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Ramadan Major Nutrient Patterns are Associated with Anthropometric Measurements and Physical Activity in Tehran, Iran

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ABSTRACT

During Ramadan fasting quantity and quality of dietary intake may change. There was no data on nutrient patterns in Ramadan fasting. The purpose of this study was to identify Ramadan major nutrient patterns among those who fast in Tehran, Iran.

510 fasting people aged 18-65 years and BMI 18.5-40 Kg/m^2 were recruited in our study by 2-stage cluster sampling method in June-July 2014. Data on the socio-demographic and physical activity level were collected by questionnaire. Usual diet during Ramadan was estimated by valid and reliable food frequency questionnaire. BMI was calculated based on measured height and weight.

Three nutrient patterns derived by conducting principal component factor analysis on 30 major nutrients. Micronutrient and fiber pattern which characterized by high intake of vitamin K, total fiber, iron, manganese, magnesium, β-carotene, folate, vitamin B12, potassium and calcium was adversely associated with weight (b=-0.16, P= 0.004). High protein pattern had great loadings on protein, riboflavin, phosphorous and zinc which physical activity level was decreased by tertiles of this pattern (b=0.13, P=0.02). High carbohydrate pattern which presented high positive loadings on carbohydrate and thiamin and negative loading on total fat, poly unsaturated fatty acids and monounsaturated fatty acids was positively associated with BMI (b= 0.12, P=0.03).

Adherence to different Ramadan nutrient patterns is associated with weight, BMI and physical activity level. People on high carbohydrate pattern may have a higher BMI and low micronutrient density diet that should be considered in Ramadan fasting nutrition educational programs.

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Introduction

Muslims fast from dawn to sunset during Ramadan (9th month of lunar calendar), which means 11-18 hours refraining from eating and drinking, according to the season Ramadan occurs in. Studies reported Ramadan fasting may lead to changes in body weight, biochemical and hormonal factors, and blood cell indices (1). Most of the physiological changes in Ramadan fasting could be due to variation in diet and meals frequency (2-4). Time and type of food consumption varies to some extent due to Ramadan fasting. Number of meals, mostly reduced to two meals a day and people mostly prefer to eat food at home and with family members (5,6). Therefore, the quantity and quality of diet may also change in this month.

Only few studies investigated dietary intake of fasting people which mainly focused on single or a few food items, macronutrients or micronutrients (3, 5-9). Findings of previous studies indicate the increasement of protein and carbohydrate intake and reduction of fat consumption in Ramadan (4, 6-9). Reduced vegetables and dairy intake were reported in studies evaluating food intake during Ramadan and calcium intake was low (5, 6).

Considering nutrients all together can help to assess dietary intakes in a way that to be closer to actual dietary habits and intake. On the other hand, from a long time ago dietary study results caused conceptual and methodological concerns due to intercorrelation and relationships between

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food and nutrients (10). The effect of a single nutrient may be too small to be detected, but the cumulative effect of several nutrients can be significant. The high intercorrelation between some nutrients is another obstacle in the way of examining the effect of each nutrient separately. People receive a wide variety of nutrients all together from foods which may have interactions or synergistic effects. Finally, since nutrients are usually associated with some particular dietary patterns, investigating nutrients singularly, may be potentially influenced by dietary patterns (10, 11). In recent studies, evaluating dietary patterns has become complementary and alternative of nutrient based studies. Dietary patterns are based on eating behaviors and thus affected by cultural and ethnical differences and many environmental factors such as food availability and affordability, the ability to prepare foods and variety of advertisements (10, 11). Therefore, it seems that study of dietary patterns can be very helpful and closer to reality and the results also seem to be easier to understand by people and can be applied in clinical guidelines (10, 12). Nutrient based dietary patterns are provided a better understanding of key biological processes in the different diets, regardless of foods that nutrients derived. Therefore, nutrient patterns can provide more extensive and comprehensive perspective of food intake (13). Although validity and reliability of the patterns should be approved in different populations based on their different dietary habits, the nutrient patterns obtained in this method are easily comparable in different populations (14). Considering few studies focused on Ramadan fasting and nutrient intake, this study aims to investigate major nutrient patterns of fasting people during Ramadan.

