

Relative validation of a quantitative FFQ for use in Brazilian pregnant women

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Abstract

Objective: To evaluate the ability of an FFQ, designed for use in Brazilian pregnant women, to estimate nutrient intakes during pregnancy.

Design: A prospective study was conducted among 103 pregnant women attended by the Brazilian national health-care service. Food intake during pregnancy was evaluated by three 24 h dietary recalls (24hR), one per trimester of pregnancy, and also by two FFQ. The FFQ with eighty-five food items included questions about frequency of intake and portion sizes during two periods: the first 24 weeks of pregnancy and the pregnancy period as a whole. Deattenuated Pearson's correlation coefficients and joint classification into quartiles of nutrient intake were applied.

Setting: Ribeirão Preto, São Paulo State, Brazil.

Subjects: One hundred and three pregnant women, aged 18–35 years.

Results: Acceptable correlation coefficients ($r > 0.35$) were found for Ca, K, Zn, Mg, fibre, vitamin C, niacin and folic acid for intake for the first 24 weeks; and for energy, lipids, protein, carbohydrate, Fe, K, Zn, fibre, vitamin B₆, riboflavin and niacin for the gestational period as a whole. A high proportion of study participants ($\geq 70\%$) were categorized into the same or adjacent quartiles for estimated energy, carbohydrate, Ca, K, fibre, Zn, cholesterol, vitamin A, riboflavin, niacin, vitamin C, vitamin E and folic acid. Gross misclassification ranged from 2.3% (dietary fibre) to 12.5% (vitamin A, thiamin and SFA).

Conclusions: The FFQ is a useful tool for assessing categories of nutrient intake during pregnancy, since a high proportion of women were classified into the same or adjacent quartiles.

Keywords

FFQ
Pregnant women
Validation studies

Inadequate maternal diet is a relevant risk factor for complications during pregnancy^(1,2), impaired fetal development⁽³⁾ and may also be linked to higher risk of chronic diseases during childhood⁽⁴⁾ and adult life⁽⁵⁾.

The FFQ is a method widely used in epidemiological studies aimed at categorizing individuals into different levels of consumption and determining their relationships with health outcomes^(6,7). The FFQ's ability to assess dietary intake of pregnant women is due to the fact this method spans a longer time frame, thus allowing the detection of changes in dietary intake during each trimester of pregnancy^(8–11).

Validation studies of FFQ for use in pregnant women have shown that nutrient estimates using this method exhibit high levels of agreement with intake estimates using the 24 h dietary recall (24hR)^(12–14) or daily records (DR)^(15,16), suggesting a good accuracy of the FFQ for assessing dietary intake in this population group. Since 24hR and FFQ might have correlated errors, related to memory and estimation of portion size, the use of multiple DR or weighed records as the reference method

is recommended. Nevertheless, when literacy or motivation of participants is low, the 24hR might be applied as the reference measure of nutrient intake⁽⁶⁾.

In an earlier study, an FFQ was developed for use in pregnant women attended by the national health-care system in the municipality of Ribeirão Preto, São Paulo State, Brazil⁽¹⁷⁾. The aim of the present study was to verify the relative validity of this FFQ against the 24hR instrument for estimating nutrient intakes over the three trimesters of pregnancy. The FFQ will subsequently be employed in an investigation exploring the relationship between dietary intake at the beginning of the pregnancy and the occurrence of gestational diabetes mellitus. However, given the lack of FFQ developed and validated specifically for use in pregnant women in Brazil, coupled with the growing body of evidence pointing to the relationship between maternal dietary intake during pregnancy and maternal and fetal outcomes, it was deemed important to also assess the accuracy of the method for estimating nutrient intakes throughout the pregnancy period as a whole.

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Accordingly, the reference periods adopted for assessing food intake were the first 6 months of pregnancy plus the pregnancy period as a whole.

Method

Study design and population

A prospective study involving 103 pregnant women users of the Brazilian national health-care system from the municipality of Ribeirão Preto, São Paulo, was conducted. The municipality is located 313 km from São Paulo, the State capital, and has an estimated population of 583 842 inhabitants⁽¹⁸⁾. A convenience study sample was employed and sample size was determined based on the recommendation that 100 individuals would be required to assess the agreement between the two methods used for assessing dietary intake⁽⁶⁾.

