



# Evaluation of dietary pattern stability and physical activity in three consecutive generations of women

Marzie Asgari Noori · Reza Ghiasvand · Zahra Maghsoudi ·  
Awat Feizi · Ahmad Esmailzadeh · Peyman Adibi · Ammar Hassanzadeh Keshteli

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## Abstract

**Objectives** This study aimed to characterize major dietary patterns (DPs) in three consecutive generations and to delineate DP changes.

**Methods** Usual dietary intakes of 547 women from three generations were assessed using a validated dish-based Food Frequency Questionnaire. Factor analysis was performed to identify DPs, participants' scores for each DP were calculated and changes in DP scores and mean consumption of food groups were evaluated. Using Latent Class Analysis (LCA), participants were ranked according to their scores receiving for each DP.

**Results** Three major DPs, defined as Traditional (TDP), Healthy (HDP), and Western (WDP) and the comparison of DP adherence between generations showed that TDP remained stable over time. WDP and HDP scores increased from Generation 1 to the recent. Based on LCA, the

“multifarious class” was similar in three generations. The “traditional class”, “transitional class”, and “health conscious class” were defined within the oldest, middle-aged, and younger generation, respectively.

**Conclusions** The younger women tended to have higher score for both WDP and HDP. This paradox may be as a result of health conscious behaviors parallel the unfavorable inevitable lifestyle changes.

**Keywords** Dietary patterns · Stability · Nutrition transition · Generation

## Introduction

As a major component of lifestyle, diet contributes to health status (Kant 2004; Hu 2002). Despite the growing interest in evaluation of dietary patterns, there is scanty knowledge about individuals' and populations' dietary pattern changes over time. The unfavorable accelerating changes in diet are reflected in increasing prevalence of

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M. A. Noori · R. Ghiasvand · Z. Maghsoudi · A. Esmailzadeh  
Food Security Research Center, School of Nutrition and Food  
Sciences, Isfahan University of Medical Sciences, Isfahan, Iran  
e-mail: Asgari.nut90@yahoo.com

Z. Maghsoudi  
e-mail: Z\_maghsoudi@hlth.mui.ac.ir

A. Esmailzadeh  
e-mail: Esmailzadeh@hlth.mui.ac.ir

M. A. Noori · R. Ghiasvand (✉) · Z. Maghsoudi ·  
A. Esmailzadeh  
Department of Community Nutrition, School of Nutrition and  
Food Sciences, Isfahan University of Medical Sciences, Isfahan,  
Iran  
e-mail: Ghiasvand\_r@yahoo.com

A. Feizi  
Faculty of Epidemiology and Biostatistics, Isfahan University of  
Medical Sciences, Isfahan, Iran  
e-mail: Awat\_feizi@hotmail.com

P. Adibi · A. H. Keshteli  
Integrative Functional Gastroenterology Research Center,  
Isfahan University of Medical Sciences, Isfahan, Iran  
e-mail: adibi@med.mui.ac.ir

A. H. Keshteli  
e-mail: hassanzadeh@med.mui.ac.ir

A. H. Keshteli  
Department of Medicine, University of Alberta, Edmonton,  
Canada

overweight, obesity, and other non-communicable diseases (NCDs), such as diabetes, cardiovascular disease (CVD), and cancer, particularly in developing countries (Newby et al. 2006; Popkin 1998; Reddy 2002; Mehio Sibai et al. 2010).

Many factors contribute to the changes in individual's dietary patterns; several studies have pointed out the social-economic status and important lifetime events, such as marriage and childbearing (Cutler et al. 2009; Northstone and Emmett 2008; Weismayer et al. 2006; Elstgeest et al. 2012). On a population scale, rapid changes in sociodemographic status, such as urbanization without sufficient steady and significant growth in economy are more important. These changes happen unavoidably during generations; therefore, it is reasonable to expect lifestyle changes over time, diet included. This context is nutrition transition, broad-spectrum changes in quantity and quality of diet (Mehio Sibai et al. 2010).

Changes in dietary patterns have been observed in the European Union, Latin American and Mediterranean countries; the findings accentuated "dynamic nature of diet" (Schmidhuber and Traill 2006; Mazzocchi et al. 2008; Bermudez and Tucker 2003; Unit 2003). In Iran, the nutrition transition and the increased risk of attributed obesity and chronic diseases have been studied (Ghassemi et al. 2002; Golzarand et al. 2012). The investigations demonstrated the trend of dietary changes in this region but they were unable to document the changes in dietary patterns based on actual and precise evidence.

Physical activity is equally important in health status and plays a prominent role in body composition and obesity risk (Popkin 1998). Apart from this effect, inadequate physical activity is a risk factor for cardiovascular diseases, diabetes mellitus type 2, osteoarthritis, and some types of cancer (Evans and Cyr-Campbell 1997). Physical activity and dietary pattern changes over time are concordant because they are affected by socioeconomic status and demographic changes. In addition to these factors, industrialization with attributed changes in women's tasks (social roles or occupation), income, and technology development lead to adopt a more inactivity pattern (Popkin et al. 2005).

