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ORIGINAL ARTICLE

Using factor analysis to identify dietary patterns in Iranian adults: Isfahan healthy heart program

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Abstract
Objective To identify dietary patterns of a representative sample of Iranian adults using factor analysis.
Methods This study was conducted in 2000–2001 as the baseline survey of Isfahan Healthy Heart Program (IHHP). We studied 12,514 participants aged ≥19 years who were randomly selected in three counties of Central Iran. A validated 48-item food frequency questionnaire was completed and factor analysis was used to identify dietary patterns.
Results Four major dietary patterns were identified, namely "Western", "animal fat", "traditional" and "Mediterranean". In both men and women, we found a significant positive relationship between age and Mediterranean diet, and a negative relationship between age and the other three dietary patterns ($P < 0.001$). The Western and traditional dietary patterns showed a significant negative relationship with education in both genders ($P < 0.01$). The Western dietary pattern correlated positively with being single, widowed, or a divorced man ($P < 0.001$).
Conclusions We identified four major dietary patterns. As dietary pattern analysis is useful to identify dietary behaviors in relation to health risks, the results can be practical.

Keywords Iran · Dietary pattern · Food frequency questionnaire · Factor analysis

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Introduction

Like many developing countries, Iran has experienced a rapid nutritional transition, with the population gravitating toward Western diets. This and other unhealthy lifestyle changes have significantly increased the prevalence of cardiovascular diseases (CVDs) and their related risk factors (SarrafZadegan et al. 1999a). CVDs are considered as the most important cause of mortality in Iran (Sarraf-Zadegan et al. 1999b) and absolute risk of ischemic heart disease was 8.9 per 1,000 person-years in Iranian adults population (Sarrafzadegan et al. 2010). Nutrition epidemiology explains the complexity of diet in

relation to non-communicable disease such as CVD, cancer, diabetes and obesity (Hu et al. 1999; Osler et al. 2001; Sanchez-Villegas et al. 2003; Schulze et al. 2003; Pala et al. 2006). Separating the effect of individual foods or nutrients on disease progress is complicated (Hoffmann et al. 2004). Assessment of dietary patterns allows the estimation of the cumulative/interactive effects of the whole diet (Hu 2002; Sanchez-Villegas et al. 2003; Schulze and Hoffmann 2006); also it is a better predictor of disease compared to a single food- or nutrient-based approach (Kant 2004).

We can identify dietary patterns by use of either the 'a priori' approach or the 'a posteriori' approach. In the 'a priori' approach, diet scores are constructed based on dietary recommendations. In the 'a posteriori' approach, diet scores are derived from data-drive statistical models (e.g. factor/cluster analysis) (Schulze et al. 2003; Kant 2004; Villegas et al. 2004b). These models can be used to define dietary patterns and assess the cumulative effect of combined foods (Millen et al. 2001; Khani et al. 2004). Several studies have shown that factor/cluster analysis can replace nutrient-based analysis in predicting the risk of disease and/or mortality in relation to food habits (Schulze et al. 2001, 2003; Hu 2002; Kerver et al. 2003; Togo et al. 2003; Khani et al. 2004; Villegas et al. 2004a, b; Millen et al. 2005). This approach can also be used to manage and prevent chronic health problems by proposing intervention strategies (Millen et al. 2001).

The food frequency questionnaire (FFQ) is a simple and inexpensive dietary assessment method which has been applied in epidemiology of nutrition (Kant 1996; Togo et al. 2001) and has been used in factor analysis (Togo et al. 2003). Such information is important for assessing the requirements of community-based interventions and defining health strategies in different populations. Very limited information exists from developing countries, which are facing rapid epidemiologic transition, and probably an epidemic of chronic diseases in the near future. The objectives of our study were to identify dietary patterns of a representative sample of Iranian adults using factor analysis. We also aimed to assess the relationship between major dietary patterns and sociodemographic characteristics.

