

Does the diet of Tehranian adults ensure compliance with nutritional targets? Observations from the Tehran Lipid and Glucose Study

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Abstract

Objective: To analyse dietary compliance with WHO/FAO nutritional objectives, identify food subgroups that contribute to discrepancies between dietary intakes and recommendations, and assess food patterns and risk factor profiles at common nutritional targets.

Design: The study was a population-based, cross-sectional assessment of the dietary patterns of Tehranian adults. Usual dietary intake was assessed in relation to common nutritional targets of public health (fat, saturated fat, dietary fibre, fruit and vegetables) using a validated FFQ. Metabolic syndrome (MetS) risk factors were diagnosed based on the Iranian-modified diagnostic criteria of the National Cholesterol Education Program Adult Treatment Panel III.

Setting: The Tehran Lipid and Glucose Study (2005–2008).

Subjects: A total of 2510 individuals (1121 men and 1389 women), aged between 19 and 70 years.

Results: Generally, 68.5% of total grain ounce-equivalents were derived from refined grains, with rice making up 36.6% of all grains consumed. Solid fat (61.1%) contributed more to discretionary energy than did added sugars (38.9%). There was a twofold difference in fruit and vegetable consumption between the lowest and highest quartile categories of dietary fibre intake. The probability of having MetS was significantly lower in the highest quartile of fibre intake *v.* the lowest (OR = 0.69, 95% CI 0.58, 0.84 *v.* OR = 0.92, 95% CI 0.80, 1.03; *P*-trend < 0.001), whereas it was higher in the highest quartile of SFA intake *v.* the lowest (OR = 0.92, 95% CI 0.78, 0.98 *v.* OR = 0.71, 95% CI 0.62, 0.89; *P*-trend = 0.01).

Conclusions: Complying with common nutritional targets of public health is inversely associated with MetS risk factors in Tehranian adults. These results may initiate measures for future development of regional food-based dietary guidelines.

Keywords
Nutritional targets
WHO/FAO guidelines
Developing countries

Dietary habits play an essential role in delaying and preventing a large number of chronic diseases⁽¹⁾. The dietary habits of Iranian adults are largely influenced by the nutrition transition currently taking place in the country in the context of rapid demographic change, social development and urbanization, which is causing significant dietary changes such as increased consumption of inexpensive dietary energy sources, like bread, sugar, fats and oils, and decreased intakes of meat, fruits and vegetables (F&V), which are relatively more expensive in Iran⁽²⁾. This phenomenon has influenced disease

patterns in Iran such that the prevalence of chronic diseases is showing an increasing trend while infectious and malnutrition diseases, although under control, are still issues of concern⁽³⁾. The prevalence of obesity in Tehran City increased significantly between 1999 and 2009 from 15.8 to 21.0% in men and from 31.5 to 38.6% in women⁽⁴⁾. As a consequence, the incidence of diabetes mellitus is on the rise: over 1% of Iranian adults aged >20 years develop type 2 diabetes annually⁽⁵⁾. The prevalence of metabolic syndrome (MetS) increased from 30.1% in 2003 to 34.7% in 2009^(6,7).

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Authorities depend on two invaluable tools for public health improvements: nutritional objectives and food guidelines^(8,9). In 1999, Becker *et al.* introduced nutritional targets for public health (total fat, SFA, dietary fibre, F&V) on the basis of which food-based dietary guidelines (FBDG) could be developed⁽⁹⁾. FBDG need to be designed based on the socio-economic context of a society to be realistic, and hence should be extracted from population-based epidemiological studies⁽⁹⁾. Several countries have developed country-based FBDG^(10,11) and, in the case of the USA, these recommendations have been developed further⁽¹²⁾. In Iran, several attempts have been made at developing country-based FBDG; however, no quantitative dietary guidelines have been decided upon and accordingly no nutritional targets have yet been set⁽¹³⁾ owing to a lack of data on prevailing dietary habits of Iranian adults.

The aims of the present study were therefore to: (i) identify food subgroups that contribute the most to discrepancies between actual dietary intakes and recommendations; (ii) analyse compliance with WHO/FAO nutritional objectives⁽¹⁴⁾; and (iii) assess food patterns and risk factor profiles, based on common nutritional targets, in a sample of Tehranian adults.

Materials and methods

Population and sampling

The present study was conducted within the framework of the Tehran Lipid and Glucose Study (TLGS)⁽¹⁵⁾, an ongoing population-based cohort study of residents of district no. 13 of Tehran City whose age and socio-economic status are representative of the overall population of Tehran^(15,16). In the third phase of TLGS (2005–2008), of 12 523 individuals aged ≥ 3 years, 4920 were selected for dietary assessments based on age- and sex-stratified random sampling. Randomization was performed because collecting dietary data from a large population would have high costs and be complex and time-consuming. Finally, the dietary data of 3462 persons aged ≥ 3 years, who agreed to participate in the survey and completed data for assessments, were available. Based on the inclusion criteria for age (19–70 years), 2881 adults, who were not on a specific diet, were included in the present analysis.

Our participants who completed the FFQ had similar characteristics to the total population in the third survey of TLGS⁽¹⁷⁾. Of the total number of participants who completed the FFQ, 45.4% were male and 76.7% were aged 19–70 years compared with 44.1% and 82.3% respectively in the third survey of TLGS. In the third examination survey of TLGS, 20.1% had academic education and 11.6% were smokers compared with 25.3% and 12.8% in participants who completed the FFQ.

Of 2881 participants, we excluded individuals for whom data on any characteristic were missing (n 103). The reported energy intake (EI) was divided by estimated

energy requirement (EER) and where EI:EER was not within ± 2 SD of the mean value⁽¹⁸⁾, reports were excluded from the study (n 274). Data for 2504 participants (1120 men and 1384 women) were finally available for analysis. The study proposal was approved by the Research Council of the Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences and informed written consent was obtained from each participant.

