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Validation of a semi-quantitative food frequency questionnaire to assess food groups and nutrient intake

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Abstract

Introduction: **Semi-quantitative Food Frequency Questionnaires (FFQs) analyze average food and nutrient intake over extended periods to associate habitual dietary intake with health problems and chronic diseases. A tool of this nature applicable to both women and men is not presently available in Mexico.**

Objective: **To validate a FFQ for adult men and women.**

Methods: **The study was conducted on 97 participants, 61% were women. Two FFQs were administered (with a one-year interval) to measure reproducibility. To assess validity, the second FFQ was compared against dietary record (DR) covering nine days. Statistical analyses included Pearson correlations and Intraclass Correlation Coefficients (ICC). The de-attenuation of the ICC resulting from intraindividual variability was controlled. The validity analysis was complemented by comparing the classification ability of FFQ to that of DR through concordance between intake categories and Bland-Altman plots.**

Results: **Reproducibility: ICC values for food groups ranged 0.42-0.87; the range for energy and nutrients was between 0.34 and 0.82. Validity: ICC values for food groups ranged 0.35-0.84; the range for energy and nutrients was between 0.36 and 0.77. Most subjects (56.7-76.3%) classified in the same or adjacent quintile for energy and nutrients using both methods. Extreme misclassification was <6.3% for all items. Bland-Altman plots reveal high concordance between FFQ and DR.**

Conclusions: **FFQ produced sufficient levels of reproducibility and validity to determine average daily intake over one year. These results will enable the analysis of possible associations with chronic diseases and dietary diagnoses in adult populations of men and women.**

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Key words: *Diet. Questionnaire. Nutrients. Energy intake. Validation.*

VALIDACIÓN DE UN CUESTIONARIO SEMI-CUANTITATIVO DE FRECUENCIA DE CONSUMO DE ALIMENTOS PARA DETERMINAR LA INGESTIÓN DE GRUPOS DE ALIMENTOS Y NUTRIENTES

Resumen

Introducción: **Los cuestionarios semicuantitativos de frecuencia de consumo (CFC) analizan ingestión promedio de alimentos y nutrimentos en períodos extensos para asociar consumo habitual con problemas de salud, como enfermedades crónicas. En México, no existe una herramienta similar, aplicable en mujeres y hombres.**

Objetivo: **Validar un CFC en mujeres y hombres adultos.**

Métodos: **El estudio incluyó 97 participantes (61% mujeres). Dos CFC fueron aplicados (un año entre ambos) para medir reproducibilidad. Para validez, se comparó el segundo CFC con registros dietéticos de nueve días. Los análisis incluyeron correlaciones de Pearson y coeficientes de correlación intraclase (CCI). Se controló desatenuación de CCI provocada por la variabilidad intraindividual. El análisis de validez se complementó con la comparación de la capacidad de clasificación entre CFC y registros dietéticos, mediante concordancia de categorías de consumo y gráficos de Bland y Altman.**

Resultados: **Reproducibilidad: los CCI para grupos de alimentos oscilaron entre 0,42-0,87 y para nutrimentos entre 0,34-0,82. Validez: los CCI para grupos de alimentos variaron entre 0,35-0,84 y para nutrimentos entre 0,36-0,77. La mayoría de sujetos (56,7-76,3%) clasificaron en el mismo quintil o adyacente por ambos métodos (media 66,1%), para energía y nutrimentos. La mala clasificación extrema para todos los ítems fue <6,3%. El análisis con gráficos de Bland y Altman determinó una buena capacidad de acuerdo del CFC, respecto a registros dietéticos.**

Conclusiones: **El CFC obtuvo reproducibilidad y validez adecuadas para determinar ingestión diaria promedio, en un año. Esto permitirá analizar posibles asociaciones con enfermedades crónicas y diagnósticos dietéticos poblacionales en mujeres y hombres adultos.**

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Palabras clave: *Dieta. Cuestionario. Nutrientes. Ingestión de energía. Validación.*

DR: Dietary record.
FFQ1: Food frequency questionnaire administered the baseline.
FFQ2: Food frequency questionnaire administered one year later after the baseline.
FFQs: Semi-quantitative food frequency questionnaires.
ICC: Intraclass Correlation Coefficients.
PREDIMED: Prevención con Dieta Mediterránea.
SD: Standard deviation.
SPSS: Statistical Package for the Social Sciences.
USDA: United States Department of Agriculture.