Methods

This study was conducted in the baseline survey of a healthy lifestyle community trial entitled the Isfahan Healthy Heart Program (IHHP). We have previously described its methodology in details (Sarraf-Zadegan et al. 2003; Sarrafzadegan 2006).

Brief description of the IHHP

IHHP was a long-term comprehensive community-based interventional program for non-communicable disease prevention and health promotion by improving lifestyle habits and reducing CVD risk factors and related morbidity/mortality. It was conducted between 2001 and 2007 in three counties including Isfahan, Najaf-Abad and Arak in Central Iran (Sarraf-Zadegan et al. 2003; Sarrafzadegan 2006). Multistage sampling method was used to stratify the study population according to area of residence and regional population distribution as per a national population census conducted in 2000. The sample size was 12,600 individuals. The individuals were selected randomly from amongst adults aged 19 years or higher, to reflect the sex/age distribution and geographic characteristics of their respective communities. The study design and sampling method have been presented elsewhere (Sarraf-Zadegan et al. 2003; Sarrafzadegan 2006). FFQ were completed for all adults aged $\geq$19 years participating in the baseline survey in 2000–2001.

Data collection

All individuals undertook a 30-minute home interview conducted by a trained health professional. The questionnaires were designed to obtain information about the socioeconomic and demographic characteristics, as well as medical/family history, lifestyle behaviors including, smoking status, amount of physical activity, and dietary habits of the respondents (Sarraf-Zadegan et al. 2003; Sarrafzadegan 2006).

Dietary assessment

The dietary habits were assessed by a validated 48-item FFQ including frequently consumed foods which was adjusted from the Countrywide Integrated Non-communicable Disease Intervention (CINDI) program questionnaire (McNaughton et al. 2007). The FFQ of CINDI was translated from English to Persian by a nutritionist and back translated by another. Then it was approved by three nutrition experts. Foods which were not consumed in Iran were excluded. As this study was done concerning CVD risk factors, some typical Iranian foods which were considered to be important contributors to total/saturated fat intake were added. The list of food item was presented elsewhere (Sarrafzadegan et al. 2009). The FFQ obtained the frequency of consumption without asking about the portion size. Participants were asked "how often did you eat these foods over the past year?" Four predefined frequency categories, namely "never", "seldom", "daily", "weekly" and "monthly" were used. All frequencies were converted to weekly consumption. The face and content validity, as well as translation of the questionnaire were assessed by an

expert panel of five nutritionists. The FFQ was pretested for precision among 200 adults aged 19–69 years who were not among samples of the main study; they completed the questionnaire twice 2 weeks apart to evaluate test–retest reliability (Mohammadifard et al. 2009).

Statistical analysis

Food patterns were identified by factor analysis (principle component) of the 48 food items surveyed through determination of weekly consumption frequency. The factors were rotated by an orthogonal transformation to minimize the number of variables that have high loadings on each factor. SPSS for Windows (version 15.0; SPSS Inc., Chicago, IL, USA) was used for data analysis. This method yields simpler structure and greater interpretability.

We focused on factors with eigen values greater than 1.0 which produced nine dietary patterns. According to the scree plot and interpretability of the factors, four major dietary patterns were clearly identified among Iranian men and women. We labeled these patterns as "Western diet", "animal fat diet", "traditional diet" and "Mediterranean diet" for use in further analyses. A factor score was calculated for every individual based on the weekly frequency consumption of the 48 items, and the rescaled score coefficient of each factor that emerged from the data. Factor loadings represent correlation coefficients between each food group and dietary pattern. In this study factor loadings ≥ 0.2 were presented. Food groups with positive loading represent contribution to a dietary pattern and those with negative loadings are inversely associated with a dietary pattern. The proportion of variance explained by each factor was calculated by dividing the sum of the squares of the respective factor loadings by the number of food groups. Multiple linear regressions were used to identify the association between dietary patterns and sociodemographic characteristics after adjustment for the effects of total physical activity, smoking, and taking antihypertensive, antihyperlipidemic and hypoglycemic medications and CVD; diabetes and cancer histories were excluded in data analysis. Dietary patterns were considered as dependent and sociodemographic factors were independent variables. Age, education, marital status and income were treated as ordinal variables and all of them were inserted in the same model. *P* value less than 0.05 was considered significant.