Physical activity assessment

Kriska *et al.*'s physical activity (PA) questionnaire⁽¹⁹⁾, a modifiable activity questionnaire (MAQ), was used to obtain data on various aspects of PA and energy expenditure by identifying the time and frequency of participating in activities during the previous year. This questionnaire was designed for easy modification to maximize the feasibility and appropriateness of PA assessment in a variety of minority populations and age groups⁽²⁰⁾. A validity and reliability study of this translated MAQ among Tehranian subjects showed that the validity correlation of total metabolic equivalents (MET) between the mean of four MAQ, completed in each season, was 0.4 and the intraclass correlation between the mean of two MAQ, completed with a 1-year interval, was 0.9 (M Delshad, A Ghanbarian and P Mirmiran, unpublished results). MET were then calculated based on the compendium of physical activities⁽²¹⁾ and the daily PA of each participant was interpreted using guidelines⁽²²⁾.

Other measures

Trained interviewers carried out face-to-face private interviews with participants, during which pre-tested questionnaires concerning age, medical history, current use of medications and smoking habits were completed⁽¹⁶⁾. Smoking status was categorized according to WHO guidelines⁽²³⁾.

All anthropometric measurements were carried out by the same examiner for all men and the same for all women. Weight was measured with participants minimally clothed, without shoes, while standing on a digital scale (model 707, range 0.1–150 kg; Seca, Hamburg, Germany). Height was measured using a tape meter (model 208 Portable Body Meter Measuring Device; Seca) while participants were standing without shoes with their head in the Frankfort horizontal plane and recorded to the nearest 0.5 cm. Waist circumference (WC) was measured at umbilical level using an out-stretched tape meter without pressure to body surfaces and was recorded to the nearest 0.1 cm.

Measurement methods for blood pressure (BP), fasting blood glucose (FBG) and lipid profiles in TLGS have been described in detail elsewhere^(15,16).

Definition of terms

Metabolic syndrome (MetS) was defined based on the Iranian-modified diagnostic criteria of the National Cholesterol Education Program Adult Treatment Panel III

(NCEP ATP III)^(24,25). MetS was considered as the co-occurrence of three or more of the following risk factors: WC \geq 95 cm; HDL cholesterol (HDL-C) $<$ 40 mg/dl for men or $<$ 50 mg/dl for women or drug treatment; TAG \geq 150 mg/dl or drug treatment; FBG \geq 100 mg/dl or drug treatment for hyperglycaemia; and hypertension, systolic BP (SBP) \geq 130 mmHg or diastolic BP (DBP) \geq 85 mmHg or drug treatment for a previous diagnosis of hypertension.

Dietary assessment

Dietary data were collected by trained dietitians with at least 5 years of experience in the TLGS survey^(15,16) using a validated FFQ⁽²⁶⁾, comprising 168 items, documenting the consumption frequency of food items during the previous year on a daily, weekly or monthly basis. Portion sizes of consumed foods were converted to grams⁽²⁷⁾ and were analysed for energy and nutrient contents using the US Department of Agriculture (USDA) food composition table (FCT)⁽²⁸⁾. However, the Iranian FCT was used for some dairy products like *kashk*, not listed in the USDA FCT. Usual restaurant recipes were used for mixed food items (e.g. pizza) to calculate their nutrient contents. The weighted contribution of each subgroup to its respective food group was examined by summing the number of servings provided by the subgroup and dividing by the total intake of that group for all individuals; legumes could be included in either the 'vegetables' or the 'meat and beans' group of MyPyramid. Being a 'consumer' of WHO/FAO dietary guidelines⁽¹⁴⁾ was defined as completely meeting the defined international dietary targets.

Food and nutritional guidelines

In the absence of complete quantitative Iranian nutritional guidelines, dietary intakes of participants were compared using the latest WHO/FAO dietary guidelines in the upper end of nutritional targets for public health, which have been used in several studies aimed at developing FBDG⁽²⁹⁻³¹⁾. Moreover, the MyPyramid food guide⁽¹²⁾ was used for determining individuals' food group intakes. The amounts of food intake (grams) were converted to cup- and ounce-equivalents using the 'food link pyramid database series'⁽³²⁾. Regarding the calculation of discretionary energy, only added sugar and solid fat were considered since most Iranians refrain from drinking alcohol based on their religious beliefs⁽¹⁷⁾.

Statistical analysis

All statistical analyses were performed using the SPSS statistical software package version 16.0 (SPSS Inc., Chicago, IL, USA) and $P < 0.05$ was considered significant. All dietary components and risk factors were normally distributed except for TAG, for which the natural logarithm was alternatively used. To identify differences in eating patterns, participants were divided into groups of low and high intake according to quartile categories of the common nutritional targets of public

health: total fat (% of energy: Q1, $<$ 26.52; Q2, 26.52–30.85; Q3, 30.86–35.42; Q4, $>$ 35.42), SFA (% of energy: Q1, $<$ 8.42; Q2, 8.42–10.12; Q3, 10.13–12.06; Q4, $>$ 12.06), F&V (g/d: Q1, $<$ 197.42; Q2, 197.42–296.46; Q3, 296.47–429.57; Q4, $>$ 429.57) and dietary fibre (g/d: Q1, $<$ 19.11; Q2, 19.11–25.96; Q3, 25.97–36.17; Q4, $>$ 36.17); differences in mean intakes from WHO/FAO goals and USDA food groups, between low and high intake groups of common nutritional targets, were tested by means of analysis of covariance. For assessing an independent association between quartile categories of nutritional targets and MetS, adjusted logistic regression was used. Those participants receiving treatment for any risk factors were excluded from analyses of the relationship between diet and that risk factor, leaving 2401 participants for the analysis of fasting FBG, 2385 for analysis of HDL-C and TAG, and 2392 for analysis of BP.

Results

Of the total population, 44.7% were males and 55.3% were females. The mean age of the men and women was 40.5 (SD 13.9) and 38.6 (SD 12.9) years, respectively, and their average BMI was 26.6 (SD 4.2) and 27.2 (SD 5.3) kg/m², respectively.