The study inclusion criteria were: (i) age 18–35 years; (ii) pre-gravid BMI of 18.5–25.0 kg/m²⁽¹⁹⁾; (iii) gestational age of up to 14 weeks at first study interview; and (iv) absence of pathologies which may change the pattern of food consumption during pregnancy such as diabetes, cardiopathies, nephropathies and hypertension.

Data collection was carried out at four basic health clinics situated in southern, eastern and western regions of the municipality by previously trained nutritionists. Participants were assessed at study baseline (up to 14th week of gestation), at the second trimester (between 14th and 28th weeks) and again at the third trimester (after 28th week of gestation). The first study assessment was carried out during the first antenatal visit of the pregnant woman between September 2009 and May 2010. The second and third assessments were performed at antenatal check-ups or during homecare visits.

Sociodemographic characteristics

Data on age, schooling, socio-economic status and presence of morbidities were collected using a structured questionnaire applied at the first study assessment. Economic status was classified according to the Brazilian Criteria for Economic Classification (CCEB) based on items owned by and educational level of the head of the family⁽²⁰⁾.

Assessment of nutritional status and gestational age

Gestational age was calculated based on the date of last menstruation and on ultrasound scan. Pre-gravid weight was reported by the pregnant woman and corrected according to data contained in medical charts. The criteria of the US Institute of Medicine⁽¹⁹⁾ were employed to calculate the adequacy of pre-gravid BMI.

Quantitative FFQ

The FFQ was previously devised for pregnant women attended by the basic health units of Ribeirão Preto, and

its methodology is described elsewhere⁽¹⁷⁾. Briefly, a 24hR was obtained from 150 pregnant women (fifty for each trimester of pregnancy). A second 24hR was obtained in a sub-sample of ninety pregnant women in order to correct for within-person variance. The food list was systematically shortened by stepwise multiple regression analysis, using the deattenuated energy-adjusted nutrients of interest as dependent variables. A total of eighty-five foods were identified which explained the greatest between-person variance of intake of each nutrient (between 74% and 99%). The 25th, 50th, 75th and 100th percentiles were employed to determine small, medium, large and extra-large portion sizes, respectively. The reproducibility of the FFQ was tested in a previous study conducted among ninety-five pregnant women. Two FFQ were obtained spaced between 15 and 45 d apart. The intra-class correlation of unadjusted nutrients was 0.81, after adjustment for energy the mean correlation was 0.70. Joint classification of energy-adjusted nutrient intakes into the same or adjacent quartiles for the two FFQ was 82%, and less than 8% of women were misclassified (data not published).

In the present study, the FFQ was applied at the second (between 14th and 28th weeks of gestation) and third (after 28th week of gestation) study assessments. Participants were asked to report the frequency of each food item since the establishment of the pregnancy.

Nutrient intake estimated by 24 h dietary recalls

Three 24hR were obtained from all study participants, corresponding to one recall per trimester of pregnancy. The 24hR were administered by a trained nutritionist employing the multiple-pass technique⁽²¹⁾. Conversion of household measures into grams of food consumed was carried out with the aid of Brazilian reference manuals containing data on recipes and household measures^(22,23).

The nutrients of interest in the present study were: energy, carbohydrate, protein, lipids, Fe, Ca, K, vitamin A, thiamin, riboflavin, niacin, vitamin C, SFA, cholesterol, folic acid, fibre, vitamin E, Zn, vitamin B₆, Mg and Cu.

Nutrient composition of the FFQ estimate was analysed using the Dietsys[®] program (HHHQ DietSys Analysis Software version 4.02; National Cancer Institute, Bethesda, MD, USA, 1999). The nutritional composition of the recalls was analysed by the NutWin[®] program (NutWin Software, Nutrition Support Program, version 1.5; Escola Paulista de Medicina, São Paulo, São Paulo State, Brazil, 2002). Food composition data were drawn from the Brazilian table of food composition⁽²⁴⁾ in conjunction with the US Department of Agriculture's National Nutrient Database for Standard Reference⁽²⁵⁾.