Limited research has been conducted and revealed the dietary evolution occurrence over generation (Tessier and Gerber 2005; Tsakiraki et al. 2011). Based on our knowledge, in Iran, transition of the dietary pattern and physical activity has not been evidenced between generations. This study aimed to characterize major dietary patterns in three Isfahani consecutive generations and to delineate dietary pattern changes in these populations. We also examined the factors determining dietary pattern changes, based on bibliographies. Furthermore, physical activity was assessed in different generations.

## Methods

### Study design and participants

This epidemiological study was conducted on women selected using a systematic cluster sampling method. Initially, district-stratified kindergartens and health care centers were selected and women who took their children to the kindergartens or referred to the health care centers were chosen. To observe their cooperation, we arranged meetings in collaboration with the administrators. Women aged 18–40 and 41–60 years who live in Isfahan were included as samples of Generation3 (G3) and Generation2 (G2), respectively. The samples of first generation, Generation1 (G1), were randomly selected from the women aged upper than 60 years referring to the health centers, the members of The Civil Servants Pension Organization (C.S.P.O) and of an educational and rehabilitation center. Exclusion criteria were being pregnant or lactating (for G2 and G3), or suffering from memory disorders and dementia (for G1). Furthermore, we excluded unhealthy people who have nutrition-related diseases such as diabetes. All respondents were informed on the aims and procedure of the study, and were ensured of our strict policy to keep their data confidential. Then their verbal consents were achieved. The present study was approved by the Research Council and Ethical Committee of Isfahan University of Medical Sciences, Isfahan, Iran.

### Dietary assessment

Individual's usual dietary intake was assessed using a 106-item, machine-readable, semi-quantitative, and dish-based FFQ (DFFQ). This DFFQ has been developed to assess dietary intakes of Iranian adults (Keshteli et al. 2014). The validity and reliability of DFFQ were assessed among an adult population, previously (Barak et al. 2014).

In this questionnaire, foods and dishes were categorized into five major groups including mixed dishes, grains, dairy products, fruits and vegetables, and miscellaneous food items and beverages. Portion sizes of each food or dish item were determined using either the natural units (e.g., 1 apple, 1 egg, 1 slice of bread), or the typical serving size, or the most common serving size. The intake frequencies were recorded using multiple choices ranging from 'never or less than once a month' to 'twelve or more times per day'. The number of choices, however, varied for different foods according to their consumption frequency.

Participants were asked to report how often, on average, they had consumed a predefined quantity of a list of foods or dish items during the previous year. However, G1 population was asked to recall the consumption frequency of a given food item during their remote past, when they

were younger (Willett 2013). To assist these subjects in recalling more accurately, they were reminded of special events, such as the Islamic Revolution of 1979, which had occurred during those ages. Furthermore, interviewers helped them remember their work and family structure (e.g., the number of children).

All items on the FFQ were converted to daily equivalent frequencies for analysis. Reported food intake was converted to gram per day. Mixed dishes, such as kebab and different stews, were disaggregated into their constituent parts and then assigned to proper food groups using recipes found in cookbooks, different restaurants, and the tables included in a book entitled “A Guideline of Value Calculation for Iranian Diet”. Then the individual foods were categorized into 34 food groups based on the similarity of their nutrient contents, especially macronutrient, and the food grouping suggested by the previous studies. Several foods (e.g., eggs, mayonnaise, salt, coffee, and tea) composed their own groups because of their distinctive nutrient profiles. To estimate energy and other nutrients intake, each food or beverage was coded on the basis of a prescribed protocol and then analyzed using Nutritionist 4 software (First Databank Inc., Hearst Corp., San Bruno, CA) which its database was modified for Iranian foods.

#### Dietary pattern derivation

To derive dietary patterns, principle component analysis was performed in different generation, separately. Varimax rotation was used for 34 defined food groups. To decide how many factors to be retained, we considered the scree plot based on eigenvalue  $>1.0$  and the factor structure as well as the interpretability of the component (Cattell 1966; Kim and Mueller 1978; Kline 2014). Dietary patterns were labeled based on foods with the highest positive factor loadings and literature.

The dietary pattern scores were calculated by multiplying gram amounts of each food group by its factor loading and summing up the products across the food groups; each participant received a score for each identified pattern.

#### Physical activity

The short form of IPAQ (International Physical Activity Questionnaire) was used for physical activity assessment. In brief, this instrument is a standardized and validated tool that included the frequency (days per week) and duration (times per day) of three specific types of physical activity, i.e., walking, moderate-intensity activity, and vigorous-intensity activity. The participants were asked to recall their physical activities for the past 7 days (Lee et al. 2011). Population of Generation1 was asked to remember their

physical activity like their usual dietary intake in the distant past. To estimate total daily physical activity levels, respective MET values (walking = 3.3, moderate-intensity activity = 4.0, vigorous-intensity activity = 8.0) were multiplied by reported time (minute), and were then summed up. Continuous scores of total physical activity were expressed as daily metabolic equivalents (MET-h/d) then values were categorized into three levels, including high, moderate, and mild (Committee 2005).

#### Anthropometric data

Anthropometric indices, included weight and height, were measured. In brief, subjects' weight was measured with digital scales while they wore minimum cloths and without shoes and recorded to the nearest 100 g. Height was measured using a non-elastic tape measure while the subjects were standing without shoes and kept the shoulders in a normal position. Body mass index (BMI) was calculated as weight (in kg) divided by height (in  $m^2$ ).

