ORIGINAL ARTICLE

Development and validation of a semi-quantitative food frequency questionnaire to assess dietary intake in Turkish adults

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Abstract

Objectives: To validate the original food frequency questionnaire in Turkish adult population.

Methods: The cross-sectional study was conducted in June and December 2008 and 2009, and comprised adults of either gender aged 30-70 years. All subjects were Caucasians and were native Turkish speakers. The food frequency questionnaire containing 229 most frequently consumed foods under 7 topics was used for data collection. It was completed twice and the 24-hour dietary recall four times in a year. In order to assess the validity of the questionnaire, Pearson correlation, attenuation coefficient, measures of agreement between the two methods, weighted kappa statistics and Bland-Altman plots were employed. SPSS 16 was used for statistical analysis.

Results: Of the 120 subjects in the study, 71(59%) were males and 49(41%) were females with an overall mean age of 50.16±9.76 years. The correlation of estimated nutrient intake between the food frequency questionnaire and 24-hour dietary recall varied between 0.200 and 0.468, energy-adjusted regression was between 0.044 and 0.611 and attenuation coefficients of regression were between 0.339 and 0.658 for the selected macro and micro nutrients. Bland-Altman plots showed an acceptable agreement between the two methods. When nutrient intake was categorised in quartiles, proportions of the same or adjacent quartiles were 98.3%, 98.4%, 98.3%, 96.7% and 95% for energy, fat, protein, carbohydrates and fibre, respectively.

Conclusion: The first food frequency questionnaire developed in Turkish language was an adequate and valid tool to assess the nutritional habits of the local population.

Keywords: Food frequency questionnaire (FFQ), 24-hour dietary recall (24HR), Dietary assessment, Validation. (JPMA 65: 756; 2015)

Introduction

Recent studies have shown a strong association between long-term dietary intake of certain food items and the risk of chronic diseases, and that this association plays a role in the pathogenesis of many metabolic and inflammatory disorders, such as animal-derived foods and risk of cardiovascular disease (CVD), salt consumption and risk of gastric cancer, vitamin D deficiency and cancer.[1-4] In Turkey, diet-related diseases are leading causes of mortality and morbidity. Burden of CVD-related disability ranks first both in male (20%) and female (15%) adults. Accordingly, CVD-specific burden of mortality is 29% in males and 31% in females. Total mortality from other diet-related conditions are as follows: 13% for cancers, 3% for digestive diseases and 2% for diabetes.[5]

Therefore, an accurate measure of dietary intake of individuals plays a critical role in establishing potential effects of specific food items and of eating habits on health and disease. To date, many different tools have been developed in order to assess the eating habits of individuals and to study the epidemiology of chronic diseases. Dietary recalls (DRs) and food records that collect food and beverage intake over a 24-hour (24HR) period are the most common ones. Although they are not gold standards as biological markers are, but they are widely used for reporting dietary assessment. However, it is known that these methods lead to underreporting of energy and dietary intake, social desirability bias and recall bias.[6,7] Because of these specific limitations, food frequency questionnaire (FFQ) is being used extensively.[8-10]

The FFQ usually measures eating habits of individuals throughout the year, and is the more appropriate tool in epidemiologic studies.[11] New measurement tools are needed to make a validation in comparison with established ones before they are used in routine practice. If there is a good agreement between them, they can be used

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interchangeably or the new method can replace the former ones. The variety of foods and their consumption is changing from one culture to another, so the FFQ validated for one population cannot be used for another population.[8]

The present study was planned to develop and validate an FFQ for assessing the dietary intake of Turkish adults.

Subjects and Methods

The cross-sectional study was conducted in June and December 2008 and 2009 and comprised adults of either gender aged 30-70 years. All subjects were Caucasians and were native Turkish speakers. After we had developed and validated the FFQ in 2009, it was used for assessing the dietary intake of Turkish adults who participated in a prospective cohort study called the Prospective Urban and Rural Epidemiological (PURE) study which was conducted in 17 countries and comprisd more than 154,000 apparently healthy individuals.[12,13]

After obtaining approval from the Ethics Committee of Marmara University, Istanbul, Turkey, volunteers for the current study were randomly selected from among the healthy participants who were part of the PURE study. All participants furnished written informed consent to participate in the study.

