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Development and validation of a food frequency questionnaire for children aged 7 to 10 years

Desenvolvimento e validação de um questionário de frequência alimentar para crianças de 7 a 10 anos de idade

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ABSTRACT

Objective

Food and nutritional evaluation of children can support public policies to combat early overweight and obesity. This study developed and validated a quantitative food frequency questionnaire for assessing the dietary intake of children.

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Methods

This is a cross-sectional study of the development of a food frequency questionnaire for 130 children of both genders aged 7 to 10 years old. For the food frequency questionnaire list, 81 food items were selected. The validity of the food frequency questionnaire was evaluated by comparison with 24-hour recalls and reproducibility was performed by comparing two food frequency questionnaires.

Results

Most of the foods with 95% relative contribution were ultra-processed, such as packaged snacks and powdered juice. In validation, correlation coefficients were found between 0.45 (p<0.000) for lipids and 0.37 (p<0.000) for carbohydrates. An adjustment for energy reduced the correlations, but there was an increase in the correlation in calcium (r=0.75) and retinol (r=0.20). In terms of reproducibility, all macronutrients and calcium showed a satisfactory intraclass correlation coefficient (>0.400) and moderate correlations [proteins (0.54; p<0.000) and lipids (0.41; p<0.000)].

Conclusion

The food frequency questionnaire developed was valid and able to assess the local food consumption by children from northeastern Brazil.

Keywords: Diet surveys. Nutrients. Nutritional transition.

RESUMO

Objetivo

A avaliação alimentar e nutricional de crianças pode subsidiar políticas públicas de combate ao sobrepeso e à obesidade precoce. Este estudo desenvolveu e validou um questionário quantitativo de frequência alimentar para avaliação do consumo alimentar de crianças de 7 a 10 anos.

Métodos

Trata-se de um estudo transversal do desenvolvimento de um questionário de frequência alimentar que avaliou 130 crianças de ambos os sexos com idades entre 7 e 10 anos. Para a lista do questionário, foram selecionados 81 itens alimentares. A validade do instrumento foi avaliada por meio da comparação com recordatórios de 24 horas e a reprodutibilidade foi realizada pela comparação de dois questionários de frequência alimentar.

Resultados

A maioria dos alimentos com 95% de contribuição relativa foi ultraprocessada, como salgadinhos embalados e suco em pó. Na validação, foram encontrados coeficientes de correlação entre 0,45 (p<0,000) para lipídios e 0,37 (p<0,000) para carboidratos. Um ajuste para energia reduziu as correlações, mas houve um aumento na correlação de cálcio (r=0,75) e retinol (r=0,20). Em termos de reprodutibilidade, todos os macronutrientes e o cálcio apresentaram coeficiente de correlação intraclasse satisfatório (>0,400) e correlações moderadas [proteínas (0,54; p<0,000) e lipídios (0,41; p<0,000)].

Conclusão

O questionário de frequência alimentar desenvolvido é válido e foi capaz de avaliar o consumo alimentar local de crianças do Nordeste do Brasil.

Palavras-chave: *Inquéritos sobre dietas. Nutrientes. Transição nutricional.*

INTRODUCTION

Obesity is a serious public health problem that has increased worldwide, especially in Low and Middle-Income Countries (LMIC) [1]. In Central Latin America, there was an annual increase of 0.95kg/m² per decade in the BMI of children and adolescents [2]. In Brazil, a recent systematic review and meta-analysis showed an increase from 8 to 12 the number of children with obesity in every 100 Brazilian children with 8.2% of the infant population being considered obese [3]. In *Vitória de Santo Antão*, a recent study carried out with children aged 7 to 10 years old observed a prevalence of 28.7% of obesity [4]. One of the factors related to the increase in cases of obesity in the LMIC is food consumption based on diet rich in calories, sugar and saturated fats, characteristics of Ultra-Processed Foods (UPF) [5]. Schoolchildren (aged 9.8±0.5 years) with overweight showed a high consumption of UPFs such as industrialized pastas, sweet biscuits, sausages, chocolate powder and soft drinks [6]. On the other hand, an increase in the consumption of fruits and vegetables was related to less development of excess body weight [6]. In addition, a recent study has shown that the diet of children aged 7-10 years is made up of more than 40% of the energy contribution from UPF [4]. Given the influence of food on the development overweight, an investigation of child food intake can be a strategy towards directing actions to combat childhood obesity.

A Food Frequency Questionnaire (FFQ) is the main instrument used to assess habitual food consumption in epidemiological studies, and enables a relationship to clinical outcomes, such as obesity [7]. In children, the validity of an investigation of food intake through a FFQ depends on the age, socioeconomic conditions, and memory of this population [8]. Recent FFQs have been developed for children in LMIC [9,10]. Horiuchi *et al.* [9] developed an FFQ for children and adolescents (6-17 years) in Cambodia, based on reported 24-hour recall (24-HRs). This FFQ was validated with higher correlations for adolescents than for children, due to their better memory performance [9]. Rodriguez *et al.* [10] also developed an FFQ for children and adolescents for the population from Lima, Peru. In this FFQ, the population evaluated came from a low-income urban region, where economic conditions may have influenced food consumption [10].

