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Nutrition Research, Vol. 18, No. 10, pp. 1649–1659, 1998

0271-5317/98 $19.00 + .00

PII S0271-5317(98)00151-1

VALIDITY OF A BRAZILIAN FOOD FREQUENCY QUESTIONNAIRE AGAINST DIETARY RECALLS AND ESTIMATED ENERGY INTAKE

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ABSTRACT

Food frequency questionnaires are commonly used to obtain dietary information in epidemiological studies, but validity studies have primarily been performed in western countries situated in the Northern Hemisphere. A food frequency questionnaire for the Brazilian diet was developed based on a previous survey and expert decision. This questionnaire was compared with four 24-hour recalls among faculty and support staff at the University of Rio de Janeiro, Brazil, and both methods were validated against estimated daily energy requirement. Results of the food frequency questionnaire and the 24-hour recalls were correlated to a similar degree as in studies of other populations. The correlation coefficients varied from 0.55 for calcium to 0.18 for vitamin A, with all but vitamin A being highly significant. The ratio of energy intake to estimated basal metabolism among men was 1.37 for the 24-hour recall and 1.31 for the food frequency; among women the ratio was 1.15 for the 24-hour recall and 1.24 for the food frequency. Women with high predicted energy expenditure often underestimated intake, with a greater discrepancy on the 24-hour recall than the food frequency.

Key words: Dietary Assessment, Bias, Misclassification, 24-hour Recall, Food Frequency.

INTRODUCTION

Food frequency questionnaires are commonly used to obtain dietary information in epidemiological studies of chronic diseases. During the last decade it has been established that dietary intake can be measured with these instruments (1-3). An advantage of a food frequency questionnaire is the possibility of ranking individual consumption with a single administration, whereas 24-hour recall of diet - a useful method to evaluate group consumption - requires data on more than one day and data handling is more complex, because questionnaires facilitate both data collection and processing.

Validity studies of food frequency questionnaires have primarily been performed in western

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countries situated in the Northern Hemisphere. However, to conduct research on diet and disease, measures of dietary intake need to be developed and validated for each population studied. One of the challenges for the accurate assessment of dietary intake is the comparability of instruments across ethnic and socioeconomic groups. Food-frequency questionnaires in minority populations have performed less well in the United States, resulting in poorer correlation coefficients from validity studies in these populations (4). It has been suggested that special protocols were needed for the assessment of poorly educated (5). Because the Brazilian population has great socioeconomic disparities, a validation study of dietary questionnaire should be tested in both poor and well-educated population.

Regardless of the reporting method of dietary intake, discrepancies between self-reported and actual intake have been demonstrated in affluent societies. Obese adults have reported lower energy intake than that estimated from energy expenditure measured with double labeled water and lower intake of protein nitrogen than urinary nitrogen excretion (6,7). Lichtman et al, 1992 (8) showed that obese subjects were not a homogeneous group in reporting portion-size of meals; subjects with a history of resistance to weight loss dieting under-reported the portion-size, and those without this history over-reported portion-size. A study comparing observed and reported energy and nutrient consumption showed a significant over-reporting of energy consumption that was not affected by body weight (9). Heitmann & Lissner, 1996 (10) showed that obese Danish adults underreported total energy and protein intake.

The issues noted here indicate that dietary instruments need to be developed and tested for individual cultures and populations. We developed a food frequency questionnaire for the Brazilian diet, compared it with four 24-hour recalls applied to University workers in Rio de Janeiro, and then validated both methods against the estimated daily energy requirement, based on World Health Organization equations.