Furthermore, the subjects were asked to answer demographic and socioeconomic questionnaires including age, household size, employment status, taking medications, medical history of disease, and educational status. All questionnaires were completed by the trained dietitian through a personal interview in a relaxed atmosphere. The questionnaires were scanned to create an electronic database for analyses.

#### Statistical analysis

Quantitative data were presented as mean  $\pm$  SD while qualitative variables as percent. One-way analysis of variance (one-way ANOVA) was performed to compare groups in terms of mean food group intake. Bonferroni correction was used for pairwise comparison between generations as post hoc analysis. The normality of quantitative variables was evaluated using Kolmogorov–Smirnov statistical test. Appropriate transformations were conducted for non-normally distributed variables. Repeated measurement analysis of variance was used to evaluate the stability of dietary pattern scores over time and between three generations. Mauchly's test was conducted to evaluate sphericity assumption; and when the assumption was not satisfied, the results of multivariate approach were considered.

Latent class analysis (LCA) was applied to determine classes of participants' levels of DP scores. LCA examines the pattern of relations among a set of observed categorical variables and identifies and classifies similar individuals into latent classes. This leads subjects, who are highly similar to each other but uniquely different from the members of other classes in terms of the evaluated

variables, into latent classes. Accordingly, comparison can be made across the latent classes with regard to the considered variables (DP score levels in the present study).

All analyses were performed using SPSS for Windows (version 16; SPSS Inc, Chicago IL), except for latent class analysis, which was performed using R free statistical software (version 3.0.2.).  $P$  value  $<0.05$  was considered the statistically significant level.

## Results

Of 658 filled questionnaires included to the present study, those who had not completed at least 75 % of the food item questions ( $n = 67$ ; G1: 9, G2: 33, and G3: 25) and those who their reported total daily energy intakes were  $\leq 800$  or  $\geq 4500$  kcal/d ( $n = 44$ ; G1: 17, G2: 15, and G3: 12) were excluded. After these exclusions, analyses were conducted on 547 women's data (G1: 181, G2: 181, and G3: 185). The response rates of G1, G2, and G3 were 94, 93, and 90 %, respectively.

The participant characteristics are shown in Table 1. There were no significant differences between three generations in terms of total energy intake and BMI ( $P > 0.05$ ). Socioeconomic status, such as marital status, and educational levels, were significantly different between three groups ( $P < 0.001$ ). The highest percentage of individuals who had high physical activity level was in G1.

Three major dietary patterns were derived using principle component analysis on 34 food groups presented in online resource 1. The Matrices of factor loading and variances of these dietary patterns are demonstrated in online resource 2. Dietary patterns were named the Traditional Dietary Pattern (TDP) (high in red meat, organ meat, vegetable, potatoes, legumes, soy, Oils, French fries, fried onion, salt, pepper, and tail fat), the Healthy Dietary Pattern (HDP) (high in dairy products, fruits, dried fruits, fruit juices, vegetables, tomatoes, nuts, and honey), and the Western Dietary Pattern (WDP) (high in processed meat, sweet desserts, carbonated drinks, sugars, and dairy fat).

### Differences in food consumption between three generations

Consumption of the 34 foods and food groups is presented in Table 2. Mean intake of coffee, fruit juice, refined grains, French fries, sweet desserts, and mayonnaise increased over generations whereas the trend of intake of tail fat, potato, whole grains, tomatoes, vegetables, fruits, and tea was reverse. Red meat, organ meat, dairy products, and sugars were consumed by G3 more than G1 and less than G2. Mean intakes of other foods or food groups were not significantly different between three generations.

Table 3 shows mean  $\pm$  SD of DP scores for different generation. The results of repeated measures ANOVA showed that there was significant differences between groups in terms of DP scores ( $P < 0.001$ ); the observed differences for all three dietary pattern scores were statistically significant between the studied generations.

TDP score was stable from generation to generation, although it was slightly higher in G2. HDP and WDP scores both increased over generations.

Table 4 demonstrates the results of the LCA for the constructed classes. Three distinct latent classes were identified for the respondents of three generations. Figure 1 shows the comparison of different classes across generations.

**Generation1** Class1 of G1 was the largest class in this population and can be named "traditional class", because TDP score of women in this class was more than other DPs. Class2 of this generation was "unhealthy class" whose probability of having high score for WDP was higher than the other DPs. Class3, "multifarious class", can be characterized by having high score for all DPs.

**Generation2** Class1, "low score for all", included women whose probability of having high score for all three DPs was low. Class2, "transitional class" comprised the individuals who had high probability for both TDP and WDP and Class3 of this generation, "multifarious class", was similar to G1 population.

**Generation3** Class1, "low score for all", of G2 and G3 population was similar. Class2 was considered the "health conscious class" as these women tended to have the highest probabilities of earning high scores for HDP. Class3 of this generation, "multifarious class", was also similar to the others.

