Progress in Nutrition 2019; Vol. 21, Supplement 1: 201-209 DOI: 10.23751/pn.v21i1-S.5935

Adherence to dietary approaches to stop hypertension diet may modify fat mass and fat free mass indexes in apparently healthy adults

Mohammad Hossein Rahimi[1], *Farzad Mohammadi*[1], *Mehdi Mollahosesini*[1], *Mir Saeed Yekaninejad*[2], *Zhila Maghbooli*[3], *Khadijeh Mirzaei*[1]

[1]Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences (TUMS), Tehran, Iran – E-mail: mirzaei_kh@tums.ac.ir; [2]Department of Epidemiology and Biostatistics, Tehran University of Medical Sciences School of Medicine, Tehran, Iran; [3]Osteoporosis Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran - E-mail: zhilamaghbooli@yahoo.com

Summary. *Background:* The anatomic site of increased body fat is important because of its effects on the body. DASH diet have positive effects on body composition through its effects on weight. Our objective of this investigation was to assay the effects of adherence to DASH diet on body fat distribution. *Methods:* A total of 256 healthy participants were included in the current cross-sectional study. Complete body composition analysis was done whereby for all the cases. BC-418MA (Tanita UK Ltd, Middlesex, United Kingdom) was used. Dietary intake was assessed with a semi-quantitative food frequency questionnaire that consisted of 147 foods and beverages (with standard serving sizes commonly consumed by Iranians. We constructed the DASH score based on 8 foods and nutrients. FM and FFM indexes defined based on fat mass and free fat mass. *Results:* Obese individuals with more adherence to DASH diet had lower FFMI (P=0.04). Lowe trunk fat was strongly associated to more adherence to DASH diet (P=0.02). Moreover, individuals those had more adherence to DASH diet had lower waist circumference (P=0.03). *Conclusions:* The current study suggests that adherence to DASH diet is highly associated with weight loss in obese individuals and may be associated to FMI and FFMI which is depended to sex.

Key words: DASH diet, fat distribution, Fat Mass Index, Fat Free Mass Index

Introduction

The anatomic site of increased body fat is important because of its effects on the body (1). Bioelectrical Impedance Analysis (BIA) is a valid and reliable measurement to estimate body composition (2). Body fat is normally distributed viscerally, internally (mostly in the liver) and subcutaneously and its distribution is individually specific (3, 4), also the endocrine functions of fat cells are depended to their anatomical sites (5). High waist circumference is suggested as a risk factor for metabolic disorders independent of (body mass index) BMI. Abdominal adiposity also is well known as a risk factor for hypertension, coronary heart disease, metabolic syndrome and stroke (6). Moreover, accumulated fat in the liver promotes tumor cells proliferation and associated with insulin resistance (5). Fat distribution is well known as a cardiovascular risk factor in adults. Furthermore, to determine the relationship between body composition and its related diseases, fat free mass (7) and fat mass (7) proposed for a more detailed anthropometric measurement (8). According to previous studies body fat mass is regarded as an important risk factor for coronary events, coronary artery disease mortality and ischemic stroke (9, 10) and low fat free mass is associated with muscular weakness (11) and higher mortality (12).

Findings from previous surveys suggest that diet quality may affect FM and FFM (13). The effects of dietary components and dietary patterns on body composition have investigated by several studies. Diet influence on abdominal fat and also total body fat loss have been shown in previous studies (13). A lower total FM in metabolically harmful adipose storage was found in low carbohydrate diet consumption groups (14). The association between Mediterranean diet and lower total and regional fat was found in a cross-sectional study (15). DASH diet is regarded as a diet which is rich in vegetables, fruits and low-fat foods (16, 17) and its positive effect on weight loss have been shown in previous investigations (18).

Objective: Our objective of this study was to investigate the effects of adherence to DASH diet on FFM, FM and body fat distribution.

Method

Participant

The original cross-sectional study was design to investigate association between adherence to DASH diet and body fat distribution and conducted from July 2015 to June 2016. 265 healthy individuals were selected trough convenience random sampling method from invited, apparently healthy persons to Shariati hospital. We excluded participants if they consumed specific body fat affecting drug. Also, they excluded if they were consumed special diet. Written informed consent was completed by all participants. Body composition factors were defined according Joint Scientific Statement. This study is approved by ethics committee (Ethic Number: 93-04-161-277 22-149580) of Tehran University of medical sciences.

