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Meal-specific dietary patterns and their contribution to habitual dietary patterns in the Iranian population

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Abstract

Recent studies have focused on habitual intake without addressing meal-specific intakes. We aimed to identify meal-specific dietary patterns and their contribution to habitual dietary patterns. This cross-sectional study was conducted on 838 adults, both sexes who attended the health centres in Tehran. Dietary data were recorded by three 24-h dietary recalls (24hDR). Dietary patterns were identified by using principal component analysis on meal-specific and overall food intakes. Intraclass correlation (ICC) was used as a measurement of consistency across meals and days. Correlation analysis and linear regression (partial R^2) were used for meals contribution. Four habitual dietary patterns were derived from average dietary intake of 3-d 24hDR labelled as 'Western', 'Healthy', 'Traditional' and 'Legume and broth'. Also, we identified two major dietary patterns on each meal level (factor 1 and 2 for breakfast, lunch, afternoon snack and dinner). The highest contribution of energy intake was observed in lunch (25·7 %), followed by dinner (20·81 %). Consistency of food groups was the highest across days (ICC tea = 0·58) and breakfasts (ICC tea = 0·60). Dinner had a strong correlation coefficient with the 'Western' habitual dietary pattern then followed by lunch. Similarly, dinner and lunch contributed the most (r and partial R^2) to the 'Western' habitual dietary pattern. Our results suggest that habitual dietary patterns to several extents are formed at meal levels, and dinner has a greater contribution to the habitual dietary patterns in Iranian people. This may help planning for local dietary guidelines according to the time of eating to promote public health.

Key words: Dietary pattern analysis: Principal component analysis: Meal pattern: Consistency in consumption

A rapid change in the nutrition transition is occurring in Iran[1] because of demographic and physical activity level change, social development and urbanisation. Gradual dietary changes have happened from choosing healthy foods to westernised foods[2] which are related to an increasing rate of non-communicable disease. Although daily intake of some healthy food groups like fruit, vegetable, dairy products and legumes has increased among the population of the Middle East from 1990 to 2017, the burden of chronic diseases rose, at once[3]. That finding suggests the association between single nutrients or foods and chronic disease might not explain the link because consumed foods are highly interrelated. Recent nutritional studies have focused on dietary patterns rather than single foods or nutrients to find a diet–disease association[4].

Meal-specific dietary patterns are a key aspect of recent nutritional epidemiology, because of the role of timing of eating in health and disease[5]. There are a few studies that investigated it[6,7]. Foods are consumed on eating occasions as meals or snacks. There is no standard definition of eating occasion[8]. However, according to previous studies, it is known as an event that provided at least 50 kilocalories[9]. Meals are also known as a large amount of food consumed regularly, between 05.00 and 11.00 hours as breakfast, 11.00 and 16.00 hours as lunch and 16.00 and 23.00 hours as dinner, whereas snacks are identified as smaller intake between main meals[10,11]. Accumulating evidence suggests that breakfast skipping[12,13], energy contribution by meals[14,15] and the number of eating occasions could affect health outcomes[8,16]. A habitual diet is an accumulation of eating occasions (meals and snacks)[4,10,17]. Most of the previous dietary patterns were derived from the FFQ ignoring information on eating occasions. Such information can be important because the way specific foods are consumed during different meals may affect health outcomes[18,19]. Diets can vary from day to day and a single day is a poor estimator of long-term intake[20], and ≥ 3 recalls (two weekdays and one weekend) could be optimal for estimating food intake[21]. In some studies, two or three

Abbreviations: ICC, intraclass correlation; 24hDR, 24-h dietary recall.

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24-h dietary recalls (24hDR), with 1 or 2 weekdays and 1 weekend day, are used to capture energy and nutrient variability of the diet[22]. Although there are many studies that have derived habitual diet from 24hDR[23–25], only a few of them have derived meal-specific dietary patterns[26].

Time of eating as well as quality and quantity of diet is an important aspect of the healthy eating pattern[27]. It has been recommended that public health strategies and dietary advice need to focus on meal-specific dietary pattern and their contribution to habitual dietary patterns[6,24]. Meal-specific dietary patterns give us information regarding eating behaviour: timing, frequency and regularity[5]. Understanding dietary patterns at meal levels may reflect how people actually eat and meal-specific dietary advice could likely be more practical.

Although some studies have addressed the meal-specific dietary patterns[6,10,18,24,28], only two studies from Germany and Japan[6,24] have investigated the association of meal-specific dietary patterns to the habitual diet. Therefore, this study aimed to investigate the meal-specific dietary patterns and the contribution of dietary intake at each meal to the formation of habitual dietary patterns in a sample of Iranian adults.