Demographic data was collected at baseline according to self-reported age, weight and height with their gender followed by body mass index (BMI) measurement of each participant.

To generate the FFQ, trained interviewers obtained DRs from 40 middle-aged volunteers [15(37.5%) males and 25(62.5%) females] living in Istanbul, which is a big city that has food representing all the different Turkish cuisines. Participants recorded their food consumption over a period of 2 days, (one weekday and one weekend). To determine the FFQ, a database of the most frequently consumed foods was constructed and the frequencies of the recorded foods were analysed. Dieticians grouped 229 foods determined as high frequency under 6 groups representing Turkish cuisine features (dairy group, meat group, cereal group, sweet food items, oil and margarine, fruit and vegetables) (Table-1). Standard recipes of the most common mixed dishes were chosen from the local cooking books. Mixed dishes were grouped according to the type of dish. Frequency of food consumption was recorded in nine different categories (>6/day, 4-5/day, 2-3/day, 1/day, 5-6/week, 2-4/week, 1/week, 1-3/month, 1-none /month). The size of the portion of the consumed food was determined by using a food atlas.

To create a food atlas, the most frequently consumed foods were used. The dishes were served in three different portions and the weight of each portion was recorded before photographs were taken by a professional photographer. Mixed dishes of Turkish cuisine were categorised according to the way they were cooked and according to their content. The same pictures were used for the same types of meal. Eventually a colour picture of each portion of food or beverage was presented to the participants. Each food had different portion sizes and the participants identified the appropriate portion size (small, medium, large).

The FFQ was administered to the participants twice a year by a dietician so that it reflected both summer and winter seasons (June and December). To determine precisely the amount of consumed food in a standardised way, pictures of 3 different sizes of each item on the FFQ were presented to the participants and the selected portion size and consumption frequency were recorded.

During the study period, all participants were interviewed four times a year (March, June, September and December) over telephone about their daily dietary intake (24HR). Each interview was during a different season. Winter and summer 24HRs were collected within the same 15-day period as the FFQ. After the telephone interview, every participant was interviewed face-to-face by a dietician to determine the amount of their consumption by using the food atlas. The amounts of consumed food were thus standardised and over- of under-reporting was prempted.

Daily nutrient intake was calculated using computer software (Ebispro, Stuttgart, Germany; Turkish version: BeBiS, Vers. 6.1). Data source of this software was 97% Bundeslebensmittelschlüssel (BLS) Version II.3 and 3% United States National Nutrient Database for Standard Reference (USDA SR 19). Daily consumption of each food group (g) was assessed using the same software.

SPSS 16 and Medcalc were used for statistical analysis. Data was expressed as mean ± standard deviation. Unpaired t-test was used to compare independent groups. Paired t-test was used to compare estimated daily nutrient intake by the FFQ and 24HRs. Correlation between estimated macro and micro nutrients by the FFQ and 24HRs was investigated with the help of the Pearson correlation coefficient and attenuation coefficient, which were calculated by a correlation test and simple linear regression respectively. Energy-adjusted nutrients were computed as residuals from the regression model.[14] If the data was not normally distributed, they were log-transformed (for fibre, cholesterol, Vitamins A, D, E, B6, food groups of dairy products, meat group and sweat products). Besides, 95% confidence intervals (CI) for the correlation coefficients were also calculated. $P<0.05$ was

considered significant. To compare 24HRs and FFQ, Bland-Altman plots were used. The average proportions of classification into the same quartiles, adjacent quartiles and distant quartiles between 24HRs and FFQs were calculated and compared by weighted kappa statistics.

Results

Of the initially registered 155 subjects, 35(22.5%) left the study for various reasons. The remaining 120(77.4%) subjects represented the study population. Of them, 71(59%) were males and 49(41%) were females with an overall mean age of 50.16±9.76 years. The males had lower BMI compared to the females (p<0.001) (Table-2).

