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Validation and Reproducibility of a Semi-Quantitative Food Frequency Questionnaire for Use in Puerto Rican Children

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Abstract

Objective—Knowledge of the diet of specific populations is of importance in the assessment of nutrient intake. Herein, we assess the reproducibility and validity of an interviewer-administered food frequency questionnaire (FFQ) in Puerto Rican children at two educational levels – elementary (ES) and high school (HS).

Methods—The FFQ contained 97 items including supplements. It was administered twice (FFQ1 and FFQ2) within a 2 week interval between which three dietary food records (DFR's) were collected. In all, 94 ES children (40 boys and 54 girls) and 89 HS children (42 boys and 47 girls) participated in this IRB-approved study.

Results—Results showed correlations between FFQ1 and FFQ2 for representative macro- and micronutrients lower than reported in the literature. Correlation coefficients were higher for HS (mean R=0.43) compared to ES (mean R=0.21) and higher for girls than for boys at both school levels. Results for validation also showed lower correlations between the FFQ2 and DFR's compared to other studies, which was higher in HS students (mean R=0.34) compared to ES students (mean R=0.10). However, these same nutrients were cross-classified into equivalent quartiles for both the FFQ and DFR with an accuracy of about 66%.

Conclusion—We have designed and validated a FFQ, appropriate for use in Puerto Rican schoolchildren to estimate energy intake in younger students and energy and micronutrients in older students. The significance of this research is that there is now an updated instrument for use in dietary studies in Puerto Rican youth.

Keywords

Food Frequency Questionnaire; Validation; Puerto Rican; Children

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Reliable, valid and practical measures of typical diets are needed for public health research. The food frequency questionnaire (FFQ) is the primary tool of dietary assessment in epidemiology research (1). Components of a basic FFQ are a food list and a response section eliciting how often each item was eaten in a given time interval. Validity and reliability are of prime concern (2). Validity is the degree to which the instrument actually assesses the usual intake of subjects. Reliability or reproducibility refers to the consistency of data obtained in more than one administration of the same instrument to the same subject at

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different times. Reproducibility of a FFQ has been shown to be affected by several factors including ethnicity, gender, age and education (3) so should be developed within specific population groups. Before use, a FFQ should be validated in a group of representative subjects of the study population. As there is no perfect measurement of diet, the relative validity of a FFQ is often compared with another dietary surveying method such as the daily food record (DFR). The DFR is chosen as errors associated with this method are independent of the errors associated with the FFQ and therefore validity is unlikely to be overestimated (4). It is the purpose of this research to assess and validate a FFQ in a population of Puerto Rican schoolchildren with testing done at the 5th grade level (younger children) and at the 11th grade level (older children). The significance of this research is to obtain a clearer idea of children's diets of which no major nutritional evaluation has been done in the past 40 years (5).

Methods

Informed Consent

In accordance with regulations on research with human subjects, approval was obtained from Institutional Review Board of the University of Puerto Rico, Medical Sciences Campus. Students and their parents signed informed consent documents. Permission to enter the schools was obtained from the Department of Public Instruction as well as principals and teachers from the participating schools.

Sample

Our study group, selected by convenience, included 95 children from elementary school (5th grade) and 90 children from high school (11th grade) both within the school system of Caguas, Puerto Rico. Height and weight were measured according to published assessment methods (1) and body mass index (BMI) calculated as weight in kg divided by the square of the height in m (kg/m^2). Exclusion limits were a mean energy intake from the DFR of <500 and >5000 kcal/d. Using this criteria, one elementary male subject was excluded from the analysis. In addition, one high school male subject did not have a complete FFQ and was also excluded from the analysis. Therefore, final number of participant was 94 elementary and 89 high school students. Sampling was conducted from the fall of 2002 thru the spring of 2003.

Data Collection

Our validation approach was similar to one used by Domel et al (6) with 4th and 5th grade students with a time frame for the FFQ set at one month. FFQ's administered to adults are often based on a 1 year time frame but younger populations recall foods eaten with greater accuracy within a shorter time span, hence the one month period (7). To assess test-retest reliability of response and consumption, each FFQ was administered by interviewers on two occasions with a 2 week separation period. Interviewing techniques were standardized by established procedures through our field coordinator, which included multiple training sessions. Validity was assessed by comparing FFQ values with means of DFR's which were collected for 3 days, beginning the day after completion of the FFQ. Students received record-keeping training by field workers. To help children estimate portion size, a book containing life-size, colored food photos was used (8). For at home collections, parents were given written instructions with sample and practice pages to help their children fill out the food records.