Body composition measurement

Complete body composition analysis was done whereby for all the cases, BC-418MA (Tanita UK Ltd, Middlesex, United Kingdom) was used. This equipment is designed to send out a very weak electric current to measure the impedance (electrical resistance) of the body. Therefore, in principle, subjects were barefoot when this device assessed them. Moreover, since impedance fluctuates in accordance with the distribution of the body fluid, we followed all of the following instructions for an accurate measurement. To prevent a possible discrepancy in measured values, we avoided taking measurements after vigorous exercise and waited until the subjects were rest sufficiently. To prevent inaccurately low body fat percentage measurements and other measurement errors, we always held both arms straight down when taking measurements. As changes in body-water distribution and body temperature can have a major impact on measurements, they were performed in the morning in a fasting condition (always urinating before taking measurements, etc.) to get a more accurate result of the measurements every single time. The device calculates the body fat percentage, fat mass and fat-free mass and predicts the muscle mass on the basis of data obtained by dual-energy X-ray absorptiometry using bioelectrical impedance analysis (19).

Dietary assessment

Dietary intake was evaluated with a semi-quantitative food frequency (FFQ) questionnaire that comprised of 147 foods and beverages (with standard serving sizes) usually consumed by Iranians. Respondents diet was based on their past year intake. Validity and reproducibility of this FFQ have been shown in previous studies (20). The frequency of each given serving consumption was reported by Respondents. The frequency of servings was categorized into nine categories: less than once a month, 1-3 times monthly, once a week, 2-4 times weekly, 5-6 times a week, once a day, 2-3 times daily, 3-5 times daily and 6 or more times daily. For each food item the portion size was classified into three categories: small, medium and large, and was converted to grams (21). Then to determine Intake of each food item in grams the portion size of the daily intake frequency was multiplied. For seasonal food consumption, the period of the year that these foods were available was considered. To estimated total energy intake, the energy value of each food was added in the FFQ. The Nutrients Composition of Iranian Foods (21) and the USDA Food Composition Data (22) were used to determine the value of food energy. The 147 food items were classified into 25 food groups regarding their similarity of nutrient content to identify dietary patterns (23).

Laboratory measurement

All baseline blood samples were collected between 8:00 and 10:00 am following an overnight fasting. Serum was centrifuged, aliquoted and stored at a temperature of -80 °C. All samples were analyzed by means of a single assay. All measurements were performed at the EMRC laboratory of Shariatei hospital. GOD/PAP method was used for the measurement of triglyceride, total cholesterol levels were measured by the Enzymatic Endpoint method, and direct high-density lipoprotein-cholesterol and low-density lipoprotein-cholesterol was measured using the enzymatic clearance assay. All measurements were done with the use of the Randox laboratories kit (Hitachi 902) (24).

Adherence to the DASH dietary pattern

The DASH score was constructed to determine participants adherence to DASH diet regarding foods and nutrients highlighted or minimized in this diet, emphasizing on eight components: high intake of vegetables, fruits, nuts and legumes, whole grains and low-fat dairy products, as well as low intakes of sweetened beverages, sodium and red and processed meats (25). A DASH score for each study participant was calculated. At first participants were categorized based on quartile categories of consuming the mentioned food items. For vegetables, fruits, nuts and legumes, whole grains and low-fat dairy products, the score of 1 was given to those in the first (lowest) dietary intake quartile and score of 4 was given to those in the fourth (highest) quartile. Scores of 2 and 3 were given to other quartiles (second and third). For sweetened beverages, sodium and red and processed meats the score of 4 was given for the lowest quartile of dietary and score of 1 was given for highest quartile. Those in the second and third quartiles were given the score of 3 and 2, respectively. Since dietary sodium intake cannot be calculated properly using a FFQ, the present scoring by means of quartiles can be least prone to misclassification compare with using quantitative classification. Finally to construct the overall adherence to the DASH diet score the scores were summed up by ranged from 8 to 32; higher DASH diet score shows more adherence to DASH diet (26).

Measurements and definition of anthropometric indexes

As shown in the following definition (27) the FM and FFM indexes are equal concepts for the BMI: FMI = $\frac{Fat\ Mass}{Height^2}\left(\frac{kg}{m^2}\right)$ and FFMI = $\frac{Fat\ free\ mass}{Height^2}\left(\frac{kg}{m^2}\right)$.

Body height (BH) and body weight (BW) were measured while the participants wore light underwear and no shoes. Then BMI expressed as: BMI = BW (kg)/BH (m). Moreover, hip circumference, was measured around the buttocks and waist circumference (in cm) and waist circumference was measured in the middle between the iliac crest twelfth and the rib (in cm).

