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# Adaptation and validation of an FFQ for 6–10-year-old children

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## Abstract

*Objective:* To adapt and test the relative validity of an instrument measuring the usual food intake of 6–10-year-old children.
*Design:* An FFQ encompassing the preceding 6 months was adapted and compared with the average of three 24 h dietary recalls.
*Setting:* Private and public schools in Porto Alegre, capital city of Rio Grande do Sul, the southernmost state in Brazil, with 1·5 million inhabitants.
*Subjects:* Children aged 6–10 years attending grades 1–4 in private and public schools in Porto Alegre.
*Results:* Ninety-one children were studied. The FFQ overestimated all nutrients. Correlations with the values obtained by 24 h dietary recalls were mostly above 0·50. The deattenuated correlations increased for all nutrients. The $\kappa$ coefficients for the adjusted nutrients varied from 0·12 (weak) to 0·34 (reasonable). Graphically, the FFQ was shown to underestimate some of the parameters and to overestimate others, with a wide CI for all nutrients.
*Conclusions:* The FFQ does not have the required relative validity to classify the intake levels of schoolchildren, and further investigation is required to understand the sources of error.

**Keywords**
Methods
Validity of tests
Questionnaires
Child

Research evidence shows that there are differences between current dietary practices and nutrition recommendations for children and adolescents. Excessive energy intake and sedentary lifestyle are strongly linked to obesity[1]. There is ample evidence that prevention of obesity in school-age children and adolescents requires changes in family and school environments, as well as improvement in their dietary pattern[2].

It is more difficult to measure children's dietary intake compared with that of adults; children present greater within-person variability in intake than adults; they have limited skills in recording or recalling what they have eaten; besides, they have limited understanding about what they eat and how the food has been cooked[3].

In both clinical and research settings, having accurate dietary data is of fundamental importance when dealing with health conditions that are associated with nutritional factors. Several instruments have been validated, mostly for adults.

The 24 h dietary recall (24-HDR) provides detailed quantitative information on foods and beverages consumed on the day before the interview[4]. It is the method most often used to obtain quantitative data, because it allows the researcher to investigate the mean intake of energy and nutrients in populations of different cultural backgrounds[5]; its application is fast and depends on the subject recalling recent intake. The 24-HDR does not depend on literacy and is the method that is less likely to interfere in dietary behaviour. However, the quality of information will depend on the interviewer's ability to obtain complete and accurate responses[6]. Information about intake over several days is necessary in order to measure the usual intake. Consequently, it is more expensive[7] and implies greater respondent burden. In the case of children <10 years of age, it is preferable that the parents or guardians answer the questions[8].

The underlying principle of the FFQ approach is that the average long-term diet (intake over weeks, months or years) is the conceptually important exposure rather than the intake on a few specific days[9]. Instead of gathering information over several days, it provides a global view of the subject's diet over a longer period of time, requiring only one interview[10]. The FFQ does not require the interviewer to be highly trained, demands fairly less time for the interview and can even be self-administered; it is relatively inexpensive, and the respondents' burden is less[8,11]. The FFQ has been used extensively over the last decades in epidemiological studies. It is most commonly used to obtain estimates of an individual's food intake in

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relation to the development of various diseases, enabling to rank subjects according to dietary intake[11,12]. The accuracy of information obtained from an FFQ depends largely on the ability of respondents to give precise information about their usual food intake[4]. When the studied population comprises children <12 years of age, the intervention of an interviewer is indispensable[8,13].

For any new questionnaire, it is important to determine whether its results are reliable and valid. For those instruments that have already been tested, it is necessary to measure their performance in different populations[14]. To study its relative validity, the agreement between the FFQ and a more accurate method must be evaluated[15]. Ideally, the errors of both methods must be as independent, or uncorrelated, as possible[14]. A good option would be to use biomarkers as the reference method, but they are often expensive, invasive and nutrient specific[16]. The diet record, particularly when food is weighed, is likely to have the least correlated errors to the FFQ. Although the 24-HDR presents some correlated errors to the FFQ, the choice of multiple 24-HDR as a standard method is well established, because it is easier to apply and demands less from the subjects than does the food record[14].

The purposes of the present study were to adapt an FFQ to measure the usual food intake of 6–10-year-old children, living in Porto Alegre, south of Brazil, and to test its relative validity, comparing it with an average of three 24-HDR. The validated FFQ will then be used to rank children according to their dietary intake.

## Materials and methods

### *Subjects and study area*

The present study was conducted on 6–10-year-old children attending grades 1–4 of primary school in Porto Alegre. From a total of 2300 children studied by our research group[17], 103 were selected, by convenience, to take part in this survey. The children had to be living with their parents or caregivers, who would answer the research instruments. Only those children who did not have any gastrointestinal, neurological or psychiatric disorder, were not on a diet for the last 6 months and were not taking any systemic drug were included in the study.

Written consent was obtained from parents or guardians, and oral consent was obtained from the children. The present study was approved by the Ethics Committee of Hospital de Clínicas de Porto Alegre.

### *Anthropometry*

Weight and height were measured in accordance with standard methods for the collection of anthropometric measures[18] by a trained researcher. All measures were taken with light clothing and without shoes. Weight was measured by a digital scale (Plenna®, São Paulo, Brazil). Height was measured to the nearest 0·1 cm using a portable stadiometer (Sanny®, São Paulo, Brazil). BMI was calculated as weight in kilograms divided by the square of height in metres (kg/m$^2$), and the Centers for Disease Control and Prevention BMI cut-offs were used to classify children's weight status[19]. Children classified as overweight and obese were grouped together, because of sample size.

### *Questionnaires*

Information on family's socio-economic status (SES) was collected using a questionnaire[20], which included questions about schooling of parents and characteristics of the house (number of bathrooms and of durable goods). Families were classified into three categories from the highest to the lowest SES (A, B and C).