Introduction

Diet has been a major focus of recent research because it is considered to be a determinant and modifiable factor in the development of chronic diseases[1]. These diseases are ranked as leading causes of morbidity and mortality in Mexico and the world[2,3]. In addition, studying the dietary habits of populations is of priority importance with regards to public health because it facilitates decision-making in the development of dietary assistance programs, the implementation of actions to improve the dietary habits of a population, the development of policies for the fortification or labeling of food and the determination of nutritional recommendations[1].

Measuring dietary intake involves challenges because each individual's eating behaviors are influenced by variables that limit assessment. It is nonetheless necessary to validate instruments that may be used to obtain a more accurate view of the realities of dietary intake. FFQs are the most commonly used tools for this purpose in epidemiological studies. They determine average intake over extended periods of time and facilitate associations between habitual dietary intake and chronic diseases, with the additional advantage that they are relatively inexpensive and quick to administer. FFQs are usually highly effective at classifying individuals in a population by food and nutrient intake; despite their accuracy in determining the absolute value of individual intake, it is recognized they have limitations[4].

Previous studies have developed and validated FFQs for administration to Mexican population groups. However, these studies were focused on female populations[5-7] to determine the intake of folates[5], antioxidants[6] and nutrients[7]. These factors preclude their administration to both genders and the possibility of determining the intake of food groups.

The purpose of this study was to measure the reproducibility and validity of a FFQ that determines the average intake of 12 food groups, energy and 26 nutrients. It can be administered to adult women and men and used in epidemiological studies that analyze the relationship between diet and chronic diseases or in dietary diagnostics/assessments of a population.

Objective

To validate a FFQ for adult men and women.

Methods

Study Subjects

The study included adult men and women in apparent good health. The average age of the study's participants (n = 97, 61% women) was 27.5 years old (18-71), with no differences in characteristics associated with gender, age or occupation, compared with subjects who failed to complete the nine-day DR (n = 51) or the second FFQ (n = 2) and were excluded from the study. The majority of participants were residents of the metropolitan area of Guadalajara, Mexico, who were generally unmarried (82%) and students or professionals in the health sector (62%). Subjects received information on the purpose and protocol of the study and signed an informed consent form. The protocol for this study complied with the provisions governing research of Mexico's General Health Act[8] as well as the tenets of the Declaration of Helsinki[9].

Validation of the Study

The volunteers for this study were recruited between november 2010 and march 2011. A nutritionist, using a standardized process, administered the baseline FFQ (FFQ1); this procedure was repeated one year later (FFQ2) and enabled the reproducibility of the instrument to be determined. The questionnaire was administered through interviews (not by self-reporting) in order to minimize errors in estimating portions and intake frequency. Participants were asked to maintain their dietary habits throughout the one-year period of the study.

The FFQ contained 162 items; it was adapted from the validated FFQ used in the PREDIMED (*Prevención con Dieta Mediterránea*) Study[10]. For each food item, a standard portion was established from which intake frequency was determined. The nutritionist used an *ad-hoc* procedure developed in Excel®, hence preventing errors resulting from rapid mental calculations. In addition, seasonal adjustments were considered for fruits or foods that are traditionally eaten more at certain times of the year. The average intake of each food was recorded using nine options as proposed by Willet[11]: never or almost never, 1-3 times per month, once per week, 2-4 times per week, 5-6 times per week, 1 serving per day, 2-3 servings per day, 4-6 servings per day and more than six servings per day.

DR was used as the benchmark method for assessing validity. Surveyors (nutritionists) trained participants to complete their own DR at the beginning of the study. Three records were collected over one year (one, four and seven months after the administration of FFQ1); each record covered three days (two weekdays and one weekend day), in order to reflect seasonal and weekly changes in food intake. DR was subsequently verified by the nutritionist in order to detect and clarify (with the help of participants) missing or confusing data.

Data Processing and Statistical Analysis

FFQs and DRs were processed using NutriCloud® software, which used Mexican food composition tables[12] and those of the USDA (United States Department of Agriculture)[13] as a baseline to determine the average daily intake of energy and 26 nutrients for both methods. Foods in the FFQ and DR were organized into 12 groups, from which we determined the average daily intake. Descriptive intake data of food groups, energy and nutrients are presented as mean and standard deviation (SD). Nutrient intakes were transformed logarithmically to improve normality (log10) and adjusted according to energy through the residual method, prior to reproducibility and validity analyses.