Nutrient Analysis

Nutrient content of foods selected for the dietary records and FFQ was determined using the Minnesota Nutrient Data System 32, (MNDS) which contains > 6000 brand-name foods, fast foods and > 16,000 other foods. In addition, it is a comprehensive nutrient data-base including data derived from the US Department of Agriculture tables, food manufacturers, the scientific literature and foreign food consumption tables, hence, it contains many ethnic food that are commonly eaten in Puerto Rico.

FFQ Design

A semi-quantitative questionnaire based on the model described by Willett et al (9) was developed. In this, children reported frequency of consumption and portion size of generally consumed foods. Related studies with children's diets (10) allowed us to create the FFQ which contained 97 items including supplements. This number of items is similar to other FFQ's designed for children and adolescents (11–13). The FFQ was administered by trained personnel. A copy of this questionnaire is available from the first author upon request.

Statistical Analysis

Means and standard deviations were calculated for study sample characteristics and for selected nutrients studied from the FFQ's and the 3 DFR's separately. All nutrients were adjusted for energy intake, using the method reported by Willett (14). Normality was tested by the Shapiro-Wilk test. All nutrients were non-normally distributed; therefore, non parametric tests were performed. To test for reproducibility, the consistency of the results from the first FFQ (FFQ1) and the second FFQ (FFQ2) were determined by the Spearman coefficient correlation (15). To test the validity, the estimated nutrients' intake from the FFQ2 was compared to the mean estimated nutrients' from the dietary records, the independent and more accurate method in our study. Spearman correlations and Wilcoxon tests were calculated between the FFQ2 and the mean of the 3 dietary records. Percent agreement was calculated to assess the ability of the FFQ2 to reliably and accurately classify subjects into similar quartiles of nutrients' intake based on results of the FFQ's and dietary records. First, quartile cut-off points were calculated for nutrients' intakes based on both methods separately. Then, a cross-classification analysis was completed to identify the proportion of subjects correctly classified (within one quartile) and grossly misclassified (lowest quartile for one method and highest quartile for the other) by the FFQ2. Statistical significance was set at $p < 0.05$. The statistical SPSS software program was used for all statistical analyses (16).

Results

Demographic characteristics and BMI of the study subjects are shown in Table 1. A total of 94 elementary school students and 89 high school students completed the study. There was a higher percentage of girls in each group (57.5% and 52.8% respectively) but no statistical differences in age or BMI were noted. As would be expected, boys were taller and heavier than girls at the high school level. Sample number for each group is close to the range of 100 subjects that has been suggested as an adequate size for a FFQ validation study (2). Tables 2 and 3 show results for the reproducibility of the FFQ in elementary and high school students, respectively. We have presented correlation coefficients (r) for representative macro- and micro-nutrients although the MNDS 32 can provide information for more than 100 food components. In terms of percent of total calories from each major contributor, there was a consistent pattern across all methods in all school levels and gender of 54% calories from carbohydrates, 14% calories from proteins and 32% calories from fat.

Literature values for FFQ reproducibility vary widely but within the general range of 0.5 to 0.9 (17) which would place our coefficients below expected values for both elementary and high school students. For elementary students, correlation coefficients averaged 0.21 and high school students averaged 0.43. At the elementary level, correlation coefficients between FFQ1 and FFQ2 was on average 0.22 for both girls and boys, which was significant for energy, calcium and vitamin B12 in girls and for fat, carbohydrate and folate in boys ($p<0.05$). It was higher in girls compared to boys at the high school level ($r=0.52$ in girls and $r=0.36$ in boys), which was significant for most nutrients ($p<0.05$) except for iron in girls and for vitamins C and B6 in boys. Amounts of individual nutrients from the FFQ1 were statistically greater than those from the FFQ2. This is in agreement with other studies in children and adolescents, which have reported higher nutrient intakes from the FFQ1 compared to the FFQ2 (3, 7, 18).