Table-1: Definition of Food Groups.

Food Group	Description
Dairy group	Milk, butter, cheese, yogurt, buttermilk, sour cream, ice-cream
Meat group	Red meat, poultry, fish, eggs, beans, meat varieties, sausages, salami and Turkish sausage
Cereal group	Bread, rice, macaroni, wheat, patty, biscuits, cereals, semolina, pasta
Sweet group	Sugar, sugar in beverages, candy, jam, honey, molasses, chocolate
Oil and margarine group	Olive oil, nut oil, sunflower oil, corn oil, margarine
Vegetable and Fruit Groups	Raw vegetables, salad, cooked vegetables, fresh and dried fruit

Table-2: Demographic Characteristics.

Demographic Characteristics	Whole Group (n=120)	Male (n=71, 59.2%)	Female (n=49, 40.8%)
Age	50.16+9.76	50.08+9.64	50.28+10.05
Weight (kg)	78.52+12.46	79.93+12.34	76.33+12.46
Height (cm)	1.65+0.09	1.70+0.07	1.56+0.05*
BMI (kg/m2)	28.90+4.86	27.39+3.78	31.22+5.45*

Data are expressed as mean ± standard deviation *:p< 0.001,unpaired t test,
BMI: Body mass index.

Daily intake of macro and micro nutrients was assessed by both FFQ and 24HR methods (Table-3). Moderate correlation for energy (0.467), for both energy unadjusted and energy-adjusted carbohydrate intake (0.468-0.534), fat (0.426-0.351), protein (0,379-0.246) and attenuation coefficients were 0.655, 0.633, 0.639, 0.490, respectively (for energy unadjusted p<0.001 and for energy adjusted p<0.001 and p<0.05). Among micro nutrients, correlation

Table-3: Values of daily intake, correlation and attenuation coefficient of macro-micro nutrients detected by FFQ and 24HRs.

Nutrients	The mean values of four FFQ	The mean of values of two 24HRs	Pearson Correlation Unadjusted^r	Attenuation coefficient^r	Pearson Correlation Adjusted^r
Energy (kcal)	2377.6±658.8	1877.8±469.4**	0.467**	0.655**	-
Protein (gr)	90.8±25.8	70.4±20.0**	0.379**	0.490**	0.246*
Fat (gr)	88.4±30.4	70.4±20.3**	0.426**	0.639**	0.351*
Carbohydrate (gr)	291.6±82.6	232.5±61.2**	0.468**	0.633**	0.534**
Fiber (gr)^r	31.9±10.6	22.7±6.2**	0.365**	0.311**	0.441**
Cholesterol (mgr)^r	318.9±154.0	203.1±85.5**	0.325**	0.340**	0.249*
PUFA (mgr)	19.4±7.4	15.7±7.2**	0.329**	0.368**	0,192
Vitamin A (retinol-µgr)^r	2389.9±1287.9	1255.7±1242.0**	0.122	0.134	0.017
Vitamin D (µgr)^r	1.64±0.8	1.9±2.8**	0.060	0.107	0.025
Vitamin E (mgr)^r	20.1±7.3	15.2±6.5**	0.341**	0.407**	0.289*
Vitamin B1 (mgr)	1.0±0.3	0.8±0.2**	0.324**	0.364**	0.179
Vitamin B2 (mgr)	1.9±0.5	1.3±0.4**	0.271**	0.381**	0.081
Vitamin B6 (mgr)^r	1.8±0.5	1.2±0.3**	0.398**	0.362**	0.055
Vitamin C (mgr)	199.4±82.9	115.7±48.5**	0.081	0.138	0.017
Sodium (mgr)	4558.2±1422.7	3952.6±1085.9**	0.376**	0.493**	0.289
Potassium (mgr)	3515.8±1094.3	2256.4±646.4**	0.200*	0.339*	0.044
Calcium (mgr)	1043.6±326.3	719.0±199.8**	0.283**	0.462**	0.221
Magnesium (mgr)	359.1±115.7	266.2±74.2**	0.392**	0.611**	0.427**
Phosphor (mgr)	1559.8±449.8	1104.4±289.0**	0.311**	0.484**	0.193
Iron (mgr)	14.7±4.5	11.1±3.1**	0.314**	0.460**	0.305
Zinc (mgr)	13.5±4.1	10.6±2.9**	0.429**	0.599**	0.539**