Materials and methods

This cross-sectional study approved by the ethic committee of Endocrinology and Metabolism Research center (E-00369). In this study we used a 2-stage cluster sample design to obtain a representative sample of fasting people. The field work for this study took place in June-July 2014. For the first stage, Tehran was divided into 4 geographical directions (north, west, east and south). Two districts were randomly selected of the municipality districts in each of the geographical directions.

In the second stage, 2 neighborhoods from each district were randomly assigned. Eligible households included resident individuals (aged 18-65 years, BMI 18.5-40 Kg/m^2 and willing to participate) who were home at the time of admission. In each household, one person was enrolled. Those who were not available at the time of data collection were admitted in a subsequent survey. Individuals who were suffering from any acute or chronic disease such as cardiovascular, renal, hepatic, thyroidal disease, cancer and etc. were excluded from the study population.

530 eligible subjects intended to fast were entered the study. Ramadan fasting was defined as 25 and 20 fasting days for men and women respectively. A structured questionnaire administered to collect socio-demographic characteristics consisted of age, sex and educational status. Anthropometric indicators were measured according to standard protocols. Height and weight were measured to the nearest 0.1cm and 0.1kg respectively. Body mass index (BMI) was estimated as the ratio of body weight to height squared. Waist circumference was determined by placing a measuring tape around the abdomen just above the right iliac crest to the nearest 0.1cm. Information on usual diet during Ramadan was evaluated by a validated and reproducible semi-quantitative food frequency questionnaire (15, 16). The adjusted food frequency questionnaire included 168 food items, food groups, and Iranian recipes, as representative of the Iranian common diet. All data collection process was performed by trained interviewers through face to face interviews. Study participants were asked to indicate their frequency of consumption of a given serving of each food item during Ramadan (daily, weekly or in the month). The reported amount of food intakes converted to grams per day using household measures (17).

In absence of a complete Iranian food composition table (IFCT) which is limited to raw materials and a few nutrients, and considering that the energy and macronutrients of many food items in IFCT are almost similar to alternative food items in the united states department of agriculture's (USDA) FCT (like

breads and fruits, correlation 0.9), USDAFCT was used to analyzed energy and nutrient content of food intake. However, for Iranian food items were not listed in the USDA FCT, Iranian food composition table was applied. In addition, mixed dishes were analyzed based on their ingredients (15).

Physical activity level (PAL) evaluated through validated questionnaire consisted of nine different metabolic equivalent (MET) levels ranged sleep/rest (0.9 METs) to high-intensity physical activities (> 6 METs) (18). For calculating average daily MET, the equivalents for each activity multiplied by the time spent on that activity. The total MET-time was then divided by 24 hours.

Considering the previous studies, 30 macronutrients and micronutrients were chosen as a comprehensive representation of the Iranian diet for identifying main nutrient patterns. To conduct principal component factor analysis (PCFA) on original information, initially nutrients intake were adjusted for calorie intake and calculated at 1000 kilocalories (19). Bartlett's test of sphericity and Kaiser–Meyer–Olkin measure were carried out to insure the high correlation between the nutrients and adequacy of the sample size, respectively (20). Principal components analysis was performed on these items followed by a varimax rotation to obtain simple structured and interpretable results. The number of nutrient patterns was determined according to factor eigenvalue greater than 1, scree plot and interpretability of factors. Considering eigenvalue greater than 3 and curve break point between factors with relatively large eigenvalues and factors with negligible eigenvalues, three nutrient patterns were extracted. Afterward, factor scores were defined for each subject and for each factor using weighted sum of each nutrient intake by factor loading (20). The Spearman correlation coefficients between the scored patterns and 25 food groups were explored. Food groups were formed based on the similarity of ingredients and specific food groups and items that are used mostly in Ramadan were classified as separated groups. The normality of variables was tested by Kolmogrov-Smirinov method. The intake of food groups were log transformed to produce normalized distributions. Analysis of variance and chi square were used to compare the distribution of quantitative and qualitative variables respectively among tertiles of each nutrient pattern. Linear regression was used to examine the relationship between demographic and anthropometric measurments with nutrient pattern tertiles. Regression and ANOVA assumptions were done before each analysis. Analyses were conducted by Statistical Package