Food subgroups are listed in descending order according to their contribution to total food group intake in Table 1; 68.5% of the total grain ounce-equivalents were derived from refined grains. Rice made up 36.6% of all grains consumed; followed by Iranian white bread (*lavash*, 17.3%; data not shown). Among the seven vegetable subgroups, dark green vegetables ranked first in total cup-equivalents of vegetables. Fruit juice contributed 9.6% of total cup-equivalents of the fruit group and the remaining was derived from whole fruit (data not shown).

In the first quartile category of total fat and SFA intake, the consumption of fruits, dark green vegetables, other vegetables, total grains, whole grains and oils was higher than in the fourth quartile, while milk consumption was higher in the fourth quartile category of total fat and SFA intake than in the first quartile. Consumption of meat and starchy vegetables in the fourth quartile of total fat intake was higher than that in the first quartile, while consumption of dark green, starchy and other vegetables was lower in the fourth quartile of SFA intake compared with the first quartile. The dietary intake of all food groups and subgroups was found to be higher in the highest quartile category of dietary fibre intake (Table 2).

About two-thirds of participants were not meeting the WHO/FAO recommendations for $n-3$ PUFA (1.8% consumers), Na (8.8% consumers) and F&V (28.8% consumers). All WHO/FAO dietary factors differed between the first and fourth quartile categories of total fat and SFA intake, with the exception of total and $n-6$ PUFA. The dietary intake pattern of participants with a low energy

Table 1 Food sources of USDA food groups, listed in descending order by percentage contribution to food group intakes, of adult participants of Tehran Lipid and Glucose Study

Rank	Food item	Contribution to intake (%)
	Grain Group	
1	Refined*	68.5
2	Whole†	31.5
	Vegetables Group	
1	Dark green‡	27.8
2	Other vegetables	23.4
3	White potatoes§	18.7
4	Starchy vegetables except potato	13.9
5	Orange¶	6.5
6	Legumes	5.9
7	Tomatoes**	3.8
	Fruit Group	
1	Citrus, melons, and berries††	75.2
2	Other	24.8
	Milk Group	
1	Yoghurt‡‡	53.1
2	Milk§§	27.5
3	Cheese	19.1
	Meat and Beans Group	
1	Poultry¶¶	25.1
2	Meat	20.0
3	Nuts and seeds	13.6
4	Frankfurters, sausage, luncheon meats (made from meat or poultry)	11.4
5	Fish and shellfish low in <i>n</i> -3 fatty acids***	10.1
6	Cooked dry beans and peas	8.3
7	Eggs	7.2
8	Organ meats (meat, poultry)†††	4.3
	Oil	
1	Vegetable oil	76.1
2	Others (mayonnaise, etc.)	11.4
3	Fish	6.7
4	Nuts and seeds	5.8
	Extras	
1	Discretionary solid fat††††	61.1
2	Added sugars§§§§	38.9

USDA, US Department of Agriculture.

*White breads, iceberg bread, noodles, vermicelli, pasta, rice, toasted bread, milled barley, sweet bread, white flour, starch and biscuits, grain-based desserts, pizza, crackers.

†Dark breads, barley bread, corn flex, bulgur, germs, popcorn.

‡Lettuce, greens, spinach.

§White potatoes, all preparations.

||Corn, green peas.

¶Pumpkin, carrots.

**Tomato, tomato sauce.

††Melons, cantaloupe, casaba melon, watermelon, sour cherry, kiwifruit, grapefruit, strawberry, oranges, tangerine, lemons, limes, cranberries, and juices made from these fruits.

‡‡Low- and high-fat yoghurts, Iranian dairy product (condensed yoghurt, yoghurt drink, *kashk*).

§§Low- and high-fat milk, chocolate milk, milk-based desserts (various types of ice cream).

|||Cheese, pizza.

¶¶Chicken (with and without skin).

***Fish and tuna fish.

†††Liver, chicken heart and kidney, lamb brains and other visceral organs.

††††Whole dairy and high-fat meats group, grain-based desserts, regular cheese, sausage, frankfurters, chicken, eggs, burgers, organ meats, beef, pizza, fried potatoes, dairy desserts, burgers, margarine, butter, hydrogenated oil, coconut fat, cream, fried vegetables, animal fat, tallow.

§§§§Grain-based desserts, fruit in syrup, dairy desserts, candy, sugar and Iranian products, honey, chocolate, jam, soda, caramel.

intake from SFA was similar to that of participants with a low energy intake from total fat, except for *n*-3 PUFA intake, which was lower in the highest quartile category of SFA intake. There was a twofold difference in F&V consumption between the lowest and highest quartile categories of fibre intake (216 *v.* 425 g/d, $P < 0.001$; Table 3).

Table 4 presents the participants' characteristics and risk profiles according to low and high quartile categories of the common nutritional targets. There were more women

among the fourth quartile category of fibre intake, compared with the first category, while they comprised a lower proportion in the fourth quartile of total fat and SFA intake. Age was significantly lower in the fourth quartile category of total fat and SFA intake while it was significantly higher in the fourth quartile category of fibre and F&V intake. The mean values for WC, FBG, LDL cholesterol, TAG and SBP, and the percentage of current smokers, were significantly higher in the fourth quartile category of total fat and SFA

Table 2 Mean intake values of USDA food groups and subgroups according to the lowest and highest quartile categories of common nutritional targets of public health in a group of adult participants of the Tehran Lipid and Glucose Study