Data are expressed as mean ± standard deviation, *p<0.05, **p<0.001 paired t test and significance of Pearson's correlation, ^{r}with log transformed,
FFQ: Food frequency questionnaire
24HR: 24-hour dietary recall
PUFA: Polyunsaturated Fatty Acid.

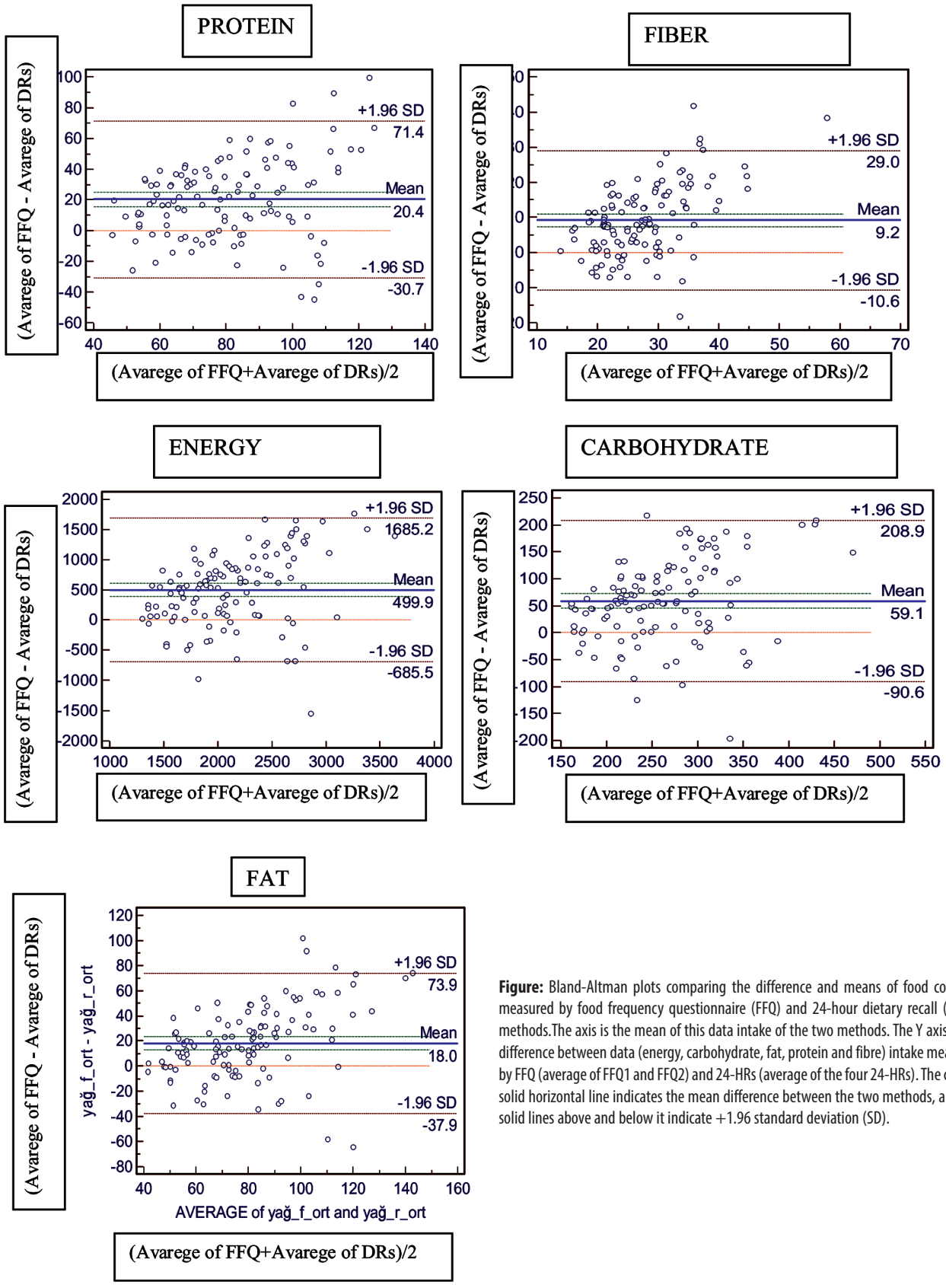

Figure: Bland-Altman plots comparing the difference and means of food contents measured by food frequency questionnaire (FFQ) and 24-hour dietary recall (24HR) methods.The axis is the mean of this data intake of the two methods. The Y axis is the difference between data (energy, carbohydrate, fat, protein and fibre) intake measured by FFQ (average of FFQ1 and FFQ2) and 24-HRs (average of the four 24-HRs). The central solid horizontal line indicates the mean difference between the two methods, and the solid lines above and below it indicate +1.96 standard deviation (SD).

Table-4: Values of daily intake, correlation and attenuation factor of food groups detected by FFQ and 24HRs.

Food Groups	The mean of values of FFQ	The mean of values of 24HRs	Pearson Correlation Unadjusted[r]	Attenuation coefficient[r]	Pearson Correlation Adjusted[r]
Meat group (gr)[r]	206.9±91.7	273.8±123.2**	0.356**	0.482**	0.269*
Sweet group (gr)[r]	49.9±33.8	31.8±19.0**	0.630**	0.760**	0.611**
Oil and margarine group (gr)	29.9±12.3	30.1±10.7**	0.305**	0.350**	0.202
Dairy groups (gr)[r]	318.6±157.3	191.9±105.2**	0.325**	0.396**	0.265**
