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Investigating the relation between macronutrients intake and anthropometric indices

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Abstract.

BACKGROUND/OBJECTIVE: Nowadays, role of diet as a possible predisposing factor to diabetes and other non-communicable diseases is considered.

MATERIALS/METHOD: A total of 1026 young unmarried women aged between 18 to 30 years old from all parts of Iran who were supported by Imam Khomeini Relief Foundation, were enrolled in this study. Anthropometric indices were measured and dietary intake was assessed with a semi-quantitative 302-item food frequency questionnaire (FFQ).

RESULTS: The dietary intakes were compared in absolute and adjusted forms between four BMI groups. The amount of energy, fat and fiber intake in the absolute forms were statistically different between various groups. Comparison of fat mass, lean mass, lean body mass and body mass did not differ significantly between quartiles of energy and dietary intake. The results of Multi-factorial analysis to determine the simultaneous effects of multiple data showed that energy intake, carbohydrate and protein intake were statistically significant in absolute terms.

CONCLUSION: According to the results of this study, it can be concluded that there is a significant relation between macronutrients intake and anthropometric indices. Also, individual's anthropometric status can be predicted according to their macronutrients intake.

Keywords: Macronutrients, anthropometric indices, diet, obesity

1. Introduction

Obesity is a major risk factor for most of non-communicable diseases. Investigations that had been conducted in Iran suggested that the prevalence of obesity increased in recent years. Its prevalence is also expected to increase in coming years in the absence of appropriate interventions to improve the standard of living and lack of access to nutritional information for the public as well as increasing urbanization [1]. Therefore, prevention of obesity should be considered as an important health policy [2]. Over the past few years, attention has increased to the effects of food composition on energy consumption and their potential role on both overweight and obesity. Results of experimental studies showed that when both fat and energy density (kJ/g) of the diet increase energy intake rises as well [3].

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It is often assumed that obese and overweight people have more dietary intake than normal subjects, although some studies have shown that energy intake in obese subjects is less than normal subjects [4]. Other studies suggested that an imbalance in macronutrient intake may also play a role in obesity [5]. Due to the complexity of energy metabolism in the body, evaluation and identification of all the components of macronutrient of diet is required in the evaluation of obesity is required. Adolescent girls are more vulnerable and at risk of malnutrition due to reasons like growth spurt during puberty, lack of body reserves, possibility of risky behaviors and improper diet. Furthermore, owing to an imbalance in intake of macronutrients such as carbohydrates, proteins and fats and lack of micronutrients intake under RDA, adolescent girls especially those from low-income population are more susceptible to diseases and infections [6].

Studies have shown that consumption of high-fat diet without high-calories cause obesity in animals whereas human studies that examine the relationship between dietary composition and obesity did not reach a conclusive result yet [7]. Some researchers did not confirm the association between macronutrients and body mass index [8] while some believed that there is a positive correlation between dietary fat intake and obesity [9]. However, other researchers disagreed about the effects of dietary carbohydrate and fat on body mass index and have announced that protein content of diet play a key role in developing obesity [10].

Obesity is a multi-causal disease resulting from various factors including genetic, behavioral and cultural habits [11–13]. Genetic factors are affected by some environmental factors such as food intake [11–13].

Due to different opinions on this subject as well as the lack of proper investigations in this field and because of its important role on public health, this study aimed to determine the relation between diet composition and anthropometric indices in a group of urban population

2. Materials and methods

2.1. Study population

In a cross-sectional study, 1281 young single women 18 to 30 years from all over the country (approximately 30 persons from each province) who were supported by the Imam Khomeini Relief Foundation participated in this study. Exclusion criteria were the presence of an acute disease including cardiovascular, gastrointestinal, renal and hepatic diseases, and cancer. We also excluded subjects who reported that their daily energy intake was below 800 kcal/d (3347 KJ/d) or above 4200 kcal/d (17537 KJ/d) [14], known as under- and over reporters. Among 1281 enrolled cases, 1026 subjects who met all the conditions were included in this study. Based on specified programs 16 camps in Samen camp center in Mashhad city were held for 6 months. In each camp, which was 5 days long, 60 women from two provinces were participated.

2.2. Anthropometric measurements

Weight was measured by using an electronic weighing scale (Rassa, Tehran, Iran) and was recorded to the nearest 100 g while subjects wore only light clothing and no shoes. Height was measured without shoes with using a portable stadiometer (OTM, Tehran, Iran) and was recorded to the nearest 0.1 cm. Body Mass Index [BMI = weight (kg)/height^2 (m)] was also calculated. Body composition was determined using BIA to assess fat and fat-free mass and thus the percentage of body fat. In particular, an eight-polar BIA meter at frequencies of 5, 50, 250 and 500 kHz, which uses segmental multi frequency analysis, was employed. Subjects were instructed to avoid strenuous exercise the day before measurements. Assessments were carried out in the fasted state after participants had emptied their bladder and had only light clothing on. All measurements were performed by trained staff.