Reproducibility was measured using Pearson correlations for the intake of food groups, energy and nutrients from the two FFQs. The validity of the FFQ was also measured for food groups, energy and nutrients, using Pearson correlations between the second FFQ2 and nine-day DR average. We subsequently calculated ICC because they combine the underlying concepts of validity and reproducibility in linear correlation and in the comparison of means in paired data. FFQ2 was chosen because it has the same administration period as DR. De-attenuation of correlation coefficients caused by intraindividual variability observed in DR was performed using standard techniques[14,15].

The classification ability of individuals was examined through concordance between intake categories expressed in contingency tables where the classification from FFQ2 quintiles are compared against DR average quintiles, for the intake of food groups and nutrients. Lastly, Bland-Altman plotting tools were used[16] to enhance the understanding of validity results and identify deviation patterns.

Statistical analyses were performed using the SPSS software version 17.0 (SPSS Inc., Chicago, USA).

Results

Average intakes of food groups and nutrients from FFQ1, FFQ2 and from the DR average are shown in table I. The habitual intake of food groups and nutrients reported through FFQ2s tended to be higher than that reported through DR (with the exceptions of cereals,

legumes, industrialized foods, folates, vitamin E and selenium).

Table II shows reproducibility (FFQ1 vs. FFQ2) and validity (FFQ2 vs. DR) results for food groups and nutrients.

Reproducibility Pearson correlations for food groups ranged from 0.27 to 0.77, while ICCs fluctuated between 0.42 and 0.87, all of which were significant (p < 0.05). Food groups with the highest ICCs were beef, pork and poultry (0.87) and alcoholic drinks (0.85). Groups with the lowest ICCs were oils and fats (0.42) and oilseeds (0.57). Pearson correlations for nutrients (p < 0.05) ranged from 0.20 to 0.69 (data adjusted for energy), and ICCs fluctuated between 0.34 and 0.82. Items with the highest ICCs (adjusted data) were ethanol (0.82) and fiber (0.78); ICCs were lowest for vitamin E (0.34) and polyunsaturated fat (0.47).

Validity Pearson correlations for food groups ranged from 0.21 to 0.71 (p < 0.05), while ICCs (p < 0.05) varied from 0.35 to 0.84. Food groups with the highest ICCs were dairy products (0.84) and alcoholic drinks (0.73); the lowest ICCs were for sugars (0.35) and oilseeds (0.43). Pearson correlations (p<0.05) for nutrients ranged from 0.22 to 0.62 (adjusted data). ICCs (p < 0.05) ranged from 0.36 to 0.77 (adjusted data). The items with the highest ICCs (adjusted data) were calcium (0.77) and ethanol (0.71). The item with the lowest ICC was sodium (0.36). Nutrients with non-significant ICCs were riboflavin, vitamin E, lipids, polyunsaturated fat and carbohydrates.

Table III presents the results of the classification ability of individuals through concordance between intake quintiles from the FFQ2 and DR average. The second column shows the percentage of individuals whose intake was classified in the lowest quintile according to DR, and in the highest quintile according to FFQ2. The third column displays the percentage of individuals whose intake was classified in the highest quintile according to DR, and in the lowest quintile according to FFQ2. Hence, these two columns indicate poor concordance by classification into opposite quintiles. The last column (good concordance) gives the percentage of individuals whose intake was categorized in the same or adjacent quintile with both methods.

For food groups, 52.6%-78.4% of individuals were classified into the same or adjacent quintile (mean 67.3%) for the different items for both methods. The food groups with the highest concordance between FFQ and DR were alcoholic drinks (78.4%), dairy products (78.0%) and vegetables (74.2%). The group with the lowest concordance was sugars (52.6%). Poor concordance by classification into opposite quintiles, after considering the sum of the second and third columns of each item, was < 5.2% (mean 2.5%) for all food groups. For nutrients, 56.7%-76.3% of individuals were classified into the same or adjacent quintile (mean 66.1%). Items with the highest concordance were thiamine (76.3%), calcium (74.2%) and folate (73.2%). Item with the lowest concordance were