Vegetable and fruit group (gr)	796.6±297.7	481.1±191.1**	0.190*	0.295*	0.176
Cereal group(gr)	413.3±139.9	391.3±111.6**	0.459**	0.576**	0.408**

Data are expressed as mean ± standard deviation, *p<0.05, **p<0.001 paired t test and significance of Pearson's correlation, [r]with log transformed
FFQ: Food frequency questionnaire
24HR: 24-hour dietary recall.

Table-5: Agreement of food consumption methods for nutrients.

Nutrient	Weighted Kappa	Same Quartile n(%)	Adjacent Quartile n(%)	Opposite quartile n(%)
Energy(kal)	0,527	48(40)	70(58.3)	2(1.7)
Protein(gr)	0,407	39(32.5)	79(65.8)	2(1.7)
Fat (gr)	0,493	59(49.2)	59(49.2)	2(1.7)
Carbohydrates (gr)	0,460	47(39.2)	69(57.5)	4(3.3)
Fibre (gr)	0,293	37(30.8)	77(64.2)	6(5)
Cholesterol (mg)	0,313	34(28.3)	80(66.7)	6(5)
PUFA(mgr)	0,353	44(36.7)	71(59.2)	5(4.2)
Vitamin A(retinol-µg)	0,153	37(30.8)	74(61.7)	9(7.5)
Vitamin D(µgr)	0,162	33(27.5)	77(64.2)	10(8.3)
Vitamin E(mgr)	0,340	40(33.3)	75(62.5)	5(4.2)
Vitamin B1(mgr)	0,270	32(26.7)	81(67.5)	7(5.8)
Vitamin B2(mgr)	0,362	33(27.5)	82(68.3)	5(4.2)
Vitamin B6(mg)	0,263	33(27.5)	80(66.7)	7(5.8)
Vitamin C(mg)	0,040	26(21.7)	81(67.5)	13(10.8)
Sodium(mgr)	0,287	46(38.3)	67(55.8)	7(5.8)
Potassium(mgr)	0,233	35(29.2)	77(64.2)	8(6.7)
Calcium (mgr)	0,300	36(30)	78(65)	6(5)
Magnesium(mgr)	0,413	42(35)	74(61.7)	4(3.3)
Phosphor (mgr)	0,393	38(31.7)	80(66.7)	2(1.7)
Iron(mgr)	0,280	31(25.8)	81(67.5)	8(6.7)
Zinc (mgr)	0,460	44(36.7)	74(61.7)	2(1.7)