Data analysis

Means and standard deviations were computed for continuous data on sociodemographic, nutritional status and lifestyle variables, and frequencies for categorical variables.

Median values and interquartile ranges were obtained for the description of FFQ and 24hR nutrient estimates for the first two trimesters and for the whole gestational period. The normality of dietary variables was verified using the Kolmogorov–Smirnov test. Variables found to have a non-normal distribution were transformed by natural logarithm prior to statistical analyses. Nutrient intakes were adjusted for total energy intake by the residual method⁽²⁶⁾.

The energy-adjusted, deattenuated Pearson's correlation coefficient was employed to validate the FFQ. The energy-adjusted Pearson's correlation coefficient was deattenuated using the formula: $[1 + (\sigma_{\text{intra}}^2/\sigma_{\text{inter}}^2)/n]^{1/2}$, where n is the number of 24hR replicates, σ_{intra}^2 represents the within-person variance and σ_{inter}^2 is the between-person variance among the 24hR⁽²⁷⁾.

The validation of the FFQ was also assessed by analysing the agreement between the two methods using cross-classification into quartiles of estimated energy and nutrients, and quadratic weighted kappa. Quadratic weighted κ is considered an appropriate test to estimate agreement when three or more categories on ordinal scales are provided⁽²⁸⁾.

All statistical analyses were performed using the SPSS statistical software package version 17.0.

Ethical aspects

The project was previously approved by the Research Ethics Committee of the Centro de Saúde Escola of the Ribeirão Preto School of Medicine, University of São Paulo (protocol no. 239) and authorized by the Municipal Secretariat for Health of Ribeirão Preto. The participants agreed to take part in the study by signing a free and informed consent form.

Results

A total of 247 pregnant women were contacted between September 2009 and May 2010. Of this group, five (2%) declined to take part in the study and 139 (56%) were excluded for not meeting the study criteria as follows: sixty-two (25%) due to age, forty-five (18%) due to inadequate pre-gravid nutritional status and thirty-two (13%) women for having advanced gestational age. This gave a total of 103 pregnant women for study.

Table 1 depicts the sociodemographic characteristics, nutritional status and lifestyle characteristics of the pregnant women at study baseline. The majority of pregnant women assessed had a schooling level of at least 8 years, belonged to economic class C or D+E, and were married.

Of the 103 pregnant women interviewed at study baseline (up to 14th week of gestation), eighty-eight (85%) underwent the second assessment (carried out between 14th and 24th weeks of gestation) and seventy-two (70%) took part in the third evaluation (between 25th and 36th weeks of gestation). Among the fifteen

Table 1 Sociodemographic characteristics, nutritional status and lifestyle of pregnant women at baseline – Ribeirão Preto, São Paulo, Brazil, 2009 (n 103)

Characteristic	Mean	SD
Age (years)	24	4.5
Weeks of gestation	11	2.1
Pre-gravid BMI (kg/m ²)	21.9	1.9
Monthly family income (\$US)	680	340
	<i>n</i>	%
Education (years of schooling)		
Up to 4	16	15.7
From 4 to 8	34	33.3
More than 8	52	51.0
Socio-economic class*		
A+B	8	7.8
C	73	70.9
D+E	22	21.4
Head of family		
Partner/husband	72	69.9
Myself	11	10.7
Other	20	19.4
Never consume alcoholic beverages	87	84.5
Smoking during pregnancy	15	14.6
Use of folic acid	44	50.0
Usually practise physical activities	17	22.7

*Brazilian Criteria for Economic Classification (CCEB)⁽²⁰⁾.

drop-outs at the second assessment, ten had miscarriages, two had moved to other cities and three were not found. Of the other sixteen drop-outs at the third study assessment, three had moved to other cities, five had premature delivery and eight were not found. Mean (SD) gestational weight gain between first and second interviews was 5.2 (SD 2.8) kg, and between first and third interviews was 9.0 (SD 3.1) kg. The average time interval between first and second interviews was 82 d (approximately 12 weeks) and between second and third interviews was 47 d (approximately 7 weeks).