## Discussion

We evaluated dietary pattern stability and physical activity in three consecutive generations of Isfahani women. Using factor analysis, three dietary patterns were separately identified in each of three generations: Traditional Dietary Pattern, Healthy Dietary Pattern, and Western Dietary Pattern. These dietary patterns were similar to those which had been found in a previous study, conducted by Esmailzadeh et al. on 40–60 years females; they also had

**Table 1** Main characteristics of participants according to their generation, Iran, 2014

	Generation1 ( <i>n</i> = 181)	Generation2 ( <i>n</i> = 181)	Generation3 ( <i>n</i> = 185)	<i>P</i> <sup>a</sup>
Age (years)	65.7 ± 5.6 <sup>b</sup>	51.1 ± 6.0	30.3 ± 5.4	<0.001
Height (m)	1.61 ± 0.6	1.73 ± 1.1	1.63 ± 0.1	0.211
BMI (kg/m <sup>2</sup> )	27.2 ± 4.9	27.6 ± 4.9	26.8 ± 4.7	0.861
Energy intake (kcal/day)	2463.9 ± 738.1	2335.5 ± 813.9	2431.5 ± 792.9	0.268
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	
Physical activity levels				
High	120 (66.9)	51 (28.2)	67 (36.4)	<0.001
Moderate	40 (22.1)	72 (39.8)	67 (36.4)	
Mild	20 (11.0)	58 (32.0)	50 (27.2)	
Marital status				
Married	93 (55.0)	154 (87.5)	168 (96.6)	<0.001
Divorced	6 (3.6)	4 (2.3)	5 (2.9)	
Widowed	70 (41.4)	18 (10.2)	1 (0.5)	
Educational levels				
Illiterate	27 (14.9)	13 (7.2)	0 (0.0)	<0.001
Elementary school	58 (32.0)	62 (34.4)	2 (1.1)	
Orientation cycle (middle school)	24 (13.3)	36 (20.0)	14 (7.6)	
Diploma	33 (18.2)	44 (24.4)	54 (29.2)	
Associate degree	22 (12.2)	11 (6.2)	30 (16.2)	
Bachelor degree	17 (9.4)	13 (7.2)	65 (35.1)	
Master's degree or above	0 (0.0)	1 (0.6)	20 (10.8)	

<sup>a</sup> Obtained from ANOVA for quantitative variables and Chi-square test for qualitative variables

<sup>b</sup> Data are expressed as mean ± SD

been labeled Healthy, Western, and Traditional dietary patterns (Esmailzadeh et al. 2007). Amini et al. in a study on Isfahani adults derived 6 major dietary patterns, of which Western and Prudent dietary patterns had relatively similar factor loadings to those of our study (Amini et al. 2010).

Then we examined stability of different DPs over time between three generations in two different aspects: (a) stability of DP scores over generation, and (b) differences in mean intake of food groups in G1, G2, and G3. TDP score showed approximate stability over time. This was not the case for WDP and HDP scores which increased from a generation to the next. According to our results, there is a significant upward trend in the intake of coffee, fruit juice, refined grains, French fries, sweet desserts, and mayonnaise but the trend concerning the consumption of tail fat, potatoes, whole grains, tomatoes, vegetables, fruits, and tea was reverse. To our knowledge, this study evaluated, for the first time, the dietary pattern changes over three consecutive generations; thus, it is difficult to compare our results to other studies. This finding, however, is somewhat congruent with the results of the survey conducted by

Ghassemi and colleagues on household level of National Household Budget and Expenditure Survey (NHBS) and National Food Consumption Survey (NFCS). They showed that, between 1985 and 1995, the urban households' consumption of bread, sugar, and fats and oils increased, while the consumption of dairy products, meat, fruits and vegetables declined, dramatically (Ghassemi et al. 2002). Golzarand et al. in their report used per capita food availability data represented as kcal/person per day from FAO food balance sheets (FAOSTAT database). They surveyed the trend of dietary consumption changes in Iran and revealed that the availability of vegetables, nuts, eggs and oils increased between 1961 and 2007 in this geographic region, significantly (Golzarand et al. 2012). These two studies did not succeed to reflect the actual dietary changes because of their methodological limitations. In other countries, few studies noted the dietary changes across generations. For instance, Tsakiraki and colleagues surveyed the evolution of two generations' diet in terms of traditional dishes (Tsakiraki et al. 2011). They illustrated increased intakes of sugar, rusks (a hard, dry biscuit or a twice-baked bread) and meat dishes and decreased