In Brazil, some FFQs have also been developed for children [11,12]. A previous study validated a FFQ administered to children (6-9 years) from Brazilian Western Amazon [11]. Another study developed and validated a FFQ for children and adolescents (4-11 years) from Salvador, in the northeast of Brazil [12]. In these studies, difficulties were observed in the validation with the child respondents, such as overestimation of consumption by the FFQ and moderate to low correlation coefficients due to systematic errors [12]. In addition, questionnaires need to be adapted to food and social diversity in the different regions of Brazil, influencing the food list and portion size to be used in different populations [12].

Vitória de Santo Antão is a city located in the urban interior of the state of *Pernambuco*, in northeast Brazil. This city has a Human Development Index (HDI) classified as medium (0.640), lower than the average for the state of *Pernambuco* (0.673). In addition, it presents characteristics of nutritional transition, due to an increase in cases of obesity in the child population after a long history of undernutrition in the region [13]. A recent study carried out in this city identified that 24% of the children from 7 to 10 years of age were overweight [14]. Given that the population has high rates of obesity accompanied by social inequalities, it is important to investigate food consumption, mainly the intake of UPF, which is an etiological factor for the development of obesity. On the other hand, few instruments exist to assess the diet for children in northeastern Brazil. Thus, the main aim of the present study was to develop and validate a quantitative FFQ for assessing the dietary intake of children between 7 and 10 years old.

METHODS

This cross-sectional study was carried out from November/2018 to October/2019 with children from five municipal schools in *Vitória de Santo Antão*. Children of both sexes participating in the project *Crescer com Saúde em Vitória de Santo Antão* were randomly selected. All children of both sexes from 7 to 10 years old enrolled were invited to participate. Of the 213 selected participants, only 189 children completed all evaluations and participated in the present study (Figure 1). Children who had difficulties in answering the 24-HRs or the FFQ (such as reporting the consumption of all or few foods on the list and repetition of the same portion for all foods) had their data disregarded, due to the high probability of information bias [8,15].

The nutritional status of each participant was assessed by body mass and height through the standardization described by previous study [13]. The Body Mass Index (BMI) for age was the index used

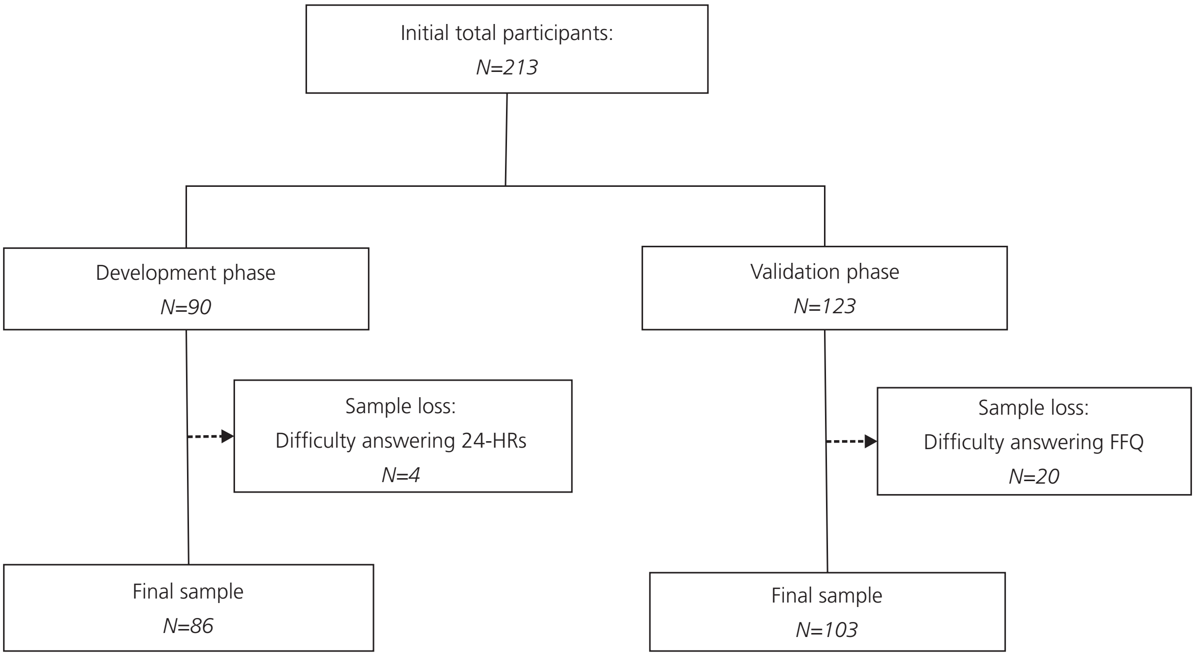

Figure 1 – Flowchart of students included in the analyses.

to perform the classification using the curves of World Health Organization's growth charts for children to classify nutritional status [16]. Children with Z scores ≥-2 and ≤+1 were classified as eutrophic; between the Z score >+1 and ≤+2 they were classified as overweight, and above the Z score +2 with obesity.