Tables 4 & 5 show the results for the FFQ validation in elementary and high school students, respectively. In this case, values for FFQ2 were compared to the mean of the 3 DFR's. Correlation coefficients for macro and micro-nutrients averaged 0.10 for elementary school students and 0.34 for high school students. Again, these results fall below most values for FFQ validations in the literature which range from 0.4 to 0.7 (9), however it should be noted that our high school students did have a better correlation than elementary students which is in agreement with other studies where it has been shown that estimation of nutrient intake is positively associated with age (3). Girls had better average correlation coefficients than boys in the validity section for macro and micronutrients being 0.16 vs 0.07 at the elementary level and 0.36 vs 0.33 at the high school level. Amounts of nutrients reported in the FFQ2 and DFR's for both elementary and high school students were different between the two assessment methods. This is a typical finding in that FFQ's are often subject to over-estimates of nutrient intake (19). In addition, Tables 4 & 5 present results for the Wilcoxon test which indicate that amounts reported for most nutrients differ significantly between the FFQ2 and the DFR's. Exceptions are energy, fat, carbohydrates and vitamin D for the total sample of elementary students and energy, iron and vitamin B12 for the total sample of high school students. There were no appreciable differences between girls and boys for this analysis.

Tables 6 and 7 show the results for the consistency of categorization using the two methods. Approximately 66% of macro-nutrients were classified in the same or within one quartile at both school levels with high school students having a slightly better performance compared to elementary students (68% vs 63%). Gross misclassification of macro-nutrients was similar in high school students (9.4%) and elementary school students (9.6%). On the contrary, gross misclassification of micro-nutrients was less in high school students (4.2%) compared to elementary school students (10.5%). This finding was not expected since it has been reported that macro-nutrients are more accurately reported than micro-nutrients for a 3 day DFR (20). On the other hand, our results for consistence of categorization compare favorably to others reported in the literature for school aged children (11, 13).

Discussion

Food frequency questionnaires have emerged as the instrument of choice to measure long-term dietary intake in epidemiological studies involving free-living populations. However, as Block has noted, "there is no such thing as ***the*** food frequency questionnaire" (21) as evolution has continued with improvements and variations in design. The basic premise, that validation studies be conducted using independent evaluators at the same time in the same population, remains unchanged. Correlation coefficients are still affected by the agreement of reference data, mode of administration, age, sex and ethnicity of the study population (22).

Our study has addressed each of these criteria, in that we present data from Puerto Rican boys and girls attending schools at two grade levels. To increase accuracy of children's reporting, we incorporated suggestions listed by Domel (23) which include working with children who have achieved at least the level of fourth grade and compared student's luncheon reports with those of trained observers (data not shown). Results show that our FFQ was reproducible for energy, fat, magnesium and vitamin B12 in elementary children while it was reproducible for energy and all the macro- and micronutrients assessed in high school students. In terms of the validity, the results showed that the FFQ had relatively good validity for energy in elementary students and for energy and all the micronutrients assessed, especially for iron and vitamin B12, in high school students. In addition, classification of children in corresponding quartiles of nutrients reported in the FFQ and DFR was reasonably accurate (approximately 70%). Regarding the FFQ, we have adapted various statistical techniques to analyze our data such as energy adjusted intakes which, according to Willet and Stampfer (14), are more relevant to dietary composition than are absolute intakes. Furthermore, we have used various combinations of comparing our 2 methods of evaluation of the FFQ validity such as FFQ1vs DFR's, and the average of FFQ1 and FFQ2 vs DFR's, data of which is not reported here. These comparisons have been carried out in other studies of FFQ validations (7, 9); however, when employed to our data, no enhancement was noticeable.

A frequent critique of FFQ's is related to their relatively low correlation with external evaluators (24). For example, to measure energy intake, the correlation coefficient of the FFQ with doubly labeled water (the "Gold Standard") was only 0.l for women and 0.2 for men (25). Using the FFQ to assess the diet of school children can even present greater methodological difficulties due to their unfamiliarity with portion sizes, knowledge of food names, food preparation and attention span. We have addressed some of these issues by providing life-sized color photos of different portion size for commonly consumed foods and given the students training on how to complete the questionnaire.

A new technique that should have great importance to improve knowledge of food names and portion-size estimation has been the introduction of computerized FFQ's especially developed for youth (26, 27). Other researchers have improved student's familiarity with dietary evaluations by preliminary training with the children and their parents before the formal FFQ study is initiated (28, 29). In relation to this observation, it should be commented that the values reported in FFQ2 used in our study correlated much closer to the DFR's than did those reported in FFQ1. This would suggest that as students become more aware of their diets through the process of filling out the DFR's, they can more accurately estimate the regular food consumption as requested in the FFQ.