Food group	Common nutritional target															
	Total fat*				SFA†				F&V‡				Fibre§			
	Lowest, Q1		Highest, Q4		Lowest, Q1		Highest, Q4		Lowest, Q1		Highest, Q4		Lowest, Q1		Highest, Q4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Fruitt	2.16	0.1	1.86	0.1	2.93	0.9	1.56	0.8	0.74	0.5	4.23	0.5	1.61	0.1	2.24	0.1
Vegetables	2.50	0.1	2.47 ^{NS}	0.1	2.55	0.1	1.85	0.1	1.33	0.1	3.86	0.1	1.92	0.1	2.71	0.1
Dark green¶	0.82	0.04	0.36	0.04	0.87	0.05	0.47	0.04	0.46	0.04	1.15	0.02	0.42	0.04	0.84	0.04
Orange¶	0.15	0.02	0.14 ^{NS}	0.02	0.18	0.02	0.14 ^{NS}	0.01	0.07	0.01	0.32	0.01	0.12	0.02	0.32	0.02
Legumes¶	0.16	0.03	0.09	0.01	0.15	0.01	0.14 ^{NS}	0.01	0.15	0.01	0.16 ^{NS}	0.02	0.08	0.01	0.22	0.02
Starchy¶	0.16	0.02	0.41	0.01	0.43	0.01	0.13	0.01	0.15	0.01	0.22	0.01	0.15	0.01	0.24	0.01
Other¶	1.33	0.05	1.11	0.05	1.48	0.04	1.12	0.05	0.63	0.04	2.12	0.04	1.01	0.05	1.38	0.05
Grains**	9.97	3.9	8.11	3.8	10.45	4.3	8.43	3.6	8.05	3.5	10.17	3.5	7.87	3.8	12.60	3.8
Whole grains**	3.85	0.1	2.00	0.1	4.09	0.1	2.19	0.1	2.91	0.1	3.08	0.1	1.74	0.1	4.02	0.1
Other grains**	6.95 ^{NS}	1.0	5.04	1.2	6.74	1.3	5.39	1.0	6.80	1.2	7.98	1.1	6.21	0.9	8.97	1.1
Lean meat and beans**	3.10	0.2	4.71	0.1	2.93	0.1	2.87 ^{NS}	0.1	3.29	0.1	4.30	0.1	3.02	0.2	3.75	0.2
Milk	2.36	0.1	2.98	0.1	1.45	0.0	3.50	0.8	2.59	0.1	2.66 ^{NS}	0.1	1.96	0.1	3.17	0.1
Oils††	2.48	0.1	1.45	0.1	3.50	0.1	2.36	0.1	1.96	0.1	3.17	0.1	2.19	0.1	2.66	0.1

USDA, US Department of Agriculture; F&V, fruit and vegetables; Q, quartile.

Values are adjusted for total reported energy intake, sex and age. Analysis of covariance was used to test the difference between quartile categories of nutritional targets. All differences between groups were statistically significant except those identified as NS.

*Quartiles based on % of energy intake: Q1, <26.52; Q2, 26.52–30.86; Q3, 30.87–35.42; Q4, >35.42.

†Quartiles based on % of energy intake: Q1, <8.42; Q2, 8.42–10.12; Q3, 10.13–12.06; Q4, >12.06.

‡Quartiles based on g/d intake: Q1, <197.42; Q2, 197.42–296.46; Q3, 296.47–429.57; Q4, >429.57.

§Quartiles based on g/d intake: Q1, <19.11; Q2, 19.11–25.96; Q3, 25.97–36.17; Q4, >36.17.

||Intake units: cup-equivalents/d.

¶Intake units: cup-equivalents/week.

**Intake units: ounce-equivalents/d.

††Fat from plant sources including vegetable oils, nuts and seeds, and fish. Intake units: g/d.

intake. Participants in the highest quartile category of SFA intake had 16.2% lower HDL-C and 14.8% higher DBP compared with those in the lowest. MET was 8.6% lower in the fourth quartile of SFA intake than in the first, while it was 43.8% higher in fourth quartile category of F&V intake and 21.3% higher in the fourth quartile category of dietary fibre intake compared with the first.

After adjustment for potential confounding variables, a significant inverse trend was observed between the probability of having MetS and high intakes of dietary fibre and low intakes of SFA (Fig. 1).

Discussion

The present research provides an insight into the dietary patterns of Tehranian adults based on the most recent data obtained. Risk factor characteristics of Tehranian adults show great compatibility with their dietary patterns when analysed according to quartile categories of common nutritional targets of public health (total fat, SFA, fibre, F&V). The results of the present study are in accordance with those of other investigations, conducted in different countries, using nutritional targets of public health or dietary patterns in relation to CVD risk factors^(29–31,33,34).

Compared with the recommendations of the Dietary Guidelines for Americans 2005⁽¹²⁾, Tehranian adults failed to meet the recommendation for whole grains; they gained

about one-third of their total grains from whole grains, whereas the recommended amount is $\geq 50\%$. The corresponding intake of refined grains was 9.5% in the US National Health and Nutrition Examination Survey (NHANES) 2001–2002⁽³⁵⁾. The fact that rice was the highest contributor to cereal intake in the present study, while it contributed only 5.3% in NHANES⁽³⁴⁾, confirms the results of previous research documenting rice as the staple food in the Middle East region^(3,13). On the other hand, the contribution of dark green vegetables to total vegetable intake in Tehranian adults was almost 30%, a figure that is much higher than the recommended amount of 17%⁽¹²⁾, while dark green vegetable intake accounted for less than 6% of total vegetable intake in NHANES⁽³⁵⁾. The contributions of orange vegetables and legumes to total vegetable intake in TLGS fell drastically short of the recommended amount of 11% and 17%, similar to NHANES⁽³⁵⁾. In our study, more than 90% of the cup-equivalents of the fruit group were from whole (non-juice) fruits, a distribution that is consistent with the 2005 dietary guideline recommendations⁽¹²⁾; in addition, the main contributors of the milk and meat group were yoghurt and poultry, while milk and meat ranked first in NHANES⁽³⁵⁾.