A quantitative FFQ was developed to assess the food consumption of the last month. The interviewers were previously trained and obtained a 24-hour recall (24-HRs). Participants recorded their food consumption over a period of the last 24 hours of three days non-consecutive (two weekdays and one weekend). To reduce the risk of inter-rater error, the same evaluator always assessed each student. Children answered the 24-HRs through the Multiple Pass method [17].

The reliability of the 24-HRs was performed in 10% of the sample (n=13) through a comparison between the responses of parents and their children. This assessment was used to assess the reproducibility of the responses of parents and children, to see if the responses were reliable. The reliability of the kcal/day response of each main meal was estimated by the Intraclass Correlation Coefficient (ICC) [4]. Good correlation coefficients (0.847; 95%CI 0.561-0.946) were found among the responses, suggesting that children are able to respond to food surveys, as suggested in previous studies [18].

Secondly, a database of the most frequently consumed foods was created. The frequencies of consumption of the recorded foods and the Relative Contribution (RC) of 95% of each food were analyzed [19]. The foods that had the high contribution to energy, carbohydrates, proteins, lipids, iron, calcium, retinol, and sodium were selected. In addition, 17 regional and seasonal foods were included based on consultation with local nutritionists. The foods were grouped by the nutritional equivalence, forming the food items. The evaluation of the nutritional composition was performed through ADS Nutri® software (Nutrition System, version 9.0, 2006, Brazil). The Brazilian Food Composition Table [20] was preferably used or, in the absence of food from it, the Sônia Tucunduva Phillipi table was used [20,21]. Standard recipes of the most common mixed dishes were chosen from the local cooking books.

Finally, the foods were grouped into 10 groups and frequency of consumption per day, week, or month (Table 1). The portion size was determined using the 24-HRs percentiles: P25 (small, S), P50 (medium, M), P75 (large, L) and P90 (extra-large, EL). When it was not possible to calculate the portion of some foods, these foods were calculated as P50. A photographic album was created with the FFQ items, to help quantify food portions [22].

Table 1 – List of foods and food portions that make up the quantitative questionnaire of food frequency development for schoolchildren aged 7 to 10 years in *Vitória de Santo Antão* (2019).

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Food Item	P25*	P50*	P75*	P90*
Cereals, breads, tubers and derivatives				
Rice	60	112	171	239
Sweet potato	70	163	245	294
Cracker	23	37	76	105
Homemade cake	18	31	50	69
Couscous	40	96	146	222
Cassava flour	12	16	24	45
Yam, *cará*	120	180	210	324
Spaghetti	75	115	171	240
Cassava	253	313	456	564
Baked corn#	48	96	147	172
Mucilon®, arrozina®, cremogema®	41	48	72	86
Bread	50	70	100	120
Popcorn	22	45	59	81
Tapioca#	56	112	168	201
Beans				
Beans, fava	105	146	174	354
Fruits				
Pineapple	75	150	225	270
Avocado#	130	350	450	540
Banana	32	47	137	165
Guava, strawberry	11	25	69	97
Jaca#	150	300	450	540
Orange	120	153	211	276
Apple, pear#	93	130	156	200
Mango	120	140	230	252
Watermelon, melon, papaya	128	196	248	352
Fruit salad	301	375	563	675
Siriguela#, cajá#, pitomba#	40	55	82	99
Grape, *acerola#, pitanga#*	25	50	170	205
Meat and eggs				
Beef	70	153	186	310
Pork	53	124	160	223
Calabrese salami, bacon, sausage	50	75	150	200
Jerked beef	30	37	63	102
Chicken	40	70	85	102
Chicken giblets	73	100	235	280
Egg	25	50	75	100
Fried fish, sardines	97	107	127	193
Ham, lunchmeat	15	25	40	54
Hamburger	45	56	100	112
Bovine viscera	16	80	93	150
Oil and fat				
Nuts	16	35	50	63
Margarine	4	10	19	34

Table 1 – List of foods and food portions that make up the quantitative questionnaire of food frequency development for schoolchildren aged 7 to 10 years in *Vitória de Santo Antão* (2019).

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Food Item	P25*	P50*	P75*	P90*
Sugar and candies				
Chocolate powder	7	15	20	30
Liquid chocolate	100	200	300	360
Sugar	4	9	23	35
Cookie without filling	23	37	76	105
Cookie with filling	30	60	90	108
Industrialized cake	40	70	105	126
Chocolate	11	20	28	53
Lollipop, candy, chewing gum, lozenge	5	10	14	20
Ice cream, popsicle, milkshake, açaí	55	66	101	170
Vegetables				
Lettuce#	15	20	45	54
Onion#	5	12	19	21
Carrot#	22	87	131	157
Pumpkin#	26	43	64	77
Tomato#	30	45	75	138
Milk and derivates				
Fermented milk, yogurt	50	90	140	191
Liquid whole milk	138	157	222	291
Powdered milk	14	20	32	44
Butter	5	10	20	27
Curd cheese	23	45	67	90
Yellow Cheese	15	20	40	90
Creamy cheese	13	25	37	44
Savory and processed foods				
French fries	62	72	97	129
Fried savory snacks	27	40	50	72
Farofa#	40	100	150	180
Instant noodles	70	80	100	160
Macaroni, lasagna, pancake	115	201	375	400
Munguzá#	80	160	240	288
Industrialized popcorn	15	20	45	77
Pirão (Flour sauce)	200	300	450	540
Pizza	101	180	217	324
Mashed potatoes, potato mayonnaise	71	181	312	444
Packet snack, potato chips	35	55	82	100
Sandwich, hot dog, hamburger	100	125	250	300
Soup	260	325	350	450
Drinks				
Coconut water#	165	240	320	432
Coffee, latte	118	148	200	258
Soft drink	169	237	250	350
Boxed juice	100	200	300	360
Fruit juice	169	250	274	450
Vitamin	150	203	250	310
Powdered juice	162	221	250	398