Table 2 shows median values for nutrient intakes based on the FFQ and 24hR instruments. Estimated energy intake was higher on the FFQ than on the 24hR for both periods. Considering the nutrient estimates for the first 24 weeks of gestation, adequate crude Pearson's correlations ($r \geq 0.4$) were found for Ca, vitamin B₆ and folic acid. Borderline correlations ($r > 0.35$ and < 0.40) were verified for Fe, K, Mg, fibre, SFA, vitamin A, thiamin, riboflavin, niacin and vitamin C. After adjustment for energy and deattenuation, good correlations were observed for Ca, K, Zn, Mg, fibre and folic acid, and borderline correlations were found for niacin and vitamin C.

Considering estimated nutrient intakes for the gestational period as a whole, adequate unadjusted correlations were found for energy and carbohydrate, and borderline correlations for lipids, Fe, niacin and fibre. After adjustments, good correlations were found for energy, carbohydrate, niacin and fibre, and borderline correlations were observed for protein, lipids, Fe, K, Zn, riboflavin and vitamin B₆ (Table 2).

Table 2 Estimated energy and nutrient intakes (median and IQR) from the FFQ and 24hR and Pearson's correlation coefficient in pregnant women – Ribeirão Preto, São Paulo, Brazil, 2009

Nutrient	24hR		FFQ		Pearson's correlation		
	Median	IQR	Median	IQR	Crude	Energy-adjusted	Deattenuated*
Estimated nutrient intakes and accuracy of FFQ for first two trimesters of pregnancy (<i>n</i> 88)							
Energy (kJ/d)	8472	4749, 10635	10740	8058, 14581	0.27	–	0.29†
Protein (g/d)	81	65, 97	98	73, 130	0.25	0.31	0.27
Lipids (g/d)	61	42, 78	68	49, 97	0.29	0.32	0.32
Carbohydrate (g/d)	267	219, 333	364	274, 503	0.28	0.25	0.31
Ca (g/d)	561	386, 823	950	656, 1264	0.51	0.51	0.57
Fe (mg/d)	8	6, 10	10	7, 15	0.35	0.13	0.14
K (g/d)	2272	1743, 2754	3280	2577, 4185	0.36	0.37	0.45
Zn (g/d)	10	8, 14	13	9, 18	0.33	0.39	0.44
Mg (mg/d)	210	162, 255	282	239, 380	0.35	0.45	0.53
Cu (mg/d)	0.8	0.7, 1.2	1.5	1.1, 2.1	0.20	0.17	0.20
Folic acid (µg/d)	144	101, 195	247	190, 345	0.42	0.37	0.44
Vitamin A (IU)	5013	2937, 9024	10320	7543, 16567	0.31	0.29	0.34
Vitamin A (RE)	653	339, 1134	1481	938, 2111	0.37	0.28	0.32
Thiamin (mg/d)	1.1	0.8, 1.5	1.8	1.3, 2.8	0.35	–0.10	–0.10
Riboflavin (mg/d)	1.4	1.1, 2.1	2.1	1.5, 3.0	0.40	0.27	0.30
Niacin (mg/d)	18	13, 21	21	16, 31	0.38	0.31	0.40
Vitamin C (mg/d)	75	29, 163	175	96, 303	0.40	0.40	0.40
Vitamin E (mg/d)	5	3, 7	7	5, 10	0.27	0.20	0.20
Vitamin B ₆ (mg/d)	0.9	0.7, 1.3	1.2	0.8, 1.6	0.46	0.28	0.34
Fibre (g/d)	20	15, 26	32	22, 40	0.36	0.52	0.60
SFA (g/d)	20	14, 27	26	10, 36	0.38	0.25	0.30
Cholesterol (g/d)	220	173, 293	249	166, 320	0.30	0.25	0.30
Mean	–	–	–	–	0.33	0.25	0.35
Estimated nutrient intakes and accuracy of FFQ for whole gestational period (<i>n</i> 72)							
Energy (kJ/d)	8539	6920, 10719	11075	8154, 13581	0.48	–	0.53†
Protein (g/d)	83	67, 98	102	73, 130	0.34	0.27	0.37
Lipids (g/d)	62	43, 79	74	46, 98	0.37	0.16	0.40
Carbohydrate (g/d)	270	225, 332	382	292, 466	0.53	0.17	0.58
Ca (g/d)	607	469, 863	967	739, 1241	0.26	0.33	0.28
Fe (mg/d)	8	7, 11	10	8, 15	0.35	0.06	0.38
K (g/d)	2344	1848, 2891	3385	2531, 4037	0.32	0.36	0.37
Zn (g/d)	10	8, 14	13	10, 17	0.34	0.22	0.38
Mg (g/d)	215	177, 279	310	244, 375	0.30	0.14	0.34
Cu (mg/d)	1.0	1.0, 1.3	1.6	1.1, 2.2	0.11	0.05	0.12
Folic acid (µg/d)	162	109, 233	273	194, 346	0.21	0.20	0.24
Vitamin A (IU)	5910	2951, 11245	11585	6756, 15814	0.29	0.33	0.32
Vitamin A (RE)	704	414, 1514	1483	885, 2275	0.30	0.33	0.34
Thiamin (mg/d)	1.3	1.0, 1.6	1.7	1.3, 2.6	0.28	–0.03	0.31
Riboflavin (mg/d)	1.7	1.0, 2.2	2.2	1.6, 3.1	0.34	0.34	0.38
Niacin (mg/d)	17	17, 22	21	16, 29	0.35	0.36	0.41
Vitamin C (mg/d)	65	23, 135	182	92, 318	0.18	0.29	0.20
Vitamin E (mg/d)	4	3, 7	7	6, 10	0.30	0.17	0.33
Vitamin B ₆ (mg/d)	1.0	0.7, 1.3	1.2	0.8, 1.7	0.32	0.18	0.37
Fibre (g/d)	22	15, 27	32	23, 38	0.37	0.19	0.41
SFA (g/d)	21	15, 27	30	19, 38	0.31	0.02	0.34
Cholesterol (g/d)	238	173, 310	265	164, 348	0.17	0.07	0.20
Mean	–	–	–	–	0.27	0.16	0.32