Our findings show limited compliance with WHO/FAO food guide dietary factors among Tehranian adults, with less than half of them meeting the recommendations for total fat, SFA, PUFA (*n-6* and *n-3*), *trans* fatty acids, Na and F&V. These issues need to be strongly emphasized for successful achievement of both the WHO/FAO nutritional

Table 3 Mean intake values for the WHO/FAO food guide dietary factors according to the lowest and highest quartiles of common nutritional targets of public health in adult participants of the Tehran Lipid and Glucose Study

WHO/FAO food guide dietary factor	Recommended range	Consumer (%)	Common nutritional target															
			Total fat*				SFA†				F&V‡				Fibre§			
			Lowest, Q1		Highest, Q4		Lowest, Q1		Highest, Q4		Lowest, Q1		Highest, Q4		Lowest, Q1		Highest, Q4	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total fat¶	15–30%	43.5	23.2	0.1	40.9	0.1	27.3	0.2	39.7	0.2	38.6	0.3	24.1	0.3	36.2	0.3	28.0	0.2
SFA¶	<10%	48.2	4.3	0.2	16.1	0.2	8.0	0.2	16.4	0.2	13.1	0.2	6.8	0.2	11.7	0.2	9.24	0.2
PUFA¶	6–10%	46.1	3.86	0.1	9.17	0.1	5.95	0.1	6.01 ^{NS}	0.1	7.22	0.1	5.49	0.1	7.21	0.1	7.29 ^{NS}	0.1
n-6 PUFA¶	5–8%	44.8	3.91	0.1	7.65	0.1	5.06	0.1	5.11 ^{NS}	0.1	5.99	0.1	4.01 ^{NS}	0.1	6.47	0.1	5.17	0.1
n-3 PUFA¶	1–2%	1.8	0.21	0.01	0.63	0.01	0.48	0.01	0.23	0.01	0.44	0.01	0.61	0.01	0.31	0.10	0.52	0.08
Trans fatty acids¶	<1%	44.7	1.31	0.04	2.09	0.04	1.31	0.04	1.68	0.03	1.37	0.03	1.33 ^{NS}	0.04	1.62	0.04	1.37	0.03
Total carbohydrate¶	55–75%	65.2	63.9	0.1	51.1	0.1	65.8	0.2	49.9	0.2	57.8	0.3	62.9	0.2	56.3	0.3	64.7	0.2
Free sugars¶	<10%	86.4	5.43	0.2	8.03	0.1	6.90	0.2	7.29	0.2	7.90	0.2	5.16	0.2	7.40	0.2	5.21	0.1
Protein¶	10–15%	70.0	13.1	0.7	10.5	0.7	13.9	0.7	11.3	0.7	13.4	0.7	13.9 ^{NS}	0.7	13.5	0.7	13.8 ^{NS}	0.7
Cholesterol**	<300 mg/d	80.6	204	5	323	5	198	5	347	5	312	5	216	5	331	5	205	5
Natt	<2 g/d	8.8	10.2	1.3	12.3	1.3	10.1	1.3	11.3	1.3	13.1	1.3	10.4	1.3	14.0	1.3	9.21	1.3
Fruit and vegetablest†	≥400 g/d	28.8	356	8	289	8	341	8	313	8	139	4	638	4	216	7	425	7
Total dietary fibre††	>25 g/d	53.1	23.8	0.6	18.9	0.6	29.7	0.6	24.6	0.6	19.2	0.6	36.3	0.6	19.5	0.3	37.4	0.3
NSP††	>20 g/d	55.0	20.1	0.4	12.7	0.4	25.7	0.5	13.4	0.4	21.2	0.5	22.2 ^{NS}	0.5	16.2	0.5	31.9	0.5

F&V, fruit and vegetables; Q, quartile.

Values are adjusted for total reported energy intake, sex and age. Analysis of covariance was used to test the difference between quartile categories of nutritional targets. All differences between groups were statistically significant except those identified as NS.

*Quartiles based on % of energy intake: Q1, <26.52; Q2, 26.52–30.86; Q3, 30.87–35.42; Q4, >35.42.

†Quartiles based on % of energy intake: Q1, <8.42; Q2, 8.42–10.12; Q3, 10.13–12.06; Q4, >12.06.

‡Quartiles based on g/d intake: Q1, <197.42; Q2, 197.42–296.46; Q3, 296.47–429.57; Q4, >429.57.

§Quartiles based on g/d intake: Q1, <19.11; Q2, 19.11–25.96; Q3, 25.97–36.17; Q4, >36.17.

||Consumer of WHO/FAO dietary guidelines refers to an individual who has fully met the defined international dietary targets.

¶Intake units: % of energy.

**Intake units: mg/d.

††Intake units: g/d.

Table 4 Characteristics and risk factors according to the lowest and highest quartiles of common nutritional targets of public health in adult participants of the Tehran Lipid and Glucose Study

Characteristic/risk factor	Common nutritional target															
	Total fat*				SFA†				F&V‡				Fibre§			
	Lowest, Q1		Highest, Q4		Lowest, Q1		Highest, Q4		Lowest, Q1		Highest, Q4		Lowest, Q1		Highest, Q4	
	% or mean	SD	% or mean	SD	% or mean	SD	% or mean	SD	% or mean	SD	% or mean	SD	% or mean	SD	% or mean	SD
Female (%)	68.5	–	42.3	–	66.4	–	43.5	–	56.0	–	58.5 ^{NS}	–	36.8	–	63.2	–
Age (years)	41.6	10	37.3	14	42.3	12	36.9	13	36.1	11	40.5	13	38.2	10	40.1	9
WC (cm)	88.5	16	93.9	12	89.1	17	97.2	16	93.0	15	89.9	15	95.0	15	89.8	12
BMI (kg/m ²)	26.7	2	28.3	2	27.4	2	26.5 ^{NS}	1	28.8	2	26.1	2	27.5	1	26.5 ^{NS}	1
MET¶	1.62	0.7	1.60 ^{NS}	0.5	1.75	0.2	1.60	0.3	1.30	0.3	1.87	0.8	1.36	0.1	1.65	0.6
Current smoker (%)	9.0	–	12.7	–	9.3	–	11.7	–	10.8	–	9.7	–	11.1	–	10.8	–
FBG (mg/dl)	110	15	138	18	110	11	115	11	123	16	111	13	106	14	104 ^{NS}	16
LDL-C (mg/dl)	185	18	197	26	186	14	195	16	198	4	183	15	196	11	182	19
LnTAG** (mg/dl)	4.75	0.2	4.91	0.2	4.73	0.2	4.91	0.2	4.83	0.2	4.77 ^{NS}	0.2	4.87	0.2	4.78	0.2
HDL-C (mg/dl)	43.7	10	38.6	11	48.1	10	40.3	12	44.1	13	45.6 ^{NS}	10	45.9	11	44.1 ^{NS}	13
SBP (mmHg)	105	17	133	19	103	18	117	18	118	17	101	19	108	18	107 ^{NS}	19
DBP (mmHg)	70.9	11	72.0 ^{NS}	12	69.5	12	79.8	11	71.8	12	68.1	11	77.0	13	69.4	11