Note: *Grams or milliliters; #Regional foods; P25, 25th percentile; P50, 50th percentile; P75, 75th percentile; P90, 90th percentile.

To perform the validation, the mean data from two FFQs (applied with a 28-day interval) were compared with the mean of three 24-HRs (applied with a 14-day interval), to evaluate the food intake of one day at the weekend and two non-consecutive days of the week. The reproducibility analysis was performed between the two FFQs.

This study was approved by the Human Research Ethics Committee of the *Universidade Federal de Pernambuco*, Brazil (CAAE: 91338718.0.0000.5208) following the principles of the Declaration of Helsink and the World Medical Association. All participants or their parents signed written informed consent and assent to participate in the study.

All analyses were performed using the SPSS version 20.0 software (SPSS, Inc. Chicago, IL) and the significance level maintained at $p<0.05$.

The nutrients of the FFQ and 24-HRs were transformed into their natural logarithm to normalize their distribution. The FFQ and 24-HRs were compared and correlated using the paired t-tests and Pearson's correlation, respectively. Data were corrected for energy through linear regression residue analysis, with total energy intake being the independent variable and nutrient intake as the dependent variable. As residues are negative values, the average energy intake was used as the constant. Due to the attenuation caused by daily variations in intra-subject food intake, the coefficients were corrected for the ratio of intra and inter-subject variances in the three 24-HRs, with the following equation: $rv=ro\ (1+\lambda/n)^{1/2}$, where rv is the true correlation, ro is the observed correlation between the FFQ and the average of 24-HRs, λ is the ratio of intra variance between subjects in the 24-HRs and n is the number of replicates, in this case, three 24-HRs.

The Bland-Altman test was used to analyze the systemic differences between 24HRs and FFQ. In this analysis, the difference between the intake of the FFQ and 24-HRs was plotted as mean consumption of both measures (FFQ+mean 24-HRs)/2).

The FFQ calibration was performed by deriving the calibration factor between the 24-HRs and the test. The coefficients were obtained by linear regression, using 24-HRs as the dependent variable and FFQ as independent. Thus, the regression constant (α) and regression slope (β) were estimated and the calibrated values for each nutrient were estimated based on the formula: Calibrated dietary intakes = α+β (FFQ).

The mean comparison test and ICC per point (ICC<0.4 indicates low reliability, ICC between 0.41 and 0.75 indicates reasonable to good reliability and ICC>0.75 indicates excellent reliability) and 95% Confidence Interval (CI) and Spearman correlation between FFQ-1 e FFQ-2 was used to assess reproducibility [23].

RESULTS

During the development stage, 86 children [44 (51.2%) boys and 42 (48.8%) girls] participated. The validation of the FFQ was carried out with 103 children [53 (51.4%) boys and 50 (48.5%) girls]. The final sample following the recommendation in studies of development and validation of FFQ to use a sample of 100-150 participants [7]. Regarding nutritional status, most participants were classified as eutrophic 70.8% (n=92); and 25.4% (n=30) of the sample demonstrated overweight/obesity.

For selection of the food list, 53 food items were obtained through 95% RC. Among the selected foods, beef was the food that made the greatest RC to the consumption of proteins (24.398), lipids (16.271), and iron (21.143). Likewise, bovine viscera showed the greatest retinol contribution (36.215). In relation to calcium, the largest RC came from dairy products (27.191). UPF, such as cake, instant noodles, packaged snacks, and powdered juice, showed higher RC for sodium (16.971), calories (18.020), and carbohydrates

(12.631), respectively. At the end, the FFQ presented a list of 81 food items that were divided into their respective portions and food groups as shown in Table 1.

The results of the validation between the mean of the two FFQ and three 24-HRs are described in Table 2. No significant mean difference was observed between FFQ and 24-HRs for carbohydrates, calcium, retinol, and sodium. Crude correlation coefficients present a variation between 0.45 ($p<0.000$) for lipids and 0.37 ($p<0.000$) for carbohydrate. No statistically significant correlations were found for iron (r=0.17; $p=0.083$) and retinol (r=0.14; $p=0.152$). After energy adjustment, correlations ranged from r=0.35 ($p<0.000$) for proteins to r=0.26 ($p=0.007$) for calcium. After de-attenuation, there was an increase in correlation coefficients, ranging from r=0.75 (calcium) to r=0.20 (retinol).