### *The 24 h dietary recall (reference method)*

The 24-HDR was chosen as the reference method. The questionnaires were administered face-to-face by trained interviewers, according to the protocol developed for the present study, and were based on the multiple-pass 24-HDR technique[21]. When it was not possible to gather details of food consumed, cooking measurement tables and regional recipe manuals were used[22–24]. All dietary recall questionnaires were reviewed by the research team before data were transformed into grams, and only then was the nutrient calculation carried out. The children's guardians answered three 24-HDR in non-consecutive days (two of them on working days, and one after a weekend or holiday). After the interview with the parents/guardians, the child was questioned about meals at school.

### *FFQ for schoolchildren*

The semi-quantitative FFQ was delineated to describe the dietary habits of 6–10-year-old children. An interviewer asked the parents or guardians about the frequency with which the child had consumed each item on the food list over the past 6 months. The respondent had to report the amount of food consumed by the child by choosing the portion size from reference pictures that was the closest match to what the child ate. The portion sizes of food were household measures (e.g. spoons, glasses, bowls, etc.) or the usual serving portion (e.g. slice, pack, standard glass, etc.). The total intake of a nutrient was calculated as the sum of the products of the intake frequency, usual serving size and the nutrient content of each food, i.e. $\Sigma$(frequency × weight of the usual serving size × nutrient content)[9]. The response categories for each food item were 'never', 'less than once a month', '1–3 times a month', 'once a week', '2–4 times a week', 'once a day, every day' and 'every day, more than once', which assign frequencies of 0, 0·02, 0·07, 0·14, 0·43, 1·0 and 2·0, respectively.

For certain foods, some extra information was required, such as the fat content of milk and the kind of carbonated soft drink or fruit drink (diet or light). At the end of the questionnaire, the respondent could add any food usually consumed by the children, if it was not on the food list. Owing to the tendency of subjects to overestimate the vegetable and fruit intake, at the end of the vegetable and fruit list the parent/guardian had to answer the question: 'How many times a week does the child eat vegetable/fruit?' The cross-checking of the two answers resulted in a weighting factor for each group (vegetable and fruit). The cross-check information helps in identifying potential misreporting, and, if appropriate, in adjusting FFQ intake[25].

A photographic album[26] of foods was used to help identify the portion sizes; some photographs of regional foods were added to the album.

Intakes of dietary nutrients were obtained from the FFQ for schoolchildren (FFQSC) and 24-HDR using the US Department of Agriculture nutrient database[27] and analysed using Nutribase 7 Clinical Nutritional Manager Software version 17·0 (CyberSoft Inc., Phoenix, AZ, USA). Nutrient data on frequently consumed foods were updated if necessary and/or complemented with data obtained from local manufacturers of specific industrialized foods.

### *Adaptation of the FFQ for schoolchildren*

In the present study, the FFQSC under evaluation was adapted from a validated FFQ for adolescents in the city of São Paulo, Brazil[10]. The original distribution of food groups was maintained (candies and pastry; milk and dairy products; fat; grains, breads and tubers; vegetables; fruits; legumes; meat and eggs; and beverages), as well as the frequency of food intake. For the adaptation phase, twenty mothers of eligible children were invited to answer a 24-HDR, answering questions about the food intake of their children on the day before. According to the answers, some food items were excluded, whereas others, especially regional foods, were included. The usual serving size was established as the mean of the study population. In order to better quantify the amount of food eaten, the portion sizes of foods were stratified into small (75 % of the mean), mean, large (125 % of the mean) and extra large (200 % of the mean). The participants of the adaptation phase did not take part in the validation phase.

The resulting FFQSC was analysed by five experts with experience in child nutrition. They suggested some additional changes in the food list, the portion size and the presentation of foods in order to improve the questionnaire.

The final version of the FFQSC comprises ninety food items and was designed to assess the amounts of food consumed over the preceding 6-month period. It was developed to be individually applied by a trained interviewer and requires around 42 min to be applied.

### *The relative validity of the FFQ for schoolchildren*

The relative validity phase was from July 2007 to June 2008. The reference method for comparison was the average of three 24-HDR. Subjects included ninety-one caregivers, who answered the FFQSC and the three 24-HDR. The interviews were mostly carried out at the children's school. On the first day of interview, guardians answered the FFQSC, followed by the first 24-HDR. The next two 24-HDR questionnaires were administered over the next 30 d, when the socioeconomic questionnaire was answered and anthropometric measures were obtained.

After collection, the data were converted into energy and nutrients (carbohydrate, sucrose, protein, fat, saturated fat, *trans* fat, monounsaturated fat, polyunsaturated fat, cholesterol, fibre, vitamins A, D and C, folic acid, Fe, Na, K and Zn).

### *Statistical analyses*

Statistical analyses were performed using the Statistical Package for the Social Sciences statistical software package version 17·0 (SPSS Inc., Chicago, IL, USA). A two-sided $P$ value of 0·05 was used as the threshold for significance. The difference between mean intakes of energy and nutrients was tested using the paired $t$ test. Nutrients that were not normally distributed were described as medians, 25th and 75th percentiles, and compared with the Wilcoxon signed rank test. Adjustment for total energy intake was carried out by the nutrient-density method for nutrients with non-symmetric distribution, and by regression analyses when nutrients were normally distributed. The residuals from the regression represent the differences between each individual's actual intake and the intake predicted by their total energy intake[28].

The association between the two methods was described by the Pearson and Spearman correlation coefficients for nutrients presenting symmetric and non-symmetric distribution, respectively. Crude and adjusted values were analysed. Data from the 24-HDR were adjusted for intra-individual variability in order to obtain the deattenuation of Pearson's correlation[9].