Statistical analysis

For evaluation normal distribution of quantitative variables Kolmogorov–Smirnov test was conducted. To compare presence of participants' characteristics significance difference between tertiles of DASH diet score, one-way ANOVA was used and re-analysis by ANCOVA for adjusting by age, weight, sex and calorie, And also after the classification of BMI, the ANCOVA test was used to for age, weight, sex and calorie adjusted characteristics of study participants according DASH diet score. The binary logistic regression model analysis was used to find the relationship between DASH diet and body composition. All statistical analysis was performed using SPSS 16 for Windows. The values were expressed as mean ± standard deviation. Statistical significance was defied as P<.05 for all tests

Results

Characteristics of study participants across tertiles of DASH diet score:

General characteristics of the participants through tertiles of DASH diet score are shown in Table1. The participants had a mean height of 167.55 (± 13.67) cm, weight of 73.51 (± 15.66) kg and BMI value of 25.93 (± 4.89) kg/m^2. As presented in the Table1 participants in the highest tertile for DASH diet score had lower TG compared with those in lower tertile (P= 0.07), although this difference was slightly statically but didn't change after adjusting for age, weight, sex and calorie. Moreover, after adjusting for weight, sex and calorie intake, we observed that participants with the highest DASH score were older than who were in lower tertile (P-value

Table1. Age, weight, sex and calorie adjusted characteristics of study participants across tertiles of DASH diet score

	Tertiles of DASH diet score					
	T1 (lowest)	**T2**	**T3 (highest)**	**Total**	**P**	**P¶**
Age (years)	33.69 ± 8.51	35.28 ± 8.65	35.99 ± 9.30	35.8 ± 8.78	0.21	0.03*
Height (cm)	169.51 ± 9.96	167.94 ± 8.88	167.42 ± 9.58	167.55 ± 13.96	0.32	0.055
Weight (kg)	74.99 ± 18.37	73.95 ± 15.14	70.99 ± 12.78	73.51 ± 15.66	0.24	0.24**
BMI (Kg/m^2)	25.99 ± 5.36	26.18 ± 4.97	25.32 ± 4.04	25.93 ± 4.89	0.50	0.12
TG (mmol/l)	139.12 ± 109.70	126.88 ± 90.09	106.91 ± 62.78	126.04 ± 96.01	0.07	0.07
Tchol (mmol/l)	184.17 ± 46.91	185.80 ± 33.81	181.98 ± 34.34	184.58 ± 40.33	0.82	0.53
HDL-C (mg/dl)	48.60 ± 12.63	47.64 ± 11.17	49.93 ± 11.12	48.78 ± 11.68	0.45	0.45
LDL-C (mg/dl)	100.91 ± 32.60	102.42 ± 21.56	99.30 ± 23.42	101.28 ± 27.22	0.75	0.66
FFM	56.20 ± 13.35	54.21 ± 11.68	52.04 ± 10.89	54.15 ± 11.97	0.10	0.69
FM	18.26 ± 9.03	19.03 ± 8.51	19.62 ± 8.05	18.97 ± 8.53	0.60	0.69
Trunk fat	28.79 ± 5.62	28.49 ± 5.63	27.09 ± 5.06	28.18 ± 5.45	0.18	0.83
Visceral fat	5.53 ± 3.40	5.57 ± 3.59	5.23 ± 3.08	5.52 ± 3.40	0.79	0.14
Waist (cm)	88.76 ± 13.38	90.63 ± 12.31	86.05 ± 11.32	88.80 ± 12.50	0.66	0.19

*P: P value, BMI body mass index, TG triglyceride, Tchol total cholesterol, HDL-C high-density lipoprotein cholesterol, LDL-C low-density, FFM fat free mass, FM fat mass; ¶ After adjustment for age, weight, sex and calorie; * After adjustment for weight, sex and calorie; ** After adjustment for age, sex and calorie.*

= 0.03). No significant difference was observed in mean weight, BMI, FFM. FM and waist circumference.

Dietary intakes of study participants across tertiles of DASH diet score

Table2 demonstrate dietary intakes of study participants across tertiles of DASH diet score. There was no significant different for macronutrients, polyunsaturated fatty acid (PUFA) and mono unsaturated fatty acid (MUFA) among tertiles for DASH diet score while participants in higher tertiles for DASH diet intakes more vitamin D, fiber and Folate. To adjusting effect of intake amount, dietary intake adjusted. After adjustment for energy intake, individuals who had most adherence to DASH diet were intake significantly more macronutrients, PUFA, MUFA, vitamin D and Folate. There were no significant different for cholesterol and energy intake before and after adjustment.