2.3. Dietary intake assessment

Dietary intake was assessed with a semi-quantitative 302-item food frequency questionnaire (FFQ) which was designed based on two other FFQs that had been previously validated in the Iranian population [15, 16]. The FFQ was self-administered and assessed the subject's intake of energy, macronutrients and fiber over the past 3 days before the first day of camp. The consumption of foods was broken down into seven frequencies: the highest was five times a day and the lowest was once over the past 3 days. Images of food portion were used to help participants better estimate usual portion size for foods such as rice and pasta. Food quantities were described using household amounts (glass, slice, plates, cups, spoons, etc.) and a sample was given for better understanding. For each food item, the daily frequency was multiplied by the amount of each portion to calculate the total consumption amount per day. Iranian food composition tables were used to calculate the daily energy, macronutrient and fiber intake [17]. Each FFQ was scanned and values converted to the gram for each item by dedicated software. A nutrient data base (Nutritionist iv designed for Iranian foods) was used for the nutrient content and energy analysis of the diet.

The dietary variables selected for the purpose of this study were crude, and adjusted total energy intake of micronutrients [18]. An adjustment was made for total energy intake through the residual method as an alternative to using nutrient densities to control for confounding by total energy intake and to remove extraneous variation due to total energy intake. Regression analyzes were used to compute residuals of nutrient intake by removing the variation caused by total energy intake. In this procedure, the nutrient intakes of the individuals in a group are regressed on their total energy intakes. The residuals from the regression represent the difference between each individual's actual intake and the intake predicted by their total energy intake [19–21]. Total energy-adjusted nutrient intakes were calculated as the residuals from the regression model, with absolute nutrient intake as the dependent variable, and total energy intake as the independent variable [19].

2.4. Ethical considerations

The study aims and method were described to the participants and a signed informed consent was obtained from them prior to participation. Specific questions including demographic information, family and medical history were completed by interviewers. Moreover, the study protocol was approved by Research Ethic Committee of Mashhad University of Medical Sciences and Imam Khomeini relief foundation.

2.5. Statistical analysis

SPSS software (version 11.5, Chicago, IL, USA) was used for statistical analysis. The normality of data was evaluated by Kolomogrov-Smirnov test. Values were expressed as mean ± SD for normally distributed variables. Baseline demographic and clinical characteristics were compared between groups using independent samples *t*-test, chi-square and/or Fisher's exact test, as appropriated. Logistic regression was used to determine the effect of each parameter on pre-HTN and HTN subjects. To determine the relationship between systolic blood pressure (SBP), diastolic blood pressure (DBP) and other clinical and biochemical parameters Pearson's.Correlation or Spearman' correlation coefficients were employed. P-value ≤ 0.05 was considered significant.

3. Results

Food intakes were compared both in absolute and adjusted form in four groups of body mass index (Table 1). As it shown in Table 1, only the amount of absolute form of energy, fat and fiber intake were statistically different between various groups. ANOVA One-way analysis of variance was used and showed that there was a significant difference in received energy between group 1 (BMI under than 18.9) with group 2 (BMI between 19–24.9) and group 3 (BMI between 25–29.9). A significant difference was also found for fat intake between group 1 (BMI under 18.9) and group 2 (BMI between 19–24.9) with group 4 (BMI between 30–34.9). Correlations were assessed using Pearson correlation coeficients and showed a strong relation between energy intake ($p < 0.01$) and fiber intake ($p < 0.05$) in absolute form. Also, a strong and significant relation was existed between adjusted fat intake and lean body mass (Table 2).

The outcomes of statistical analysis revealed that the comparison of fat mass, fat free mass and lean body mass as well as body mass index in quartiles of energy and food intake are not different statistically (Table 3).

Logistic regression was used to predict the individual effect of each factor on obesity. The test results showed that the fiber intake in both absolute and adjusted form is a predictor of obesity and significant factor for predicting obesity statistically ($p < 0.05$) (Table 4).