The $\kappa$ statistic was used to compare categories of nutrient intakes measured by the two methods, informing the per cent agreement. It permits to distinguish the proportion of subjects who, by chance, show good association. The subjects were ranked into the same quartile, or into adjacent or opposite quartiles. The first quartile represents subjects with the lower intake of a nutrient and the fourth quartile represents those in the upper intake of the same nutrient.

The agreement between observations was also analysed as proposed by Bland and Altman[29] to verify how much the FFQSC probably differs from the 24-HDR (relative bias). The 95 % limits of agreement, estimated as the mean difference plus or minus 1·96 times the standard deviation of the difference, shows the interval between which 95 % of the differences between the measures obtained by the two methods are expected to be.

## Results

From a total of 103 children, twelve were excluded from the analysis because of incomplete data. These children did not differ from the ninety-one children included in the validation study (forty-four boys (48·4 %) and forty-seven girls (51·6 %)). Table 1 shows the characteristics of the ninety-one children.

Table 2A presents average intakes of energy and nutrients as measured by the FFQSC and 24-HDR. The crude estimations of energy and nutrient intakes obtained with the FFQSC were statistically greater than the average of the 24-HDR. After adjusting for total energy (Table 2B), the differences between FFQSC and 24-HDR fell for most of the nutrients. Nevertheless, they were roughly unchanged for carbohydrate, fat and monounsaturated fat, and increased by approximately 1·0 % for sucrose.

**Table 1** Descriptive characteristics of the children included in the study (*n* 91)

| Characteristics | *n* | % |
|---|---|---|
| Age (years) | | |
| 6 | 7 | 7·7 |
| 7 | 17 | 18·7 |
| 8 | 29 | 31·9 |
| 9 | 30 | 33·0 |
| 10 | 8 | 8·8 |
| Gender | | |
| Male | 44 | 48·4 |
| Female | 47 | 51·6 |
| Economic classification (from the highest to the lowest) | | |
| A | 36 | 39·6 |
| B | 41 | 45·1 |
| C | 14 | 15·4 |
| Weight status for age and gender (*n* 90) | | |
| Wasted | 6 | 6·6 |
| Eutrophic | 50 | 54·9 |
| Overweight | 34 | 37·4 |

There were no significant differences between the averages obtained from the FFQSC and the FFQSC after being adjusted for the weighting factor. It was obtained by cross-checking the information of fruit and vegetables consumed over the week and the FFQSC list for those foods (data not shown).

Pearson's correlation coefficients between the two methods are presented in Table 3. Correlations above 0·50 were found for energy, carbohydrate, fat, saturated fat, monounsaturated fat, polyunsaturated fat, fibre, Ca, K, vitamins A, C and D. The correlations ranged from 0·24 to 0·47 for protein, cholesterol, Fe, Na, Zn and folic acid. There were no significant correlations for sucrose and *trans* fat. When adjusted for energy intake, the correlations for protein, carbohydrate, fat, Na, Zn, Fe, monounsaturated fat, polyunsaturated fat and cholesterol decreased. For saturated fat and vitamin D, the correlations did not change; for fibre, Ca, K, folic acid and vitamins A and C, the correlations increased. Adjustment for within-person variability increased all the correlation coefficients.

Table 4A shows the ability of the FFQSC to classify individuals into the same quartile of intake as estimated from the 24-HDR. In terms of crude values, the proportion of subjects appearing in the same quartile ranged from 34 % for Fe to 70 % for energy. It was 44 % for nutrients in general. Otherwise, the proportion of children classified into opposite quartiles was 18 %, ranging from 12 % for fat to 24 % for sucrose. The strength of agreement according to the $\kappa$ statistic ranged from 0·12 (slight) for Fe to 0·36 (fair) for vitamin C. Zn, folic acid and *trans* fat did not present significant agreement.

**Table 2A** Daily intakes of energy and nutrients as estimated by the FFQSC and the 24-HDR (*n* 91)

| | FFQSC | | 24-HDR | | | |
|---|---|---|---|---|---|---|
| Energy/nutrient | Mean or median | SD OR IQR | Mean or median | SD OR IQR | Difference %† | *P* value |
| Energy (kJ) | 10 620·2 | 3937·1 | 8249·6 | 2113·3 | 22·3 | <0·0001 |
| Protein (g) | 103·9 | 42·2 | 79·7 | 23·4 | 23·3 | <0·0001 |
| Carbohydrate (g) | 332·6 | 117·8 | 262·1 | 71·7 | 21·2 | <0·0001 |
| Sucrose (g)‡ | 5·2 | 3·2–13·9 | 3·5 | 0·8–7·5 | 32·2 | <0·001 |
| Fibre (g) | 23·68 | 9·88 | 15·5 | 6·5 | 34·5 | <0·0001 |
| Fat (g) | 89·9 | 40·7 | 68·8 | 20·5 | 23·5 | <0·0001 |
| Saturated fat (g) | 28·35 | 12·32 | 23·0 | 7·3 | 19·1 | <0·0001 |
| Monounsaturated fat (g) | 28·9 | 14·8 | 22·6 | 7·3 | 21·9 | <0·0001 |
| Polyunsaturated fat (g) | 21·0 | 10·4 | 15·9 | 6·5 | 24·2 | <0·0001 |
| *Trans* fat (g)‡ | 0·8 | 0·5–1·9 | 0·3 | 0·0–0·8 | 68·4 | <0·0001 |
| Cholesterol (mg)‡ | 247·5 | 186·5–340·4 | 211·5 | 165·9–274·1 | 14·6 | <0·0001 |
| Fe (mg) | 16·4 | 6·8 | 12·8 | 4·1 | 22·5 | <0·0001 |
| Ca (mg) | 1236·3 | 465·4 | 976·7 | 398·1 | 21·0 | <0·0001 |
| Na (mg) | 3127·5 | 1377·2 | 2165·4 | 761·6 | 30·8 | <0·0001 |
| K (mg) | 3056·3 | 1088·5 | 2126·9 | 636·6 | 30·4 | <0·0001 |
| Zn (mg) | 13·8 | 5·6 | 10·5 | 3·3 | 23·6 | <0·0001 |
| Vitamin C (mg)‡ | 128·6 | 65·0–110·1 | 70·4 | 36·2–110·1 | 45·3 | <0·0001 |
| Vitamin D (μg)‡ | 3·9 | 1·4–1·55 | 2·6 | 1·4–4·2 | 32·7 | <0·0001 |
| Vitamin A (μg RE)‡ | 552·0 | 410·8–733·0 | 406·9 | 309·0–575·5 | 26·3 | <0·0001 |
| Folic acid (μg)‡ | 120·9 | 84·1–198·9 | 85·8 | 54·3–126·8 | 29·0 | <0·0001 |