Item (units/day)	FFQ1		FFQ2		DR	
	Mean	SD	Mean	SD	Mean	SD
Food groups (g)						
Dairy products	479.1	301.3	420.0	266.8	359.9	185.9
Oils and fats	45.5	28.9	41.6	30.4	29.2	16.9
Fruits	536.5	302.7	499.6	295.4	217.6	148.6
Vegetables	313.2	177.8	325.9	173.2	184.5	99.8
Cereals	241.1	125.0	231.6	116.7	306.8	126.5
Legumes	37.0	35.5	34.2	35.9	54.3	39.9
Oilseeds	17.4	20.7	14.2	15.7	5.1	8.7
Beef, pork and poultry	148.5	89.6	138.4	65.5	113.2	58.4
Fish and seafood	54.0	51.8	57.7	66.4	24.9	22.8
Industrialized food	142.2	100.5	115.0	72.6	141.6	78.6
Sugars	47.6	39.1	41.0	36.2	30.8	27.3
Alcoholic drinks	79.4	147.7	58.3	88.9	47.2	118.5
Energy and nutrients						
Energy (kcal)	2924.3	1149.5	2601.5	936.9	2041.4	621.3
Fiber (g)	24.6	10.8	23.7	11.8	19.7	7.9
Carbohydrates (g)	367.6	167.2	328.8	136.7	267.7	81.2
Protein (g)	108.9	41.2	98.9	38.3	88.6	26.7
Lipids (g)	115.0	47.8	101.0	35.8	71.2	24.3
Saturated fat (g)	36.4	16.4	30.9	12.2	22.8	8.9
Monounsaturated fat (g)	37.6	16.9	33.8	12.3	21.8	7.8
Polyunsaturated fat (g)	21.4	10.3	19.3	10.1	14.5	5.7
Cholesterol (mg)	409.8	196.6	394.5	201.7	241.3	92.5
Calcium (mg)	1235.2	530.5	1128.1	480.3	894.3	287.6
Phosphorus (mg)	1792.5	667.6	1645.0	635.0	1207.2	389.2
Iron (mg)	25.5	11.9	23.0	11.5	19.2	7.5
Magnesium (mg)	480.6	175.1	456.9	177.4	331.8	109.8
Sodium (mg)	2896.9	1629.5	2487.0	1269.4	2243.8	774.2
Potassium (mg)	4602.8	1523.9	4338.5	1677.9	2561.0	719.6
Zinc (mg)	12.4	5.0	11.4	4.4	10.7	3.7
Vitamin A (µg)	1134.0	625.0	1092.7	589.3	670.4	399.9
Vitamin C (mg)	352.7	192.9	339.2	215.4	139.2	69.6
Thiamin (mg)	2.4	1.1	2.1	0.9	1.5	0.6
Riboflavin (mg)	4.3	2.8	4.1	4.4	1.7	0.6
Niacin (mg)	25.1	11.4	23.2	10.0	19.8	8.0
Vitamin B6 (mg)	2.6	1.2	2.4	1.0	2.0	1.0
Folate (µg)	263.8	110.3	249.6	102.1	263.6	126.7
Vitamin B12 (µg)	8.3	4.3	7.6	4.0	5.9	3.2
Vitamin E (mg)	1.2	1.5	1.3	1.2	2.4	1.3
Selenium (µg)	47.8	26.9	49.8	26.3	61.9	25.7
Ethanol (g)	6.2	9.1	5.0	7.5	2.8	7.3

vitamin E (56.7%). The poor concordance by classification into opposite quintiles was <6.3% (mean 2.4%) for all nutrients.

The Bland-Altman plots shown in figure 1 are for beef, pork and poultry foods and fruits, while figure 2 shows plots for energy and iron. The horizontal axis represents average intake for corresponding items according to FFQ and DR, while the vertical axis represents the difference between both methods. These figures illustrate the configuration of measurements obtained for the other food groups and nutrients and confirm the tendency to overestimate FFQ2 in comparison with DR (observed in descriptive data) based on the mean of the differences (continuous line); for most items it was higher than zero

with the exception of cereals, legumes, industrialized foods, folate, vitamin E and selenium (data not shown). Moreover, most of the dots were within the limits of agreement (±1.96 SD of the mean of the differences) for all items. However, in some cases (e.g. fruits and iron –figures 1b and 2b–) the graph suggests poorer concordance when intake amounts increase.