PUFA: Polyunsaturated Fatty Acid.

was fair but still statistically significant for energy unadjusted (p<0.001 each) except Vitamin A, Vitamin D and Vitamin C (Table-4). Fibre intake detected by both methods correlated moderately for both energy unadjusted and energy adjusted (r=0.365; p<0.001 and r=0.441; p<0.001), attenuation coefficient of fibre was 0.311 (p<0.001). The lowest correlation coefficients were observed in vitamins A, D and C. The best correlation coefficients for both energy unadjusted, which are higher than 0.4, were obtained in carbohydrates, fat and zinc, and for energy-adjusted in carbohydrates, fibre, magnesium and zinc.

Correlation of daily consumption of food groups for both energy unadjusted and energy-adjusted were also moderate; r was 0.325-0.265, 0.630-0.611, 0.356-0.269, 0.459-0.408, 0.305-0.202 for dairy products, sweet group, meat group, cereals and oil group respectively (Table-4). The correlation coefficient of vegetable and fruit groups was fair but statistically significant for both energy unadjusted and energy-adjusted (r: 0.19; p= 0.03 and r=0.17; p=0.07). Attenuation of correlations was found for food groups between 0.295-0.760.

Mean values of FFQs and 24HRs were divided into quartiles, and then weighted kappa statistics were

Table-6: Agreement of food consumption methods for food groups.

Food Groups	Weighted Kappa	Same Quartile n(%)	Adjacent Quartile n(%)	Opposite quartile n(%)
Meat group(gr)	0,473	44(36.7)	74(61.7)	2(1.7)
Sweet group(gr)	0,347	47(39.2)	67(55.8)	6(5)
Oil and margarine groups (gr)	0,270	34(28.3)	81(67.5)	5(4.2)
Dairy groups(gr)	0,381	43(35.8)	73(60.8)	4(3.3)
Vegetable and fruit groups (gr)	0,227	29(24.2)	85(70.8)	6(5)
Cereal groups(gr)	0,530	49(40.8)	68(56.7)	3(2.5)

calculated to determine measures of agreement between FFQs and 24HRs. The same, adjacent or opposite quartiles were also determined (Table-5).

Percentages of classifying into the same or adjacent quartiles was 98.3%, 98.4%, 98.3%, 96.7% for energy, fat, protein, and carbohydrate respectively. The highest figures were 98.3 % for phosphorus, 98.4% for zinc, 96.7 % for magnesium, and the lowest value was 89.2% for Vitamin C. The percentage of classifying into the same or adjacent quartiles was in between those figures for the other micronutrients. Food groups had almost perfect agreement, which were higher than 95% (98.3% meat products, 97.5% cereals, 96.6% dairy products, 95.8% oil group, 95% sweet products, 95% vegetables and fruits).

Moderate agreement between the two methods, which was defined as weighted kappa value of 0.6-0.4, was obtained in energy (0.53), protein (0.41), fat (0.49,) carbohydrate (0.46), magnesium (0.41), zinc (0.46). There was no agreement on consumption of Vitamin A, Vitamin D and Vitamin C. The other micro nutrients had fair agreement, defined as weighted kappa values of 0,2-0.4.

In terms of food groups, meat products (0.47) and cereal (0.53) consumption showed moderate degree of agreement. Sweet products (0.34), oil groups (0.27), dairy products (0.38), and vegetables and fruits (0.22) had fair degree of agreement (Table-6).

To illustrate the limits of agreement between two methods, the Bland-Altman scatter plots were used for daily energy, protein, fat and carbohydrate intake (Figure). Different values of FFQ and 24HR were plotted against the total average then the mean±1.96 standard deviation (SD) for each subject was accepted as agreement limits. It was expected that all subjects would fall between these agreement limits. All plots showed an acceptable level of agreement between the two methods, confirming that 24HR may be replaced with FFQ.