FFQSC, FFQ for schoolchildren; 24-HDR, 24 h dietary recall; IQR, interquartile range; RE, retinol equivalents.
†Difference % = (FFQSC − 24-HDR)/FFQSC × 100.
‡Values are median and IQR.

**Table 2B** Nutrient intakes, adjusted by energy, as estimated by the FFQSC and the 24-HDR (*n* 91)

| Nutrient | FFFSC Mean | FFFSC SD | 24-HDR Mean | 24-HDR SD | Difference %† | *P* value |
|---|---|---|---|---|---|---|
| Protein (g) | 108·9 | 61·4 | 85·7 | 54·3 | 21·3 | <0·0001 |
| Carbohydrate (g) | 337·8 | 135·0 | 265·9 | 86·1 | 21·3 | <0·0001 |
| Sucrose (g)‡ | 0·0025 | 0·001–0·0005 | 0·002 | 0·0004–0·004 | 33·3 | 0·027 |
| Fibre (g) | 27·6 | 19·1 | 19·0 | 15·5 | 30·9 | <0·0001 |
| Fat (g) | 92·0 | 48·4 | 70·3 | 25·4 | 23·6 | <0·0001 |
| Saturated fat (g) | 29·8 | 16·8 | 24·4 | 11·3 | 18·1 | <0·0001 |
| Monounsaturated fat (g) | 30·2 | 19·5 | 23·5 | 10·1 | 22·0 | <0·0001 |
| Polyunsaturated fat (g) | 22·3 | 13·6 | 17·3 | 10·4 | 22·4 | <0·0001 |
| *Trans* fat (g)‡ | 0·0004 | 0·0002–0·0008 | 0·0002 | 0·0–0·0003 | 50·0 | <0·001 |
| Cholesterol (mg)‡ | 0·11 | 0·08–0·13 | 0·11 | 0·09–0·13 | 0·0 | 0·94 |
| Fe (mg) | 17·3 | 9·3 | 14·1 | 8·8 | 18·3 | <0·01 |
| Ca (mg) | 1399·7 | 817·7 | 1159·1 | 809·6 | 17·2 | <0·0001 |
| Na (mg) | 3279·9 | 1940·0 | 2379·8 | 1439·2 | 27·4 | <0·0001 |
| K (mg) | 3257·7 | 1646·2 | 2302·9 | 1162·7 | 29·3 | <0·0001 |
| Zn (mg) | 14·6 | 9·0 | 11·4 | 6·6 | 22·0 | <0·0001 |
| Vitamin C (mg)‡ | 0·04 | 0·02–0·08 | 0·03 | 0·02–0·05 | 25·0 | <0·0001 |
| Vitamin D (μg)‡ | 0·0012 | 0·0005–0·0017 | 0·0012 | 0·0005–0·0020 | 0·0 | 0·80 |
| Vitamin A (μg RE)‡ | 0·23 | 0·17–0·31 | 0·21 | 0·16–0·30 | 8·7 | 0·15 |
| Folic acid (μg)‡ | 0·05 | 0·03–0·07 | 0·04 | 0·02–0·06 | 20·0 | 0·02 |

FFQSC, FFQ for schoolchildren; 24-HDR, 24 h dietary recall; IQR, interquartile range; RE, retinol equivalents.
†Difference % = (FFQSC − 24-HDR)/FFQSC × 100.
‡Values are median and IQR.

**Table 3** Correlation coefficients of energy and nutrient intakes between the 24-HDR and the FFQSC (*n* 91)

| Energy/nutrient | Correlation coefficients: Crude correlation† | Adjusted correlation | Deattenuated correlation‡ |
|---|---|---|---|
| Energy (kJ)§ | 0·62* | – | – |
| Protein (g)§ | 0·46* | 0·37* | 0·55 |
| Carbohydrate (g)§ | 0·60* | 0·58* | 0·72 |
| Sucrose (g)ll | 0·18 | 0·16 | 0·26 |
| Fibre (g)§ | 0·58* | 0·59* | 0·78 |
| Fat (g)§ | 0·63* | 0·59* | 0·76 |
| Saturated fat (g)§ | 0·63* | 0·63* | 0·81 |
| Monounsaturated fat (g)§ | 0·59* | 0·51* | 0·69 |
| Polyunsaturated fat (g)§ | 0·55* | 0·46* | 0·67 |
| *Trans* fat (g)ll | 0·25** | 0·23** | 0·40 |
| Cholesterol (mg)§ | 0·45* | 0·44* | 0·61 |
| Fe (mg)§ | 0·34* | 0·26** | 0·33 |
| Ca (mg)§ | 0·68* | 0·69* | 0·85 |
| Na (mg)§ | 0·47* | 0·38* | 0·59 |
| K (mg)§ | 0·57* | 0·61* | 0·78 |
| Zn (mg)§ | 0·36* | 0·26** | 0·37 |
| Vitamin C (mg)ll | 0·63* | 0·64* | 0·81 |
| Vitamin D (μg)ll | 0·74* | 0·74* | – |
| Vitamin A (μg RE)ll | 0·52* | 0·54* | 0·77 |
| Folic acid (μg)ll | 0·22** | 0·34* | 0·49 |

24-HDR, 24 h dietary recall; FFQSC, FFQ for schoolchildren; RE, retinol equivalents.
*$P<0{\cdot}01$, **$P<0{\cdot}05$.
†The energy and nutrient values were log-transformed to normalize the distribution.
‡The deattenuated correlation was calculated according to the equation: $r_c = r_o(1+(S_w^2/S_b^2)n)^{0{,}5}$; $r_c$, corrected correlation; $r_o$, observed correlation; $S_w^2$, within-person variance; $S_b^2$, between-person variance; *n*, number of observations.
§Pearson correlation coefficient.
llSpearman correlation coefficient.