Discussion

FFQ obtained a high level of reproducibility (CCI between 0.61 and 0.80) and reasonably acceptable levels of validity (CCI between 0.41 and 0.80) for 79%

	Reproducibility				Validity			
	r[b]		ICC[b]		r[b]		ICC[b,c]	
Item[a]	Unadjusted	Energy-adjusted	Unadjusted	Energy-adjusted	Unadjusted	Energy-adjusted	Unadjusted	Energy-adjusted
Food groups								
Dairy products	0.73		0.82		0.71		0.84	
Oils and fats	0.27		0.42		0.35		0.53	
Fruits	0.59		0.74		0.37		0.54	
Vegetables	0.50		0.66		0.46		0.64	
Cereals	0.61		0.76		0.53		0.67	
Legumes	0.48		0.64		0.42		0.59	
Oilseeds	0.40		0.57		0.27		0.43	
Beef, pork and poultry	0.77		0.87		0.51		0.68	
Fish and seafood	0.64		0.78		0.30		0.46	
Industrialized food	0.64		0.78		0.41		0.59	
Sugars	0.72		0.84		0.21		0.35	
Alcoholic drinks	0.74		0.85		0.55		0.73	
Energy and nutrients								
Energy	0.69	0.82	0.50	0.67				
Fiber	0.63	0.65	0.77	0.78	0.29	0.40	0.44	0.58
Carbohydrates	0.70	0.41	0.82	0.57	0.45	0.16[d]	0.60	0.27[d]
Protein	0.66	0.39	0.80	0.56	0.41	0.38	0.58	0.56
Lipids	0.55	0.34	0.71	0.50	0.48	0.10[d]	0.64	0.18[d]
Saturated fat	0.67	0.45	0.80	0.62	0.55	0.32	0.71	0.49
Monounsaturated fat	0.44	0.37	0.61	0.54	0.45	0.32	0.62	0.49
Polyunsaturated fat	0.36	0.31	0.52	0.47	0.36	0.12[d]	0.52	0.21[d]
Cholesterol	0.60	0.45	0.75	0.62	0.47	0.32	0.64	0.49
Calcium	0.67	0.62	0.80	0.75	0.56	0.62	0.70	0.77
Phosphorus	0.66	0.45	0.80	0.61	0.50	0.40	0.66	0.58
Iron	0.58	0.36	0.74	0.53	0.41	0.38	0.57	0.61
Magnesium	0.61	0.48	0.76	0.65	0.43	0.42	0.60	0.59
Sodium	0.66	0.40	0.79	0.57	0.25	0.22	0.38	0.36
Potassium	0.62	0.54	0.76	0.70	0.31	0.49	0.45	0.62
Zinc	0.71	0.41	0.83	0.57	0.44	0.32	0.61	0.48
Vitamin A	0.58	0.47	0.74	0.64	0.43	0.43	0.60	0.62
Vitamin C	0.62	0.63	0.76	0.77	0.32	0.42	0.49	0.60
Thiamin	0.69	0.41	0.81	0.58	0.47	0.39	0.63	0.55
Riboflavin	0.53	0.45	0.69	0.62	0.18[d]	0.13[d]	0.23[d]	0.16[d]
Niacin	0.70	0.51	0.82	0.67	0.45	0.51	0.62	0.69
Vitamin B6	0.67	0.41	0.80	0.58	0.42	0.47	0.59	0.62
Folate	0.61	0.55	0.76	0.71	0.34	0.38	0.51	0.55
Vitamin B12	0.73	0.63	0.85	0.77	0.51	0.36	0.67	0.54
Vitamin E	0.18	0.20	0.30	0.34	0.12[d]	0.09[d]	0.19[d]	0.18[d]
Selenium	0.57	0.45	0.72	0.62	0.37	0.34	0.53	0.51
Ethanol	0.69	0.69	0.81	0.82	0.58	0.53	0.73	0.71

r, Pearson correlation; ICC, Intraclass Correlation Coefficient.
[a]Intakes of food groups, energy and nutrients were transformed (log10) to improve normality.
[b]All correlations with p<0.05, with the exception of those marked with [d].
[c]The ICC are shown de-attenuated.

of food groups and nutrients. When considering the 12 food groups, energy and the 26 nutrients analyzed, ICCs for reproducibility and validity ranged from fair to excellent (0.34-0.87 and 0.35-0.84, respectively), with the exception of 5 nutrients (with ICCs of non-significant validity).