Methods

Study population

A cross-sectional study was conducted among apparently healthy men and women from Iran who attended healthcare centres of Tehran to assess the association between diet quality and obesity, from February 2019 to August 2019. A sample size of 546 individuals was calculated based on the following formula[29] $n = (z^2p(1-p))/d^2$, according to the prevalence of obesity (68·5 %) in Tehran[30], an error coefficient of $d = 0{\cdot}04$ and at α level of 0·05. Considering the effect design of 1·5 and exclusion of participants with under- and over-reporting, the final sample size of 840 participants was estimated. Participants were recruited using two-stage cluster sampling from five geographic areas of Tehran within twenty-five healthcare centres. A convenient sampling method was used to select the study participants from each healthcare centre, using the proportion-to-size approach. The inclusion criteria were having 18–59 years old and BMI of 18·5–39·9 kg/m^2. The exclusion criteria were pregnancy or lactation and participants who had been diagnosed with chronic disease.

Ethical approval

Sample collection was facilitated by coordinating with the healthcare centres of Tehran. The study was ethically approved by the Ethics Committee of Tehran University of Medical Sciences (Ethics Number: IR.TUMS.VCR.REC.1398.990). The purpose of the study was explained to the participants, and all participants were given written informed consent preceding to enter the study.

Data collection

Data were collected from each person by face-to-face interview. Socio-demographic characteristics were completed that included age, sex, marriage status, income, smoking status, education level, occupation status and family size by using pre-specified data extraction forms. Dietary data were obtained using non-consecutive 3-d 24hDR conducted by trained interviewers

Dietary intake assessment

The first 24hDR was recorded in the first visit to the healthcare centre. The following 24hDR were collected via telephone on a random day. The amount of foods in gram was recorded for each eating occasion. A total of 2659 recalls were recorded, and daily intakes of all food items were derived from 24hDR converted into grams by using household measures[31] (online Supplementary Table S1).

Meal definitions

Meals were known as occasions where large amounts of foods were consumed or were standardised based on time of consumption[9,10] to contain no more than one breakfast, lunch and dinner, but allowing for multiple snacks. Breakfast was defined as an eating occasion where a large amount of food or energy was consumed between 05.00 and 11.00 hours and lunch, if it was consumed between 11.00 and 16.00 hours, then diner was defined as the main meal when was eaten between 16.00 and 23.00 hours based on prior studies[11]. We chose these cut points to enable better comparison with published studies.

Physical activity

Physical activity was measured by the short form of the International Physical Activity Questionnaire[32]. The reliability and validity of the questionnaire were assessed across twelve countries[33]. Participants reported within the previous 7 d a person spent walking, doing a moderate-intensity activity and/or doing vigorous-intensity activities. The overall physical activity level in metabolic equivalent minutes per week (MET-minutes/week) was measured. MET scores were categorised into three levels: point score < 600 MET-min/week as low physical activity, point score 600–3000 MET-min/week as moderate physical activity and point score > 3000 MET-min/week as high physical activity[34].

Anthropometric assessments

Body weight was measured in participants while wearing light clothes to the nearest 0·1 kg by a digital Seca scale with a measurement accuracy 100 g[35]. Height was gauged in a standing situation, shoulders and barefoot touching the wall to the nearest 0·5 cm. BMI was calculated by dividing weight in kg to height in squared metres (kg/m^2).

Dietary pattern analysis

We derived 420 food items from 24hDR on the level of meals (breakfast, lunch, afternoon and dinner) that were classified into thirty-six food groups including breads, rice and pasta, other cereals, fresh fruits and juices, dried fruits, green leafy vegetables, red and orange vegetables, cabbage family, other vegetables, potato, red meat, chicken, fish, processed meat, organ meat, broth, egg, legume, nut, cheese, low-fat milk and dairy products, high-fat milk and dairy products, liquid vegetable oils, solid oil, olive oil, butter, pickle, salty snacks, sugar and sweets, industrial beverages and juices, tea, coffee, herbal teas, sauces, spices and condiments. This classification was done based on the similarity of nutrient content in each food item and previous literature[24,25,27] (online Supplementary Table S1). Food groups were adjusted for energy intake by using the residual method[36]. Average of dietary intake on the level of meals including breakfast, lunch, afternoon snack and dinner and on the level of day (obtained from the average of three 24hDR) was used to derive dietary patterns.