**Table 2** Differences in food groups intake between three generations, Iran, 2014

Food groups	Generation1	Generation2	Generation3	Significance <sup>a</sup>	Result	Pair-wised comparison
Red meat	74.5 ± 40.6 <sup>b</sup>	63.9 ± 36.9	67.9 ± 39.5	0.035	G1 > G3 > G2	G1–G2 G1–G3
Processed meat	1.9 ± 9.5	7.4 ± 11.1	12.6 ± 13.4	<0.001	G3 > G2 > G1	G1–G2 G1–G3 G3–G2
Fish	12.8 ± 16.3	13.1 ± 13.7	14.0 ± 13.3	0.697	G3 > G2 > G1	
Organ meat	7.1 ± 8.4	3.7 ± 6.6	4.2 ± 7.8	<0.001	G1 > G3 > G2	G1–G2 G1–G3
Poultry	39.5 ± 32.7	49.4 ± 35.3	51.1 ± 33.8	0.002	G3 > G2 > G1	G1–G2 G1–G3
Eggs	26.3 ± 16.8	23.7 ± 17.2	26.1 ± 19.0	0.303	G3 > G2 > G1	
Dairy product	376.8 ± 221.0	299.2 ± 218.6	308.8 ± 222.9	0.001	G1 > G3 > G2	G1–G2 G1–G3
Tea	372.3 ± 269.9	284.5 ± 215.1	233.9 ± 221.0	<0.001	G1 > G2 > G3	G1–G2 G1–G3
Coffee	8.2 ± 29.6	12.2 ± 40.4	21.5 ± 55.8	0.011	G3 > G2 > G1	G1–G3
Fruits	121.5 ± 73.9	94.9 ± 79.6	92.8 ± 71.0	<0.001	G1 > G2 > G3	G1–G2 G1–G3
Dried fruits	17.3 ± 17.4	16.6 ± 16.3	16.5 ± 20.1	0.897	G1 > G2 > G3	
Fruits juices	25.6 ± 50.1	26.5 ± 43.8	40.1 ± 62.7	0.014	G3 > G2 > G1	G1–G2 G2–G3
Vegetables	207.7 ± 92.4	172.5 ± 80.6	152.5 ± 78.0	<0.001	G1 > G2 > G3	G1–G2 G1–G3
Tomatoes	86.3 ± 57.5	69.2 ± 55.9	62.8 ± 48.3	<0.001	G1 > G2 > G3	G1–G2 G1–G3
Legumes	73.2 ± 47.5	62.6 ± 38.8	52.1 ± 32.9	<0.001	G1 > G2 > G3	G1–G2 G1–G3 G3–G2
Soy	1.7 ± 1.8	2.1 ± 2.2	2.2 ± 2.7	0.083	G3 > G2 > G1	G1–G2
Refined grains	253.3 ± 152.3	305.7 ± 164.5	312.3 ± 152.1	<0.001	G3 > G2 > G1	G1–G2 G1–G3
Whole grains	133.5 ± 131.7	98.7 ± 107.3	84.7 ± 120.6	<0.001	G1 > G2 > G3	G1–G2 G1–G3
Potatoes	39.6 ± 29.6	31.2 ± 25.7	23.1 ± 24.6	<0.001	G1 > G2 > G3	G1–G2 G1–G3 G3–G2
French fries	24.4 ± 15.1	27.3 ± 17.6	32.0 ± 20.8	<0.001	G3 > G2 > G1	G1–G3 G3–G2
Fried onion	0.5 ± 0.7	1.0 ± 1.2	1.1 ± 0.8	<0.001	G3 > G2 > G1	G1–G2 G1–G3
Nuts	10.8 ± 12.7	8.2 ± 8.8	8.9 ± 11.3	0.070	G1 > G3 > G2	
Mayonnaise	2.2 ± 12.5	3.8 ± 4.3	6.3 ± 15.0	0.003	G3 > G2 > G1	G1–G3
Sweet Desserts	25.0 ± 27.8	25.8 ± 28.5	41.3 ± 41.6	<0.001	G3 > G2 > G1	G1–G3 G3–G2
Chocolate milk	3.6 ± 14.5	8.6 ± 30.1	19.6 ± 39.1	<0.001	G3 > G2 > G1	G1–G3 G3–G2
Vegetable oil	39.4 ± 14.6	41.4 ± 16.3	43.1 ± 17.4	0.098	G3 > G2 > G1	

**Table 2** continued

Food groups	Generation1	Generation2	Generation3	Significance <sup>a</sup>	Result	Pair-wised comparison
Carbonated drinks	6.2 ± 19.9	18.6 ± 28.7	27.2 ± 55.4	<0.001	G3 > G2 > G1	G1–G2 G1–G3
Pickles	11.1 ± 11.9	11.1 ± 14.5	11.0 ± 11.1	0.989	G3 > G1 > G2	
Salt	8.1 ± 4.2	7.4 ± 3.2	7.4 ± 3.2	0.106	G1 > G2 > G3	
Pepper	2.7 ± 2.5	3.2 ± 2.8	3.6 ± 3.1	0.016	G3 > G2 > G1	G1–G3
Sugars	19.9 ± 15.9	15.1 ± 16.9	15.3 ± 16.9	0.007	G1 > G3 > G2	G1–G2 G1–G3
Dairy fat	3.5 ± 4.8	5.7 ± 9.7	7.5 ± 7.0	<0.001	G3 > G2 > G1	G1–G2 G1–G3
Honey	5.2 ± 5.5	4.7 ± 7.1	3.8 ± 7.1	0.107	G1 > G2 > G3	
Tail fat	5.5 ± 4.5	3.4 ± 3.1	3.1 ± 3.0	<0.001		G1–G2 G1–G3

<sup>a</sup> Obtained from ANOVA

<sup>b</sup> Values are expressed as mean ± SD of g/day intake

**Table 3** Intergenerational stability of dietary patterns, Iran, 2014

Dietary patterns	Generation1	Generation2	Generation3	Group <sup>a</sup>	DP × group <sup>b</sup>
Traditional DP	49.4 ± 15.5	54.3 ± 18.8	49.4 ± 17.5	<0.001	<0.001
Healthy DP	76.5 ± 31.3	94.7 ± 41.2	100.5 ± 48.5	<0.001	
Western DP	16.0 ± 6.4	44.8 ± 24.6	47.7 ± 21.4	<0.001	