MATERIALS AND METHODS

Population

Employees of the State University of Rio de Janeiro were systematically sampled from professional lists (386 men and 434 women) and support staff lists (45 men and 77 women). Professional staff were all teachers. Among the support staff, women did housekeeping and men were involved in campus safety, mail delivery, etc. From each list, 30 individuals were invited to participate in the study. Employees were allowed a half-day off in order to participate in the study. Interviews and measurements were made in the building where participants worked during the work period. All participants signed informed consent. Of the total of 120 employees enrolled, data on the food frequency questionnaire was obtained on 94 subjects (3 with incomplete recalls were excluded). Eighty-eight subjects, 46 support staff (22 men and 24 women) and 42 professional staff (20 men and 22 women) completed both interviews.

Dietary assessment methods

Data on food intake were obtained by interview with seven trained nutritionists who also measured weight and height. Participants were scheduled to visit on Mondays and Wednesday or Thursday mornings in order to acquire information for both weekends and weekdays. At the first interview, the food frequency questionnaire (usual intake during the last year) was followed by recall of the previous 48 hour intake (two 24 hour dietary recalls). Two weeks later, an interview was conducted by another nutritionist to recall the previous 48 hour intake (two 24-hour recalls).

A semiquantitative food frequency questionnaire was developed from data obtained in a National survey carried out in 1974-1975 (11), in which 7-day food weighing was performed by trained interviewers. From this survey, we included the 61 most commonly consumed foods. These foods represented 86 percent of total energy intake, 84 percent of vitamin A intake, and 76 percent of vitamin C intake in the 1974 - 1975 survey in the state of Rio de Janeiro. The questionnaire's final version contained 73 food items (Table 1), which included these 61 foods plus other foods that, based on expert opinion, were commonly consumed by today's urban population. The usual portions were recorded for each item. For most items there were two options only: soup spoon and cup. For a number of common foods there were more choices. Thus, for rice there was four options: soup spoon, rice spoon (a spoon larger than a regular soup spoon), larger spoon used for frying and soup plate half full. For beans the options were two different sizes of ladle and soup spoon; for pasta there were six options. Frequencies of consumption were recorded by day, week, month, or year as well as never and almost never. Daily frequencies were calculated by considering never and almost never as zero.

The 24-hour recalls of food intake captured in detail all specific foods, preparation methods, and all portion sizes as consumed. The quantity of food was recorded using local serving utensils. The nutritionist asked subjects to recall the last meal and successively all intakes including snacks in the previous day to calculate the first 24 hour recall. The same process was continued to capture the previous 24 hour recall.

Physical activity estimates

Subjects were asked to recall their usual activities. The physical activity questionnaire included time daily spent walking to work or school, time spent weekly on extra walking, and time and kind of weekly exercise. Daily activity factors were calculated based on very light, light, moderate and heavy activity and duration of work, commuting, and exercise activities. These factors were multiplied by the resting energy expenditure estimates from World Health Organization equations, based on sex, age, and weight (12) and added to eight hours of resting energy expenditure during sleep.

Data analysis

Energy and nutrient calculations from the 24-hour and from the food frequency questionnaire were determined from the same food composition databases. A program (SISNUT) that allowed entry of usual Brazilian portion-size and foods was used (13). This program incorporated Brazilian food composition data of 1650 foods and 235 prepared foods to calculate daily nutrient and total energy intake (14). Analysis was done with SAS (15).

Energy requirement was estimated from the 10th edition of the United States Recommended Dietary Allowances. Subjects were classified by body mass index (BMI weight in kg/ height^2 in m) as overweight or normal weight using a BMI cutoff of 27 kg/m^2. Alcohol intake in grams was estimated assuming that 360 ml of beer contained 13.2 g of alcohol, 120 ml wine equaled 10.8 g of alcohol, and a standard drink of spirits equaled 15.1 g of alcohol (16).

Pearson correlation coefficients between food frequency and the mean of four 24-hour recalls were determined for energy and nutrients. All correlation coefficients were calculated after $\log_e$ transformation of energy and nutrients because of their distributions were skewed to the right. The possibility of poor recall in the second 24 hour recall was tested by comparing the means of first and second recalls for energy and nutrient intake.