Finally, ethnicity and income status have been identified as factors related to low reliability and validity of a Youth/Adolescent FFQ which would therefore appear to have limited use for low income Afro-American and Hispanic 7th and 8th graders (30). Our FFQ tested only Puerto Rican children and income level was not assessed, so no comparable data could be obtained.

The main limitation of the FFQ designed was its length, averaging 45 minutes for elementary students and 30 minutes for high school students to complete. A shorter version may have improved reproducibility and validity in participating students. In addition, many studies use more than 3 DFRs, as most nutrients require more than 3 days to accurately assess their intake (31).

In summary, we have designed a FFQ for Puerto Rican youth that has been shown to be reproducible and valid for energy in elementary students and energy and micronutrients in high school students. Extension for the time in which DFR's were collected would undoubtedly improve correlations as would adaption of new computer-assisted technology especially designed for this population.

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Table 1

Demographic characteristics and BMI of the study subjects

Characteristics	Elementary children			High school children		
	Total (n=94) mean (SD)	**Girls (n=54) mean (SD)**	**Boys (n=40) mean (SD)**	**Total (n=89) mean (SD)**	**Girls (n=47) mean (SD)**	**Boys (n=42) mean (SD)**
Age (y)	10.4 (0.9)	10.3 (0.8)	10.5 (1.0)	15.9 (0.7)	15.8 (0.8)	16.1 (0.5)
Weight (kg)	40.8 (12.4)	40.9 (12.2)	40.8 (12.7)	62.9 (14.5)	59.5 (13.7)	66.8 (14.6) *
Height (cm)	140.3 (9.5)	141.4 (9.3)	138.9 (9.7)	163.8 (10.9)	157.9 (7.8)	170.9 (9.7) *
BMI (kg/m^2)	20.6 (5.0)	20.3 (4.9)	21.0 (5.2)	23.4 (5.1)	23.9 (5.2)	22.9 (5.1)

* Significantly different than girls by Wilcoxon test at $p<0.05$;

SD: Standard Deviation

Table 2

Reproducibility of estimated energy intake and energy-adjusted nutrient intake from the initial FFQ (FFQ1) and repeat FFQ (FFQ2) in elementary children

Nutrient	Total (n=94)			Girls (n=54)			Boys (n=40)		
	FFQ1 mean (SD)	FFQ2 mean (SD)	r	FFQ1 mean (SD)	FFQ2 mean (SD)	r	FFQ1 mean (SD)	FFQ2 mean (SD)	r
Energy (kcal)	2855.9 (1310.7)	2135.7 (836.3)	0.30*	2760.4 (1426.8)	2076.4 (829.4)	0.37*	2984.8 (1140.4)	2215.6 (849.4)	0.28
Protein (g)	95.5 (12.6)	71.4 (13.6)	0.11	94.3 (12.1)	72.2 (13.2)	0.12	97.1 (13.2)	70.3 (14.4)	0.13
Fat (g)	105.7 (17.4)	76.4 (12.1)	0.26*	104.8 (18.9)	78.2 (11.4)	0.15	106.9 (15.2)	74.0 (12.7)	0.48*
CHO (g)	391.8 (44.7)	297.8 (36.3)	0.16	395.6 (45.7)	293.1 (34.6)	0.05	386.7 (43.4)	304.2 (38.0)	0.35*
Ca (mg)	1253.9 (312.9)	981.1 (381.8)	0.18	1300.5 (286.1)	996.5 (416.6)	0.35*	1191.0 (339.4)	960.2 (333.2)	0.05
Fe (mg)	17.6 (5.0)	14.4 (6.1)	0.16	17.8 (5.4)	13.8 (5.4)	0.19	17.4 (4.6)	15.2 (7.0)	0.11
Mg (mg)	343.7 (53.9)	262.1 (55.3)	0.26*	349.1 (50.2)	265.6 (56.7)	0.23	336.3 (58.4)	257.2 (53.7)	0.29
Vit C (mg)	208.6 (161.5)	134.5 (111.2)	0.19	219.4 (170.3)	135.6 (71.9)	0.22	194.2 (149.6)	133.0 (149.9)	0.12
Vit B6 (mg)	2.5 (0.7)	1.9 (0.8)	0.16	2.5 (0.7)	1.9 (0.7)	0.20	2.6 (0.7)	2.0 (0.9)	0.12
Vit B12 (mcg)	5.1 (2.0)	6.8 (25.8)	0.33*	4.9 (1.8)	8.7 (34.0)	0.40*	5.3 (2.3)	4.3 (2.8)	0.25
Folate (mcg)	409.4 (179.1)	323.5 (178.9)	0.19	414.1 (187.0)	321.1 (168.4)	0.09	403.1 (170.0)	326.8 (194.4)	0.31*
Vit D (mcg)	9.3 (4.7)	9.0 (13.1)	0.20	9.0 (4.2)	9.9 (16.9)	0.24	9.7 (5.4)	7.8 (4.7)	0.17