Analyzed by repeated measurement ANOVA

DP dietary pattern

<sup>a</sup> Mean of DPs scores compared between generations

<sup>b</sup> Trend of DPs changes compared between generations

**Table 4** Latent class models across generations—prevalence of latent class membership and item response probabilities within each of three classes, Iran, 2014

	Generation1			Generation2			Generation3		
	Class1	Class2	Class3	Class1	Class2	Class3	Class1	Class2	Class3
DP scores <sup>a</sup>									
Traditional DP	0.58	0.18	0.89	0.12	0.95	0.96	0.03	0.45	0.95
Healthy DP	0.16	0.10	0.78	0.19	0.44	0.76	0.15	0.90	0.63
Western DP	0.14	0.64	0.87	0.11	0.85	0.60	0.21	0.12	0.94
Class size(%)	40.5	34.0	25.5	37.6	32.2	30.2	38.8	19.7	41.5

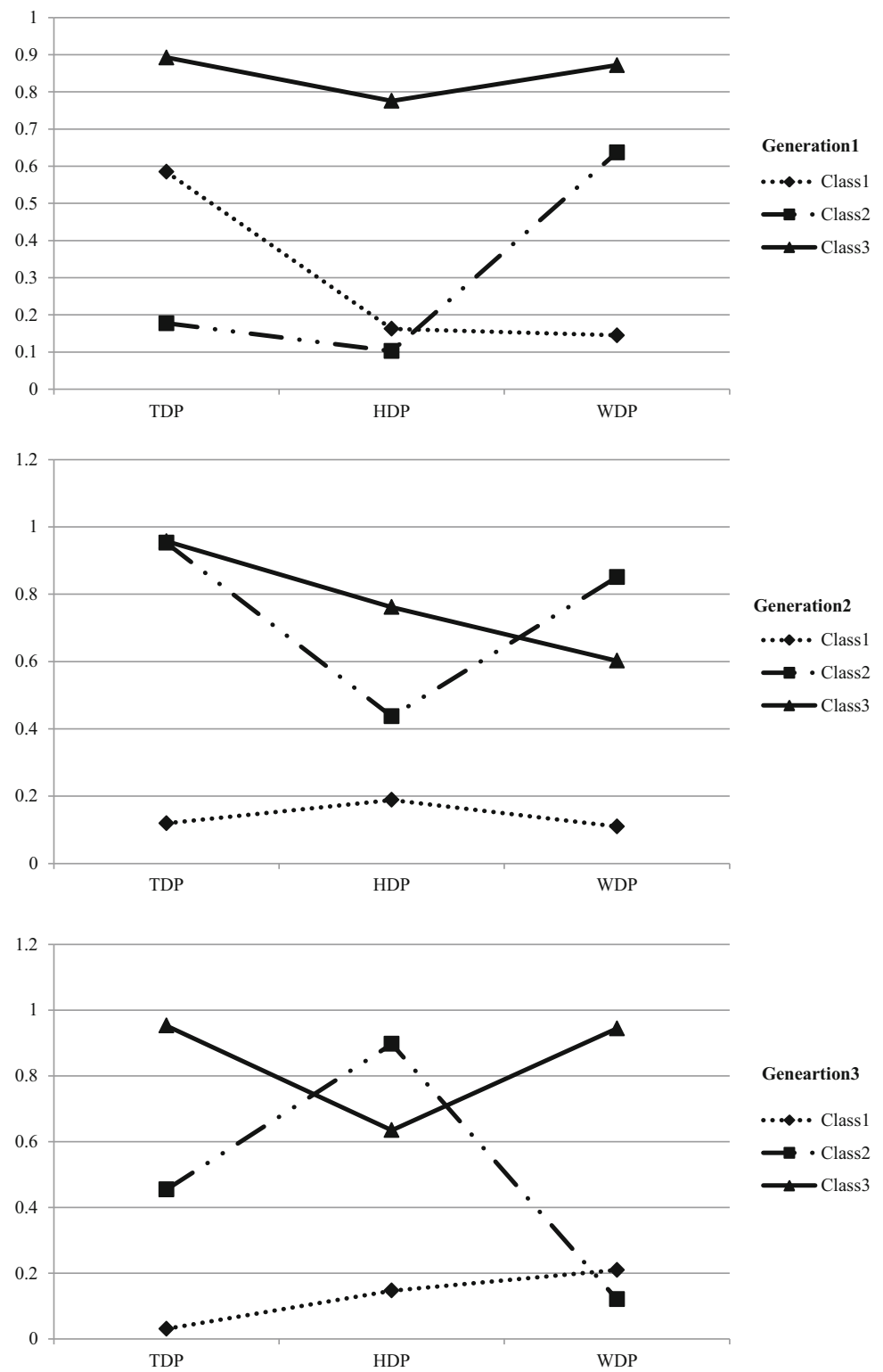
DP dietary pattern

<sup>a</sup> Item response probabilities within each class

consumption of green vegetables, pulses and wine in the younger women compared with their mothers; they expressed these changes as a westernized diet. Their findings are quite similar to our results but comparison between them is not without flaws because of the heterogeneity of diet between different societies and countries.