RESULTS

The most frequently consumed foods were rice (consumed by 81.3% at least daily), beans and French bread (consumed by about 60 % at least daily) (Table 1). A few foods included in the food frequency questionnaire had very low frequencies of consumption. These foods were coconut (80 % never eating) and low fat milk, yogurt, cream cheese, sweet bread, and spirits (70 % never eating) (Table 1).

Based on the food frequency questionnaire, the daily consumption of foods differed between the two groups of workers. The support staff ate significantly higher amounts of beans, rice, and cereals and lower amounts of fruits, milk products, and sweets (Table 2).

The correlation coefficients for energy intake in each 24-hour recall with the food frequency questionnaire were: 0.32 for day 1 (p-value=0.004), 0.34 for day 2 (p-value=0.002; 0.20 for day 3 (p-value=0.08), 0.36 for day 4 (p-value=0.001). The mean energy consumption for the first 24 hour recall was 1979 kcal and the mean for the second 24-hour recall was 1849 kcal (p-value for t-test comparing means was 0.68).

The two dietary collection methods resulted in similar mean values of energy consumption (Table 3). The correlation coefficients of nutrients from the 24-hour recalls and the food frequency questionnaire varied from 0.18 for vitamin A to 0.55 for calcium, with all but vitamin A being highly significant. When this validity analysis was broken-down by occupation, the correlation coefficients were greater for professionals, except for protein and calcium (Table 4).

Among men, there was a non-significant increase in energy consumption with increasing energy requirement, whereas for women, energy consumption measured by either method decreased with increasing predicted energy requirement (Table 5) indicating that overweight women underestimate their intake. This differential bias appeared to be more important with the 24-hour recalls than with the food frequency questionnaire, because the intercept was greater and the slope more negative with the regression based on 24 hour recall. This conclusion is also suggested by the smaller ratio of energy intake based on 24-hour recall/estimated basal metabolism among overweight. Thus, energy intake/estimated basal metabolism among overweight men was 0.99 for the 24-hour intakes and 1.09 for the food frequency. Among overweight women, these ratios were 0.64 for the 24-hour and 0.69 for the food frequency. For all subjects, these ratios were 1.37 for the 24-hour and 1.31 for the food frequency among men and 1.15 for the 24-hour and 1.24 for the food frequency among women.

Thirty-one percent of men and 33 percent of women were overweight (BMI of 27 k/m^2). Overweight was more common among the support staff, of whom 45.5 percent of men and 45.8 percent of women were overweight, than in the professional staff, of whom 15.x percent of men and 18.x percent of women were overweight. This pattern of reduced energy intake reported by the overweight was not necessarily paralleled by reduced intake of macro nutrients and vitamins and minerals, so that nutrient densities also varied between normal and overweight (Table 6).

Comparing the nutrient differences per 1000 kcal consumption among overweight and normal weight men, both methods of intake estimation indicated a reduction of carbohydrates and an increase of fat. Among women, the pattern was different with overweight women reporting reduced intake of fat and increased consumption of carbohydrates. In addition, overweight women reported lower energy consumption than normal weight women on both methods, whereas overweight men reported lower consumption on the 24-hour recalls only (Table 6).

TABLE 1

Percentage of Persons Never Consuming or Consuming at Least Daily* the Foods Included in the Food Frequency Questionnaire, among Brazilian University Workers.