Calibration coefficients (α and β) and mean intake calibrated are shown in Table 2. The β coefficient ranged from 0.43 (95%CI 0.24-0.62) for calcium and 0.18 (95%CI -0.06-0.42) for retinol. The mean calibration values between FFQ and 24-HRs were similar for energy and all nutrients. The Bland Altman test demonstrated that there are no systematic differences between the methods (Table 2).

Table 2 – Validation, calibration, and systematic differences between the quantitative food frequency questionnaire and 24-hour recall answered by 103 students from *Vitória de Santo Antão* (2019).

Energy/ nutrients	FFQ	24-HRs			Pearson Coefficient Correlation			FFQ calibrated			Bland Altman plots
	Median (Max-Min)	Median (Max-Min)	%MD	*p*-value	Crude (*p*-value)	Adjusted (*p*-value)	De-attenuated	α (95%CI)	β (95%CI)	Mean±SD	Mean difference (lower-upper limit)
Energy (Kcal)	1628.8	1602.73	1.6	0.039	0.477	–	–	2.11	0.34	3.21±005	0.03
	(547.5-2818.8)	(802.3-3073.8)			(0.000)			(1.71-2.51)	(0.21-0.47)		(- 0.31-0.25)
Protein (g)	56.58	64.55	-14.09	0.000	0.414	0.355	0.547	1.24	0.32	1.81 ± 0.06	- 0.07
	(15.8-132.6)	(18.6-144.0)			(0.000)	(0.000)		(0.99-1.49)	(0.18-0.46)		(- 0.42- 0.28)
Fat (g)	52.25	51.47	9.03	0.031	0.457	0.256	0.537	1.17	0.33	1.73 ± 0.07	- 0.04
	(10.93-248.3)	(19.5-174.6)			(0.000)	(0.009)		(0.95-1.39)	(0.20-0.45)		(- 0.46-0.38)
Carbohydrate (g)	270.97	259.03	4.38	0.814	0.374	-0.165	0.394	1.62	0.32	2.41 ± 0.05	0.00
	(72.4-499.7)	(113.9-723.3)			(0.000)	(0.097)		(1.23-2.01)	(0.16-0.48)		(- 0.33-0.34)
Calcium (mg)	334.35	358.48	-13.42	0.562	0.414	0.266	0.751	1.41	0.43	2.51 ± 0.10	0.01
	(75.6-1020.4)	(61.3-989.7)			(0.000)	(0.007)		(0.93-1.89)	(0.24-0.62)		(- 0.51-0.54)
Iron (mg)	6.93	7.86	-7.22	0.001	0.172	0.189	0.243	0.65	0.36	0.96 ± 0.06	- 0.12
	(2.4-15.81)	(3.34-10.87)			(0.083)	(0.056)		(0.30-1.00)	(-0.04-0.78)		(- 0.89-0.63)
Retinol (µg)	128.54	102.04	20.62	0.099	0.142	0.070	0.200	1.64	0.18	2.03 ± 0.07	0.10
	(7.7-1488.7)	(1.45-4965.3)			(0.152)	(0.483)		(1.11-2.18)	(-0.06-0.42)		(- 1.11-1.31)
Sodium (mg)	1601.76	1595.18	0.42	0.768	0.386	0.166	0.509	2.14	0.32	3.19 ± 0.07	0.00
	(216.7-4456.2)	(497.0-5178.8)			(0.000)	(0.093)		(1.65-2.64)	(0.17-0.48)		(- 0.45-0.44)

Note: FFQ, Food Frequency Questionnaire; R24H, 24-hours recall; %MD, % mean difference = (FFQ - 24-HRs)/FFQx100.

In the reproducibility, no mean difference was found between the questionnaires for energy, protein, carbohydrate, calcium, iron, and retinol ($p>0.05$). However, FFQ-1 showed a tendency to overestimate fat and sodium intake. All macronutrients and micronutrients had poor ICC (>0.500), except proteins. For correlations between FFQs, moderate correlations were found for calories (r=0.43; $p<0.000$), protein (r=0.54; $p<0.000$), lipids (r=0.41; $p<0.000$), iron (r=0.47; $p<0.000$) and sodium (r=0.43; $p=0.000$). The other nutrients showed weak correlations (Table 3).

Table 3 – Analyzes regarding the reproducibility of the food frequency questionnaires answered by 103 students from *Vitória de Santo Antão* (2019).