Table 1. Descriptive characteristics of the 510 study participants

Characteristics*	
Age (years)	35.22±12.93
Sex (n)	
Male	147 (28.9)
female	363 (71.1)
Weight (Kg)	70±14.30
BMI (kg/m²)	25±21
WC (cm)	86.75±50.56
Education (n)	
Primary school	9 (3.02)
Guidance school	12 (4.02)
High school	85 (28.52)
University	192 (64.42)
PAL (MET)	1.40±0.19

* Data are presented as mean ± Standard Deviation (SD) or n (%)

Table 2. Daily mean intake and percentile distribution of energy, macronutrients and micronutrients

Nutrients	Mean ± SD	25	50	75
Calorie (kcal)	1822±756	1275	1708	2177
Protein (gr)	70±29	50	65	85
Carbohydrate (gr)	278±110	199	264	329
Total fat (gr)	64±38	37	54	80
Cholesterol (mg)	221±130	136	190	265
SFA* (gr)	21±12	14	19	26
MUFA** (gr)	23±16	12	19	29
PUFA*** (gr)	12±11	5	9	15
Sodium (gr)	2131±1451	1298	1787	2483
Potassium (gr)	3909±1873	2550	3497	4938
Vitamin A (µg)	1118±846	527	916	142
β-carotene (µg)	2815±1893	1517	2309	3678
Vitamin C (mg)	127±92	63	103	169
Calcium (mg)	1157±543	774	1032	1433
Iron (mg)	33±25	16	25	39
Vitamin D (µg)	41.9±35.5	19.2	30.7	50.9
Vitamin E (mg)	8.2±9.0	3.7	5.7	9.5
Thiamin (mg)	1.3±0.5	0.9	1.2	1.6
Riboflavin (mg)	1.9±0.8	1.3	1.7	2.3
Niacin (mg)	19.0±8.3	13.2	17.7	22.9
Pyridoxine (mg)	1.8±1.0	1.2	1.6	2.2
Folate (µg)	289±145	187	255	349
Cobalamin (µg)	5.1±7.5	2.5	3.4	4.7
Biotin (µg)	25.0±10.5	17.5	23.1	29.9
Pantothenic acid (µg)	5.0±2.3	3.3	4.5	6.3
Phosphorus (mg)	1289±532	917	1212	1545
Magnesium (mg)	335±14	229	308	408
Zinc (mg)	10±4	7	9	12
Copper (µg)	1.4±0.8	0.8	1.2	1.7
Manganese (mg)	6.3±3.3	3.8	5.5	7.8
Fiber (g)	20±11	13.1	17.7	26.7

*Saturated fatty acids
**Monounsaturated fatty acids
***Polyunsaturated fatty acids

Table 3. Factor loading matrix[1,2] and explained variances for the three major nutrient patterns identified by factor analysis

Nutrient	Nutrient pattern		
	Micronutrient and fiber	High protein	High carbohydrate
Vitamin K	0.89	-	-
Total fiber	0.85	-	-
Iron	0.84	-	-
Manganese	0.81	-	-
Magnesium	0.80	0.30	0.31
β-Carotene	0.78	-	-
Folate	0.76	-	-
Vitamin B12	0.76	-	-
Potassium	0.76	-	0.31
Calcium	0.6	0.47	-
Vitamin C	0.56	-	0.31
Vitamin E	0.47	-	-0.37
Sodium	0.45	-	-
Vitamin B6	0.38	-	0.31
Copper	0.36	0.33	-
Protein	0.30	0.79	-
Vitamin B2	0.36	0.77	-
Phosphorous	0.3	0.77	-
Zinc	0.43	0.69	-
Vitamin D	-	0.57	-
Cholesterol	-	0.57	-
Saturated fatty acids	-	0.50	-0.36
Vitamin B3	0.31	0.45	0.41
Vitamin A	0.32	0.41	-
Total fat	-	-	-0.92
Poly unsaturated fatty acids	-	-0.33	-0.78
Carbohydrate	-	-0.43	0.77
Monounsaturated fatty acids	-	-	-0.77
Vitamin B1	-	-	0.73
lycopene	-	-	-
Explained variance (%)	33.98	13.53	11.04

1. Estimated from a principal component factor analysis performed on 30 nutrients.
2. The magnitude of each loading indicates the importance of the corresponding nutrient to the factor. Loadings >0.60 are shown in bold; loadings <0.30 are suppressed.