Table 1
Median and inter quartiles of absolute and adjusted amounts of macronutrients according to BMI in subjects

Variables		Under 18.9	19–24.9	25–29.9	30–34.9	*P*-value
Crude intake	Energy intake	1567 (1207–2032)	1529 (1224–1893)	1710 (1300–1040)	1709 (1333–2520)	<0.05*
	Protein (g)	59 (41–82)	53 (40–73)	58 (44–83)	60 (45–86)	0.14
	Fat (g)	67 (50–95)	62 (47–87)	70 (51–102)	79 (55–103)	<0.05*
	Cho (g)	223 (171–330)	208 (163–266)	224 (180–300)	222 (175–383)	0.18
	Fiber (g)	9.9 (6.9–14)	9.3 (6.7–12.7)	10.2 (7.8–14.5)	12.2 (7.5–19.8)	<0.05*
Adjusted energy	Protein (g)	46 (38–58)	48 (40–56)	47 (40–56)	44.5 (39–57)	0.22
	Fat (g)	57 (51–65)	59 (53–65)	59 (52–67)	60 (53–69)	0.26
	Cho (g)	159 (143–177)	158 (141–173)	155 (138–175)	160 (140–175)	0.29
	Fiber (g)	5.8 (7.7–10)	6.2 (8.1–11.1)	5.1 (7.1–9.2)	6.3 (8.2–11.4)	0.11

Values expressed as median and interquartile range for non-normally distributed data. ANOVA One-way analysis of variance test was used. *<0.05.

Table 2
Relation between the absolute and adjusted amounts of macronutrients with BMI, lean mass, fat mass, and muscle mass in studied subjects

Variables		BMI	FFM	FM	LBM
Crude intake	Energy intake	0.081**	−0.01	0.049	0.07
	Protein (g)	0.01	−0.01	0.07	0.09
	Fat (g)	0.03	0.003	0.029	0.07
	Cho (g)	0.007	−0.015	0.033	0.04
	Fiber (g)	0.05*	0.017	0.67*	0.14
Adjusted energy	Protein (g)	−0.02	−0.011	−0.33	−0.02
	Fat (g)	0.04	0.61*	0.017	0.046
	Cho (g)	−0.04	−0.032	0.023	−0.027
	Fiber (g)	0.05	0.063	0.022	0.035

Correlations were assessed using Pearson correlation coeficients. For non-normally distributed data such as triglycerides Pearson correlations were used. **Correlation is significant at the <0.01 level (2-tailed). *Correlation is significant at the <0.05 level (2-tailed). FFM = Fat Free Mass, FM = Fat Mass, LBM = Lean Body Mass, BMI = Body Mass Index.

4. Discussion

In this study according to Table 2, a strong and significant relation was found between adjusted amount of fat intake and body fat mass. Moreover, there is a significant association between consumed fiber with BMI and fat mass. Azizi et al. stated that in their study women with high-fiber diet had the lowest body mass index and waist circumference, however both men and women who had the lowest amount of fiber in diet, had the highest body mass index and waist circumference [1]. Our results showed that high fiber intake can decrease the body mass index and other anthropometric indices. Some of the investigations highlighted the connection between the amounts of fiber intake in our usual diet and anthropometric indices as our finding in this study [22–25]. In addition, Gertraud Maskarinec et al. also reported that consuming foods from high-fiber groups including vegetables is inversely related to the body mass index [22].

Assessing and evaluating the dietary intake of macronutrients becomes a debatable subject because of some issues in data collection including misreporting, under- and over-reporting of dietary intake as well as the used methods and procedures [26, 27]. One Iranian study revealed that under-reporters were older and had higher BMI than normal-reporters, however over-reporters were younger and had lower BMI compared with normal-reporters [28].Their final result showed a high prevalence of misreporting of energy intake in Tehran [28].

Table 3
Mean and standard deviation of body mass index, fat free mass, fat mass and muscle mass in different quartiles of macronutrients

Variables	Energy Intake (Kcal)			
	Q1	Q2	Q3	Q4
FFM	11.2 ± 2.5	11.2 ± 2.5	11.2 ± 2.6	11.2 ± 2.6
FM	11.1 ± 5.1	11.5 ± 5.5	11.4 ± 6.2	12.3 ± 6.2
LBM	42.1 ± 5.8	41.7 ± 6	41.3 ± 5.9	41.8 ± 6.1
BMI	21 ± 3.9	21.5 ± 3.6	21.3 ± 3.1	22 ± 4.7
	Fat (g)			
FFM	11.2 ± 2.5	11.1 ± 2.6	11.1 ± 2.7	11.4 ± 2.5
FM	11.5 ± 5.7	11.7 ± 6.2	11.3 ± 5.2	12.1 ± 5.7
LBM	41.9 ± 5.8	41.3 ± 5.4	41.5 ± 6.7	42.8 ± 6
BMI	21.3 ± 3.9	21 ± 3.9	22 ± 4.2	21.6 ± 5.6
	Cho (g)			
FFM	11.1 ± 2.6	11.3 ± 2.6	11 ± 2.6	11.2 ± 2.7
FM	11.1 ± 5.7	11.6 ± 5.7	11.6 ± 5.6	11.9 ± 5.9
LBM	41.9 ± 6.3	41.5 ± 5.7	40.9 ± 5.9	41.9 ± 6
BMI	21.4 ± 3.6	21.6 ± 4.2	21.2 ± 4.3	21.6 ± 5.2
	Pro (g)			
FFM	11.2 ± 2.4	11.2 ± 2.7	11.2 ± 2.6	11.2 ± 2.6
FM	11.5 ± 5.2	11.5 ± 5.5	11.2 ± 6.2	12.1 ± 5.8
LBM	41.5 ± 5.7	41.6 ± 5.6	41.8 ± 5.9	41.9 ± 6.1
BMI	21.4 ± 4	22.1 ± 3.9	21 ± 4	21.6 ± 5.1
	Fiber(g)			
FFM	11.1 ± 2.6	11.2 ± 2.6	11.2 ± 2.5	11.2 ± 2.6
FM	10.7 ± 5	11.7 ± 5.4	12 ± 6.7	11.9 ± 5.8
LBM	41.6 ± 6	41.5 ± 5.6	41.1 ± 5.9	41.8 ± 6
BMI	21.2 ± 3.7	21.4 ± 4.1	22 ± 3.9	21.5 ± 4.2