24hR, 24 h dietary recall, IQR, interquartile range, RE, retinol equivalents.

*Nutrient intake values were natural log-transformed and energy-adjusted.

†Nutrient intake values were natural log-transformed only.

The joint classification between methods is presented in Table 3. Concerning estimated nutrient intakes for the first two trimesters of pregnancy, 32% of women were classified into the same quartile by both methods; approximately 72% were classified into the same or adjacent quartiles, while only 7.8% of the women were classified into opposite quartiles. For estimated nutrient intakes for the gestational period as a whole, approximately 33% of pregnant women were classified into the same quartile, 71% into the same or adjacent quartiles and 7.8% into

opposite quartiles according to the two different methods of assessing food consumption. However, lower agreements into the lowest and highest quartiles were found for both periods of pregnancy.

Discussion

The FFQ used in the present study was the first developed and validated specifically for pregnant women in Brazil.

Table 3 Joint classification into quartiles for nutrient intakes estimated by the two methods and quadratic kappa statistic in pregnant women – Ribeirão Preto, São Paulo, Brazil, 2009

Nutrient*	Same quartile		Lowest quartile		Highest quartile		Same+adjacent quartiles		Opposite quartile		Quadratic κ	P value
	n	%	n	%	n	%	n	%	n	%		
Estimated nutrient intakes and accuracy of FFQ for first two trimesters of pregnancy (n 88)												
Energy (kJ/d)†	31	35.2	9	10.2	5	5.7	71	80.7	6	7.0	0.31	0.03
Protein (g/d)	22	25.0	9	10.2	6	7.0	59	67.0	3	3.5	0.23	<0.0001
Lipids (g/d)	31	35.2	10	11.3	6	7.0	58	66.0	9	10.2	0.12	<0.0001
Carbohydrate (g/d)	34	38.6	12	13.6	7	8.0	68	77.2	6	7.0	0.26	<0.0001
Ca (g/d)	39	44.3	10	11.3	9	10.2	71	80.7	4	4.5	0.45	<0.0001
Fe (mg/d)	31	35.2	11	12.5	4	4.5	63	71.6	8	9.0	0.21	<0.0001
K (g/d)	24	27.3	12	13.6	9	10.2	62	70.5	6	7.0	0.22	0.4
Vitamin A (IU)	27	30.7	10	11.3	7	8.0	62	70.5	11	12.5	0.12	<0.0001
Vitamin A (RE)	29	33.0	9	10.2	7	8.0	66	75.0	7	8.0	0.27	<0.0001
Thiamin (mg/d)	20	22.7	6	7.0	5	5.7	55	62.5	11	12.5	0.009	<0.0001
Riboflavin (mg/d)	30	34.1	11	12.5	8	9.0	68	77.2	6	7.0	0.32	0.6