Results

The interview response rate was 98%. Our sample comprised 12,514 individuals, of whom 6,391 (51.1%) were women and 6,123 (48.9%) were men. Of this population, 9,093 (72.7%) lived in cities and 3,421 (27.3%) in rural areas. Table 1 shows 22 food/food groups derived from 48

Table 1 Food groupings used in the dietary pattern analyses of healthy Iranian adults: Isfahan Healthy Heart Program, 2000–2001

Food group	Food item
Whole dairy products	Whole fat milk, whole fat yogurt
Fast foods	Sausages, hamburger, pizza
Animal fats	Ghee, butter, tallow
Organ meats	Liver, lung
Fruits and vegetables	Fruits, vegetables
Sweets	Pastry, biscuits, cookies, chocolates, jam
Red meat	Beef, lamb
Chicken	Chicken
Fish	Fish
Hydrogenated oil	Hydrogenated oil
Liquid oil	Liquid oil
Olive oil	Olive oil
Bread	All kinds of bread
Rice	Rice
Pickle and sour cucumber	Pickle and sour cucumber
Beans	Beans
Egg	Egg
Dried fruits	Dried fruits, date
Salty nuts and seeds	Salty almond, pistachio, walnut and all kinds of seeds
Canned food	All kinds of canned food
Carbonated beverages	All kinds of carbonated beverages
Junk foods	Potato chips, Cheese puffs

Table 2 Factor-loading matrix for major dietary patterns in healthy Iranian adults: Isfahan Healthy Heart Program, 2000–2001

Western diet (Component 1)		Animal fat diet (Component 2)		Traditional diet (Component 3)		Mediterranean diet (Component 4)	
Food groups	Loading factor	Food groups	Loading factor	Food groups	Loading factor	Food groups	Loading factor
Men							
Sweets	0.974	Animal fats	0.926	Potato	0.821	Liquid oil	0.970
Carbonated beverages	0.729	Whole dairy products	0.594	Beans	0.676	Chicken	0.264
Fast foods	0.349	Egg	0.202	Red meats	0.553	Fish	0.246
Junk foods	0.337			Egg	0.288	Olive oil	0.219
Salty nuts and seeds	0.310			Dried fruits	0.276	Fruits and vegetables	0.211
Canned foods	0.219					Hydrogenated oil	−0.331
Organ meats	0.207						
Women							
Sweets	0.966	Animal fats	0.935	Potato	0.830	Liquid oil	0.964
Carbonated beverages	0.657	Whole dairy products	0.521	Beans	0.634	Chicken	0.329
Junk foods	0.332			Red meats	0.577	Fruits and vegetables	0.292
Fast food	0.299	Organ meats	0.212	Egg	0.267	Fish	0.274
Salty nuts and seeds	0.256	Egg	0.205	Dried fruits	0.241	Olive oil	0.254
						Hydrogenated oil	−0.302