*p<0.05;

SD: Standard Deviation

Table 3

Reproducibility of estimated energy intake and energy-adjusted nutrient intake from the initial FFQ (FFQ1) and repeat FFQ (FFQ2) in high school children

Nutrient	Total (n=89)			Girls (n=47)			Boys (n=42)		
	FFQ1 mean (SD)	FFQ2 mean (SD)	r	FFQ1 mean (SD)	FFQ2 mean (SD)	r	FFQ1 mean (SD)	FFQ2 mean (SD)	r
Energy (kcal)	3149.6 (1490.1)	2475.8 (1249.6)	0.30*	2865.2 (1536.7)	2068.5 (1237.3)	0.34	3461.2 (1389.0)	2921.9 (1115.1)	0.28*
Protein (g)	110.1 (21.7)	90.6 (17.7)	0.42*	104.6 (18.4)	92.3 (13.8)	0.58*	88.7 (21.1)	88.7 (21.1)	0.35*
Fat (g)	113.2 (21.9)	92.8 (14.2)	0.45*	112.1 (23.3)	95.3 (14.3)	0.56*	90.0 (13.9)	90.0 (13.9)	0.35*
CHO (g)	432.9 (63.0)	324.8 (45.8)	0.45*	442.4 (59.5)	318.5 (40.6)	0.59*	331.7 (50.5)	331.7 (50.5)	0.38*
Ca (mg)	1285.3 (577.0)	1001.3 (508.0)	0.46*	1239.4 (570.9)	1088.2 (468.2)	0.60*	906.2 (537.8)	906.2 (537.8)	0.38*
Fe (mg)	20.7 (6.7)	17.1 (6.4)	0.33*	20.5 (6.6)	17.1 (5.6)	0.23	17.0 (7.2)	17.0 (7.2)	0.37*
Mg (mg)	397.3 (91.2)	301.9 (75.5)	0.55*	398.7 (79.7)	313.6 (68.7)	0.54*	289.0 (81.2)	289.0 (81.2)	0.57*
Vit C (mg)	310.4 (411.4)	176.1 (155.8)	0.40*	272.9 (265.5)	192.5 (180.7)	0.52*	158.1 (122.6)	158.1 (122.6)	0.26
Vit B6 (mg)	3.0 (1.2)	2.3 (0.9)	0.40*	3.0 (1.3)	2.4 (0.8)	0.53*	2.2 (0.9)	2.2 (0.9)	0.26
Vit B12 (mcg)	4.9 (3.2)	5.1 (3.1)	0.44*	4.4 (3.2)	5.2 (2.8)	0.60*	4.9 (3.5)	4.9 (3.5)	0.36*
Folate (mcg)	542.9 (288.2)	387.8 (198.7)	0.51*	565.4 (311.7)	420.0 (197.7)	0.66*	352.6 (196.1)	352.6 (196.1)	0.4*
Vit D (mcg)	9.4 (6.7)	7.4 (6.0)	0.48*	9.3 (6.6)	7.9 (5.9)	0.52*	6.8 (6.1)	6.8 (6.1)	0.43*

* $p<0.05$;

SD: Standard Deviation

Table 4

Validation of estimated energy intake and energy-adjusted nutrient intake from the FFQ2 and DFR's in elementary children