Statistical methods

Demographic characteristics of participants were compared by using χ^2 for categorical variables and t test for continuous variables between men and women. Dietary patterns were identified using principal component analysis. Principal component analysis extracts common patterns according to the correlation matrix of food intake[37]. The Kaiser-Meyer-Olkin (> 0·50) measured sampling adequacy, and Bartlett's test of sphericity investigated the adequacy of test items and sample size for factor analysis. The factor loading shows the correlation between food groups and food patterns and varies from −1 to +1. A positive loading indicates a positive association with the factor, whereas a negative loading shows an inverse relationship with the factor. Larger positive or negative factor loadings for foods show which food groups are important in that component (dietary pattern). The factor loadings with a magnitude of ≥ |0·3| were written in the tables[38]. The number of major dietary patterns to retain was determined based on the screen plot (factors with eigenvalues > 1·5) and the interpretability of the identified patterns. We used intraclass correlation (ICC) to measure the consistency in the consumption of foods across meals levels[39]. Spearman's correlation analysis was performed to obtain the correlation coefficient between average intake on meals level and pattern scores on the habitual level. Then, multiple linear regression was used to investigate the contribution of different meal dietary patterns to the habitual dietary pattern with habitual intake as the dependent variable, meal-specific dietary patterns as independent variables and sex, age, physical activity, education level, smoking status, daily energy intake and BMI as covariates. A partial R^2 value was reported for the association of the meal-specified patterns across habitual dietary patterns. Participants who consumed the meal on 3-d 24hDR were known as regular eaters and skipped the meal at least on 1 d were known as irregular eater. All statistical analysis was conducted in SPSS software (SPSS Inc., version 22). A P value less than 0·05 was defined significant.

Results

This cross-sectional study was conducted on 838 adults, including 146 men and 692 women with an age range of 20–59 years old and mean age of 42·15 (SD 10·6). Mean BMI was 27·2 (SD 4·51) kg/m^2. Of 838, fifty participants had 2-d 24hDR and 788 participants had 3-d 24hDR.

Characteristics of the participants are presented in Table 1. All participants consumed ≥ 1 lunch and dinner. Two participants did not intake breakfast and six participants did not consume afternoon snacks on any of 24hDR. Smoking status, educational level, energy intake in breakfast, lunch and afternoon snacks showed a significant difference among men and women. The contribution of energy intake across three main meals and afternoon snacks is indicated in Fig. 1. The highest contribution of energy intake was observed in lunch (25·7 %), followed by dinner (20·81 %), breakfast (18·25 %) and afternoon snack (12·75 %). The regularity in breakfast consumption, number of participants who consumed the meal on all days, was the highest in comparison with other meals then followed by dinner, lunch and afternoon snacks (Table 1).

Mean (SD) intake of food groups across meals (breakfast, lunch, evening snack and dinner) and the day is shown in Table 2. Greater mean intake of bread, organ meat, egg, cheese, butter and sugar and sweet groups was seen in the breakfast meal compared with other meals. Mean intake of red and orange vegetables, cabbage family, potato, red meat, chicken, broth, legume, olive, liquid vegetable and solid oil, pickle, salty snack, industrial beverages and juices, sauces, spices and condiment groups was great in lunch meal. In contrast, people had a greater intake of fresh fruits and juices, dried fruits, nuts, herbal tea and coffee groups in the afternoon snack. In comparison with other meals, greater rice and pasta, other cereals, other vegetables, processed meat, low-fat milk and dairy products and high-fat milk and dairy products were at dinner meal.

We identified four major dietary patterns in our population using PCA that explained 20·9 % of the total variation in the sample based on scree plot (online Supplementary Table S1). The Kaiser-Meyer-Olkin index was 0·54, and Bartlett's test was significant (P < 0·001). Factor loading of habitual intake has been indicated in Table 3. Four major dietary patterns labelled as: 'Western' dietary pattern, 'Healthy' dietary pattern, Traditional dietary pattern, and 'Legume and broth' dietary pattern with an explained variance of 6·98, 5·67, 4·67 and 4·6, respectively. 'Western' dietary pattern was characterised by higher consumption of breads, other cereals, process meat, cheese, sugar and sweets, industrial beverages and juices. 'Healthy' dietary pattern was characterised by higher intake of green leafy vegetables, red and orange vegetables, egg, liquid vegetable oils and tea. Traditional dietary pattern was characterised by high positive loadings of rice and pasta, tea, herbal teas, condiments, butter and negative loading of egg. 'Legume and broth' dietary pattern was known by high positive loading of cabbage family, broth, legume, spices and condiments and negative loading of rice and pasta and sugar and sweet groups.

We also extracted two principal patterns with a Kaiser-Meyer-Olkin index of > 0·5 and a significant Bartlett's test (P < 0·001) in meal levels (factor 1 and factor 2 for breakfast, lunch, afternoon snack and dinner). Factor loadings of food groups at meal levels have been shown in online Supplementary Table S3.