Software for Social Science, version 16 (SPSS Inc., Chicago, IL, USA). An alpha level less than 0.05 was accepted in all tests as statistically significant and with the sample size of 530; a power value of %90 was generated.

Results

Among 530 included participants, 510 persons completed the study according the agreed fasting definition. Demographic and anthropometric characteristics of the study population were presented in Table 1. 147 male and 363 female attended in this study. The mean weight and waist circumference were 70.0±14.3 kg and 86.7±50.5 cm, respectively. The Majority of the participants (%64.42) had a university degree.

Dietary intake and distribution of energy, macro- and micronutrients are shown in Table 2.

Nutrients and loading factors matrix for three nutrient patterns retained from the factor analysis was presented in Table 3. The first factor named micronutrient and fiber, characterized by high intake of vitamin K, total fiber, iron, manganese, magnesium, β-carotene, folate, vitamin B12, potassium and calcium. This factor explained 33.98% of the variance. Factor 2 was named high protein had great loadings on protein, riboflavin, phosphorous and zinc. The factor explained 13.53% of the variance. The third factor named high carbohydrate and presented high positive loadings on carbohydrate and thiamin and negative loading on total fat, poly unsaturated fatty acids (PUFA) and monounsaturated fatty acids (MUFA) and explained 11.04% of the variance. All together, these three nutrient patterns explained 58.55% of the variance.

Spearman correlation coefficients between food groups and nutrient pattern scores were presented in Table 4. The micronutrient and fiber pattern showed a positive correlation with vegetables (r= 0.45, P<0.001) and soups (r= 0.30, P<0.001). The high protein pattern revealed a positive correlation with fish and poultry (r= 0.32, P<0.001), dairy (r=0.40, P<0.001) and an adverse correlation with zoolbia and bamieh (two traditional Persian starch-based sweets, which is fried and coated in sugar syrup) (r=-0.44, P<0.001). There was a positive correlation between high carbohydrate pattern and breads and rice (r= 0.33, P<0.001), zoolbia and bamieh (r= 0.43, P<0.001) and an adverse correlation with nuts (r= -0.36, P<0.001).

Characteristics of participants according to tertiles of each factor were presented in (Tables 5-7). Table 5 showed that weight were decreased by tertiles of micronutrient and fiber pattern (b=-0.16, P= 0.004). The high protein pattern had a positive association with physical activity level (b=0.13, P=0.02) (Table 6). Adherence to high carbohydrate pattern was positively associated with BMI (b= 0.12, P=0.03) (Table 7).

Table 4. Spearman Correlation coefficients between nutrient pattern scores and food groups

Food group	Food items	Micronutrient and fiber	High protein	High carbohydrate
Breads and rice	Lavash,Taftoon, Rice, Barbari, Spaghetti, Sangak, Baget, Barley bread	-	-	0.33**
Potato	Potato, Fried potato	-	-	-
Sweets and condiments	Biscuit, Cake, Donate, Gaz, Sohan, Candy, Sugar, Honey, Jam, Halva	-	-	-
Legumes and whole grains	Corn, Barley, Legumes,Beans, Soy	-	-	-
Red meats	Beef, Lamb, Ground meat	-	-	-
Fish and poultry	Chicken, Fish	-	0.32**	-
Canned fish	Canned fish	-	-	-
Eggs	Eggs	-	-	-
Fast foods	Hamburger, Sausage, Pizza	-	-	-
Visceral meats	liver, Visceral meats	-	-	-
Dairy	Milk, Cocoa milk, Yogurt, Cheese, Dough, Ice cream	-	0.40**	-
Butter and cream	Cream, Butter	-	-	-
Vegetables	salads, Squash, Eggplant, Celery, Cucumber, String bean, Carrot, Pea, Garlic, Onion and etc.	0.45**	-	-
Pickles	Pickles	-	-	-
Fruits	Cantaloupe, Melon, Apricot, Pear, Watermelon, Cherry, Apple, Peach, Mango, Fig, Grape, Kiwi, Orange, Plum, Banana and etc.	-	-	-
Dates	Dates	-	-	-
Juices	Fruit juices	-	-	-
Soft drinks	Soft drinks, bear	-	-	-
Salty snacks	Chips, Salty snacks	-	-	-
Chocolate	Chocolate, Dark chocolate	-	-	-
Tea and coffee	Tea, Green tea, Coffee	-	-	-
Halim	Halim	-	-	-
Soups	Ash, soup	0.30**	-	-
Porridges	Porridges	-	-	-
Zoolbia and bamieh	Zoolbia, Bamieh	-	-0.44**	0.43**