Nutrient	Total (n=94)				Girls (n=54)				Boys (n=40)			
	FFQ2 mean (SD)	DFR's mean (SD)	r	Wilcoxon (p value)	FFQ2 mean (SD)	DFR's mean (SD)	r	Wilcoxon (p value)	FFQ2 mean (SD)	DFR's mean (SD)	r	Wilcoxon (p value)
Energy (kcal)	2135.7 (836.3)	2200.1 (542.2)	0.23*	0.210	2076.4 (829.4)	2189.5 (537.1)	0.37*	0.200	2215.6 (849.4)	2214.4 (555.6)	0.08	0.800
Protein (g)	71.4 (13.6)	79.9 (14.1)	0.05	0.001	72.2 (13.2)	77.0 (13.4)	0.12	0.040	70.3 (14.4)	83.8 (14.3)	0.05	0.001
Fat (g)	76.4 (12.1)	79.5 (10.6)	0.15	0.800	78.2 (11.4)	77.1 (9.6)	0.29*	0.700	74.0 (12.7)	82.7 (11.0)	0.10	0.010
CHO (g)	297.8 (36.3)	295.3 (32.1)	0.09	0.500	293.1 (34.6)	303.9 (29.3)	0.28*	0.090	304.2 (38.0)	283.6 (32.5)	0.00	0.010
Ca (mg)	981.1 (381.8)	759.4 (224.3)	0.16	<0.01	996.5 (416.6)	744.4 (229.8)	0.18	<0.01	960.2 (333.2)	779.6 (217.9)	0.12	0.010
Fe (mg)	14.4 (6.1)	18.0 (5.6)	0.08	<0.01	13.8 (5.4)	17.8 (5.7)	0.11	<0.01	15.2 (7.0)	18.3 (5.7)	0.03	0.010
Mg (mg)	262.1 (55.3)	216.0 (19.1)	0.16	<0.01	265.6 (56.7)	218.9 (18.5)	0.16	<0.01	257.2 (53.7)	212.1 (19.6)	0.07	<0.01
Vit C (mg)	134.5 (111.2)	86.2 (17.7)	0.05	<0.01	135.6 (71.9)	88.9 (17.7)	0.07	<0.01	133.0 (149.9)	82.6 (17.3)	0.06	0.010
Vit B6 (mg)	1.9 (0.8)	2.0 (0.2)	0.05	<0.01	1.9 (0.7)	2.0 (0.2)	0.02	0.030	2.0 (0.9)	2.0 (0.2)	0.04	0.300
Vit B12 (mcg)	6.8 (25.8)	5.2 (0.6)	0.07	<0.01	8.7 (34.0)	5.3 (0.6)	0.14	<0.01	4.3 (2.8)	5.1 (0.7)	0.05	0.030
Folate (mcg)	323.5 (178.9)	477.9 (47.1)	0.09	0.020	321.1 (168.4)	485.2 (48.5)	0.11	<0.01	326.8 (194.4)	468.1 (43.7)	0.08	<0.01
Vit D (mcg)	9.0 (13.1)	6.4 (1.1)	0.05	0.200	9.9 (16.9)	6.5 (1.1)	0.02	0.700	7.8 (4.7)	6.1 (1.1)	0.11	0.130

*p<0.05;

SD: Standard Deviation

Table 5

Validation of estimated energy intake and energy-adjusted nutrient intake from the FFQ2 and DFR's in high school children