Energy/ nutrients	FFQ1		FFQ2		% MD	*p*-value*	ICC	(CI 95%)	Pearson correlation	*p*-value
	Median	(Max-Min)	Median	(Max-Min)						
Energy (Kcal)	1691.6	(496.1-3843.3)	1496.7	(501.1-3165.5)	-11.5	0.06	0.468	(0.298-0.608)	0.43	0.000
Protein (g)	59.0	(17.0-126.0)	50.0	(13.0-156.0)	-15.2	0.33	0.542	(0.384-0.669)	0.54	0.000
Fat (g)	57.0	(16.0-477.0)	46.5	(10.0-197.0)	-18.4	0.03	0.471	(0.301-0.612)	0.41	0.000
Carbohydrate (g)	281.5	(78.0-612.0)	252.5	(65.0-627.0)	-10.3	0.12	0.367	(0.181-0.527)	0.36	0.000
Calcium (mg)	331.0	(51.0-1450.0)	299.0	(95.0-1126.0)	-14.2	0.16	0.478	(0.307-0.618)	0.36	0.000
Iron (mg)	7.0	(2.0-15.0)	6.0	(2.0-21.0)	-9.66	0.93	0.357	(0.175-0.516)	0.47	0.000
Retinol (µg)	133.0	(3.0-2521.0)	102.0	(30.0-2837.0)	-23.3	0.07	0.238	(0.048-0.412)	0.23	0.015
Sodium (mg)	1761.0	(238.0-4672.0)	1462.0	(196.0-4240.0)	-16.9	0.02	0.436	(0.263-0.581)	0.43	0.000

Note: *t-test paired with values normalized by logarithmic transformation. CI: Confidence Interval; FFQ1: Food Frequency Questionnaire 1; FFQ2: Food Frequency Questionnaire 2; ICC: Intra-class Correlation Coefficients; %MD, % mean difference = (FFQ2 – FFQ1)/FFQ1x100.

DISCUSSION

A quantitative FFQ with 81 food items was developed for children aged 7 to 10 years. According to the literature, a list of food items for FFQ must contain between 50-100 items [24]. Small food lists can underestimate results, with the risk of inaccurate, while long lists can make FFQ exhaustive, and overestimate analyzes [25]. Previous studies have chosen the semi-quantitative approach [10,26]. For this FFQ, we opted for the quantitative approach, as well as previous study, that allowed better quantification of specific nutrient intake [26]. The UPF, such as powdered juice, snack packets, and instant noodles were the foods with higher RC to the children's diet. Previous studies conducted with children from LMIC have found a high contribution of foods like those present in this study [9,25]. It is believed that the increase in the consumption of UPF during childhood in different regions occurs due to the process of food globalization [27].

The validity was tested with the 24-HRs, which was presented as the most reliable indirect method to evaluate consumption when compared to direct methods, such as double-labeled water [18]. The percentage of mean difference between the two methods for energy and macronutrients was less than 10.00%, except for proteins. For micronutrients, only calcium and retinol presented percentage mean differences higher than 10%. A previous study found differences around -37.00% (protein) and -17.00% (calcium) [9]. In this same study, the FFQ presented lower energy intake values than the reference methods, like our questionnaire [9]. Regarding to the retinol, we observed a mean difference of 20.62%; another study, however, found a higher mean difference for this nutrient [12]. For most of the evaluated nutrients, there was a low mean difference, in contrast with previous studies conducted with children, where the percentage mean difference found was greater than 10% for all nutrients [9,28]. This result demonstrates that FFQ developed did not show large differences in food consumption when compared to the 24-HRs.

The crude correlation coefficients between FFQ and 24-HRs were moderate for all nutrients. However, no correlations were found for iron and retinol. Other's validation studies found low or nonexistent

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correlations for iron in the childhood [10,29]. Studies with adults, however, have found better results for the quantification of food intake of iron [30,31]. Retinol is a nutrient found in few foods due to its low availability; thus, underreporting the intake might have caused the questionnaire to be less specific to quantify its intake. Aligned with our data, other studies based on FFQ have been unable to assess retinol intake [10].

After the adjustment by energy, a reduction in the correlation coefficients was observed. The same has been observed in previous studies [9,12]. This is due to under or over reporting of food intake [23]. On the other hand, de-attenuation increased the correlation coefficients, making the correlations high and moderate, as in other studies [9,32]. Among the calibration factors, a higher value for calcium was found (0.43). This result was higher than that found in a previous study [33]. Calibrated FFQ values were like the reference method, demonstrating good calibration of the developed instrument. Through the Bland-Altman, it was observed that there was agreement between the two methods, since the random values were close to zero and within the upper and lower limits, indicating no systematic bias [34]. Similarly, these results have been described in other studies [35,36].

In reproducibility, there were no significant mean differences between FFQs for most nutrients, except lipids and sodium. Previous studies have not observed mean difference of values between lipid and sodium intake [9,28,37]. This variation may have occurred due to the amount of food included in the FFQ list. However, if a short list were drawn up, there could be a restriction and underestimation of food consumption in addition, the temporal variation between the application of the two FFQs (28-day interval) may have influenced the differences in food intake [15,28]. On the other hand, when we evaluate the reliability of the responses, in the present FFQ, only carbohydrates (0.36), iron (0.35) and retinol (0.23) had low ICC. The other nutrients showed a reasonable to good ICC (>0.43). In a previous study of Lebanese children, a range of ICCs from 0.65 (protein) to 0.73 (calcium) was found [33]. In adults, studies have shown a range from 0.58 (carbohydrate and retinol) to 0.73 (energy) and all evaluated nutrients presented significant correlations [29]. Among macronutrients, the correlations ranged from 0.36 (carbohydrate) to 0.54 (protein). These correlations were similar [9,28] and larger than in another previous study [10].