Pearson's correlation coefficient of <0.3 are not shown for simplicity
* P-value< 0.05
**P-value< 0.001

Table 5. characteristics of participants according to tertiles of micronutrient and fiber pattern*

	T_1	T_2	T_3	P**	P†
Sex (%)					
Male	34.4	29	23.2	0.22	-
Female	65.7	71	76.8		
Education (%)					
Primary school	3.2	3	2	0.66	-
Guidance school	4.2	6	1		
High school	27.4	27	31.3		
University	65.3	64	65.7		
Age (years)	34.84±12.78	36.27±13.54	34.56±12.52	0.61	(-0.009) 0.87
Weight (kg)	72.60±16.22 ‡	70.80±14.06	66.72±11.78‡	0.012	(-0.16) 0.004
BMI (Kg/m^2)	25.56±6.28	25.72±5.04	24.90±4.10	0.503	(-0.05) 0.37
Waist circumference (cm)	85.16±12.80	92.55±85.28	82.39±10.30	0.348	(-0.23) 0.70
PAL (MET)	1.36±0.15	1.43±0.20	1.39±0.22	0.069	(-0.06) 0.30

* Qualitative and quantitative data presented as the percent and mean ± SD (Standard Deviation) in tertiles respectively
** P -value of analysis of variance for quantitative and chi square for qualitative variables
† P-value of linear regression
‡ Post hoc test showed a significant difference between T_1 and T_3

Discussion

In our study three nutrient patterns retained. Micronutrient and fiber pattern characterized by high intake of vitamin K, total fiber, iron, manganese, magnesium, β-carotene, folate, vitamin B12, potassium and calcium. High protein pattern included protein, vitamin B2, phosphorous and zinc and high carbohydrate pattern displayed high loadings for carbohydrate and vitamin B1 and negative loading on total fat, PUFA and MUFA. Result of the study showed micronutrient and fiber pattern was inversely associated with weight, high protein pattern and high carbohydrate pattern were associated with physical activity level and BMI respectively.

Table 6. characteristics of participants according to tertiles of high protein pattern*

	T_1	T_2	T_3	P**	P†
Sex (%)					
Male	28.3	26	32.3	0.61	-
Female	71.7	74	67.7		
Education (%)					
Primary school	3.1	4	1	0.18	-
Guidance school	5.2	2	4		
High school	35.4	29.3	21.2		
University	56.2	64.6	73.7		
Age (years)	35±12.74	34.65±12.94	35.48±13.22	0.86	(-0.002) 0.97
Weight (kg)	70.63±15.44	67.92±14.19	71.60±13.07	0.17	(0.02) 0.63
BMI (Kg/m^2)	25.16±6.26	24.83±4.75	26.20±4.39	0.64	(0.08) 0.16
Waist circumference (cm)	84.18±12.83	90.56±85.81	85.49±11.01	0.15	(0.01) 0.84
PAL (MET)	1.35±0.20‡	1.42±0.19‡	1.41±0.18	0.01	(0.13) 0.02

* Qualitative and quantitative data presented as the percent and mean ± SD (Standard Deviation) in tertiles respectively
**P-value of analysis of variance for quantitative and chi square for qualitative variables
†P-value of linear regression
‡Post hoc test showed a significant difference between T_1 and T_2

Table 7. characteristics of participants according to tertiles of high carbohydrate pattern*