F&V, fruit and vegetables; Q, quartile; WC, waist circumference; MET, metabolic equivalents; FBG, fasting blood glucose; LDL-C, LDL cholesterol; HDL-C, HDL cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Variables were adjusted for age, sex, energy intake, smoking status and physical activity except otherwise noted. Analysis of covariance was used to test the difference between quartile categories of nutritional targets, except for percentage of females and current smokers for which the χ^2 test was used. Participants receiving treatments for any risk factors were excluded from the analysis (leaving *n* 2401 for analysis of FBG, *n* 2392 for analysis of SBP and DBP, and *n* 2385 for analysis of TAG and HDL-C). All differences between groups were statistically significant except those identified as NS.

*Quartiles based on % of energy intake: Q1, <26.52; Q2, 26.52–30.86; Q3, 30.87–35.42; Q4, >35.42.

†Quartiles based on % of energy intake: Q1, <8.42; Q2, 8.42–10.12; Q3, 10.13–12.06; Q4, >12.06.

‡Quartiles based on g/d intake: Q1, <197.42; Q2, 197.42–296.46; Q3, 296.47–429.57; Q4, >429.57.

§Quartiles based on g/d intake: Q1, <19.11; Q2, 19.11–25.96; Q3, 25.97–36.17; Q4, >36.17.

||Adjusted for sex, physical activity, smoking status and energy intake.

¶Adjusted for age, sex, energy intake and smoking status.

**TAG was transformed to the natural logarithm.

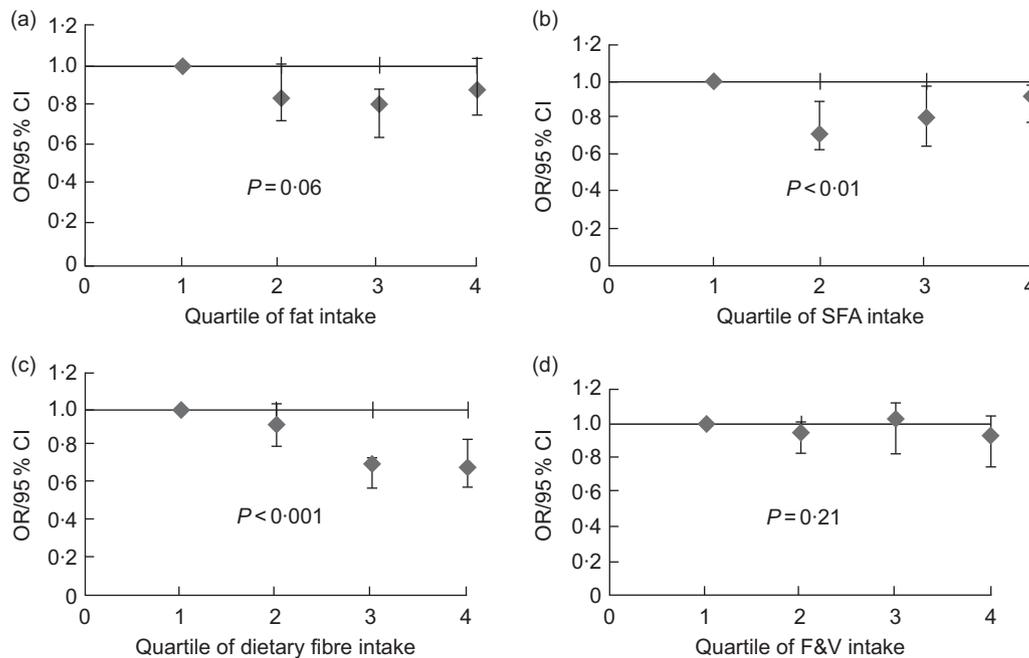


Fig. 1 Multivariate-adjusted odds ratios, with 95% confidence intervals represented by vertical bars, for clustering of three or more metabolic syndrome (MetS) risk factors across quartile categories of total fat (a), SFA (b), dietary fibre (c) and fruit and vegetables (F&V) (d) in participants of the Tehran Lipid and Glucose Study. After adjustment for potential confounding variables, participants in the fourth quartile of SFA intake had higher risk of having MetS compared with those in the first quartile (OR = 0.92, 95% CI 0.78, 0.98 v. OR = 0.71, 95% CI 0.62, 0.89; P -trend = 0.01), while those in the fourth quartile of fibre intake had lower risk of MetS compared with those in the first quartile (OR = 0.69, 95% CI 0.58, 0.84 v. OR = 0.92, 95% CI 0.80, 1.03; P -trend < 0.001)

goals and common targets of public health. The low consumption of F&V was accompanied by low compliance of dietary fibre intake with WHO/FAO recommendations, since the main dietary sources of fibre are cereals (especially whole grains), fruits and vegetables⁽³⁶⁾. The most important difference in the highest quartile category for fibre was the markedly higher F&V intake.

The largest disparity with the recommendations in the Tehranian population was observed for the intake of n -3 PUFA. The main source of fat in the Tehranian population was solid fat taken from animal products and the ratio of n -6 to n -3 fatty acids was 12.26, which is four to six times the optimal amount⁽³⁷⁾.