We ranked participants according to their dietary pattern scores by LCA. Three classes were distinctively defined within three generations; these included “traditional class” (in G1), “transitional class” (in G2), and “health conscious class” (in G3). Comparing the structure of these classes can confirm the dietary pattern changes over generations.

**Fig. 1** Item-response probabilities for three dietary pattern scores (*TDP* Traditional Dietary Pattern, *WDP* Western Dietary Pattern, *HDP* Healthy Dietary Pattern) within each of three classes. Generation1; Class1 (40.5 %), Class2 (34.0 %), Class3 (25.5 %). Generation2; Class1 (37.6 %), Class2 (32.2 %), Class3 (30.2 %). Generation3; Class1 (38.8 %), Class2 (19.7 %), Class3 (41.5 %). Iran, 2014



Several studies emphasized the changes in diet structures such as increasing intake of fat, especially saturated fat, sugar and energy-dense foods and reducing intake of fruits, vegetables and fiber as principal elements of the

nutrition transition but attempts to clarify the causes of such changes are scarce (Popkin 2002). Globalization is a cornerstone of nutrition transition, which affects food availability through changing food production, providence,

and distribution pathways (Atinmo et al. 2009). The increasing trend of coffee, fruit juice, refined grains, French fries, sweet desserts, and mayonnaise consumption may be affected by modernization, and adoption of the westernized lifestyle. Cereals, including bread and rice, are important staple foods in Iranian population, but it seems that the younger (G3) tend to choose refined grains rather than whole grains.

Contrary to the past, when local and seasonal production patterns were restricting food choices, it now seems further factors, such as not allocating enough time to prepare dishes, are crucial in decreased intake of potatoes, whole grains, tomatoes, vegetables, and fruits in the younger. Food intake has a close relationship with, income and improved purchasing power (which may be a result of increased GNP in developing countries), but dietary choices may be controlled by non-economic (say, cultural and social) factors (Popkin et al. 2005; Hawkes 2006).

The percentage of individuals in G1 with high physical activity was two- to threefold more than the other two generations. In contrast, that was inverse percentage of mild physical activity. It seems development of household technology, such as food processors, washing machines, vacuum cleaners, and other equipment related to the physical activity changes across recent decades (Popkin 2001). There is several evidence that physical activity changes as one of major elements of lifestyle besides nutrition transition, significantly link with rapid increases in obesity, NIDDM and other related chronic diseases (Popkin 1998).

Our study suffers from some limitations. Current diet and physical activity status may bias their remote recall in the oldest generation (G1). However, previous studies demonstrated that retrospective reports can be used to estimate past dietary intake and there were a relatively appropriate correlation coefficient between original diet and remote recalled diet (Byers et al. 1987; Fraser et al. 1998). Falkner et al., showed that there was a significant underestimate between original and long-term recalled physical activity reports (Falkner et al. 2001); thus, recalling physical activity of G1 from distant past attenuated the result and the true differences between generations were even stronger than what we reached.

Strength of our study should also be noted. Different statistical techniques used to address intergenerational changes of the dietary patterns. Our participants were representative sample of women and due to the central role of mothers in decision making on food choices (Scaglioni et al. 2008; Hannon et al. 2003), it seems that our findings can be generalized to other family members.

As for the characteristics of major dietary patterns, the generalization of the results of this study to other areas of Iran should be treated with caution because the heterogeneity of diet in different areas of this country is

remarkable. However, it seems that the trend of dietary changes in different areas may follow a similar pattern due to the similarity of sociodemographic features of Iranian population.

The comparison between three generations in two dimensions corroborated dietary changes and differences, changes in dietary pattern scores and differences in mean consumption of food groups. Some advantageous changes occur because people are more health conscious nowadays and other unfavorable ones may parallel the lifestyle changes. Therefore, understanding of dietary changes and their mechanisms is critical for nutritional intervention planning.

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**Compliance with ethical standards**

**Conflict of interest** The authors declare no conflict of interest.

## References

- Amini M, Esmailzadeh A, Shafaeizadeh S et al (2010) Relationship between major dietary patterns and metabolic syndrome among individuals with impaired glucose tolerance. *Nutrition* 26(10):986–992
- Atinmo T, Mirmiran P, Oyewole OE et al (2009) Breaking the poverty/malnutrition cycle in Africa and the Middle East. *Nutr Rev* 67(s1):S40–S46
- Barak F, Falahi E, Keshteli AH et al (2015) Adherence to the dietary approaches to stop hypertension (DASH) diet in relation to obesity among Iranian female nurses. *Public Health Nutr* 18:705–712
- Bermudez OI, Tucker KL (2003) Trends in dietary patterns of Latin American populations. *Cad Saúd Pública* 19:S87–S99
- Byers T, Marshall J, Anthony E, Fiedler R, Zielezny M (1987) The reliability of dietary history from the distant past. *Am J Epidemiol* 125(6):999–1011
- Cattell RB (1966) The scree test for the number of factors. *Multivar Behav Res* 1(2):245–276
- Committee IR (2005) Guidelines for data processing and analysis of the international physical activity questionnaire (28)—short and long forms. Retrieved September 17 2008
- Cutler GJ, Flood A, Hannan P et al (2009) Major patterns of dietary intake in adolescents and their stability over time. *J Nutr* 139(2):323–328
- Elstgeest LE, Mishra GD, Dobson AJ (2012) Transitions in living arrangements are associated with changes in dietary patterns in young women. *J Nutr* 142(8):1561–1567
- Esmailzadeh A, Kimiagar M, Mehrabi Y et al (2007) Dietary patterns, insulin resistance, and prevalence of the metabolic syndrome in women. *Am J Clin Nutr* 85(3):910–918
- Evans WJ, Cyr-Campbell D (1997) Nutrition, exercise, and healthy aging. *J Am Diet Assoc* 97(6):632–638
- Falkner KL, McCann SE, Trevisan M (2001) Participant characteristics and quality of recall of physical activity in the distant past. *Am J Epidemiol* 154(9):865–872
- Fraser GE, Lindsted KD, Knutsen SF et al (1998) Validity of dietary recall over 20 years among California Seventh-day Adventists. *Am J Epidemiol* 148(8):810–818