After adjusting for energy (Table 4B), the proportion of subjects classified into the same quartile ranged from 32 % for sucrose and *trans* fat to 53 % for vitamin D. The average was 40·5 % for nutrients in general.

The proportion of children classified into opposite quartiles ranged from 8 % for vitamin D to 23 % for sucrose (average 17 %).

After adjustment for energy, polyunsaturated fat and Fe did not show significant agreement, unlike Zn, which presented significant agreement, although very low. The nutrients showing better agreement were saturated fat, K, vitamins C and D. The nutrients that presented worse subject classification were Na, protein, monounsaturated fat, *trans* fat, sucrose and Zn. The κ values continued to

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**Table 4A** Assessment of agreement between the FFQSC and 24-HDR

| | First quartile 24-HDR | | Fourth quartile 24-HDR | | Overall | | | |
|---|---|---|---|---|---|---|---|---|
| Energy/nutrient | First quartile FFQSC (%) | Fourth quartile FFQSC (%) | Fourth quartile FFQSC (%) | First quartile FFQSC (%) | Exact (%) | Opposite (%) | $\kappa$ | *P* value |
| Energy (kcal)† | 14 | 1 | 13 | 0 | 70 | 15 | 0·24 | <0·0001 |
| Protein (g) | 14 | 1 | 13 | 1 | 44 | 16 | 0·25 | <0·0001 |
| Carbohydrate (g) | 12 | 1 | 13 | 2 | 37 | 21 | 0·17 | 0·006 |
| Sucrose (g) | 9 | 8 | 9 | 4 | 36 | 24 | 0·15 | 0·013 |
| Fibre (g) | 14 | 1 | 14 | 1 | 45 | 18 | 0·27 | <0·0001 |
| Fat (g) | 13 | 0 | 14 | 1 | 46 | 12 | 0·28 | <0·0001 |
| Saturated fat (g) | 14 | 0 | 17 | 0 | 48 | 14 | 0·31 | <0·0001 |
| Monounsaturated fat (g) | 12 | 1 | 13 | 1 | 39 | 18 | 0·18 | 0·003 |
| Polyunsaturated fat (g) | 11 | 1 | 13 | 2 | 35 | 21 | 0·14 | 0·025 |
| *Trans* fat (g) | 8 | 6 | 11 | 3 | 32 | 20 | 0·10 | 0·126 |
| Cholesterol (mg) | 14 | 2 | 10 | 0 | 41 | 13 | 0·21 | 0·001 |
| Fe (mg) | 9 | 3 | 12 | 3 | 34 | 22 | 0·12 | 0·046 |
| Ca (mg) | 17 | 1 | 11 | 0 | 40 | 19 | 0·20 | 0·001 |
| Na (mg) | 15 | 1 | 10 | 4 | 43 | 20 | 0·24 | <0·0001 |
| K (mg) | 14 | 2 | 13 | 0 | 46 | 14 | 0·28 | <0·0001 |
| Zn (mg) | 12 | 3 | 11 | 3 | 32 | 29 | 0·10 | 0·131 |
| Vitamin C (mg) | 18 | 0 | 14 | 1 | 52 | 15 | 0·36 | <0·0001 |
| Vitamin D ($\mu$g) | 17 | 0 | 15 | 0 | 51 | 14 | 0·34 | <0·0001 |
| Vitamin A ($\mu$g RE) | 12 | 1 | 12 | 4 | 41 | 20 | 0·21 | <0·001 |
| Folic acid ($\mu$g) | 9 | 6 | 9 | 4 | 28 | 29 | 0·03 | 0·587 |

FFQSC, FFQ for schoolchildren; 24-HDR, 24 h dietary recall; RE, retinol equivalents.
Results are classified into quartiles for energy and nutrient intakes (*n* 91).
†1 kcal = 4·184 kJ.