The dietary patterns of individuals in relation to both WHO/FAO recommendations and USDA food guidelines in quartile categories of total fat and SFA intake had similarities, and the dietary pattern of individuals in quartile categories of fibre intake was in line with the pattern seen in quartiles of F&V intake. Therefore it was hypothesized that the dietary patterns of participants in the lowest quartiles of total fat and SFA intakes and highest quartiles of fibre and F&V intakes could be used to develop FBDG based on the Tehranian dietary pattern, since it permits achievement of dietary recommendations. Analysing the dietary patterns of participants in the low and high quartiles of nutritional targets can be used as a model for developing realistic dietary guidelines; it can also help authorities to aim interventions at increasing the

percentage of consumers or average intakes of certain food items. To be pragmatic, dietary guidelines should be based on an assessment of the data available and include evaluation of prevailing dietary patterns compared with recommended optima⁽³⁸⁾. Large disparities between prevailing and ideal dietary habits need to be addressed by means of a step-wise approach.

Being a women, older, more physically active and a non-smoker were associated with being in the lowest quartiles of total fat and SFA and highest quartiles of fibre and F&V. Common risk factors for CVD increased with being in the highest quartiles of total fat and SFA and lowest quartiles of fibre and F&V. The probability of having MetS was higher in the highest quartile of SFA intake and lowest quartile of fibre intake, suggesting that increasing fibre intake and decreasing SFA intake would be good strategies to decrease the risk of MetS in both genders.

There are some potential limitations in the present research. First, we assessed the dietary patterns of Tehranian adults against the latest USDA food groups, due to the lack of quantitative dietary guidelines for the Iranian population⁽¹³⁾. Also, the common targets of public health are mainly established for the EU countries and applying them to other nations could be problematic; however, to compensate for these limitations, we assessed the dietary patterns of Iranian adults against the WHO/FAO food guide dietary factors and also evaluated the face validity of these dietary recommendations by considering the

metabolic risk factors and demographic profiles of individuals. Another limitation was calculating discretionary energy based solely on the solid fat and added sugar intakes due to a lack of data on alcohol consumption. Alcohol consumption is prohibited in the Islamic Republic of Iran and those who do drink refrain from reporting their intake; therefore there are currently no official, semi-official or reported data on prevalence of alcohol consumption in Iran⁽³⁹⁾. Moreover, the cross-sectional nature of the data cannot show accurately the compliance of participants with nutritional targets and its relationship with risk profiles; thus it is recommended that future studies be conducted in a population-based cohort format. Also use of an FFQ for collection of dietary data may make the interpretation of the dietary intake erratic, although the FFQ used in the present study was validated⁽²⁶⁾.

The strength of the present study is that it is the first population-based analysis from the Middle East region, in a developing country, attempting to investigate dietary patterns in relation to WHO/FAO, USDA and nutritional targets of public health and simultaneously their impact on risk factors. The long-term aim of the study is to develop country-based dietary guidelines according to dietary patterns of individuals who demonstrate good compatibility with current dietary recommendations. Furthermore, the study results indicate the major subgroups contributing to different food groups, which can be used for targeting key foods in each food group in an attempt to eliminate those foods which contribute the most to dietary imbalance.

Conclusions

The proportion of Tehranian adults meeting WHO/FAO recommendations varies according to nutrient, with *n*-3 PUFA and Na recommendations being the most difficult to meet. The findings of the present study confirm that complying with the common nutritional targets of public health is inversely associated with MetS risk factors in Tehranian adults. Moreover, the assessment of food and nutrient intakes in quartiles of nutritional targets provides the first indications for future development of regional FBDG. The results of the present study suggest dietary interventions which need to be considered as priorities for the Iranian population.

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and wrote the manuscript; P.M. and F.A. designed and supervised the study and edited the final manuscript. The authors would like to thank the adults who participated in the study. They are grateful to the staff of the nutrition department of the Obesity Research Center, Shahid Beheshti University of Medical Sciences and also thank Ms N. Shiva for the language editing of the manuscript.

References

1. Brunner EJ, Rees K, Ward K *et al.* (2007) Dietary advice for reducing cardiovascular risk. *Cochrane Database Syst Rev* issue 4, CD002128.
2. Ghassemi H, Harrison G & Mohammad K (2002) An accelerated nutrition transition in Iran. *Public Health Nutr* **5**, 149–155.
3. Atinmo T, Mirmiran P, Oyewole OE *et al.* (2009) Breaking the poverty/malnutrition cycle in Africa and the Middle East. *Nutr Rev* **67**, Suppl. 1, S40–S46.
4. Hosseinpanah F, Barzin M, Eskandary PS *et al.* (2009) Trends of obesity and abdominal obesity in Tehranian adults: a cohort study. *BMC Public Health* **9**, 426.
5. Harati H, Hadaeagh F, Saadat N *et al.* (2009) Population-based incidence of type 2 diabetes and its associated risk factors: results from a six-year cohort study in Iran. *BMC Public Health* **9**, 186.
6. Azizi F, Salehi P, Etemadi A *et al.* (2003) Prevalence of metabolic syndrome in an urban population: Tehran Lipid and Glucose Study. *Diabetes Res Clin Pract* **61**, 29–37.
7. Delavari A, Forouzanfar MH, Alikhani S *et al.* (2009) First nationwide study of the prevalence of the metabolic syndrome and optimal cutoff points of waist circumference in the Middle East: the national survey of risk factors for noncommunicable diseases of Iran. *Diabetes Care* **32**, 1092–1097.
8. Serra-Majem L, Aranceta J; SENC Working Group on Nutritional Objectives for the Spanish Population, Spanish Society of Community Nutrition (2001) Nutritional objectives for the Spanish population. Consensus from the Spanish Society of Community Nutrition. *Public Health Nutr* **4**, 1409–1413.
9. Becker W, Gibney M, Kearney J *et al.* (1999) Foreword. *Br J Nutr* **81**, Suppl. 2, S29.
10. Chinese Nutrition Society (2000) Dietary guidelines and food guide pagoda. *J Am Diet Assoc* **100**, 886–887.
11. Koening J & Elmadfa I (1999) Food-based dietary guidelines – the Austrian perspective. *Br J Nutr* **81**, Suppl. 2, S31–S35.
12. US Department of Health and Human Services & US Department of Agriculture (2005) *Dietary Guidelines for Americans, 2005*, 6th ed. Washington, DC: US Government Printing Office; available at <http://www.health.gov/dietaryguidelines/dga2005/document/pdf/dga2005.pdf>
13. Safavi SM, Omidvar N, Djazayeri A *et al.* (2007) Development of food-based dietary guideline for Iran: a preliminary report. *Ann Nutr Metab* **51**, Suppl. 2, 32–35.
14. World Health Organization/Food and Agriculture Organization of the United Nations (2003) *Diet, Nutrition and the Prevention of Chronic Diseases. Report of a Joint WHO/FAO Expert Consultation. WHO Technical Report Series* no. 916. Geneva: WHO.
15. Azizi F, Ghanbarian A, Momenan AA *et al.*; the Tehran Lipid and Glucose Study Group (2009) Prevention of non-communicable disease in a population in nutrition transition: Tehran Lipid and Glucose Study phase II. *Trials* **10**, 5.
16. Azizi F, Rahmani M, Emami H *et al.* (2002) Cardiovascular risk factors in an Iranian urban population: Tehran Lipid and Glucose Study. *J Soc Prev Med* **47**, 408–426.
17. Hosseini-Esfahani F, Jessri M, Mirmiran P *et al.* (2010) Adherence to dietary recommendations and risk of