- Ghassemi H, Harrison G, Mohammad K (2002) An accelerated nutrition transition in Iran. *Public Health Nutr* 5(1a):149–155
- Golzarand M, Mirmiran P, Jessri M et al (2012) Dietary trends in the Middle East and North Africa: an ecological study (1961 to 2007). *Public Health Nutr* 15(10):1835–1844
- Hannon PA, Bowen DJ, Moinpour CM et al (2003) Correlations in perceived food use between the family food preparer and their spouses and children. *Appetite* 40(1):77–83
- Hawkes C (2006) Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity and diet-related chronic diseases. *Global Health* 2(1):4
- Hu FB (2002) Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol* 13(1):3–9
- Kant AK (2004) Dietary patterns and health outcomes. *J Am Diet Assoc* 104(4):615–635
- Keshteli AH, Esmailzadeh A, Rajaie S et al (2014) A dish-based semi-quantitative food frequency questionnaire for assessment of dietary intakes in epidemiologic studies in Iran: design and development. *Int J Prev Med* 5(1):29
- Kim JO, Mueller CW (1978) *Factor analysis: statistical methods and practical issues*, vol 14. Sage
- Kline P (2014) *An easy guide to factor analysis*. Routledge, London
- Lee PH et al (2011) Validity of the international physical activity questionnaire short form (IPAQ-SF): a systematic. *Int J Behav Nutr Phys Act* 8:115
- Mazzocchi M, Brasili C, Sandri E (2008) Trends in dietary patterns and compliance with World Health Organization recommendations: a cross-country analysis. *Public Health Nutr* 11(05):535–540
- Mehio Sibai A, Nasreddine L, Mokdad AH et al (2010) Nutrition transition and cardiovascular disease risk factors in Middle East and North Africa countries: reviewing the evidence. *Ann Nutr Metab* 57(3–4):193–203
- Newby P, Weismayer C, Åkesson A et al (2006) Longitudinal changes in food patterns predict changes in weight and body mass index and the effects are greatest in obese women. *J Nutr* 136(10):2580–2587
- Northstone K, Emmett PM (2008) A comparison of methods to assess changes in dietary patterns from pregnancy to 4 years post-partum obtained using principal components analysis. *Br J Nutr* 99(05):1099–1106
- Popkin BM (1998) The nutrition transition and its health implications in lower-income countries. *Public Health Nutr* 1(01):5–21
- Popkin BM (2001) The nutrition transition and obesity in the developing world. *J Nutr* 131(3):871S–873S
- Popkin BM (2002) The shift in stages of the nutrition transition in the developing world differs from past experiences! *Public Health Nutr* 5(1A):205–214
- Popkin BM, Duffey K, Gordon-Larsen P (2005) Environmental influences on food choice, physical activity and energy balance. *Physiol Behav* 86(5):603–613
- Reddy KS (2002) Cardiovascular diseases in the developing countries: dimensions, determinants, dynamics and directions for public health action. *Public Health Nutr* 5(1a):231–237
- Scaglioni S, Salvioni M, Galimberti C (2008) Influence of parental attitudes in the development of children eating behaviour. *Br J Nutr* 99(S1):S22–S25
- Schmidhuber J, Traill WB (2006) The changing structure of diets in the European Union in relation to healthy eating guidelines. *Public Health Nutr* 9(05):584–595
- Tessier S, Gerber M (2005) Factors determining the nutrition transition in two Mediterranean islands: Sardinia and Malta. *Public Health Nutr* 8(08):1286–1292
- Tsakiraki M, Grammatikopoulou MG, Stylianou C et al (2011) Nutrition transition and health status of Cretan women: evidence from two generations. *Public Health Nutr* 14(05):793–800
- Unit HN (2003) Commodities consumed in Italy, Greece and other Mediterranean countries compared with Australia in 1960s and 1990s. *Asia Pac J Clin Nutr* 12(1):23–29
- Weismayer C, Anderson JG, Wolk A (2006) Changes in the stability of dietary patterns in a study of middle-aged Swedish women. *J Nutr* 136(6):1582–1587
- Willett W (2013) *Nutritional epidemiology*. Oxford University Press, Oxford