Niacin (mg/d)	29	33.0	10	11.3	7	8.0	67	76.1	6	7.0	0.31	0.11
Vitamin B ₆ (mg/d)	25	28.5	7	8.0	6	7.0	63	71.6	6	7.0	0.23	0.03
Vitamin C (mg/d)	29	33.0	11	12.5	10	11.3	64	72.7	3	3.5	0.33	<0.0001
Dietary fibre (g/d)	37	42.0	8	9.0	7	8.0	71	80.7	2	2.3	0.49	0.02
Folic acid (μ g/d)	27	30.7	11	12.5	9	10.2	68	77.2	5	5.7	0.33	0.07
Vitamin E (mg/d)	35	40.0	8	9.0	7	8.0	71	80.7	7	8.0	0.32	<0.0001
Zn (g/d)	31	35.2	7	8.0	10	11.3	65	73.8	4	4.5	0.33	0.97
Mg (mg/d)	26	29.5	12	13.6	7	8.0	61	69.3	5	5.7	0.23	0.15
Cu (mg/d)	25	28.5	9	10.2	9	10.2	66	75.0	9	10.2	0.21	<0.0001
SFA (g/d)	25	28.5	8	9.0	6	7.0	55	62.5	11	12.5	0.08	0.05
Cholesterol (g/d)	27	30.7	6	8.3	7	8.0	64	72.7	7	8.0	0.23	0.78
Mean	28	31.7	9	10.6	7	8.2	63	72.0	6	7.8	0.24	–
Estimated nutrient intake and accuracy of FFQ for whole gestational period (n 73)												
Energy (kJ/d)†	28	38.8	10	13.7	9	12.3	63	87.5	1	1.4	0.30	0.4800
Protein (g/d)	24	33.3	5	7.0	8	11.1	52	72.2	4	5.5	0.28	0.13
Lipids (g/d)	20	27.7	7	9.7	4	5.5	51	70.8	5	7.0	0.21	0.45
Carbohydrate (g/d)	23	32.0	6	8.3	8	11.1	51	70.8	4	5.5	0.25	0.63
Ca (g/d)	22	30.5	6	8.3	8	11.1	55	76.4	5	7.0	0.30	0.4454
Fe (mg/d)	20	27.7	7	9.7	3	4.1	46	63.8	8	11.1	0.05	<0.0001
K (g/d)	30	41.6	10	13.7	8	11.1	61	84.7	7	9.7	0.50	0.2668
Vitamin A (IU)	28	38.8	8	11.1	9	12.3	52	72.2	4	5.5	0.31	0.4259
Vitamin A (RE)	26	36.1	7	9.7	6	8.3	52	72.2	8	11.1	0.18	0.0034
Thiamin (mg/d)	17	23.6	5	7.0	1	1.4	44	61.1	11	15.2	-0.07	0.2779
Riboflavin (mg/d)	37	51.4	9	12.3	11	15.2	56	77.7	3	4.1	0.45	0.0087
Niacin (mg/d)	23	32.0	9	12.3	6	8.3	55	76.4	2	2.7	0.38	<0.0001
Vitamin B ₆ (mg/d)	23	32.0	7	9.7	8	11.1	46	63.8	5	7.0	0.15	<0.0001
Vitamin C (mg/d)	22	30.5	5	7.0	7	9.7	51	70.8	5	7.0	0.23	0.0489
Dietary fibre (g/d)	27	37.5	7	9.7	7	9.7	52	72.2	7	9.7	0.22	0.0994
Folic acid (μ g/d)	22	30.5	8	11.1	5	7.0	51	70.8	4	5.5	0.34	0.2896
Vitamin E (mg/d)	22	30.5	7	9.7	4	5.5	53	73.6	7	9.7	0.21	0.0833
Zn (g/d)	21	29.1	5	7.0	7	9.7	51	70.8	6	8.3	0.20	0.6448
Mg (mg/d)	22	30.5	8	11.1	6	8.3	57	79.0	5	7.0	0.33	0.5739
Cu (mg/d)	19	26.4	7	9.7	4	5.5	45	62.5	4	5.5	0.14	0.0954
SFA (g/d)	24	33.3	8	11.1	7	9.7	50	69.4	4	5.5	0.25	0.8446
Cholesterol (g/d)	23	32.0	7	9.7	6	8.3	51	70.8	8	11.1	0.15	0.2486
Mean	23	32.6	7	10.0	6	8.2	51	71.0	5	7.8	0.23	–