Nutrient	Total (n=89)				Girls (n=47)				Boys (n=42)			
	FFQ2 mean (SD)	DFR's mean (SD)	r	Wilcoxon (p value)	FFQ2 mean (SD)	DFR's mean (SD)	r	Wilcoxon (p value)	FFQ2 mean (SD)	DFR's mean (SD)	r	Wilcoxon (p value)
Energy (kcal)	2475.8 (1249.6)	2179.4 (718.1)	0.23	0.070	2068.5 (1237.3)	1821.8 (533.6)	0.34*	0.397	2921.9 (1115.1)	2571.0 (693.7)	0.08	0.111
Protein (g)	90.6 (17.7)	79.5 (15.6)	0.15	<0.01	92.3 (13.8)	76.6 (13.4)	0.01	<0.01	88.7 (21.1)	82.7 (17.3)	0.29	0.068
Fat (g)	92.8 (14.2)	81.4 (9.9)	0.15	<0.01	95.3 (14.3)	81.8 (7.9)	0.24	<0.01	90.0 (13.9)	80.9 (11.8)	0.11	<0.01
CHO (g)	324.8 (45.8)	284.8 (30.7)	0.10	<0.01	318.5 (40.6)	287.0 (26.1)	0.12	<0.01	331.7 (50.5)	282.4 (35.2)	0.14	<0.01
Ca (mg)	1001.3 (508.0)	702.4 (253.0)	0.26*	<0.01	1088.2 (468.2)	725.5 (254.5)	0.32*	<0.01	906.2 (537.8)	677.0 (251.9)	0.20	0.002
Fe (mg)	17.1 (6.4)	17.1 (6.2)	0.37*	0.700	17.1 (5.6)	17.1 (6.0)	0.18	0.800	17.0 (7.2)	17.1 (6.5)	0.47*	0.361
Mg (mg)	301.9 (75.5)	232.5 (60.0)	0.48*	<0.01	313.6 (68.7)	226.6 (59.7)	0.50*	<0.01	289.0 (81.2)	238.9 (60.3)	0.53*	<0.01
Vit C (mg)	176.1 (155.8)	161.5 (384.8)	0.48*	<0.01	192.5 (180.7)	164.7 (384.9)	0.52*	<0.01	158.1 (122.6)	157.9 (389.4)	0.45*	0.010
Vit B6 (mg)	2.3 (0.9)	2.1 (1.0)	0.53*	0.020	2.4 (0.8)	2.2 (1.1)	0.57*	0.029	2.2 (0.9)	2.1 (0.9)	0.47*	0.335
Vit B12 (mcg)	5.1 (3.1)	5.5 (4.5)	0.35*	0.350	5.2 (2.8)	6.1 (5.1)	0.46*	0.190	4.9 (3.5)	5.0 (3.6)	0.21	0.945
Folate (mcg)	387.8 (198.7)	506.0 (165.8)	0.51*	0.010	420.0 (197.7)	490.3 (152.8)	0.54*	<0.01	352.6 (196.1)	523.1 (179.4)	0.53*	<0.01
Vit D (mcg)	7.4 (6.0)	5.6 (3.9)	0.47*	<0.01	7.9 (5.9)	6.0 (4.2)	0.47*	<0.01	6.8 (6.1)	5.2 (3.6)	0.45*	0.052

* p<0.05;

SD: Standard Deviation

Table 6

Comparisons of the second FFQ scores with mean daily intakes derived from the diet records, based on cross classification by quartiles in elementary children (%)

Nutrient	Same quartile	Within 1 quartile	Within 2 quartiles	Gross-misclassification
Energy (kcal)	32.3	34.4	24.0	7.3
Protein (g)	29.2	29.2	31.3	8.3
Fat (g)	33.3	33.3	21.9	9.4
CHO (g)	29.2	33.3	21.9	13.5
Ca (mg)	22.9	36.5	31.3	7.3
Fe (mg)	25.0	42.7	19.8	10.4
Mg (mg)	25.0	41.7	22.9	8.3
Vit C (mg)	33.3	29.2	20.8	14.6
Vit B6 (mg)	30.2	34.4	25.0	8.3
Vit B12 (mcg)	29.2	25.0	31.3	12.5
Folate (mcg)	21.9	38.5	24.0	13.5
Vit D (mcg)	25.0	36.5	26.0	9.4

Table 7

Comparisons of the second FFQ scores with mean daily intakes derived from the diet records, based on cross classification by quartiles in high school children (%)

Nutrient	Same quartile	Within 1 quartile	Within 2 quartiles	Gross-misclassification
Energy (kcal)	27.1	43.8	15.6	6.3
Protein (g)	19.8	42.7	18.8	10.4
Fat (g)	28.1	34.4	18.8	10.4
CHO (g)	26.0	31.3	24.0	10.4
Ca (mg)	35.4	27.1	20.8	8.3
Fe (mg)	31.3	40.6	16.7	3.1
Mg (mg)	38.5	37.5	12.5	3.1
Vit C (mg)	42.7	28.1	17.7	3.1
Vit B6 (mg)	36.5	37.5	14.6	3.1
Vit B12 (mcg)	33.3	31.3	20.8	6.3
Folate (mcg)	33.3	42.7	12.5	3.1
Vit D (mcg)	35.4	35.4	17.7	3.1