Some limitations regarding our study should be considered. First, the under or overestimation of food consumption by the present population reached in this study may have caused some errors. However, children in the age group assessed have been found to be more accurate in answering food surveys than their parents [18]. In addition, to avoid errors related to memory, we designed an FFQ that assessed a month's food intake. Second, since only children attending school were the respondents, sole focus on these children could be questioned. But since 94.3% of children in this age group attend school anyway, we did not consider this a problem. In addition, our results showed excellent correlations between the responses reported by children and parents, agreeing with studies showing that children of the age group evaluated are able to respond to food research [18].

Few studies and questionnaires have been developed for children, mainly in the Brazilian northeast. This is the first questionnaire developed and validated for children from a region far from large urban centers in northeastern Brazil, and the first developed for the state of *Pernambuco*. The present FFQ can also be used in other parts of the Northeast of Brazil, subject to prior adaptation.

CONCLUSION

We developed a first FFQ to evaluate the food consumption of children aged 7 – 10 years old in Pernambuco, Northeast Brazilian State. The questionnaire was found to be valid and reproducible, able to assess energy consumption, macronutrients, and some micronutrients (calcium, iron, and sodium). We developed an FFQ that can be answered by children, without parental help, reducing the limitations usually found in food intake assessment studies. In addition, this questionnaire aims to provide data to strengthen public policies in food and nutrition, especially in the fight against obesity.

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C O N T R I B U T O R S

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R E F E R E N C E S

1. Oddo VM, Mueller NT, Pollack KM, Surkan PJ, Bleich SN, Jones-Smith JC. Maternal employment and childhood overweight in low- and middle-income countries. Public Health Nutr. 2017;20(14):2523-36.
2. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128•9 million children, adolescents, and adults. Lancet. 2017;390(10113):2627-42.
3. Ferreira CM, Reis NDD, Castro AO, Höfelmann DA, Kodaira K, Silva MT, *et al.* Prevalence of childhood obesity in Brazil: systematic review and meta-analysis. J Pediatr (Rio J). 2021.
4. Oliveira T, Ribeiro I, Jurema-Santos G, Nobre I, Santos R, Rodrigues C, *et al.* Can the Consumption of Ultra-Processed Food Be Associated with Anthropometric Indicators of Obesity and Blood Pressure in Children 7 to 10 Years Old? 2020;9(11).
5. Leandro CG, da Fonseca E, de Lim CR, Tchamo ME, Ferreira ESWT. Barriers and enablers that influence overweight/obesity/obesogenic behavior in adolescents from lower-middle Income countries: a systematic review. Food Nutr Bull. 2019:379572119853926.
6. Liberali R, Kupek E, Assis MAA. Dietary patterns and childhood obesity risk: a systematic review. Child Obes. 2020;16(2):70-85.
7. Golley RK, Bell LK, Hendrie GA, Rangan AM, Spence A, McNaughton SA, *et al.* Validity of short food questionnaire items to measure intake in children and adolescents: a systematic review. J Hum Nutr Diet. 2017;30(1):36-50.
8. Tugault-Lafleur CN, Black JL, Barr SI. A systematic review of methods to assess children's diets in the school context. Adv Nutr. 2017;8(1):63-79.
9. Horiuchi Y, Kusama K, Sar K, Yoshiike N. Development and validation of a Food Frequency Questionnaire (FFQ) for assessing dietary macronutrients and calcium intake in Cambodian school-aged children. Nutr J. 2019;18(1):11.
10. Rodriguez CA, Smith ER, Villamor E, Zavaleta N, Respicio-Torres G, Contreras C, *et al.* Development and Validation of a Food Frequency Questionnaire to Estimate Intake among Children and Adolescents in Urban Peru. Nutrients. 2017;9(10).

11. Scagliusi FB, Garcia MT, Indiani ALC, Cardoso MA. Relative validity of a food-frequency questionnaire developed to assess food intake of schoolchildren living in the Brazilian Western Amazon. Cadernos de saude publica. 2011;27:2197-206.

12. Matos SM, Prado MS, Santos CA, D'Innocenzo S, Assis AM, Dourado LS, *et al.* Validation of a food frequency questionnaire for children and adolescents aged 4 to 11 years living in Salvador, Bahia. Nutr Hosp. 2012;27(4):1114-9.

13. Moura-Dos-Santos MA, De Almeida MB, Manhaes-De-Castro R, Katzmarzyk PT, Maia JA, Leandro CG. Birthweight, body composition, and motor performance in 7- to 10-year-old children. Dev Med Child Neurol. 2015;57(5):470-5.

14. Dos Santos FK, Moura Dos Santos MA, Almeida MB, Nobre IG, Nobre GG, Ferreira ESWT, *et al.* Biological and behavioral correlates of body weight status among rural Northeast Brazilian schoolchildren. Am J Hum Biol. 2018;30(3):e23096.

15. Cui Q, Xia Y, Wu Q, Chang Q, Niu K, Zhao Y. A meta-analysis of the reproducibility of food frequency questionnaires in nutritional epidemiological studies. Int J Behav Nutr Phys Act. 2021;18(1):12.