food items. Iranian men and women followed four major dietary patterns (Table 2). They were labeled as "Western diet", "animal fat diet", "traditional diet" and "Mediterranean diet". Despite some differences, men and women followed essentially the same major dietary patterns. The Western diet was characterized by high intake (i.e. high positive factor loadings) of sweets, carbonated beverages, fast foods, junk foods, salty nuts/seeds, canned foods, and organ meat in men, and sweets, carbonated beverages, junk foods, fast foods and salty nuts/seeds in women. The animal fat diet was described as high intake (i.e. high positive factor loadings) of animal fats, whole dairy products and eggs in men, and animal fats, whole dairy products, organ meat and eggs in women. The traditional diet was characterized by high intake of potatoes, beans, red meat, eggs and dried fruits in men and women. The Mediterranean diet was characterized by high intake of liquid oil, chicken, fish, dates, olive oil and fruit and vegetables, and low intake of hydrogenated oil in men, and high intake of liquid oil, chicken, dates, fruit and vegetables, fish and olive oil, and low intake of hydrogenated oil in women. Table 3 shows the association between dietary patterns and sociodemographic characteristics. While age correlated positively with the Mediterranean diet, it was found to be inversely related to other dietary patterns ($P < 0.05$). The Western and traditional dietary patterns had a significant negative relationship with education, whereas the Mediterranean diet showed a significant positive correlation with education in both men and women ($P < 0.01$). The relationship between dietary pattern and marital status was insignificant, except for the Western diet which correlated significantly with being single, widowed, and a divorced man ($P < 0.001$). Income had a significant relationship with the Mediterranean diet in both men and women ($P < 0.001$).

In men, the four factors accounted for 42.5% of the total between-person variance in dietary patterns (i.e. variance explained). In women the four factors accounted for 41.4% of the total variance.

Discussion

Identifying dietary patterns by use of factor analysis is an analytical approach to reflect dietary complexities (Schulze and Hoffmann 2006) that are epidemiologically more important than individual components (Hu et al. 2000). Understanding dietary patterns is essential to prevent chronic diseases, especially CVD and its major risk factors which are known to have multiple dietary components (Kerver et al. 2003; Schulze and Hoffmann 2006). Findings in factor analysis were unlike in different studies (Martinez et al. 1998; Sieri et al. 2004; Osler et al. 2001). It might not be repeated (Martinez et al. 1998) or might have similar results in different societies (Sieri et al. 2004; Osler et al. 2001). Hence we used factor analysis to define dietary patterns of Iranian adults in Central Iran. Our findings were largely similar to previous studies (Slattery et al. 1998;

Table 3 Regression model for association between dietary patterns and sociodemographic characteristics in healthy Iranian adults: Isfahan Healthy Heart Program, 2000–2001

Dietary patterns	R^2	Age	Education	Marital status	Income
Men					
Western diet	0.11	−0.19***	−0.05**	0.03***	0.06
Animal fat diet	0.03	−0.18***	−0.03	−0.01	0.02
Traditional diet	0.01	−0.05*	−0.12***	0.002	−0.01
Mediterranean diet	0.08	0.17***	0.25***	0.04	0.11***
Women					
Western diet	0.06	−0.11***	−0.12***	0.03	0.05
Animal fat diet	0.03	−0.15***	0.007	−0.02	0.03
Traditional diet	0.01	−0.12***	−0.13***	−0.01	0.002
Mediterranean diet	0.09	0.22***	0.31***	−0.01	0.11***

Data are expressed as standardized coefficients β. Multiple linear regressions were used by adjusting for the effects of total physical activity, smoking, and taking antihypertensive, antihyperlipidemic and hypoglycemic medications

*** P value < 0.001

** P value < 0.01

* P value < 0.05

Kerver et al. 2003; Fung et al. 2004). We identified four major dietary patterns in Iranian men and women, although small gender differences were perceived in some food items/groups. Two dietary patterns, namely Western and animal fat diets were considered unhealthy, while the Mediterranean dietary pattern was considered healthy. Terry et al. (2001) recognized three major dietary patterns in Swedish women: "Healthy," "Western" and "Drinker". Hu et al. (2000) identified two major dietary patterns: "Prudent" and "Western". The former consisted of vegetables, fruits, legumes, whole grains, and fish. The "Western" diet which was identified in American men consisted of processed meat, red meat, butter, high-fat dairy products, eggs, and refined grains. Slattery et al. (1998) recognized five major dietary patterns in the American population: "Western", "Prudent", "high fat/sugar dairy", "substitutes", and "Drinker". We broadly identified two main dietary patterns in this study including "Mediterranean" and "Western" such as American and Swedish populations (Hu et al. 2000; Khani et al. 2004; Schulze and Hoffmann 2006). However, dietary patterns are best identified using factor analysis to account for geographical, cultural and methodological variations between populations (Hu et al. 2000).Our findings are consistent with a previous study of a population of Korean-Americans revealing three similar major food patterns in men and women, with minor gender differences (Yang et al. 2005). In our study, 42.5% of the total variance for men and 41.4% of the total variance for women accounted for the four major dietary patterns, whereas the corresponding figures were 29.5% for men and 27.4% for women in Korean-American population (Yang et al. 2005).

