.58 ± 13.70
BFM (Kg)	23.76 ± 7.46	21.70 ± 5.64	23.78 ± 6.29
BFP (%)	31.25 ± 8.37	28.89 ± 7.24	31.27 ± 9.99
Trunk fat (Kg)	14.26 ± 4.37	14.47 ± 6.15	13.73 ± 4.87
TBW (L)	38.54 ± 8.79	39.47 ± 7.34	36.28 ± 6.65

BMR basal metabolic rate, *BFFM* body free fat mass, *BFM* body fat mass, *BFP* body fat percentage, *TBW* total body water, *DII* dietary inflammatory index, *HEI* healthy eating index

Table 3 Correlations between low and high antioxidant pattern, DII and HEI with body composition

		BMR (Kcal)	BFFM (Kg)	BFM (Kg)	BFP (%)	Trunk fat (Kg)	TBW (L)
Low-antioxidant pattern	*r*	−0.040	−0.031	−0.069	−0.028	0.009	−0.026
	P value	0.765	0.816	0.605	0.836	0.944	0.843
High-antioxidant pattern	*r*	−0.397	−0.346	0.127	0.163	−0.019	−0.391
	P value	**0.002**	**0.007**	0.338	0.219	0.884	**0.002**
DII	*r*	−0.007	−0.024	0.134	0.088	0.118	−0.033
	P value	0.956	0.858	0.316	0.512	0.377	0.806
HEI	*r*	−0.161	−0.143	−0.090	−0.024	−0.091	−0.135
	P value	0.228	0.284	0.502	0.858	0.495	0.313

BMR basal metabolic rate, *BFFM* body free fat mass, *BFM* body fat mass, *BFP* body fat percentage, *TBW* total body water, *DII* dietary inflammatory index, *HEI* healthy eating index

Bold numbers show significant differences

Table 4 Linear regression between high-antioxidant pattern as an independent parameter and body composition in normal weight subjects with MetS (data adjusted by age and sex)

Metabolic syndrome +	B	p value
BMR (kcal)	−116.22	**0.005**
BFFM (Kg)	−4.646	**0.027**
BFM (Kg)	0.73	0.510
BFP (%)	1.086	0.380
Trunk fat (Kg)	−0.609	0.470
TBW (L)	−3.205	**0.005**

BMR basal metabolic rate, *BFFM* body free fat mass, *BFM* body fat mass, *BFP* body fat percentage, *TBW* total body water

Bold numbers show significant differences

abdominal fat is a more accurate predictor of the risk of atherosclerosis than total weight [27–30]. This finding is unsurprising because abdominal adipose mass is a metabolically active tissue that is capable of secreting hormones that influence serum lipid concentrations, glucose and insulin regulation, inflammatory pathways, and endothelial function [27–29].

In response to acute or chronic calorie restriction, reduced BMR is a well-established physiological adaptation. When the decrease in BMR is greater than can be accounted for by changes in body composition, it is called metabolic economy [31]. BMR is the basic requirement for energy supply to all respiratory tissues at rest, which is a repeatable and valid measure of energy production and closely parallels measures of mitochondrial function [32]. It is largely determined by the metabolic requirement of the organ tissue mass, including the liver, brain, heart, etc. [33]. A previous study suggests that there is an energy cost associated with the factors that comprise MetS [34].

Conclusion

Our results show the correlation between dietary patterns and body composition changes in normal weight subjects with MetS applying cross-sectional and prospective models. A high antioxidant dietary pattern was independently associated with a lower BMR and BFFM compared with a low antioxidant dietary pattern. In contrast, no significant association was observed for DII and body composition, recommending that an inflammatory dietary pattern may not play a important function in body composition of normal weight subjects with MetS.

Declarations

Conflict of interest The authors have no conflict of interest to disclose.

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