We analysed the consistency of intakes (gram of food groups intake across 3 d) in the level of meals and day using ICC (Table 4). Consistency of food groups was the highest across day and breakfast. The highest consistency across the day was seen in bread (ICC = 0·41), rice and pasta (ICC = 0·51), liquid vegetable oils (ICC = 0·50) and tea (ICC = 0·58). The highest

Table 1. Baseline lifestyle, socio-demographic and dietary characteristic of the population sample*
(Mean values and standard deviations; numbers and percentages)

	Men		Women		Total		
Characteristics	*n*	%	*n*	%	*n*	%	*P*
Number	146	17·4	692	82·6	838	100	
Age(year)							
Mean	40·06		42·52			42·15	0·84
SD	10·33		10·61			10·6	
BMI (kg/m^2)							
Mean	27·22		27·23			27·23	0·09
SD	4·98		4·41			4·51	
Physical activity level							
Low	73	50	363	52·5	436	52·6	0·63
Moderate	60	41·1	259	37·4	319	38·1	
High	12	8·2	62	9	74	8·8	
Education							
Illiterate	3	2·1	53	7·7	56	6·7	< 0·001
Under diploma and diploma	62	42·5	418	60·4	480	57·3	
Educated	80	54·8	216	31·2	296	35·3	
Smoking Status							
Not smoking	126	86·3	664	96	790	94·3	< 0·001
Ex smoker	3	1·4	11	1·6	14	1·7	
Smoker	17	11·6	12	1·7	28	3·3	
Participants consumed on ≥ 1 meals							
Breakfast	145	98·3	691	98·3	836	99·8	0·42
Lunch	146	100	690	100	838	100	0·41
Afternoon Snack	141	98·6	689	99·2	830	98·8	0·09
Dinner	146	100	692	100	838	100	0·32
Participants consumed meals on all days							
Breakfast	126	87·4	660	91·2	789	93·9	0·06
Lunch	133	92·5	643	92·6	776	92·6	0·91
Afternoon Snack	127	85·2	633	89·7	760	91·1	0·08
Dinner	135	89·6	653	93·6	788	92·9	0·83
	Mean	SD	Mean	SD	Mean	SD	
Energy intake kcal/d	1721·53	350·98	1673·26	379·27	1681·68	374	0·09
Energy intake, kcal/meal†							
Breakfast	427·31	148·02	416·43	157·17	418·32	151·54	0·01
Lunch	538·13	150·54	535·38	184·92	535·86	179·33	0·03
Afternoon Snack	141·71	102·26	176·01	124·08	170·03	121·21	0·04
Dinner	527·61	202·33	504·05	194·92	508·16	196·31	0·14

* Values are mean values and standard deviations, otherwise it is indicated.
† Number of participants consumed the meals (main meals and afternoon snack) on all recalled days.

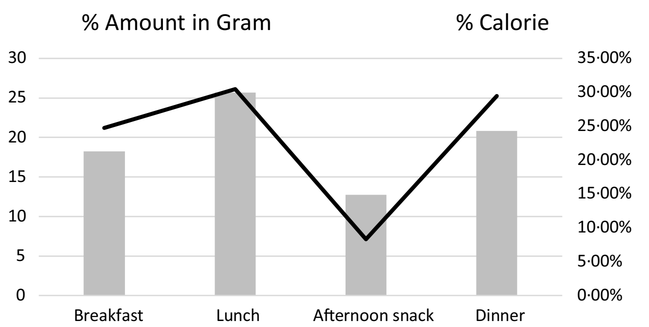

Fig. 1. Mean contribution, percentage amount in (▬) gram and (—) energy percentage of main meals and afternoon snack to the total amount of food consumed across a day.

consistency in breakfast was seen in bread (ICC = 0·51) and tea (ICC = 0·60). The consistency in lunch meal was highest in rice and pasta (ICC = 0·53), green leafy vegetables (ICC = 0·41), liquid vegetable oil (ICC = 0·51) and high-fat milk and dairy products (ICC = 0·43). The other meals indicated very low consistency in the food group's consumption.

Spearman's correlation analysis showed that dinner had the highest correlation with the habitual dietary pattern then followed by lunch, breakfast and afternoon snack, respectively (Table 5).

The results of multiple linear regression for the contribution of meal-specific dietary patterns to the four habitual dietary patterns are shown in Table 6. Our results showed that factor 1 dinner (37 %) and factor 1 lunch (20 %) were major and positive contributors to 'Western' habitual dietary patterns. For the 'Traditional' habitual dietary pattern, the contribution of meal-specific dietary patterns was low. The corresponding meal-specific patterns for the 'Legume and broth' dietary pattern were the factor 1 lunch (11 %), largely and positively.