FFM = Fat Free Mass, FM = Fat Mass, LBM = Lean Body Mass, BMI = Body Mass Index.

Regarding dietary intake in diabetics, some studies reported that the intakes of macronutrients including fiber, carbohydrates and fat were less than 75% of recommended values in diabetic patients type 2; [29] whereas the results of Shahraki et al. study in 2004 are in contrary to these findings [30]. In Shahraki investigation, the participants' energy intake and macronutrients, except for cholesterol and carbohydrates, were higher than the recommended daily allowances and authors emphasized on reducing diet calorie [30].

Furthermore, it should be noted that the effects of diet on body mass index by sex was confirmed in other studies [2, 31–33]. Recent investigations stated that in evaluating the anthropometric indices, some of the factors including gender [34–38], ethnicity and living location [36, 37] as well the age of subjects [34, 38, 39] should be considered due to their influence on anthropometric indices. In this regard, Masaru Sakurai et al. stated that specific anthropometric variables should be taken into account for men and women in Asian population for obesity [35].

The results of our study showed that comparisons of fat mass, fat free mass and lean body mass as well as body mass index were similar significantly between quartiles of energy and food intakes. In study of TOGO P et al. a similar conclusion was made, they reported that there had not been a consistent and significant relation between body mass index and obesity with dietary patterns derived from factor analysis [40]. Moreover, they found a strong and significant relation between adjusted fat intake and lean mass. This finding was also supported by other investigations [41–44]. Bray et al. proposed this relation and stated that a reduction in fat intake decreases the gap between total

Table 4
Logistic regression in order to predict obesity based on absolute and adjusted amount of macronutrients intake

Variable		Odds Ratio (95% CI) Obesity
Crude Intake	Energy intake	(0.99–1.02)
	Protein (g)	(0.87–1.04)
	Carbohydrate (g)	(0.93–1.01)
	Fat (g)	(0.93–1.01)
	Fiber (g)	*(1.02–1.20)**
Total energy adjusted	Carbohydrate (g)	(0.94–1.02)
	Fat (g)	(0.91–1.07)
	Protein (g)	(0.95–1.03)
	Fiber (g)	*(1.04–1.21)**

Adjusted odds ratios with 95% confidence intervals (95% CI) obtained from multiple logistic regressions. Models were adjusted by logistic regression analysis for the association with increased BMI among our subjects. *<0.05.

energy intake and total energy expenditure and thus is an effective approach for reducing the present epidemic of obesity worldwide [45].

Test results revealed that the difference between energy, carbohydrate and protein intake were statistically significant in absolute form among groups. Some of the related studies supported this finding and confirmed the role of adjusted carbohydrates and protein intake in predicting anthropometric indices in healthy community population [46, 47], however other studies revealed that this relation should be considered stronger in early childhood, the period of complementary feeding and the transition to the family diet that high protein or energy diet is associated with unfavorable body composition at older ages [48, 49].

5. Conclusion

Regarding to the results of this study, it can be concluded that there is a significant relationship between macronutrients intake and anthropometric indices, in addition individual's anthropometric status can be predicted according to macronutrients intake. regarding to the young age of participants of this study which were recruited from low-income population, the results of this study provides valuable data for practitioners who have responsibility for advising individuals on their diet as well as health authorities in order to have precise control and scientific-based monitoring on public health and on nutritional status of community especially in developing and undeveloped countries.

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Conflict of interest

The authors have no conflict of interest regarding to this experiment.

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