**Table 4B** Assessment of agreement between the FFQSC and 24-HDR after adjusting for energy

| | First quartile 24-HDR | | Fourth quartile 24-HDR | | Overall | | | |
|---|---|---|---|---|---|---|---|---|
| Nutrient | First quartile FFQSC (%) | Fourth quartile FFQSC (%) | Fourth quartile FFQSC (%) | First quartile FFQSC (%) | Exact (%) | Opposite (%) | $\kappa$ | *P* value |
| Protein (g) | 11 | 4 | 9 | 3 | 35 | 21 | 0·14 | 0·025 |
| Carbohydrate (g) | 13 | 1 | 13 | 2 | 40 | 21 | 0·19 | 0·001 |
| Sucrose (g) | 8 | 7 | 8 | 4 | 32 | 23 | 0·14 | 0·025 |
| Fibre (g) | 15 | 2 | 12 | 1 | 43 | 20 | 0·24 | <0·0001 |
| Fat (g) | 12 | 1 | 15 | 2 | 43 | 19 | 0·24 | <0·0001 |
| Saturated fat (g) | 15 | 0 | 15 | 0 | 51 | 12 | 0·34 | <0·0001 |
| Monounsaturated fat (g) | 9 | 1 | 13 | 1 | 35 | 14 | 0·14 | 0·025 |
| Polyunsaturated fat (g) | 8 | 1 | 13 | 1 | 33 | 14 | 0·11 | 0·080 |
| *Trans* fat (g) | 7 | 5 | 10 | 3 | 32 | 19 | 0·14 | 0·025 |
| Cholesterol (mg) | 11 | 1 | 13 | 0 | 39 | 12 | 0·24 | <0·001 |
| Fe (mg) | 8 | 4 | 8 | 3 | 29 | 19 | 0·05 | 0·433 |
| Ca (mg) | 15 | 1 | 13 | 1 | 44 | 19 | 0·25 | <0·0001 |
| Na (mg) | 10 | 3 | 10 | 3 | 34 | 20 | 0·12 | 0·046 |
| K (mg) | 14 | 1 | 14 | 0 | 48 | 12 | 0·31 | <0·0001 |
| Zn (mg) | 9 | 3 | 10 | 3 | 35 | 17 | 0·14 | 0·025 |
| Vitamin C (mg) | 13 | 1 | 14 | 1 | 47 | 12 | 0·36 | <0·001 |
| Vitamin D ($\mu$g) | 15 | 0 | 15 | 0 | 53 | 8 | 0·44 | <0·001 |
| Vitamin A ($\mu$g RE) | 14 | 0 | 10 | 4 | 38 | 19 | 0·22 | <0·001 |
| Folic acid ($\mu$g) | 8 | 1 | 12 | 1 | 29 | 16 | 0·09 | 0·131 |

FFQSC, FFQ for schoolchildren; 24-HDR, 24 h dietary recall; RE, retinol equivalents.
Results are classified into quartiles, for nutrient intake, adjusted by energy (*n* 91).

be low, ranging from 0·12 (slight) for Na to 0·44 (fair) for vitamin D.

Figure 1 shows Bland and Altman's[29] agreement analysis for protein. It illustrates what was observed for most nutrients. It seems that there were no differences in agreement as the intake increased. The large scatter of results indicated a bias between the two methods for most nutrients. This bias was not systematic; it was positive for some nutrients (overestimation) and negative for other nutrients (underestimation).

## Discussion

The FFQ analysed in the present study lacks relative validity and does not allow the examiner to confidently

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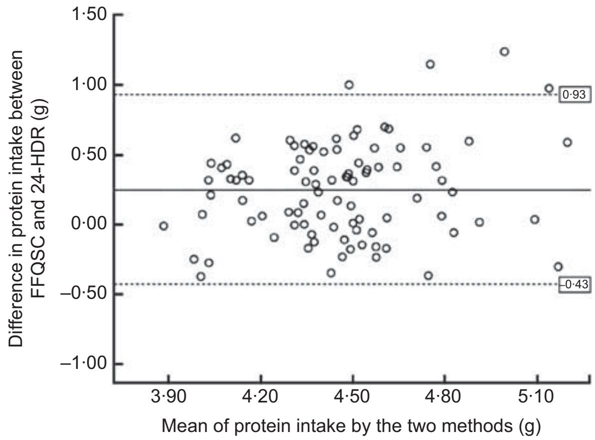


**Fig. 1** Agreement between FFQ for schoolchildren (FFQSC) and 24 h dietary recall (24-HDR); middle solid line indicates mean difference; upper and lower dashed lines indicate mean difference ± 1·96 × SD of the difference limits of agreement (i.e. 95 %; *n* 91)

classify subjects according to food intake levels. Therefore, it is far from ideal as a tool for epidemiological studies. The number of children presenting any health disorder, such as hypertension, dyslipidemia or obesity, is increasing. Nevertheless, there are only very few instruments that analyse the usual diet of children in this age range. Therefore, we chose to adapt an FFQ validated for adolescents[10], thus bypassing the cumbersome development of a food list for the instrument. This adaptation was carried out with the cooperation of experts in children's diet, which oversaw the adaptation of the original food list[9]. The protocol of the present study was similar to that used to validate the original questionnaire. The number of days used to calculate the average of 24-HDR was maintained, as increasing the day of observations, in general, does not improve the relative validity of FFQ[11]; the method under evaluation (FFQSC) was applied before the reference method in order to avoid any influence from the 24-HDR[14]. Although the FFQ for adolescents (FFQA) was designed to be self-administered, the FFQSC was designed to be answered by the child's guardian since many children are not able to self-report their intake[8].

Only two other studies have tried to validate an FFQ for this age range in Brazil. Assis *et al.*[30] tested the validity of a different FFQ, designed to be applied in this group, comparing it with the direct observation of three school meals. The respondents were 131 children aged 8–10 years, living in Camboriú, Santa Catarina, south of Brazil, attending a public school. In another study[31] with 151 children (5–10-year-olds) living in São Paulo, Brazil, an FFQ, designed to be applied in adults in reference to the previous month, was tested against the average of three food records. The authors concluded that other studies would be necessary to validate the instrument.

The FFQ in the present study overestimated all nutrients, whereas the FFQA[10] gave similar values for energy, fat, vitamin C and Ca, overestimated values of carbohydrate and fibre and underestimated protein, polyunsaturated fat, cholesterol, vitamin A and Fe. The FFQA was not validated for sucrose, monounsaturated fat, *trans* fat, Na, K, Zn, vitamin D and folic acid. The FFQSC showed higher average intakes than the FFQA. The finding of overestimation is in agreement with other studies[31–34]. Fumagalli *et al.*[31] did not show significant differences for carbohydrate, protein, Ca and Fe, but their FFQ overestimated fibre, fat, saturated fat, cholesterol and Zn to a greater extent.