16. World Health Organization. BMI-for-age (5-19 years). Geneva: Organization; 2007 [cited 2020 Sep 25]. Available from: https://www.who int/growthref/who2007_bmi_for_age/en/index html.

17. Dalwood P, Marshall S. Diet quality indices and their associations with health-related outcomes in children and adolescents: an updated systematic review. Nutr J. 2020;19(1):118.

18. Burrows T, Goldman S, Rollo M. A systematic review of the validity of dietary assessment methods in children when compared with the method of doubly labelled water. Eur J Clin Nutr. 2019;74(5):669-81.

19. Block G, Hartman AM, Dresser CM, Carroll MD, Gannon J, Gardner L. A data-based approach to diet questionnaire design and testing. Am J Epidemiol. 1986;124(3):453-69.

20. Núcleo de Estudos e Pesquisas em Alimentaçãod. Tabela brasileira de composição de alimentos (TACO). Campinas: Unicamp; 2011.

21. Philippi ST. Tabela de composição de alimentos: suporte para decisão nutricional. Barueri: Manole; 2013. 164 p.

22. Santos GCJN, Isabele G, Ribeiro IC, Oliveira TLPS, Santos RM, Canuto R. *et al*. Álbum fotográfico de quantificação alimentar para crianças. Recife: Editora UFPE; 2019. p 68.

23. Willett W. Nutritional epidemiology: Oxford University Press; 2012.

24. Perez Rodrigo C, Aranceta J, Salvador G, Varela-Moreiras G. Food frequency questionnaires. Nutr Hosp. 2015;31(Suppl 3):49-56.

25. Saravia L, Gonzalez-Zapata LI, Rendo-Urteaga T, Ramos J, Collese TS, Bove I, *et al.* Development of a Food Frequency Questionnaire for Assessing Dietary Intake in Children and Adolescents in South America. Obesity (Silver Spring). 2018;26(Suppl 1):S31-S40.

26. Shaikh NI, Frediani JK, Ramakrishnan U, Patil SS, Yount KM, Martorell R, *et al.* Development and evaluation of a Nutrition Transition-FFQ for adolescents in South India. Public Health Nutr. 2017;20(7):1162-72.

27. Mikkila V, Vepsalainen H, Saloheimo T, Gonzalez SA, Meisel JD, Hu G, *et al.* An international comparison of dietary patterns in 9-11-year-old children. Int J Obes Suppl. 2015;5(Suppl 2):S17-21.

28. Fatihah F, Ng BK, Hazwanie H, Norimah AK, Shanita SN, Ruzita AT, *et al.* Development and validation of a food frequency questionnaire for dietary intake assessment among multi-ethnic primary school-aged children. Singapore Med J. 2015;56(12):687-94.

29. Liu D, Ju H, Yang ZY, Zhang Q, Gao JF, Gong DP, *et al.* Food Frequency Questionnaire for Chinese Children Aged 12-17 Years: Validity and Reliability. Biomed Environ Sci. 2019;32(7):486-95.

30. Mascarenhas JMO, Silva RDCR, Machado MEPC, Santos CADST, Marchioni DML, Barreto ML. Validation of a food frequency questionnaire designed for adolescents in Salvador, Bahia, Brazil. Rev Nutr. 2016;29(2):163-71.

31. Yanagisawa A, Sudo N, Amitani Y, Caballero Y, Sekiyama M, Mukamugema C, *et al.* Development and Validation of a Data-Based Food Frequency Questionnaire for Adults in Eastern Rural Area of Rwanda. Nutr Metab Insights. 2016;9:31-42.

32. van Dongen MC, Wijckmans-Duysens NE, den Biggelaar LJ, Ocké MC, Meijboom S, Brants HA, *et al.* The Maastricht FFQ: development and validation of a comprehensive food frequency questionnaire for the Maastricht study. Nutrition. 2019;62:39-46.

33. Moghames P, Hammami N, Hwalla N, Yazbeck N, Shoaib H, Nasreddine L, *et al.* Validity and reliability of a food frequency questionnaire to estimate dietary intake among Lebanese children. Nutr J. 2016;15:4.

34. Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res. 1999;8(2):135-60.

35. Herter-Aeberli I, Graf C, Vollenweider A, Haberling I, Srikanthan P, Hersberger M, *et al.* Validation of a Food Frequency Questionnaire to Assess Intake of n-3 Polyunsaturated Fatty Acids in Switzerland. Nutrients. 2019;11(8):1863.

36. Fangupo LJ, Haszard JJ, Leong C, Heath AM, Fleming EA, Taylor RW. Relative Validity and Reproducibility of a Food Frequency Questionnaire to Assess Energy Intake from Minimally Processed and Ultra-Processed Foods in Young Children. Nutrients. 2019;11(6):1290.

37. Selem SS, Carvalho AM, Verly-Junior E, Carlos JV, Teixeira JA, Marchioni DM, *et al.* Validity and reproducibility of a food frequency questionnaire for adults of Sao Paulo, Brazil. Rev Bras Epidemiol. 2014;17(4):852-9.

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