Discussion

In this study, we investigated the contribution of meal-specific dietary patterns to the formation of habitual dietary patterns in the Iranian adult population. We found different contributions of the meals in the formation of habitual dietary patterns for

Table 2. Consumption of thirty-seven food groups across day and meals
(Mean values and standard deviations)

	Breakfast		Lunch		Afternoon snacks		Dinner		Day	
Food groups (g/d)	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Breads	40·14	31·37	20·91	36·62	0·58	3·39	33·44	5·16	65·3	51·61
Rice and pasta	1·78	7·28	53·20	124·60	0·42	3·38	57·21	49·38	176·55	72·47
Other cereals	0·43	3·55	1·18	6·62	0·41	3·31	1·79	3·33	3·91	10·62
Fresh fruits and juices	3·33	9·69	2·80	7·50	40·66	46·96	3·40	12·61	104·98	70. 9
Dried fruits	0·12	1·2	0·26	1·52	0·97	6·02	0·1	0·84	2·21	7·98
Green leafy vegetables	5·7	14·39	16·50	19·86	8·58	18·05	18·14	29·21	66·21	49·97
Red and orange vegetables	4·6	12·61	20·39	24·34	1·68	8·46	18·20	22·46	8·18	12·38
Cabbage family	0·01	0·34	2·26	8·51	0·00	0·00	1·05	6·85	3·21	9·58
Other vegetables	0·2	3·01	10·18	17·87	5. 8	15·40	11·66	25·18	45·21	36·38
Potato	0·13	2·14	1·89	9·37	0·00	0·00	1·15	7·29	52·81	9·81
Red meat	0·08	1·50	6·33	11·50	0·00	0·00	2·95	5·52	8·21	12·51
Chicken	1·1	3·54	20·92	18·17	0·19	3·07	11·4	16·16	70. 31	28·18
Fish	0·00	0·00	2·07	7·93	0·00	0·00	1·95	8·86	3. 5	11·88
Processed meat	0·29	3·29	2·90	14·30	0·00	0·00	4·39	18·16	7·15	17·38
Organ meat	1·22	10·13	0·64	6·52	0·00	0·00	0·79	4	21. 2	12·68
Broth	0·04	1·13	6·18	22·45	0·00	0·00	3·87	18·87	9·9	28·34
Egg	7·78	12·73	5·74	11·02	0·1	1·25	6·89	13·36	23·54	21·88
Legume	0·45	2·65	15·26	15·29	0·33	2·09	12·68	15·31	28·25	26·65
Nut	1·33	7·09	0·2	0·77	1·75	6·70	0·17	1·16	4·96	10·38
Cheese	15·31	10·67	0·4	2·86	0·59	2·53	1·85	5·06	18·58	13·32
Low-fat milk and dairy products	11·51	29·31	39·69	55·17	5·08	19·62	40·83	55·33	45. 118	92·4
High-fat milk and dairy products	0·00	0·00	7·6	25·49	2·18	9·75	5·65	18·36	16·01	31·64
Liquid vegetable oils	0·7	1·32	9·26	5·34	0·9	0·68	7·26	4·32	16·66	7·82
Solid oil	0·32	1·37	1·90	4·45	0·05	0·17	1·05	2·85	3·54	5·12
Olive oil	0·00	0·00	0·44	1·78	0·00	0·00	0·33	1·45	0·76	2·32
Butter	1·52	2·30	0·79	1·78	0·03	0·41	0·58	1·46	2·92	3·88
Pickle	0·02	0·27	3·34	7·19	0·13	2·45	2·63	6·46	5·92	10·64
Salty snacks	0·04	0·89	4·06	9·17	1·63	6·23	2·95	7·76	8·91	14·80
Sugar and sweets	14·15	28·56	13·24	33·28	9·02	13·12	13·12	31·50	63·35	51·93
Industrial beverages and juices	0·04	1·33	13·04	33·18	0·36	6·25	11·95	31·16	24·23	45·36
Tea	148·38	76·24	0·63	7·08	148·08	81·17	7·72	27·47	541·8	184·32
Coffee	0·52	5·38	0·09	2·23	0·7	6·08	0·00	0·00	2·33	13·92
Herbal teas	0·27	4·37	0·09	2·63	3·33	16·92	0·18	3·71	12·36	33·58
Sauces	0·04	0·53	5·95	6·16	0·07	0·72	5·44	6·02	11·80	9·52
Spices	0·06	0·74	1·05	3·24	0·12	0·88	0·85	2·56	1·46	2·02
Condiments	0·02	0·12	1·19	2·01	0·06	0·5	0·85	1·86	2·26	4·62

which the consistency of food groups consumption was poor to moderate (ICC < 0·6). Multiple linear regression analysis showed dinner had the highest percentage in 'Western' and 'Traditional' dietary patterns and lunch had the most percentage in the formation of 'Healthy' and 'Legume and broth' dietary pattern of habitual dietary pattern.

Our results showed that participants had very regular breakfast consumption habits (92·8 %). Previous studies showed that regular breakfast eaters have had higher dietary quality[40,41]. Breakfast eating could increase the thermic effect of food and fat oxidation compared with breakfast skipping[42]. In line with our findings, a study by Vainik *et al.* showed that consistent eating patterns are associated with better health status. They also showed that inconsistency in meals is related to eating in the evening, eating with others, eating away from home and having consumed alcohol[43]. Another study indicated eating breakfast was associated with healthier cardiometabolic profiles, and consistency in breakfast consumption could potentially reinforce this effect[44].