Table 2. Dietary intakes of study participants across tertiles of DASH diet score

	Tertiles of DASH diet score				
	T1 (lowest)	**T2**	**T3 (highest)**	**P**	**P***
Total energy intake (kcal)	2216.05	2175.73	2242.43	0.77	0.48
Protein (g/d)	79.83	80.75	85.64	0.25	0.05
Fat (g/d)	71.92	70.26	67.88	0.57	<0.01
Carbohydrate (g/d)	322.55	315.93	333.80	0.42	0.04
Fiber (g/day)	40.90	43.01	47.55	0.04	<0.01
Chol (mg/d)	238.05	230.44	235.12	0.87	0.9
MUFA (g/d)	23.60	22.55	21.25	0.16	<0.01
PUFA (g/d)	13.94	13.70	12.81	0.30	<0.01
Vitamin D (μ/d)	1.47	1.83	1.96	0.02	0.03
Folate (m/d)	504.91	527.37	597.15	<0.01	<0.01

*P: P value, Chol Cholesterol, MUFA Mono Unsaturated Fatty Acid, PUFA Poly Unsaturated Fatty Acid *: After adjustment for energy intake*

Characteristics of participants according DASH diet score among BMI groups

As shown in Table3, 4 and 5 we classified participant according their BMI rates, which involved normal weight, overweight and obese. The scores for tertiles of adherence to DASH diet are presented for body composition factors in each BMI group. In normal weight group (table3) before adjustment people with higher DASH score had marginally higher BMI (P= 0.07), but after adjusting for age, weight, sex and calorie intake, no significant difference was found (P=0.67). Although there was not any significant changes in FFM level, but significant higher levels of FM was observed in participants with higher DASH score before adjustment (P=0.01), but not after adjustment (P=0.95). Despite all these, there was no change in body weight in the normal weight group before and after adjusting. Change in waist was significant after adjusting (P=.03) which was not seen before adjusting (P=0.18). Adherence to DASH diet in obese participant had more ef-

Table 3. Age, weight, sex and calorie intake adjusted characteristics of study participants According DASH diet score among BMI groups for normal weight.

	Tertiles of DASH score				
	T1 (lowest)	**T2**	**T3 (highest)**	**P**	**P¶**
Weight (kg)	61.12 ± 9.52	62.54 ± 8.19	61.23 ± 8.70	0.73	0.16*
BMI (Kg/m^2)	21.03 ± 2.31	22.03 ± 1.80	21.96 ± 2.06	0.07	0.67
TG (mmol/l)	98.31 ± 62.03	107.30± 105.18	87.61 ± 55.17	0.55	0.40
Tchol (mmol/l)	173.22 ± 30.34	177.17 ± 33.70	177.63 ± 41.21	0.84	0.70
FFM	50.35 ± 10.05	49.49 ± 9.72	48.14 ± 9.24	0.64	0.95
FM	10.85 ± 4.96	13.04 ± 4.88	14.16 ± 4.45	0.01	0.95
FFMI	17.27 ± 1.98	17.32 ± 2.05	17.11 ± 1.89	0.90	0.40
FMI	3.86 ± 1.93	4.71 ± 1.95	5.15 ± 1.75	0.02	0.94
Trunk fat	26.80 ± 4.19	26.04 ± 4.74	25.08 ± 3.90	0.39	0.78
Visceral fat	2.70 ± 2.08	2.90 ± 1.66	3.06 ± 1.91	0.74	0.69
Waist (cm)	78.89 ± 9.32	81.11 ± 6.00	77.75 ± 8.33	0.18	0.03

*P: P value, BMI body mass index, TG triglyceride, Tchol total cholesterol, FFM fat free mass, and FM fat mass; FFMI: fat free mass index, FMI: fat mass index; * After adjustment for age, sex and calorie; ¶ After adjustment for age, weight, sex and calorie.*

Table 4. Age, weight, sex and calorie intake adjusted characteristics of study participants According DASH diet score among BMI groups for overweight

	T1 (lowest)	**T2**	**T3 (highest)**	**P**	**P¶**
Weight (kg)	77.72 ± 9.80	77.31 ± 8.83	77.73 ± 9.08	0.98	0.06*
BMI (Kg/m^2)	27.46 ± 1.31	27.17 ± 1.23	27.03 ± 1.04	0.32	**<0.01**
TG (mmol/l)	153.19 ± 120.64	120.50 ± 44.98	119.71 ± 71.79	0.23	0.13
Tchol (mmol/l)	194.52 ± 58.44	183.75 ± 29.61	188.96 ± 25.25	0.62	0.26
FFM	57.15 ± 11.94	55.89 ± 10.35	56.1 ± 11.96	0.89	0.46
FM	20.57 ± 5.41	21.41 ± 5.54	21.60 ± 4.83	0.70	0.45
FFMI	20.07 ± 2.41	19.55 ± 2.14	19.32 ± 1.98	0.37	0.22
FMI	7.43 ± 2.30	7.62 ± 2.18	7.69 ± 2.21	0.88	0.21
Trunk fat	29.27 ± 5.87	29.24 ± 4.84	28.88 ± 5.92	0.96	0.89
Visceral fat	6.45 ± 1.93	6.62 ± 2.28	6.50 ± 2.37	0.95	0.22
Waist (cm)	91.43 ± 7.34	92.25 ± 7.73	91.59 ± 7.93	0.91	0.83