The range of reproducibility coefficients was similar to that reported by other studies on specific popula-tions[17-18]. Others reported slightly higher[10,17] or lower[7,18-21] correlations. When comparing reproducibility results with those obtained in a previous study in Mexican women[7], the ICCs in our study were good for most items (food groups and nutrients), unlike the previous study, which showed fair ICCs for most nutrients. The differences could be due to the fact that the preceding study included women from the general population

Item	Lowest quintile in DR and highest quintile in FFQ2	Highest quintile in DR and lowest quintile in FFQ2	Classified in DR within one (or adjacent) quintile in FFQ2
Food groups			
Dairy products	0.0	0.0	78.0
Oils and fats	2.1	1.0	67.0
Fruits	1.0	0.0	68.0
Vegetables	2.1	0.0	74.2
Cereals	1.0	2.1	73.2
Legumes	1.0	2.1	61.9
Oilseeds	2.1	1.0	57.7
Beef, pork and poultry	1.0	4.1	64.9
Fish and seafood	0.0	0.0	63.9
Industrialized food	2.1	2.1	68.0
Sugars	4.1	1.0	52.6
Alcoholic drinks	0.0	0.0	78.4
Energy and nutrients			
Energy	1.0	1.0	72.2
Fiber	1.0	1.0	60.8
Carbohydrates	1.0	0.0	70.1
Protein	1.0	1.0	67.0
Lipids	1.0	1.0	66.0
Saturated fat	0.0	0.0	69.1
Monounsaturated fat	3.1	0.0	62.9
Polyunsaturated fat	3.1	0.0	60.8
Cholesterol	0.0	2.1	57.7
Calcium	1.0	0.0	74.2
Phosphorus	1.0	0.0	61.9
Iron	0.0	1.0	70.1
Magnesium	0.0	1.0	64.9
Sodium	2.1	1.0	57.7
Potassium	3.1	3.1	66.0
Zinc	1.0	1.0	58.8
Vitamin A	0.0	0.0	70.1
Vitamin C	1.0	2.1	62.9
Thiamin	0.0	2.1	76.3
Riboflavin	2.1	3.1	69.1
Niacin	2.1	1.0	72.2
Vitamin B6	2.1	3.1	67.0
Folate	0.0	1.0	73.2
Vitamin B12	0.0	1.0	67.0
Vitamin E	3.1	2.1	56.7
Selenium	2.1	2.1	66.0
Ethanol	1.0	2.1	64.9

with an average of seven years of formal education, unlike the most subjects of our study who had completed 12 or more years of education or in methodological differences.

The range into which validity coefficients fluctuated is similar to those reported by other studies on different populations[7,10,17,22-24]. Others reported slightly lower correlations[18,19,21,25-29]. The number of days used as a parameter of comparison is a factor that may affect validity. It was observed that the studies producing the lowest correlation coefficients were based on fewer days (three or four)[19,21,25-30], in contrast to our study and others that included at least nine days of assessment[7,10,17,23,24]. Variability in diet has been shown to have a greater effect on validity when fewer days are used in the assessment[31].