We identified four habitual dietary patterns in our study that Western and Healthy dietary patterns are similar to those found in other studies in Iran and Western countries. The characteristics of the 'Western' dietary pattern in our study were similar to those identified in studies from Iran[25,45–47]. It was also comparable with the 'Western' pattern in the German population identified by Schwedhelm *et al.*[24]. High factor loading of sugar in this dietary pattern was not surprising. This was reported in previous studies as a source of energy intake in the Iranian diet[45,46,48]. Westernised lifestyle and socio-demographic transition in Iran have led to the widespread use of dietary patterns similar to European countries[49]. Our results also showed that the 'Western' dietary pattern was explained mainly by dinner followed by lunch. Previous studies indicated higher adherence to the Western diet was associated with a higher risk of chronic disease[50–52]. Late-night eating has also been associated with a risk of obesity[53]. Japanese women who also consumed late dinners or bedtime snacks were more likely to skip breakfast[54]. In contrast, several studies have suggested that eating in the morning may be protective against the development of chronic disease[55]. Adherence to Western dietary patterns especially eating more energy at dinner may produce a disruption in the circadian system that might be detrimental to health[56–58]. These findings could help planning for local dietary guidelines according to the time of eating to promote public health.

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Table 3. Average habitual food intake (g/d)* and factor loading† for the habitual dietary pattern

Food groups	Average habitual intake (g/d)	Western	Healthy	Traditional	Legume and broth
Breads	65·33	0·32	0·28	−0·14	0·09
Rice and pasta	176·77	−0·09	0·22	0·56	−0·31
Other cereals	3·9	0·44	−0·20	0·07	0·06
Fresh fruits and juices	104·98	−0·06	0·11	0·18	0·04
Dried fruits	2·21	0·05	0·09	0·01	−0·09
Green leafy vegetables	63·54	0·15	0·32	0·15	0·01
Red and orange vegetables	45·26	0·26	0·35	−0·03	−0·19
Cabbage family	3·18	−0·08	0·21	0·25	0·58
Other vegetables	27·93	0·03	0·16	0·10	0·09
Cooked potato	28·25	0·04	0·37	−0·29	−0·12
Red meat	8·18	0·09	−0·15	0·11	0·14
Poultry	31·70	−0·11	−0·06	0·29	−0·32
Fish	3·96	0·16	−0·09	−0·09	−0·11
Processed meat	7·96	0·55	0·02	−0·05	0·04
Organ meat	2·21	−0·02	−0·16	0·04	0·15
Broth	9·81	0·01	−0·16	−0·14	0·38
Egg	23·50	−0·06	0·43	−0·43	−0·13
Legume	5·92	0·04	0·12	0·17	0·31
Nut	4·97	0·16	0·09	0·20	−0·20
Cheese	18·52	0·36	−0·09	0·06	0·08
Low-fat milk and dairy products	118·46	−0·04	−0·01	0·19	−0·12
High-fat milk and dairy products	16·64	−0·08	−0·14	0·14	0·02
Liquid vegetable oils	16·66	0·11	0·68	−0·06	0·07
Solid oil	3·18	0·04	−0·01	0·02	−0·10
Olive oil	0·76	0·29	−0·15	0·12	−0·21
Butter	2·92	0·02	−0·06	0·37	−0·29
Pickle	5·92	0·16	0·04	−0·15	0·02
Salty snacks	8·91	0·10	0·16	−0·04	−0·02
Sugar and sweets	63·2	0·78	−0·14	0·07	−0·37
Industrial beverages and juices	24·23	0·88	−0·16	−0·04	−0·02
Tea	530·45	0·11	0·37	0·35	−0·01
Coffee	2·33	0·06	−0·11	−0·03	0·19
Herbal teas	12·3	−0·03	−0·04	0·35	−0·18
Sauces	11·23	−0·04	0·05	−0·01	−0·09
Spices	2·20	0·13	0·18	0·23	0·59
Condiments	1·90	0·01	0·20	0·41	0·35

* Habitual dietary pattern derived from principal component analysis.
† Factor loading is shown in bold while absolute values ≥ 0·3.

'Healthy' dietary pattern in our study was also comparable with previously reported studies[24,45,48] and some extent similar to the Brazilian dietary pattern which was labelled as 'vegetables/fruits'[59] and to the Chinese dietary pattern which was labelled as 'Balanced'[60]. Dietary patterns could vary according to sex, socio-economic status, ethnicity[61] and food insecurity[62]. Moreover, the difference in dietary habits may be due to food beliefs, religious beliefs, cultural, socio-economic and occupation status[63]. Extracting habitual dietary patterns shows the interrelation of foods and nutrients and gives important information about the overall intake of people. Accumulating evidence reported an association between habitual intake and chronic disease. However, as the contribution of intake of individual nutrients/foods to the habitual dietary patterns is related to the eating occasions and meals, recent publications in nutrition research have focused on meal patterns. Then, meal-specific dietary patterns provide evidence on how people consume foods and how diet quality may be influenced by the different nutritional compositions in main meals. The number of studies focusing on meal-specific dietary patterns is growing. We previously reported the association of major dietary patterns at breakfast[64] and lunch[65] and dinner[50] levels with obesity.