*P: P value, BMI body mass index, TG triglyceride, Tchol total cholesterol, FFM fat free mass, and FM fat mass; FFMI: fat free mass index, FMI: fat mass index; *After adjustment for age, sex and calorie; ¶ After adjustment for age, weight, sex and calorie.*

Table 5. Age, weight, sex and calorie intake adjusted characteristics of study participants According DASH diet score among BMI groups for obese participants

	T1 (lowest))	T2	T3 (highest)	P	P¶
Weight (kg)	106.15 ± 19.82	91.79 ± 11.84	85.06 ± 6.87	**0.02**	**0.01***
BMI (Kg/m^2)	34.97 ± 5.81	33.30 ± 2.99	32.69 ± 1.39	0.33	0.17
TG (mmol/l)	211.25 ± 139.66	173.35 ± 90.15	145.50 ± 49.41	0.30	0.38
Tchol (mmol/l)	185.33 ± 38.03	199.50 ± 31.68	180.90 ± 35.36	0.31	0.99
FFM	71.78 ± 15.09	61.42 ± 12.87	52.53 ± 9.21	0.06	0.27
FM	32.02 ± 8.66	29.08 ± 7.33	32.53 ± 7.64	0.45	0.27
FFMI	23.40 ± 3.85	22.29 ± 2.56	20.11 ± 2.54	0.04	0.95
FMI	10.53 ± 2.79	10.90 ± 3.49	12.57 ± 3.02	0.30	0.13
Trunk fat	33.70 ± 5.88	32.50 ± 5.91	26.81 ± 4.17	**0.02**	0.57
Visceral fat	10.81 ± 2.82	10.00 ± 3.21	9.50 ± 1.58	0.54	0.77
Waist (cm)	111.60 ± 11.25	106.20 ± 8.12	98.30 ± 7.68	**0.07**	0.81

*P: P value, BMI body mass index, TG triglyceride, Tchol total cholesterol, FFM fat free mass, and FM fat mass; FFMI: fat free mass index, FMI: fat mass index; * After adjustment for age, sex and calorie; ¶ After adjustment for age, weight, sex and calorie*

fects on their body composition compare with normal weight and overweight (table4) individuals (28). A noticeable lower body weight was found in obese individuals (table5) who were most adherents to DASH diet (P= 0.02 before and 0.01 after adjustment for age, sex and calorie, respectively) while, there was no significant change in their BMI. Obese participants in highest tertile for DASH diet score had lower FFM (P=0.06) which was not significant after adjustment (P=0.27). There was no significant change in FM before and after adjustment. Results also showed no significant difference in FMI while participants in highest tertile had lower FFMI compare with those in lowest tertile (P= 0.04 before adjustment. Lower trunk fat (P = 0.02 and waist circumference (P=0.07 was observed in participants who were in highest tertile for DASH score which were not significant after adjustment (P-value was 0.57 and 0.81 respectively.

Association of adherence to DASH diet and body composition indexes through Adjusted Model

Results from Table6 shows that adherence to DASH diet score and its relation to body composition indexes through binary logistic regression model, which involves crude model and model 1 (adjusted for age and energy intake). As shown in table, before and after adjustment for age and calorie intake male participants in second tertile had higher FFMI compare to first tertile which regarded as reference, although this difference is marginally significant before adjustment (OR:3.25; 95% CI: 0.83-12.48) and after adjustment (OR:4.39; 95% CI: 0.98-19.53), but it is noticeable. Also marginally increasing trend for FFMI was observed in males after adjustment which demonstrated positive relation between DASH diet adherence and body free fat mass. Moreover, no significant difference was found for FMI in different groups before and after adjustment.

Discussion

Significant lower trunk fat was found in obese participants with most adherence to DASH diet. Slightly and significant lower waist circumference was observed in obese and normal individuals, respectively. Noticeable lower body weight was observed in obese participants with most adherence to DASH diet before and after adjusting for potential confounders.

DASH diet, a healthy diet high in vegetables, fruits, low-fat dairy products and nuts (29) is a beneficial diet not only in decrease hypertension (30) but also is suggested to have some other beneficial effect including reducing risk of cardiovascular disease (25), insulin resistance (31) and cancer (32). The current study demonstrated a relation between adherence to DASH diet and body fat. Results showed that this relation was strong in obese individuals; moreover, it had

Table 6. Association of adherence to DASH diet and body composition indexes through Adjusted Model