RE, retinol equivalents.

In addition, few validation studies of FFQ for pregnant women have assessed the accuracy of the method for estimating nutrient intakes during different periods of pregnancy. The FFQ showed acceptable accuracy ($r > 0.35$), based on energy-adjusted and deattenuated Pearson's correlation coefficient, for estimating Ca, K, Zn, Mg, Fe, fibre, SFA, vitamin A, thiamin, riboflavin, niacin, vitamin C and folic acid for the first two trimesters of pregnancy. Considering the gestational period as a whole, acceptable correlation was found for energy, carbohydrate, protein,

lipids, Fe, K, Zn, fibre, vitamin B₆, riboflavin and niacin. A high proportion of study participants ($\geq 70\%$) were categorized into the same or adjacent quartiles for estimated energy, carbohydrate, Ca, K, fibre, Zn, cholesterol, vitamin A, riboflavin, niacin, vitamin C, vitamin E and folic acid in both gestational periods.

In a study involving Finnish pregnant women, Erkkola *et al.*⁽¹⁵⁾ found estimated nutrient intakes measured by an FFQ to be 30–40% higher than mean values calculated using food records. According to Robinson *et al.*⁽¹¹⁾,

higher consumption reported by FFQ may result from the bigger portions used in the FFQ or be due to over-reporting of intake frequency. To develop the FFQ used in the present study, nutrient intake was adjusted by energy and within-person variation⁽¹⁷⁾ in order to reduce the risk of the instrument overestimating intake. Although the food list of the FFQ assessed is very similar to the lists used in other FFQ devised for use in Brazil^(29,30), portion sizes were consistently larger.

The values of Pearson's correlation coefficient in the present study were, on average, lower for macronutrients, although satisfactory correlation was confirmed for the majority of the nutrients of interest in this investigation. Other studies in pregnant women employing Pearson's correlation coefficient for FFQ validation have also found lower-than-expected correlation coefficients. For instance, in a study of eighty US pregnant women using three replicates of 24hR, Forsythe and Gage⁽¹⁰⁾ found Pearson's correlation coefficients ranging from 0.42 for vitamin B₁₂ to 0.46 for Fe. In a study conducted among pregnant women in Brazil, Giacomello *et al.*⁽¹⁴⁾ identified Pearson's correlation coefficients of between 0.01 for saturated fats and 0.47 for Ca, taking two 48hR as the reference method. The low correlation coefficients seen in validation studies of FFQ for pregnant women can be partially explained by the high within-person variability in estimated energy and nutrient intakes during this phase of life, especially when few replications of 24hR or records are taken as the reference method⁽¹²⁾.

After adjustments for energy, higher correlations between the dietary methods were found for protein, lipids, K, Zn, Mg and fibre estimates for the first 24 weeks of pregnancy. Considering the gestational period as a whole, higher correlations were verified for Ca, K, vitamin A, niacin and vitamin C. The improvement in correlations after energy adjustment might be related to the correction of correlated errors on nutrient and energy estimates^(26,27).

International validation studies of questionnaires developed and validated for use in pregnant women suggest this method is a valuable tool for assessing the dietary intake of pregnant women^(12,15,16), evidenced by acceptable correlation coefficient values⁽⁸⁾. Current recommendations advise against the use of Pearson's correlation coefficient alone for assessing agreement between two methods, instead suggesting its use in association with other analysis techniques, such as categorization into intake levels, weighted κ statistics and the Bland–Altman method⁽⁶⁾. However, Bland–Altman analysis requires a minimum sample size of 100 individuals.