Discussion

The study developed an FFQ on the basis of 229 food items and portion sizes of the dishes. It was subsequently validated. Although biological markers are suggested as the gold standard for evaluating dietary intake, but 24HRs are used for the validation of FFQs[15] due to feasibility.

Mean of FFQs seems to give more overestimated energy and macro nutrient intake than 24 HRs, respectively as 1877.8±469, 2377.6±658.8. One of the reasons of this may be that the mean intake of foods for FFQ is particularly for longer periods of time, i.e. one year, but 24HRs or DRs provide information on recent food intake.[16-18] To overcome this discrepancy, in our study 24HRs were collected four times a year, each being in a different season, and the FFQ was administered twice a year, but overestimations happened. Another reason of this is that the FFQ may also reflect methodological issues. As in other studies, this methodology makes it possible to detect all sources of food, but lead to overestimation, still allowing proper categorisation of consumption.[7,19,20]

Validity analyses were evaluated by using the Pearson correlation and by simple linear regression. In that analysis 24HRs were accepted as the reference method. Correlation was defined as poor if $r<0.2$, moderate if the correlation varied between 0.2 and 0.6, and high if $r>0.6$.[20,21] In the present study, the Pearson's correlation coefficients for both energy unadjusted and energy-adjusted were between 0.200-0.468 and 0.044-0.611, attenuation coefficients of regression were between 0.339-0.658, except for vitamin C, Vitamin A and Vitamin D. The measured Vitamin C and Vitamin A intake was higher in FFQ whereas Vitamin D intake was higher in 24HRs. In our study, correlations for energy intake, macro nutrients and food groups except for fruit and vegetables were better than in the others. It can therefore be said that the Turkish FFQ was accurate in measuring total energy, macro nutrients, minerals, the Vitamin B group, and Vitamin E intake in comparison with the 24HRs.

Similar validation studies have reported correlation rates between 0.13 and 0.74.[22-24] The most conspicuous difference between our study and those reporting high correlation rates is the time elapsed between 24HRs. One

study collected two 24HRs 20 days apart,[25] whereas in the present study, 24HRs were performed at three-month intervals being once in each season. However, differences in time can show changes due to seasonality in dietary intake. Fruits and vegetables are especially the main source for nutrients like Vitamin C and retinol, and the true correlations can be lower.[26-28]

Both the correlation analysis and agreement analyses of the two methods can indicate differential under- and over-reporting.[29] In the present study, agreement in terms of classification was good. More than 95% of participants were classified in the same or adjacent quartiles for all of the nutrients except Vitamins A, C and D. This is similar to other studies.[30,31] In epidemiological studies finding high or low consumers of a specific food type is sufficient to establish a relationship with the person's health status. In this study, in terms of classification of consumption patterns, FFQ represents 24 hours as a required and fulfilled epidemiological research tool criteria for macro nutrients, for minerals and for specific food groups. Bland-Altman analysis also supports this notion.

Bland-Altman analyses showed that there is an acceptable consistency between the present FFQ and 24HRs, which was used as the reference.[32] These findings were consistent with the acceptability results reported in other studies.[30,33]

As the strength of the present study, we can say that this FFQ is the first one particular to the Turkish cuisine, which will be a perfect example for other cuisines. Another important point in this study is the use of a food atlas which is easily understandable to everybody. The amount of consumed food in the food atlas very closely reflects on the true dietary intake in daily life. The other advantage of the Turkish FFQ is that it contains specific most commonly consumed dishes as separate food items. The 24HRs were performed at three-month intervals, once in each season. It is important that there is a period of time between the 24HRs and that they are performed in different seasons.

The questionnaire's inability to represent those under the age of 30 years was a limitation, since only adults older than 30 years were included. Another limitation of the study was the fact that biological markers could not be used as reference food intake measurements because this would have been an invasive method and also expensive.

Conclusion

The validity of the Turkish FFQ was positively demonstrated and is likely to make a considerable contribution to further studies on this issue due to it being the first questionnaire developed for the Turkish population.

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