In our study, the Western and animal fat diets were presented in components 1 and 2, while the Mediterranean diet was presented in component 4. It can, therefore, be concluded that the Iranian adults have adopted an unhealthy diet consistent with the Western dietary pattern. The Mediterranean dietary pattern has perceived protective effects against chronic conditions such as CVD and cancer (Joshipura et al. 1999; Kris-Etherton et al. 2001); hence, lower adherence to the Mediterranean diet in the Iranian population may lead to increased prevalence of chronic non-communicable diseases in Iran, on a par with trends observed in Japan and the United States of America (Willett and Hunter 1994).

The significant relationship between dietary patterns and sociodemographic characteristics confirms the benefits of healthy food consumption (González et al. 2002).The hypothesis that healthy food consumption is a part of health-related characteristics was supported by significant relation of the dietary patterns to sociodemographic characteristics. Our results showed significant relationships between unhealthy dietary patterns (i.e. Western and animal fat diets) and sociodemographic characteristics such as being younger and less educated, both in men and women. Singles, widows and divorced men were more likely to adopt unhealthy dietary patterns than married individuals. Also, being educated was associated with a higher likelihood of preferring a Mediterranean dietary pattern to a Western one. We found a greater tendency in higher-income individuals to follow a Mediterranean diet.

Highly educated Spanish individuals apparently abandoned the Spanish-Mediterranean dietary pattern. Sanchez-Villegas et al. (2003) reported that the younger Spanish

were more likely to follow the Western dietary pattern. It seems that younger Iranians are also more interested in the Western dietary pattern. Contrary to our findings, married Spanish men seemed less likely to adhere to traditional dietary habits (Sanchez-Villegas et al. 2003). In a study of healthy American adults, Kerver et al. (2003) reported similar results with age and education, but inverse results with income. They also showed that women and high socioeconomic populations are more likely to consume vegetable-rich dietary patterns. Randall et al. (1990) reported that differences of income affected women's dietary patterns. In the study conducted by Yang et al. (2005), Korean-American women who had lived longer in the US consumed food items in the Western dietary pattern.

Besides sociodemographic factors, lifestyle characteristics and CVD risk factors may affect dietary patterns, therefore the effects of total physical activity, smoking, taking antihypertensive, antihyperlipidemic or hypoglycemic medications were statistically controlled for the multivariate analyses.

Study limitations and strengths

This study had some limitations. Our FFQ contained 48 common food items. It was shorter than some other FFQs used to obtain information about dietary patterns (Khani et al. 2004). Also, our questionnaire was qualitative and did not quantify food and the absence of the measure of total energy intake. Under-reporting and/or over-reporting is also a common drawback to which we were not immune. However, FFQs used in most large epidemiologic studies are more concerned with assessment of common dietary elements than with other factors (Kerver et al. 2003). Perhaps the main strength of this study is that it is the first of its kind in a large representative sample of population in a developing country.

Conclusions

We conclude that Iranian adults follow four major dietary patterns, namely "Western", "animal fat", "traditional" and "Mediterranean". There are only small differences between men and women in some food items/groups. The Western diet was presented in the first component, hence it can be concluded that the Iranian families have adopted Western dietary habits. Older individuals and those who were more educated, as well as married men were more likely to follow healthier dietary habits. Higher income was associated with a Mediterranean dietary pattern.

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Conflict of interest The authors declare that they have no conflict of interests.

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