	NEVER	DAILY		NEVER	DAILY
RICE	4.4	81.3	BEANS	12.1	60.4
PASTRY	11.0	4.4	MANIOC FLOUR	48.4	13.2
FRENCH BREAD	12.1	54.9	SWEET BREAD	73.6	3.3
CAKES	28.6	2.2	SALTED BISCUIT	24.2	22.0
SALTED CORN PUDDING	53.8	27.5	SWEET BISCUIT	571.1	4.4
CORN	61.5	0	LENTILS/GARBANZO	45.1	0
CHICKEN	0	10.2	MAYONNAISE+	1.6	3.3
EGGS	0	1.4	MATE	4.9	19.5
LETTUCE	16.5	16.5	COLLARD	26.4	1.1
CABBAGE	24.2	4.4	CHICORY	54.9	2.2
TOMATO	13.2	30.8	CHAYOTE	25.3	4.4
PUMPKIN	23.1	1.1	SQUASH	51.6	27.5
OKRA	36.3	29.7	CUCUMBER	49.5	4.4
CARROTS	8.8	11.0	ONION	19.8	54.9
COULEE FLOUR	33.0	2.2	BEETROOT	35.2	5.5
PEPPER	47.3	9.9	POTATOES	22.0	8.8
MILK	46.2	33.0	GARLIC	36.3	57.1
LOW FAT MILK +	75.8	17.6	YOGURT+	76.9	17.6
CREAM CHEESE+	73.6	2.2	CHEESE	25.3	30.8
MARGARINE	46.2	36.3	BUTTER	64.8	20.9
BANANA	30.8	9.9	ORANGE	16.5	25.3
APPLE+	41.8	7.7	PAPAYA	34.1	11.0
PINEAPPLE	37.4	3.3	WATERMELON	53.8	2.2
MANGO	42.9	14.3	AVOCADO	45.1	3.3
PASSION FLOWER	45.1	2.2	LEMON	37.4	4.4
GUAVA	67.0	2.2	GRAPES	51.6	3.3
COCONUT	82.4	0	PEAR	63.7	3.3
PORK MEAT WITH BONE	44.0	1.1	BEEF MEAT WITH BONE	40.7	0
SAUSAGES/DOGS+	29.7	2.2	WITHOUT BONE	5.5	1.1
SHRIMP+	54.9	0	LIVER	46.2	0
SUGAR	18.7	80.2	FISH	5.5	1.1
CHOCOLATE +	47.3	1.1	BACON+	61.5	6.6
ICE CREAM+	54.9	2.2	CANDIES	61.5	11.0
COFFEE	7.7	90.1	DEEP FRIED SNACKS+	33.0	1.1
WINE	48.4	0	PUDDING+	41.8	3.3
COLAS	48.4	13.2	BEER	37.4	3.3
			JUICE	20.9	29.7

* questionnaire included options for frequency by day, week, month, year, but only extremes are shown.

+ included based on expert opinion.

TABLE 2

Daily Consumption(g) for Foods and Food Groups, Based on Food Frequency Questionnaire, among Brazilian University Workers, by Occupation.

	SUPPORT	PROFESSIONAL	p-value*
Beans	90.2	39.4	0.0001
Rice	73.1	42.1	0.005
Cereals	191.1	114.5	0.008
Coffee	21.6	23.2	0.75
Colas	51.9	63.0	0.61
Juices	114.7	136.4	0.51
Sugar	77.2	57.6	0.25
Deep Fried snacks	8.6	12.3	0.23
Vegetables	140.4	185.4	0.17
Milk products	182.7	278.0	0.04
Butter,Bacon, Margarine	10.0	9.3	0.83
Fruits	430.6	640.7	0.04
Meat	129.0	93.0	0.14
Fish/ Shrimp	33.4	43.9	0.23
Sweets	16.5	63.0	0.01
Alcohol	6.9	6.6	0.93

*p-value associated to t-test

TABLE 3

Mean Consumption and Standard Deviation (SD) of Energy and Nutrients for The Mean of Four 24-Hour Recalls and Food Frequency and Pearson Correlation Coefficient(r) for Comparison between Methods.