			Crude model				Model 1[¶]			
			OR	**95% CI**	**P**	**Pt**	**OR**	**95% CI**	**P**	**Pt***
FFMI	*Male*	T1	1			0.10	1			**0.06**
		T2	3.25	0.83-12.48	**0.08**		4.39	0.98-19.53	**0.051**	
		T3	2.68	0.67-10.79	0.16		3.48	0.78-15.43	0.10	
	Female	T1	1			0.65	1			0.93
		T2	0.78	0.28-2.17	0.63		0.93	0.31-2.77	0.89	
		T3	1.00	0.38-2.60	0.99		1.27	0.45-3.52	0.64	
FMI	*Male*	T1	1			0.98	1			0.94
		T2	1.15	0.35-3.79	0.80		1.22	0.34-4.32	0.75	
		T3	1.85	0.57-6.04	0.30		2.14	0.62-7.33	0.22	
	Female	T1	1			0.46	1			0.66
		T2	0.66	0.23-1.89	0.44		0.75	0.25-2.27	0.62	
		T3	1.00	0.38-2.60	0.99		1.17	0.43-3.16	0.75	
		T2	1.28	0.46-3.57	0.63		1.41	0.46-4.26	0.54	
		T3	1.41	0.53-3.76	0.48		1.80	0.62-5.22	0.27	

** P: P value, Pt: P–value for trend trough Binary Logistic Regression Model; FFMI: fat free mass index, FMI: fat mass index, ¶ Adjusted for age and energy intake*

slight association with body fat in normal and overweight individuals. Higher fat mass in most adherence individuals to DASH diet was not expected regarding previous studies which have shown adherence to DASH diet reduce lipid and body weight (33, 34).

Our results showed that FM and FMI were strangely higher in participants who had most adherence to DASH diet in the normal weight group (this significant elevated level was not seen after adjusting for age, weight, sex and calorie). Because of emphasizing in the DASH diet on vegetable and fruit intake (35) it was expected to fat indexes such as FM and FMI be lower in individuals with most adherence to DASH diet. To clarify this paradox we divided participants according gender, then binary logistic regression was done to show association between adherence to DASH diet and FMI. Since any significant association was not found for both groups (male and female) we can justify higher body fat in most adherent individuals (in normal weight group) may related to higher body fat in females.

In line with previous studies (28, 35) current study demonstrated lower BMI in participants with most adherence to DASH diet in overweight group. In obese group DASH diet had inverse association with body weight, as people with most adherence to DASH diet had less body weight, this results are in agreement with Smith et al. (36) study. Increase in PUFA intake also can be another effects of DASH diet to lose weight, long chain n-3 PUFA in the diet are suggested to reduce obesity through restore endocannabinoid system (ESC) tone (37). Decrease in body weight can prevent vast range of disease including all-cause mortality, various cancers, coronary and cerebrovascular diseases, hypertension, type 2 diabetes mellitus, asthma and liver disease (38). Our findings suggesting that DASH diet can play an important role to reduce risk of these disease especially in obese population through reduce body weight. Regarding importance of fat distribution and its effects on body, such as its role in cardiovascular disease and blood pressure (39) we investigate the relation between DASH diet and body fat distribution. Results from current study showed reverse association between adherence to DASH diet and trunk fat and also waist circumference, as obese and overweight individuals who had most adherence to DASH diet had lower trunk fat and waist circumference. Our results showed higher vitamin D intake in this individuals, previous studies have suggested vitamin D deficiency may resulting to calcium accumulation in adipocyte cells which leading to adipogenesis (40). Therefore, our findings suggesting DASH diet to reduce risk of vast range of disease through handling body fat distribution in positive way. The low number of participants in low weight group was an important limitation in our study which made it impossible to do statically analysis to assessment the relation between DASH diet score and body fat distribution in this group. Because of study design we cannot declare mechanism behind reduced fat accumulation in special anatomic sites such as waist circumference. As far as our knowledge, the strength of this study is the first survey that study relation between adherence to DASH diet and body fat distribution.

In conclusion, the findings of current study suggest that adherence to DASH diet is highly associated with lower weight in obese individuals. Furthermore, lower waist circumference and body trunk fat may be associated with DASH diet consumption. Regarding the fact that because of its effects on metabolic disorders the anatomic site of increased body fat is important it seems DASH diet may be helpful in reduced metabolic disorders.

Acknowledgements

This research study was financially supported by Tehran University of Medical (ID grant: 93-04-161-27722) Sciences and Endocrinology and metabolism research center - osteoporosis research center - Tehran University of Medical Sciences. The authors declare that they have no conflicts of interest.

Authors Contribution

Study concept and design: Khadijeh Mirzaei; acquisition of data: Khadijeh Mirzaei, Mohammad Hossein Rahimi and Mehdi Mollahosesini; analysis and interpretation of data: Khadijeh Mirzaei and Mir Saeed Yekaninejad; drafting of the manuscript: Farzad Mohammadi, Mohammad Hossein Rahimi and Mehdi Mollahosesini; critical revision of the manuscript for important intellectual content: Khadijeh Mirzaei, Zhila Maghbooli and Farzad Mohammadi; statistical analysis: Khadijeh Mirzaei and Mir Saeed Yekaninejad; administrative, technical, and material support: Khadijeh Mirzaei; study supervisions: Khadijeh Mirzaei and Zhila Maghbooli.