- metabolic syndrome: Tehran Lipid and Glucose Study. *Metabolism* **59**, 1833–1842.
18. McCrory MA, Hajduk CL & Roberts SB (2002) Procedures for screening out inaccurate reports of dietary energy intake. *Public Health Nutr* **5**, 873–882.
 19. Kriska AM, Knowler WC, Laporte RE *et al.* (1990) Development of questionnaire to examine relationship of physical activity and diabetes in Pima Indians. *Diabetes Care* **13**, 401–411.
 20. Kriska AM & Caspersen CJ (1997) Introduction to the collection of physical activity questionnaires. In A Collection of Physical Activity Questionnaires for Health-related Research [AM Kriska and CJ Caspersen, editors]. *Med Sci Sports Exerc* **29**, Suppl., S5–S9.
 21. Ainsworth BE, Haskell WL, Whitt MC *et al.* (2000) Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc* **32**, 9 Suppl., S498–S504.
 22. US Department of Health and Human Services, Centers for Disease Control and Prevention (2003) General Physical Activities Defined by Level of Intensity. http://www.cdc.gov/nccdphp/dnpa/physical/pdf/PA_Intensity_table_2_1.pdf
 23. World Health Organization (1998) *Guideline for Controlling and Monitoring the Tobacco Epidemic*. Geneva: WHO.
 24. Grundy SM, Cleeman JI, Daniels SR *et al.* (2005) Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation* **112**, 2735–2752.
 25. Azizi F, Khalili D, Aghajani H *et al.* (2010) Appropriate waist circumference cut-off points among Iranian adults: the first report of the Iranian National Committee of Obesity. *Arch Iran Med* **13**, 243–244.
 26. Mirmiran P, Esfahani FH, Mehrabi Y *et al.* (2009) Reliability and relative validity of an FFQ for nutrients in the Tehran Lipid and Glucose Study. *Public Health Nutr* **13**, 645–662.
 27. Ghaffarpour M, Houshiar-Rad A & Kianfar H (1999) *The Manual for Household Measures, Cooking Yields Factors and Edible Portion of Food*. Tehran: Keshaverzi Press.
 28. US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory (2006) USDA Nutrient Database for Standard Reference, Release 19. <http://www.nal.usda.gov/fnic/foodcomp/search/> (accessed December 2009).
 29. Becker W (1999) Dietary guidelines and patterns of food and nutrient intake in Sweden. *Br J Nutr* **81**, Suppl. 2, S113–S117.
 30. Matthys C, De Henauw S, Bellemans M *et al.* (2006) Sources of saturated fatty acids in Belgian adolescents' diet: implications for the development of food-based dietary guidelines. *Br J Nutr* **95**, 546–554.
 31. Tur JA, Romaguera D & Pons A (2005) Does the diet of the Balearic population, a Mediterranean-type diet, ensure compliance with nutritional objectives for the Spanish population? *Public Health Nutr* **8**, 275–283.
 32. Friday JE & Bowman SA (2006) MyPyramid Equivalents Database for USDA Survey Food Codes 1994–2002 Version 1.0. <http://www.ars.usda.gov/ba/bhnrc/fsrg/> (accessed January 2009).
 33. Lutsey PL, Steffen LM & Stevens J (2008) Dietary intake and the development of the metabolic syndrome: the Atherosclerosis Risk in Communities study. *Circulation* **117**, 754–761.
 34. Nettleton JA, Steffen LM, Ni H *et al.* (2008) Dietary patterns and risk of incident type 2 diabetes in the Multi-Ethnic Study of Atherosclerosis (MESA). *Diabetes Care* **31**, 1777–1782.
 35. Bachman JL, Reedy J, Subar AF *et al.* (2008) Sources of food group intakes among the US population, 2001–2002. *J Am Diet Assoc* **108**, 804–814.
 36. Cleveland LE, Moshfegh AJ, Albertson AM *et al.* (2000) Dietary intake of whole grains. *J Am Coll Nutr* **19**, 3 Suppl., 331S–338S.
 37. Haag M (2003) Essential fatty acids and the brain. *Can J Psychiatry* **48**, 195–203.
 38. Wearne SJ & Day MJ (1999) Clues for the development of food-based dietary guidelines: how are dietary targets being achieved by UK consumers? *Br J Nutr* **81**, Suppl. 2, S119–S126.
 39. Food and Agriculture Organization of the United Nations (2007) FAOSTAT online database, Food Balance Sheets, Islamic Republic of Iran, 2007. <http://faostat.fao.org/site/368/default.aspx#ancor> (accessed January 2010).