	T_1	T_2	T_3	P**	P†
Sex					
Male	31.3	29	26.3	0.73	-
Female	68.7	71	73.7		
Education					
Primary school	1	4	3.1	0.55	-
Guidance school	2	5.1	4.1		
High school	28.6	24.2	33		
University	68.4	66.7	59.8		
Age (years)	33.82±11.96	35.04±13.37	36.83±13.37	0.26	(0.09) 0.10
Weight (kg)	69.55±14.32	68.47±13.51	72.12±14.95	0.180	(0.07) 0.20
BMI (Kg/m^2)	24.74±5.79‡	25.16±3.97	26.30±5.61‡	0.54	(0.12) 0.03
Waist circumference (cm)	83.01±10.51	90.92±16.23	86.34±13.05	0.09	(0.02) 0.64
PAL (MET)	1.41±0.19	1.39±0.19	1.38±0.21	0.60	(-0.05) 0.30

*Qualitative and quantitative data presented as the percent and mean ± SD (Standard Deviation) in tertiles respectively
**P-value of analysis of variance for quantitative and chi square for qualitative variables
†P-value of linear regression
‡Post hoc test showed a significant difference between T_1 and T_3

To our knowledge, this is the first study investigating food intakes in the form of nutrient patterns during Ramadan fasting. Ramadan fasting causes major changes in lifestyle of people fasting in Ramadan. Ramadan affects dietary habits including frequency of the meals to the food quality. Few studies investigated the quality and quantity of Ramadan fasting diet. However, it seems that fat intake reduced in Ramadan diet (6-9). however, in a study in Algeria, no modification was observed in the amount and type of fat consumption, and cholesterol intake (3). Carbohydrate and protein intake was reported to supply greater proportion of energy in fasting people comparing to usual diet throughout the rest of the year (4, 6-8, 21). Depending on Ramadan food habits, rice and flour consumption may increase during Ramadan. Also the type of the carbohydrate consumed in Ramadan changes and sugar consumption may significantly increase (3). El Ati et. al. (21) showed that carbohydrate intake in men was increased due to increase consumption of dates, honey, pastry, sweets and soft drinks. In Iranian diet, rice and grain are consumed as major staple foods (22). In our study, zoolbia and bamieh showed positive correlation with high carbohydrate pattern.

Since nutrient patterns in this study were extracted base on nutrients, they cannot be directly compared with dietary pattern which derived from food groups and food items. But they share some components with food groups. Micronutrient and fiber pattern and high carbohydrate pattern in this study represented common characteristics with Mediterranean like and Ramadan style dietary patterns obtained in another study on Tehrainan fasting people and high protein pattern, high loaded with protein,

vitamin B2, phosphorous and zinc had common components with the Western like dietary pattern (23).

Adherence to micronutrient and fiber pattern (associated with vegetables and soups) was negatively associated with weight which is in company with results of previous studies of dietary pattern in Tehranian population. Esmaillzadeh et. al. and Rezazadeh et. al. reported that individuals in the upper category of the healthy pattern (characterized by high loading mainly for vegetables and fruits) were less likely to be obese (24, 25). Individuals in the upper quintile of healthy dietary pattern were more likely to be physically active (24). In this study, fasting people with higher physical activity level tended to follow high protein pattern (contained some components in common with healthy dietary pattern).

To our knowledge, this is the first study investigated Ramadan fasting major nutrient patterns and their associated factors. Holistic view of nutrient pattern can be a privilege in dietary recommendation for proper food intake during Ramadan fasting and developing dietary modification strategies especially in fasting people who consume high carbohydrate pattern. But some subjective decisions in factor analysis should also be taken into account. Also, studies in different countries may be affected by the differences in dietary habits among populations.

Adherence to different Ramadan nutrient patterns may be related different aspects of life style of fasting people such as weight, BMI and physical activity level. People on high carbohydrate nutrient pattern which was mostly associated with high intake of grains and sweets may have a higher BMI and low micronutrient density diet during Ramadan. This is an important point in fasting people health that should be considered in Ramadan fasting nutrition educational programs.

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Conflict of interest

There are not any financial and non-financial competing interests (political, personal, religious, ideological, academic, intellectual, commercial or any other) to declare in relation to this manuscript.

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