Compared with the FFQA (0·46–0·87), the FFQSC (0·22–0·68) presented lower crude correlations with the 24-HDR for energy, protein, carbohydrate, fat and Fe; similar correlations for polyunsaturated fat, fibre and cholesterol; and higher correlations for vitamins A, C and Ca. Fumagalli *et al.*[31] (0·21–0·68), Field *et al.*[33] (0·19–0·31) and Marshal *et al.*[34] (0·20–0·52) found poorer correlations, whereas the results of Wilson *et al.*[35] (0·69, for energy) and Bertoli *et al.*[32] (0·5–0·7) were similar to ours.

After adjusting for total energy intake, the correlation decreased for some of the nutrients, instead of improving, as could be expected, since the intake variability of these nutrients is related to energy intake. The decrease may be related to an over- or underestimation of the nutrient intake[36].

When the adjusted correlations were corrected for intra-individual variability, all correlation values improved, as occurred with Slater *et al.*[10], Fumagalli *et al.*[31] and Field *et al.*[33], pointing to a greater variability in the diet of these subjects.

The agreement between the two methods is at best fair, reaching a $\kappa$ value of 0·4. Our results are similar to those of some studies[35,37–39], and superior to others[10,31,40]. Nevertheless, the present study observed that many children were classified into opposite quartiles (12–24 %), resulting in lower $\kappa$ values. The comparison with other studies is difficult, because some of them do not inform the agreement into opposite quartiles, or even the $\kappa$ coefficient. Our results are better than those of Fumaggali *et al.*[31], but classified more subjects into opposite quartiles than did Slater *et al.*[10]. The difference between the FFQA and the FFQSC may be due to the age range of the subjects, which is characterized by a gradually increasing independence of children in terms of diet. Although the children were asked about their meals outside home, or in the absence of their parents, children <12 years of age have limited ability to recall the portion size of foods they have consumed[41,42].

The FFQSC evaluates the food eaten by children over the previous 6 months, whereas the 24-HDR estimates the average of food intake of the previous 45 days. This may limit the agreement between these two methods.

Comparison data were collected over a 1-year period, but the majority of the data was collected from July to December, representing the food consumption over winter and spring. Therefore, seasonal effects may not have been completely accounted for.

The choice of 24-HDR as the reference method could in itself be a limitation. It depends, as in the FFQSC, on the subjects' memory[9,11]. Nevertheless, this choice was carefully weighed, since the food record method would be operationally difficult, more costly and less well accepted by participants.

Although the adaptation of the FFQ is theoretically possible, desirable and should ideally be carried out before it is used for each different population[11], the procedure appears to be very laborious and bias prone. The FFQ presented good correlation with the reference method, tending to overestimate the nutrients. However, it lacks relative validity, and does not provide the necessary confidence to rank subjects by levels of food intake in epidemiological studies, as far as the comparison with 24-HDR is concerned.

Although our results are similar to those of others, our conclusion is different. Other studies tended to consider that the FFQ is valid in the face of very similar results to ours. We would challenge this conclusion in as far as our results show that the adapted FFQ is inaccurate.

Therefore, we do not recommend the use of this particular FFQ in the current stage, and will wait until further studies ensure that this instrument – or an alternative FFQ – is accurate enough to allow researchers and/or practitioners to use it with confidence.

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## References

1. American Heart Association, Gidding SS, Dennison BA *et al.* (2006) Dietary recommendations for children and adolescents: a guide for practitioners. *Pediatrics* **117**, 544–559.
2. Daniels SR, Arnett DK, Eckel RH *et al.* (2005) Overweight in children and adolescents: pathophysiology, consequences, prevention, and treatment. *Circulation* **111**, 1999–2012.
3. Rockett HRH & Colditz GA (1997) Assessing diets of children and adolescents. *Am J Clin Nutr* **65**, Suppl. 3, 1116–1122.
4. Rutishauser IHE (2005) Dietary intake measurements. *Public Health Nutr* **8**, 1100–1107.
5. Fisberg RM, Martini LA & Slater B (2005) Métodos de inquéritos alimentares. In *Inquéritos Alimentares: Métodos e Bases Científicos*, pp. 1–29 [RM Fisberg, B Slater, DML Marchioni *et al.*, editors]. Barueri: Manole.
6. Buzzard M (1998) 24-hour dietary recall and food record methods. In *Nutritional Epidemiology*, 2nd ed., pp. 50–73 [WC Willett, editor]. Oxford: Oxford University Press.
7. Cullen KW, Watson MS & Zakeri ISSA (2008) Relative reliability and validity of the block kids questionnaire among youth aged 10 to 17 years. *J Am Diet Assoc* **108**, 862–866.
8. Biró G, Hulshof KFAM, Ovesen L *et al.* (2002) Selection of methodology to assess food intake. *Eur J Clin Nutr* **56**, 25–32.
9. Willett W (1998) *Nutritional Epidemiology*, 2nd ed. Oxford: Oxford University Press.
10. Slater B, Philippi ST, Fisberg RM *et al.* (2003) Validation of a semi-quantitative adolescent food frequency questionnaire applied at a public school in São Paulo, Brazil. *Eur J Clin Nutr* **57**, 629–635.
11. Cade J, Thompson R, Burley V *et al.* (2002) Development, validation and utilisation of food-frequency questionnaires – a review. *Public Health Nutr* **5**, 567–587.
12. Thompson FE & Byers T (1994) Dietary Assessment Resource Manual. *J Nutr* **124**, Suppl. 11, 2245S–2317S.
13. Moore GF, Tapper K, Murphy S *et al.* (2006) Validation of a self-completion measure of breakfast foods, snacks and fruits and vegetables consumed by 9- to 11-year-old schoolchildren. *Eur J Clin Nutr* **61**, 1–11.
14. Willett WC & Lenart E (1998) Reproducibility and validity of food-frequency questionnaires. In *Nutritional Epidemiology*, 2nd ed., pp. 101–147 [W Willett, editor]. Oxford: Oxford University Press.
15. Slater B & Lima FEL (2005) Validade e reprodutibilidade dos métodos de inquérito alimentar. In *Inquéritos Alimentares: Métodos e Bases Científicos*, pp. 108–131 [RM Fisberg, B Slater, DML Marchioni *et al.*, editors]. Barueri: Manole.
16. Lopes ACS, Caiaffa WT, Mingoti AS *et al.* (2003) Ingestão alimentar em estudos epidemiológicos. *Rev Bras Epidemiol* **6**, 209–219.
17. Alves BS (2007) Obesidade na infância: critérios diagnósticos e impacto no rendimento escolar. Master's Degree Thesis, Universidade Federal do Rio Grande do Sul.
18. National Health and Nutrition Examination Survey (2004) *Anthropometry Procedures Manual*. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Medical Statistics; available at http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/BM.pdf
19. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM *et al.* (2000) CDC growth charts: United States. *Adv Data* **314**, 1–27.
20. Associação Brasileira de Empresas de Pesquisa (2003) *CCEB 2003 – Critério de Classificação Econômica Brasil*. São Paulo, SP: Associação Brasileira de Empresas de Pesquisa; available at http://www.abep.org/codigosguias/ABEP_CCEB_2003.pdf
21. Jonnalagadda SS, Mitchell DC, Smiciklas-Wright H *et al.* (2000) Accuracy of energy intake data estimated by a multiple-pass, 24-hour dietary recall technique. *J Am Diet Assoc* **100**, 303–308.
22. Pinheiro ABV, Lacerda EMA, Benzecry EH *et al.* (2005) *Tabela Para Avaliação de Consumo Alimentar em Medidas Caseiras*. São Paulo: Atheneu.
23. Fisberg RM & Villar BS (2003) *Manual de Receitas e Medidas Caseiras Para Cálculo de Inquéritos Alimentares*. São Paulo: Signus.
24. Ben ML (2007) *Quanto Pesa? Tabela de Pesos e Medidas de Alimentos*. Porto Alegre: Ediplat.
25. Calvert C, Cade J, Barrett JH *et al.* (1997) Using cross-check questions to address the problem of mis-reporting of specific food groups on food frequency questionnaires. *Eur J Clin Nutr* **51**, 708–712.