The classification ability obtained by FFQ was slightly better than that produced in other studies, when is compared the average extreme misclassification of FFQ against DR average[10,22,25,26,29]. However, it is noteworthy that some studies, for the purposes of comparison, grouped participants into tertiles[25,26] or quartiles[22,29,32] instead of quintiles as in our study, chosen to facilitate more precise classifications.
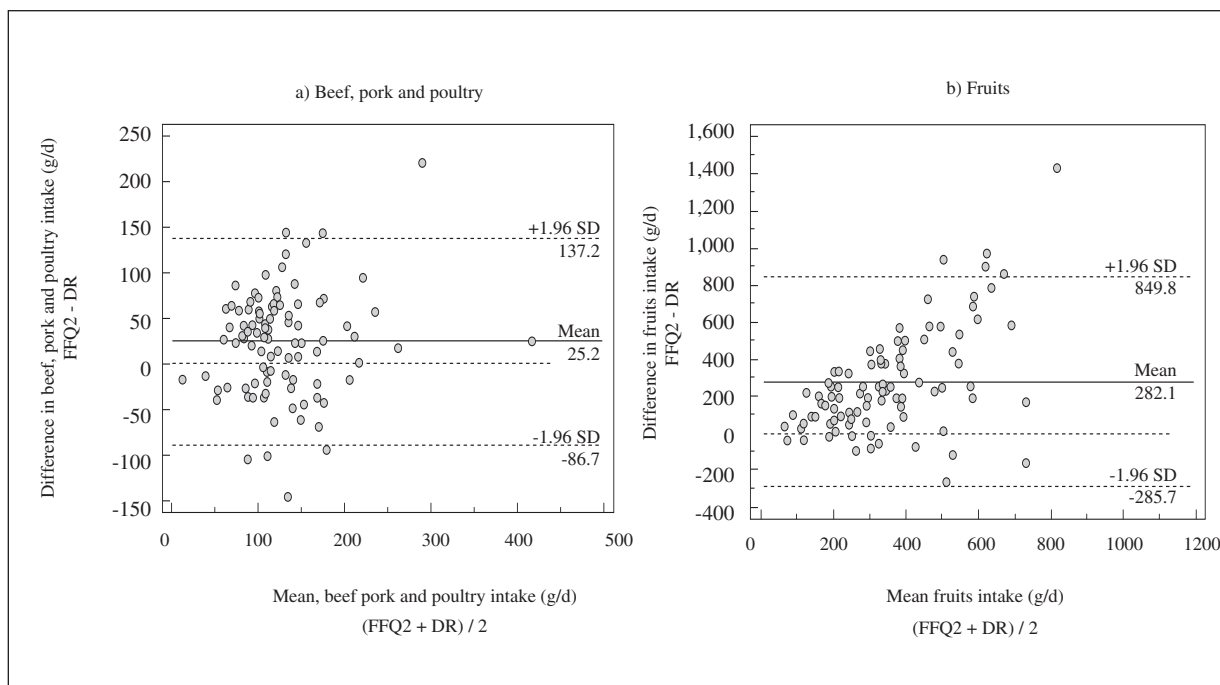
Fig. 1.— Bland-Altman plots illustrating the relationship between average intake of a) beef, pork and poultry and b) fruits, estimated with the FFQ2 and nine-day DR average (n = 97).
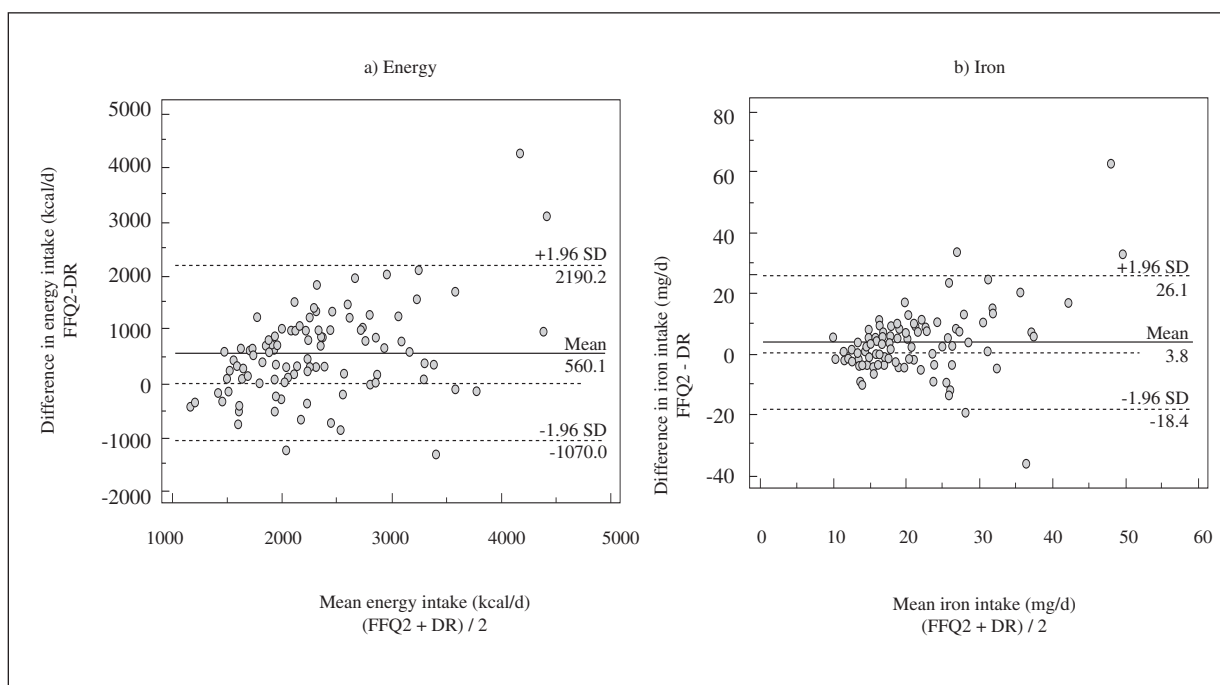