References

1. Oliveira PMd, Silva FAd, Oliveira RMS, et al. (2016) Association between fat mass index and fat-free mass index values and cardiovascular risk in adolescents. Rev Paul Pediatr (English Edition);34 (1):30-7.
2. Clasey JL, Bradley KD, Bradley JW, et al. (2011) A new BIA equation estimating the body composition of young children. Obesity;19 (9):1813-7.
3. Palmer BF, Clegg DJ. (2015) The sexual dimorphism of obesity. Mol Cell Endocrino;402:113-9.
4. Vernon G, Baranova A, Younossi Z. (2011) Systematic review: the epidemiology and natural history of non-alcoholic fatty liver disease and non-alcoholic steatohepatitis in adults. Aliment Pharmacol Ther;34 (3):274-85.
5. Iwase T, Sangai T, Nagashima T, et al. (2016) Impact of body fat distribution on neoadjuvant chemotherapy outcomes in advanced breast cancer patients. Cancer Med;5 (1):41-8.
6. Lubkowska A, Radecka A, Bryczkowska I, et al. (2015) Serum Adiponectin and Leptin Concentrations in Relation to Body Fat Distribution, Hematological Indices and Lipid Profile in Humans. Int J Environ Res Public Health;12 (9):11528-48.
7. Hoffman L. (1982) Sodium valproate and thrombocytopenia. Canadian Medical Association Journal;126 (4):358.
8. de Oliveira PM, da Silva FA, Oliveira RMS, et al. (2015) Association between fat mass index and fat-free mass index values and cardiovascular risk in adolescents. Revista Paulista de Pediatria (English Edition).
9. Calling S, Hedblad B, Engström G, et al. (2006) Effects of body fatness and physical activity on cardiovascular risk: risk prediction using the bioelectrical impedance method. Scand J Public Health;34 (6):568-75.
10. Park J-K, Park H, Kim K-B. (2015) The relationship between distribution of body fat mass and carotid artery intima-media thickness in Korean older adults. J Phys Ther Sci;27 (10):3141.
11. Emtner M, Hallin R, Arnardottir RH, et al. (2015) Effect of physical training on fat-free mass in patients with chronic obstructive pulmonary disease (COPD). Ups J Med Sci;120 (1):52-8.
12. Genton L, Graf CE, Karsegard VL, et al. (2013) Low fat-free mass as a marker of mortality in community-dwelling healthy elderly subjects. Age Ageing;42 (1):33-9.
13. Goss AM, Goree LL, Ellis AC, et al. (2013) Effects of diet macronutrient composition on body composition and fat distribution during weight maintenance and weight loss. Obesity;21 (6):1139-42.
14. Goss AM, Chandler-Laney PC, Ovalle F, et al. (2014) Effects of a eucaloric reduced-carbohydrate diet on body composition and fat distribution in women with PCOS. Metabolism;63 (10):1257-64.
15. Boghossian NS, Yeung EH, Mumford SL, et al. (2013) Adherence to the Mediterranean diet and body fat distribution in reproductive aged women. Eur J Clin Nutr;67 (3):289-94.