	24-HOUR RECALLS		FOOD FREQUENCY			
	Mean	SD	Mean	SD	r	p-value
Energy (kcal)	1913	793	1914	846	0.44	0.0001
Protein (g)	79	34	58	34	0.44	0.0001
Carbohydrate(g)	236	111	296	139	0.34	0.001
Fat (g)	66	32	49	35	0.41	0.0001
Iron (mg)	13.4	6.6	15.1	7.0	0.43	0.0001
Vitamin A (RE)	1636	1450	1179	2676	0.18	0.08
Vitamin C(mg)	110	114	329	242	0.23	0.02
Calcium (mg)	567	374	619	384	0.55	0.0001

TABLE 4

Pearson Correlation Coefficient(r) for Comparison of Energy and Nutrients between the Mean of Four 24-Hour Recalls and Food Frequency Questionnaire.

	SUPPORT		PROFESSIONAL	
	r	p-value*	r	p-value*
Energy (kcal)	0.42	0.003	0.60	[illegible]
Protein (g)	0.53	0.01	0.47	0.001
Carbohydrate(g)	0.22	0.13	0.46	0.001
Fat (g)	0.34	0.01	0.70	0.001
Iron (mg)	0.45	0.001	0.46	0.002
Vitamin A (RE)	0.15	0.29	0.34	0.01
Vitamin C(mg)	0.27	0.06	0.52	0.0002
Calcium (mg)	0.55	0.001	0.44	0.002

*p-value associated to correlation

TABLE 5

Linear Regression With $\log_e$ of the Daily Energy Requirement (ER)in kcal as Independent Variable According to Method of Data Collection, and Associated P-Values for the Slope.

MEN	$\log_e$ Kcal of FFQ* =5.31+0.29 ($\log_e$ ER)	p=0.38
	$\log_e$ Kcal of 24-recalls =7.04+0.084 ($\log_e$ ER)	p=0.74
WOMEN	$\log_e$ Kcal of FFQ* =11.5 - 0.53 ($\log_e$ ER)	p=0.007
	$\log_e$ Kcal of 24-recalls =13.2 - 0.77 ($\log_e$ ER)	p=0.006

* Food frequency questionnaire

DISCUSSION

The food frequency questionnaire designed for the Brazilian diet showed correlations with the mean of four repeated 24 hour recalls that were similar to those obtained in food frequency questionnaire validation studies from other countries (17-19). For most foods and nutrients, the correlation between the measurements obtained with dietary questionnaires and a reference method have been approximately 0.4-0.7 (3). In a review of food frequency questionnaires used in ehtnic minority populations of United States the range of correlation coefficients were about the same observed for the nonminority population, however the mean intakes derived from questionnaires were greater among minorities (4). In the current study correlations of the food frequency with four 24-hour recalls ranged from 0.18 for vitamin A to 0.55 for calcium. In a large epidemiological study among U.S. nurses, a food frequency questionnaire compared to a one week diet records had correlation coefficients of 0.18 for protein, 0.27 for total fat, and 0.48 for total carbohydrate (17).

TABLE 6

Energy, Percent energy From Fat, and Nutrient Intake by Method of Data Collection and Overweight (BMI >=27 kg/m^2), and Difference in Nutrient Densities Between Overweight and Normal Workers.

	FOOD FREQUENCY		difference* per 1000 kcal	24-HOUR RECALL		Difference* Per 1000 kcal
	BMI<27	BMI>=27		BMI<27	BMI>=27	
	(n=29)	(n=13)	MEN	(n=29)	(n=13)	
Energy (kcal)	2224	2302		2520	1968	
% energy from fat	0.23	0.27		0.30	0.30	
Proteins (g)	68	85	+6.4	101	87	+4.4
Carbohydrates g	337	298	-21.5	316	222	-12.5
Fat (g)	60	75	+5.6	86	69	+0.9
Iron (mg)	16	20	+1.5	18	14	-0.03
Vitamin A (RE)	1606	1879	+94	1324	872	-82.3
Vitamin C(mg)	348	356	-1.8	161	69	-28.8
Calcium (mg)	672	762	+29	733	552	-10.1
	(n=31)	(n=15)	WOMEN	(n=31)	(n=15)	
Energy (kcal)	1788	1471		1641	1389	
% energy from fat	0.22	0.20		0.32	0.29	
Proteins (g)	51	39	-2.0	67	56	-0.51
Carbohydrates g	294	247	+3.5	202	189	+12.8
Fat (g)	42	29	-3.8	59	44	-4.2
Iron (mg)	15	11	-0.91	11	9.7	+0.28
Vitamin A (RE)	1777	1308	-104	1429	822	-278
Vitamin C(mg)	358	230	-43.8	95	94	+9.8
Calcium (mg)	637	388	-92.4	535	355	-7.0