In this study, we also found that habitual dietary patterns were originated from a complex combination of food groups across meals. We found that dietary pattern score on the level of meals indicated dinner food intake had a greater influence on the formation of the habitual dietary pattern followed by lunch. Multiple linear regression analysis indicated dinner contributed the most percentage of the habitual dietary pattern. There are some reports from Germany, China and Brazil in adults. Schwedhelm *et al.* also reported that habitual patterns to some extent originate at the meal level. They showed dinner had the greatest contribution to the habitual dietary pattern followed by lunch[24]. Murakami *et al.* showed major meal-specific dietary patterns in the Japanese context differentially contributed to major habitual dietary patterns. Three dietary patterns were derived for breakfast, four in lunch and five in dinner, and the most percentage of contribution to the habitual dietary patterns were seen in breakfast, lunch and dinner, respectively[6]. Breakfast showed the least contribution of a habitual dietary pattern among Iranian adults. Health benefits of breakfast consumption were reported in previous studies such as better metabolic and hormonal function, controlling appetite[66] and enough energy intake and consequently weight management[67]. It has been reported that breakfast frequency is a major factor related

Table 4. Intraclass correlation of consumption across meals and day

Food groups (g/d)	Breakfast	Lunch	Afternoon snacks	Dinner	Day
Breads	0·51	0·21	0·04	0·44	0·41
Rice and pasta	0·01	0·53	0·01	0·37	0·51
Other cereals	0·01	0·03	0·01	0·04	0·06
Fresh fruits and juices	0·06	0·21	0·09	0·04	0·18
Dried fruits	0·00	0·17	0·03	0·01	0·33
Green leafy vegetables	0·01	0·41	0·14	0·21	0·31
Red and orange vegetables	0·02	0·31	0·06	0·47	0·24
Cabbage family	0·00	0·05	0·00	0·03	0·03
Other vegetables	0·02	0·18	0·12	0·15	0·13
Potato	0·03	0·04	0·00	0·01	0·01
Red meat	0·02	0·10	0·00	0·07	0·04
Chicken	0·08	0·30	0·02	0·14	0·22
Fish	0·00	0·03	0·00	0·08	0·09
Processed meat	0·05	0·00	0·00	0·13	0·16
Organ meat	0·01	0·00	0·00	0·04	0·03
Broth	0·12	0·06	0·00	0·10	0·02
Egg	0·14	0·31	0·01	0·15	0·27
Legume	0·05	0·16	0·02	0·37	0·15
Nut	0·20	0·03	0·03	0·08	0·01
Cheese	0·30	0·02	0·12	0·19	0·12
Low-fat milk and dairy products	0·22	0·37	0·07	0·12	0·13
High-fat milk and dairy products	0·00	0·43	0·04	0·11	0·21
Liquid vegetable oils	0·35	0·51	0·02	0·06	0·50
Solid oil	0·05	0·16	0·00	0·31	0·31
Olive oil	0·00	0·12	0·00	0·05	0·10
Butter	0·11	0·33	0·006	0·05	0·14
Pickle	0·04	0·11	0·03	0·21	0·24
Salty snacks	0·02	0·08	0·15	0·12	0·13
Sugar and sweets	0·19	0·03	0·35	0·27	0·22
Industrial beverages and juices	0·00	0·13	0·05	0·23	0·14
Tea	0·60	0·06	0·54	0·17	0·58
Coffee	0·007	0·00	0·02	0·00	0·04
Herbal teas	0·003	0·00	0·04	0·02	0·27
Sauces	0·009	0·14	0·01	0·07	0·13
Spices	0·007	0·24	0·01	0·03	0·06
Condiments	0·02	0·16	0·005	0·09	0·11

n 838 participants with at least two 24hDR.
ICC = intraclass correlation coefficient or consistency in intake of each food groups across meals and day.
ICC > 0·41 are shown in bold as more than moderate agreement.