26. Zaboto CB (1996) *Registro Fotográfico Para Inquéritos Dietéticos: Utensílios e Porções*. Campinas e Goiânia: NEPA-UNICAMP.
27. US Department of Agriculture, Agricultural Research Service (2005) *US Department of Agriculture Nutrient Data Base for Standard Reference, release 14*. Washington, DC: USDA.
28. Willett WC, Howe GR & Kushi LH (1997) Adjustment for total energy intake in epidemiologic studies. *Am J Clin Nutr* **65**, Suppl. 4, 1220S–1228S.
29. Bland JM & Altman DG (1999) Measuring agreement in method comparison studies. *Stat Methods Med Res* **8**, 135–160.
30. Assis MAA, Guimarães D, Calvo MCM *et al*. (2007) Reprodutibilidade e validade de questionário de consumo alimentar para escolares. *Rev Saude Publica* **41**, 1054–1057.
31. Fumagalli F, Monteiro JP, Sartorelli DS *et al*. (2008) Validation of a food frequency questionnaire for assessing dietary nutrients in Brazilian children 5 to 10 years of age. *Nutrition* **24**, 27–32.
32. Bertoli S, Petroni ML, Pagliato E *et al*. (2005) Validation of food frequency questionnaire for assessing dietary macronutrients and calcium intake in Italian children and adolescents. *J Pediatr Gastroenter Nutr* **40**, 555–560.
33. Field AE, Peterson KE, Gortmaker SL *et al*. (1999) Reproducibility and validity of a food frequency questionnaire among fourth to seventh grade inner-city school children: implications of age and day-to-day variation in dietary intake. *Public Health Nutr* **2**, 293–300.
34. Marshall TA, Gilmore JME, Broffitt B *et al*. (2008) Relative validity of the Iowa fluoride study targeted nutrient semi-quantitative questionnaire and the block kids' food questionnaire for estimation beverage, calcium, and vitamin D intakes by children. *J AM Diet Assoc* **108**, 465–472.
35. Wilson AMR & Lewis RD (2004) Disagreement of energy and macronutrient intakes estimated from a food frequency questionnaire and 3-day diet record in girls 4 to 9 years of age. *J AM Diet Assoc* **104**, 473–478.
36. Willett WC & Stampfer M (1998) Implications of total energy intake for epidemiologic analyses. In *Nutritional Epidemiology*, 2nd ed., pp. 273–301 [W Willett, editor]. Oxford: Oxford University Press.
37. Andersen LF, Lande B, Trygg K *et al*. (2004) Validation of a semi-quantitative food-frequency questionnaire used among 2-year-old Norwegian children. *Public Health Nutr* **7**, 757–764.
38. Huybrechts I, Bacquer D, Matthys C *et al*. (2006) Validity and reproducibility of a semi-quantitative food-frequency questionnaire for estimating calcium intake in Belgian preschool children. *Br J Nutr* **95**, 802–816.
39. Vereecken CA & Maes L (2003) A Belgian study on the reliability and relative validity of the Health Behaviour in School-Aged Children food-frequency questionnaire. *Public Health Nutr* **6**, 581–588.
40. Kiwanuka SN, Astrom AN & Trovik TA (2006) Sugar snack consumption in Ugandan schoolchildren: validity and reliability of a food frequency questionnaire. *Community Dent Oral Epidemiol* **34**, 372–380.
41. Livingstone MBE, Robson PJ & Wallace JMW (2004) Issues in dietary intake assessment of children and adolescents. *Br J Nutr* **92**, 213–222.
42. Baxter SD, Smith AF, Hardin JW *et al*. (2007) Conventional energy and macronutrient variables distort the accuracy of children's dietary reports: illustrative data from a validation study of effect of order prompts. *Prev Med* **44**, 34–41.