* differences between the nutrient density (nutrient/ 1000 kcal) between groups with BMI >= 27 kg/m^2 and BMI < 27 kg/m^2.

Martin-Moreno et al., 1993 (18) compared a food frequency questionnaire to a 4-day diet records and reported correlation coefficients of 0.69 for calories, 0.65 for protein, and 0.57 for fat, with other correlations mostly 0.50 or more. Fidanza et al, 1995 (20), in Italy, observed correlations coefficients up to 0.84 for alcohol intake, but lower correlations with carbohydrate (0.37) and Vitamin C (0.33). In a Danish study, correlation coefficients ranged from 0.17 for vitamin A to 0.64 for vitamin C (19). In a validation study conducted in Mexico, a food frequency questionnaire was tested against four groups of four consecutive days 24 -hour recalls and correlation coefficients ranged from 0.32 for vitamin E to 0.64 for vitamin A (21).

Consumption diaries are considered a better option than 24 hour recalls to validate a frequency questionnaire, because errors due to memory would be uncorrelated (22). However, because the support staff included many persons with very few years of education, this method would not work for the range of participants in this study. Another possible methodological weakness of our study was the close timing among the application of the methods of food intake estimation. The food frequency questionnaire and day 1 and day 2 of the 24-hour recalls were conducted at about the same time, which could increase the correlation between methods. However, the correlation between food frequency with each one of the four 24-hour recalls was about the same (0.35), except for day 3 (0.20). In addition, if the timing between methods was important, it would be expected that correlation would have been greatest with day 1 when the food frequency questionnaire was administered, whereas the highest correlation was observed with the day 4 recall.

The use of 48 hour recalls has not been commonly reported, but it may be a viable choice to deal with day to day variability in the 24 hour recalls. The means for energy and nutrients were very close comparing the first and the second 24 hour recalls. It would be worthwhile to validate this finding in further studies, which might reduce the number of interview visits.

Food frequency questionnaires tend to overestimate the consumption of single food items(19) which, in this study, appeared to be true for fruits and as a consequence vitamin C. The high consumption of vitamin C as measured by the food frequency questionnaire was high (242 mg compared with 110 mg from the 24-hour recalls). These high levels of consumption were not expected from the analysis of the earlier National ENDEF survey in which the density of vitamin C per 1000 calories for the Rio de Janeiro sample was close that obtained through the 24-hour recall but was one fourth of the mean value obtained in this study using the food frequency questionnaire. Other comparisons of nutrient intake between the 24-hour recalls and food frequency did not vary as markedly.

The differences that we observed in nutrient density between normal and overweight groups may indicate different patterns of consumption or more likely a reporting bias as has been shown in many studies with obese participants (6-9). Although the WHO predicted energy expenditure is only an estimate, the logical inconsistency of a negative association of energy intake and predicted energy expenditure for women indicates a substantial bias in obtaining these estimates through commonly used interview methods. Differences between nutrient density in obese and non-obese groups suggest that low energy intake does not predict a proportional reduction of nutrients. This possible differential mis-classification of energy and nutrient intake by body weight could create a non-fixed systematic bias in many epidemiological studies of consumption. Such a bias can not be corrected in analysis regardless of whether consumption is being considered as a risk factor, a confounder, or an outcome.

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Accepted for publication May 6, 1998.