16. Choi S-H, Choi-Kwon S. (2015) The effects of the DASH diet education program with omega-3 fatty acid supplementation on metabolic syndrome parameters in elderly women with abdominal obesity. Nutr Res Pract;9 (2):150-7.
17. Onvani S, Haghighatdoost F, Azadbakht L. (2015) Dietary approach to stop hypertension (DASH): diet components may be related to lower prevalence of different kinds of cancer: A review on the related documents. J Res Med Sci;20 (7):707.
18. Shenoy SF, Poston WS, Reeves RS, et al. (2010) Weight loss in individuals with metabolic syndrome given DASH diet counseling when provided a low sodium vegetable juice: a randomized controlled trial. Nutr J;9 (1):1.
19. Mirzaei K, Hossein-nezhad A, Emamgholipour S, et al. (2012) An Exonic Peroxisome Proliferator-Activated Receptor-γ Coactivator-1α Variation May Mediate the Resting Energy Expenditure through a Potential Regulatory Role on Important Gene Expression in This Pathway. J Nutrigenet Nutrigenomics;5 (2):59-71.
20. Mirmiran P, Esfahani FH, Mehrabi Y, et al. (2010) Reliability and relative validity of an FFQ for nutrients in the Tehran lipid and glucose study. Public Health Nutr;13 (05):654-62.
21. Azar M, Sarkisian E. (1980) Food composition table of Iran: National Nutrition and Food Research Institute. Tehran: Shahid Beheshti University Press Iran CIT0001.
22. Mirmiran P, Hosseini-Esfahani F, Jessri M, et al. (2011) Does dietary intake by Tehranian adults align with the 2005 dietary guidelines for Americans? Observations from the Tehran lipid and glucose study. J Health Popul Nut:39-52.
23. (!!! INVALID CITATION !!! (24-26)).
24. Mirzaei K, Hossein-nezhad A, Emamgholipour S, et al. (2012) An Exonic Peroxisome Proliferator-Activated Receptor-γ Coactivator-1α Variation May Mediate the Resting Energy Expenditure through a Potential Regulatory Role on Important Gene Expression in This Pathway. Journal of nutrigenetics and nutrigenomics;5 (2):59-71.
25. Fung TT, Chiuve SE, McCullough ML, et al. (2008) Adherence to a DASH-style diet and risk of coronary heart disease and stroke in women. Arch Intern Med;168 (7):713-20.
26. Saneei P, Fallahi E, Barak F, et al. (2015) Adherence to the DASH diet and prevalence of the metabolic syndrome among Iranian women. Eur J Nutr;54 (3):421-8.
27. Schutz Y, Kyle U, Pichard C. (2002) Fat-free mass index and fat mass index percentiles in Caucasians aged 18-98 y. Int J Obes;26 (7).
28. Soltani S, Shirani F, Chitsazi MJ, et al. (2016) The effect of dietary approaches to stop hypertension (DASH) diet on weight and body composition in adults: a systematic review and meta.analysis of randomized controlled clinical trials. Obes Rev;17 (5):442-54.
29. Sacks FM, Moore TJ, Appel LJ, et al. (1999) A dietary approach to prevent hypertension: a review of the Dietary Approaches to Stop Hypertension (DASH) Study. Clin Cardiol;22 (S3):6-10.
30. Saneei P, Salehi-Abargouei A, Esmaillzadeh A, et al. (2014) Influence of Dietary Approaches to Stop Hypertension (DASH) diet on blood pressure: A systematic review and meta-analysis on randomized controlled trials. Nutr Metab Cardiovasc Dis;24 (12):1253-61.
31. Liese AD, Nichols M, Sun X, et al. (2009) Adherence to the DASH Diet is inversely associated with incidence of type 2 diabetes: the insulin resistance atherosclerosis study. Diabetes care;32 (8):1434-6.
32. Jones-McLean E, Hu J, Greene-Finestone L, et al. (2015) A DASH dietary pattern and the risk of colorectal cancer in Canadian adults. Chronic Dis Inj Can;35 (1).
33. Blumenthal JA, Babyak MA, Hinderliter A, et al. (2010) Effects of the DASH diet alone and in combination with exercise and weight loss on blood pressure and cardiovascular biomarkers in men and women with high blood pressure: the ENCORE study. Arch Intern Med (Chic);170 (2):126-35.
34. Obarzanek E, Vollmer WM, Lin P-H, et al. (2007) Effects of individual components of multiple behavior changes: the PREMIER trial. Am J Health Behav;31 (5):545-60.
35. Hajna S, Liu J, LeBlanc PJ, et al. (2012) Association between body composition and conformity to the recommendations of Canada's Food Guide and the Dietary Approaches to Stop Hypertension (DASH) diet in peri-adolescence. Public Health Nutr;15 (10):1890-6.
36. Smith PJ, Blumenthal JA, Babyak MA, et al. (2010) Effects of the dietary approaches to stop hypertension diet, exercise, and caloric restriction on neurocognition in overweight adults with high blood pressure. Hypertension;55 (6):1331-8.
37. Kim J, Li Y, Watkins BA. (2013) Fat to treat fat: emerging relationship between dietary PUFA, endocannabinoids, and obesity. Prostaglandins & other lipid mediators;104-105:32-41. Epub 2013/03/08.
38. Knight JA. (2011) Diseases and disorders associated with excess body weight. Ann Clin Lab Sci;41 (2):107-21.
39. He Q, Horlick M, Fedun B, et al. (2002) Trunk fat and blood pressure in children through puberty. Circulation;105 (9):1093-8. Epub 2002/03/06.
40. Reis JP, von Mühlen D, Miller ER, et al. (2009) Vitamin D status and cardiometabolic risk factors in the United States adolescent population. Pediatrics;124 (3):e371-e9.

Correspondence:
Khadijeh Mirzaei, PhD
Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences (TUMS), Tehran, Iran. P.O.Box:14155-6117, Tehran, Iran
Telephone: +98-21-88955569 - Fax: +98-21-88984861
E-mail: mirzaei_kh@tums.ac.ir

Zhila Maghbooli, Assistant professor
Osteoporosis Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran. P.O.Box: 14114-13137
E-mail: zhilamaghbooli@yahoo.com