Fig. 2.—Bland-Altman plots illustrating the relationship between average intake of a) energy and b) iron, estimated using FFQ2 and nine-day DR average (n = 97).

The tendency towards overestimation of FFQ2 with respect to DR average reflected graphically in Bland-Altman analyses has been identified in other studies[10,25-27], and it has been documented that this situation is to be expected when FFQs contain more than 100 items[10,26]. The existence of the opposite trend in studies with only 47-84 items confirms this notion[17,19,29]. Our FFQ contains 162 items, exceeding the average number of items used in the FFQs of other studies. However, this number was considered appropriate because the FFQ will also be used to create a diet quality index which will in part seek to determine whether diets are varied, which would not be very feasible with a reduction in the number of foods included.

Strengths and Limitations

Validation of the FFQ on adult men and women is considered as a strength because it fills a need in the field of nutrition in Mexico. To our knowledge, no tool which includes this feature has thus been reported. The inclusion of the food group intake in the assessment, as opposed to only nutrients, allows a more complete analysis of dietary intake which may subsequently guide, in a more efficient way, the resulting recommendations aimed at establishing healthful eating patterns. Furthermore, the assessment of dietary intake in different seasons of the year, and the fact that participants entered the study at different times enabled us to obtain a more complete view of habitual diets.

The use of different methods to assess FFQ validity offers a broad perspective with implications for future administrations. Reproducibility correlations offer a consistency measure for each of the FFQ items, while validity correlations reported a perspective on the relationship between the data obtained from the FFQs in comparison with a method considered superior (DR). The comparison of classification ability through concordance between FFQ and DR intake categories helps to show their usefulness in the classification of a population based on food and nutrient intake. For their part, Bland-Altman's analyses demonstrate agreement between the two methods.

The standardization of FFQ administration by a nutritionist using *ad hoc* calculation tools also reduces potential calculation errors when completing FFQ. Even though this factor was considered to be a strength, it could have also led to an overestimation of results with this instrument. However, no major discrepancies in validation coefficients were identified in comparison with other studies in which FFQ was self-administered[7,10,17,22-24,33]. FFQ was administered through interviews to minimize bias due to a possible lack of understanding of the process and interpretation of intake frequency (as reported from perceptions of portions recorded in the FFQ). It is suggested, therefore, the administration of the FFQ the same way in future uses.

Choosing the DR average as a tool of comparison could be considered a limitation. Disadvantages such as the tendency of subjects to modify their diet, the omission of food from the report and even the preference for more healthful eating habits resulting from participant awareness of being assessed[30] disqualify it from "gold standard" status. This may explain to some extent the tendency for intakes reported in DR to be underestimated. However, despite the inherent disadvantages of DR, this method was chosen because it is otherwise considered superior and more feasible, and because it produces fewer errors of memory and food portion perception than the 24-hour recall method. This comparison method is also used in validation studies[7,17,19,21,22,24,25,28].

The homogeneity of participants may be a limiting factor of this study, as most participants had a high level of education and were students or professionals in the health sector. However, the conduction of FFQs by nutritionists (through interviews) will help to minimize this limitation in future administrations.

Conclusions

FFQ is a satisfactory instrument for the measurement of food groups and nutrients intake in adult men and women. This tool will help to obtain an overview of intake during an average day of the year preceding assessment and hence enable other studies to analyze possible associations with chronic diseases and carry out dietary diagnoses on populations.

The high concordance between FFQ and DR suggests the usefulness of FFQs in future epidemiological studies aimed at classifying populations according to intake levels. Nonetheless, items with low correlations of reproducibility and validity should be examined carefully when the objective is not just to classify a population, but to precisely determine intake.

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