Table 5. Correlation of habitual* dietary pattern on the meal dietary pattern

Dietary pattern scores	Habitual dietary pattern score			
	Western	Healthy	Traditional	Legume and broth
Breakfast	0·32	0·41	0·50	0·21
Lunch	0·53	0·49	0·31	0·51
Afternoon snack	0·31	0·41	0·32	0·18
Dinner	0·56	0·51	0·52	0·38

* Habitual level indicated the average food groups consumed daily. Meal level indicated average food groups consumed on the level of meal, habitual dietary pattern derived from principal component analysis.

to habitual diet quality[13]. We also found that regularity in breakfast consumption was high in comparison with other meals in our study that suggests breakfast meal is the best choice to have dietary interventions in Iranian adults and may help policymakers to approach effective public health policies. Additionally, it

Table 6. Multiple linear regression analyses of habitual dietary pattern and meal dietary pattern (β-coefficients and 95 % confidence intervals)

Meal-specific dietary pattern	Habitual dietary pattern score											
	Western			Healthy			Traditional			Legume and broth		
	R^2 model = 0·62			R^2 model = 0·49			R^2 model = 0·21			R^2 model = 0·34		
	β	95 % CI	Partial R^2	β	95 % CI	Partial R^2	β	95 % CI	Partial R^2	β	95 % CI	Partial R^2
Breakfast												
Factor 1*	−0·12	−0·09, −0·13	0·01	0·15	0·13, 0·18	0·02	0·09	0·05, 0·13	0·01	−0·06	−0·05, −0·08	0·0036
Factor 2**	−0·01	−0·03, 0·09	0·0009	−0·12	−0·10, −0·17	0·02	0·03	0·02, 0·06	0·004	0·11	0·09, 0·15	0·02
Lunch												
Factor 1	0·44	0·40, 0·49	0·20	0·13	0·11, 0·16	0·04	0·08	0·04, 0·12	0·004	−0·30	−0·27, −0·36	0·11
Factor 2	−0·18	−0·18, −0·01	0·04	0·50	0·47, 0·57	0·27	−0·01	−0·01, 0·04	0·0009	−0·07	−0·05, 0·09	0·08
Afternoon snack												
Factor 1	0·03	0·02, 0·06	0·0009	−0·04	−0·03, −0·06	0·0009	−0·009	0·0005, −0·001	0·004	−0·002	−0·001, −0·005	0·0016
Factor 2	0·08	0·06, 0·11	0·0036	0·02	0·01, 0·04	0·0001	0·05	0·01, 0·10	0·0036	0·03	0·01, 0·04	0·0009
Dinner												
Factor 1	0·61	0·57, 0·69	0·37	0·007	0·006, 0·008	0·01	0·15	0·11, 0·21	0·02	−0·03	−0·01, −0·06	0·0008
Factor 2	−0·06	−0·07, −0·64	0·0036	0·51	0·47, 0·55	0·26	−0·03	−0·01, −0·07	0·0025	−0·11	−0·8, −0·15	0·01

β, Beta-coefficient.
All adjusted model for sex, age, physical activity, education level, smoking statues, energy intake and BMI.
* Factor 1 = first dietary pattern.
** Factor 2 = second dietary pattern.

has been shown that the feeding pattern is related to circadian alignment and metabolic health.[68,69]. In a recent study, skipping breakfast among healthy men in comparison with three meals consumer with isoenergetic diet for 6 d resulted in phase delay the circadian rhythm of the core body temperature, even though the sleep–wake cycles did not change[70]. Skipping breakfast may increase fat oxidation, insulin concentration and metabolic inflexibility that leads to a low-grade inflammation and impaired glucose homoeostasis[71]. Note that differences in meals contribution of habitual dietary patterns could be because of differences in community, culture and eating habits in different populations.

Limitations

We used 24hDR as short-term dietary assessment methods, which provide more detailed information about types and amounts of food than long-term assessment methods[72], although it has been shown that 24hDR are associated with a large within-person variation of dietary estimates. Moreover, previous studies assessed the validity of three 24hDR has indicated mixed results[73,74], especially among populations with heterogeneity. All self-reported dietary assessment methods have measurement errors, but 24hDR have been shown to be more accurate than FFQ; furthermore, they allow for meal-specific analysis, which FFQ does not[75]. Besides, this study was conducted within the limited period of around 4 months, so there was no seasonal variation, which might have introduced additional bias in the assessment of average dietary patterns. Misreporting of dietary intake is a serious problem associated with self-reported dietary assessment methods, particularly among overweight and obese individuals[75]. Subjective selecting food groups and determining the number of factors or principal components are the limitation of using principal component analysis[76], the definition of eating occasions, the number of factors extracted might have a kind of inconsistency in results, so it needs careful interpretation.

Conclusion

Our results suggest that habitual dietary patterns to several extents are formed at meals level, and dinner than lunch, respectively, has a greater contribution to habitual dietary patterns. Due to circadian rhythm association of time of food intake and disease, this knowledge may help design intervention studies aimed at uncovering diet–disease associations sensitive to food combinations and meal timing.

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Supplementary material

For supplementary material referred to in this article, please visit https://doi.org/10.1017/S0007114521005067

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