In the present study, the percentage of pregnant women classified into the same consumption quartile (32–33%) by both the FFQ and 24hR, and into opposite (7.8%) quartiles, was similar to that reported by other validation studies of FFQ for Portuguese pregnant women⁽³¹⁾. The agreement between the methods observed in the present study was also similar to that seen in a previous study

conducted in Brazil assessing the accuracy of an FFQ developed for adults in estimating nutrient intakes among pregnant women, in which 30% of pregnant women were classified into the same quartile of estimated nutrients and 8% into opposite quartiles. The proportion of agreement in the same or adjacent quartiles observed in the present study (~72%) was similar to that reported in an FFQ validation study performed among pregnant Finnish women⁽¹⁵⁾ in which 69% of the women were classified into the same or adjacent quintiles and 5% into opposite quintiles.

The quadratic weighted κ value found in the present study was low, in line with findings of a previous FFQ validation study conducted in Brazil reporting κ values ranging from 0.39 for vitamin C to 0.06 for Cu⁽¹⁴⁾.

According to Beaton⁽³²⁾, the fact that the FFQ under- or overestimates nutrients is not an issue in epidemiological studies aimed at identifying diet–disease associations provided that the classification of individuals by intake levels is acceptable. Given this premise, if the aim of the FFQ is to categorize individuals into quartiles of intake then the FFQ used in the present study can be deemed effective since, for the majority of nutrients, 70% or more of the pregnant women were categorized into the same or adjacent quartiles. Therefore, these results show that the FFQ can be employed for this purpose. However, low proportions of women were correctly classified into the lowest and highest quartiles.

Despite the limitation of using a fixed list of foods as well as standardized food portions, factors which could compromise accuracy of nutrient estimates when employing the FFQ, the high number of 24hR or food records replicates needed to achieve an accurate estimate of nutrients during pregnancy can render the assessment of dietary intake impractical in this population group in epidemiological studies. Based on the data of the present study, considering within-person variance data and accuracy values of approximately 20%, four 24hR would be needed to accurately estimate energy intake, three for carbohydrates, eighteen for lipids, seven for protein, twenty-four for Ca and nine for fibre (data not shown).

The main limitation of the current study was the use of only a small number of 24hR as the 'gold standard' for estimating nutrients of the usual dietary intake of pregnant women. The FFQ and 24hR have similar magnitudes of error for measures such as memory bias, perhaps constituting another limitation of the study. However, given the low literacy and motivation of participants in the present study, multiple 24hR was considered the most appropriate reference method. Moreover, a minimum sample size of 100 individuals is recommended for analyses using the Bland–Altman method. The initial sample of the present study numbered 103 pregnant women. However, after losses to follow-up, only eighty-eight pregnant women continued to the second assessment of

the study whereas seventy-two remained for the third assessment, restraining the use of Bland–Altman analysis in the present study⁽³³⁾.

The sample of the present study was pregnant women attended by the national health-care system in Ribeirão Preto, São Paulo State. According to the National Household Survey, 74% of Brazilians are users of this health service in the country, and share similar characteristics on schooling level and economic classes⁽³⁴⁾. The applicability of the tested FFQ in studies conducted among pregnant women in Brazil will be dependent on nutrients of interest to the investigation and on the similarity of food habits, which might diverge according to the region of the country. Therefore, calibration studies are recommended prior to utilization of the FFQ in different populations.

Conclusions

The FFQ developed was assessed and validated for pregnant women. The results showed acceptable correlation of the instrument for estimating intakes of Ca, K, Zn, Mg, fibre, vitamin C, niacin and folic acid for the first two trimesters of pregnancy, and for energy, lipids, protein, carbohydrate, Fe, K, Zn, fibre, vitamin B₆, riboflavin and niacin taking the gestational period as a whole. Furthermore, the FFQ proved a satisfactory method of categorizing estimated nutrients of interest in the diet of the pregnant women assessed.

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