FOOD AND NUTRITION IN COLLECTIVE HEALTH

DOI: 10.12957/demetra.2020.44161

DEMETRA Alimentação, Nutrição & Saúde

Thays Ataide-Silva [1]
Catherine Cavalcanti Padilha[1]
Michele Ferro de Amorim Cruz[1]
Ewerton Amorim dos Santos[1]
Sandra Mary Lima Vasconcelos[1]

[1] Universidade Federal de Alagoas, Faculdade de Nutrição, Laboratório de Nutrição em Cardiologia (Nutricardio®), Programa de Pós-Graduação em Nutrição. Maceió, AL, Brasil

Correspondence
Sandra Mary Lima Vasconcelos
sandra-mary@hotmail.com

Development,validation and reproducibilityof a food frequency questionnaire focused on adult hypertensive and/or diabetic individuals

Elaboração, validação e reprodutibilidade de um questionário de frequência alimentar para hipertensos e/ou diabéticos

Abstract

Objective: The aims of the current study are to develop and assess the validity and reproducibility of a food frequency questionnaire (FFQ) focused on hypertensive and/or diabetic individuals living in Maceió City - AL, Brazil. ***Methods***: The questionnaire was developed based on 1,603 twenty-four-hour recall dietary surveys (24-HDR). Three FFQs and three 24-HDRs were concomitantly applied to a sample of 40 individuals, at maximum interval of 45 days between applications, in order to assess FFQ validity and reproducibility. Validity assessment was based on Pearson's (PCC) or Spearman's (SCC) correlation coefficient between FFQs 1, 2, 3 and the mean of three 24-HDRs (the 24-HDR was used as reference standard). Reproducibility assessment was based on the intraclass correlation coefficient (ICC) among FFQs. ***Results***: PCCs or SCCs recorded the recommended validity values (from 0.4 and 0.7) for energy, macronutrients, calcium and sodium in FFQs 1 and 2 (satisfactory validity), whereas other nutrients recorded PCC < 0.4. All investigated nutrients presented ICC within the recommended reproducibility values, except for potassium, which recorded ICC equal to 0.28 between FFQs 1 and 3. ***Conclusion***: The FFQ developed and evaluated in the current study is a good food intake-evaluation instrument to assess energy, macronutrients, calcium and sodium in hypertensive and/or diabetic individuals, since it can provide important information for studies about nutritional epidemiology in this target population.

Keywords: Food Consumption. Nutrition Surveys. Hypertension. Diabetes Mellitus. Adults.

Resumo

Objetivo: O presente estudo teve por objetivo elaborar e avaliar a validade e a reprodutibilidade de um questionário de frequência alimentar (QFA) para hipertensos e/ou diabéticos do município de Maceió-AL, Brasil. ***Métodos***: O QFA foi elaborado a partir de 1.603 inquéritos dietéticos recordatórios de 24 h (IDR24H). Para avaliar a validade e a reprodutibilidade do QFA aplicaram-se, em uma amostra de 40 indivíduos, três QFAS e três IDR24H concomitantemente e com intervalo máximo de 45 dias entre as aplicações. A validade foi avaliada por meio dos coeficientes de correlação de Pearson (CCP) ou de Spearman (CCS) entre o QFA 1, 2 e 3, e a média dos 3IDR24H, adotando-se o IDR24H como padrão de referência; e a reprodutibilidade, por meio do coeficiente de correlação intraclasse (CCI) entre os QFAs. ***Resultados***: Quanto à validade, os CCP ou CCS atingiram os valores recomendados entre 0,4 e 0,7 para energia, macronutrientes, cálcio e sódio para as aplicações 1 e 2 do QFA (validade

satisfatória); e para os demais nutrientes, CCP < 0,4. Quanto à reprodutibilidade, todos os nutrientes estudados apresentaram CCI dentro dos valores recomendados, exceto potássio entre QFA1 e QFA3 (CCI = 0,28). *Conclusão*: O QFA elaborado e avaliado neste estudo constitui um bom instrumento de avaliação de consumo alimentar para avaliação de energia, macronutrientes, cálcio e sódio para hipertensos e/ou diabéticos, podendo fornecer informações importantes para estudos de epidemiologia nutricional neste público-alvo.

Palavras-chave: Consumo alimentar. Inquérito nutricional. Hipertensão. Diabetes mellitus. Adulto.

INTRODUCTION

Food frequency questionnaires (FFQs) are the method of choice to evaluate the association between diet and chronic non-communicable diseases (CNCDs) such as systemic arterial hypertension (SAH) and diabetes mellitus (DM).[1-3] FFQ food list should be ideally defined based on target population's eating habits,[4,5] followed by options concerning food intake frequency in time units (days, weeks, semesters or years), which may, or may not, include fractionations of these units. Besides food intake frequency, information about the size of consumed portions of each food item can be recorded in FFQs.[6,7]

FFQs have the advantage of evaluating diets for a long period-of-time, since exposure time in this instrument is more important than food or nutrient intake at specific days.[8,9] They also enable stratifying results in nutrient intake quartiles or quintiles in order to analyze risk trends based on exposure level and on differences among extreme food intake levels.[8,10] However, instruments focused on recording food intake, such as FFQs, have limitations, since they may lose food intake information details; it happens because their quantification process is sometimes inaccurate and even requires participants to recall past habits.[11] Aspects such as interviewees' schooling and age can affect the collected information;[11] thus, it is necessary developing specific FFQs for specific groups and goals.[12]

Once developed, FFQs should be subjected to validation studies focused on investigating to what extent these instruments measure what is actually proposed.[13] Validation studies consist in comparing results of FFQ nutrient or food intake estimates based on more precise "gold standard" methods, such as biological markers, or on reference methods such as dietary surveys.[8,9,11] These surveys comprise the self-reported dietary intake (RDI), according to which individuals themselves write down in specially-designed forms all food and beverages consumed over the course of a day;[14] as well as the 24-hour dietary recall (24-HDR),[15] which defines and quantifies all food and beverages consumed in the period prior to the interview, which may be the previous 24 hours or, more often, the day before it.[14]

Although RDI is the dietary method presenting lesser errors, 24-HDR is the instrument most used in epidemiological studies,[8,9] due to advantages such as rapid application, low cost, acceptability by interviewees and being based on individuals' recent memory. In addition, 24-HDR is the method that least presents changes in individuals' eating behavior;[16,17] thus, it is mainly indicated for low schooling populations with limited availability to record information.[8] The 24-HDR is featured by high intrapersonal variability due to the random nature of diets, which change from day to day, as well as to the seasonality of many food items. Given this feature, the 24-HDR selected for validation must be repeatedly applied (at least twice) to help minimizing its bias and reducing nutrient intake dispersion, which can compromise correlation measurements.[18,19] Besides validity, reproducibility is also necessary to certify the quality of a given instrument, since it measures results' similarity on two, or more, different measurement occasions.[18,20,21]

Although some instruments used to measure food intake have already been developed and validated in Brazil,[6,10,11,18,22-27] it is essential emphasizing that different demographic and cultural groups require FFQs cable of covering their dietary specificities.[5,18] It is necessary collecting reliable information about individuals' usual food intake and the content of several nutrients in food items and preparations in order to identify dietary risk factors in population groups living in Brazil. Epidemiological studies focused on investigating the association between diets and chronic diseases require using standardized methodologies to assess individual food intake in population samples, based on valid, accurate and economically viable instruments.[8,28]

In light of the foregoing, the aim of the current study was to develop and evaluate the validity and reproducibility of a FFQ focused on hypertensive and/or diabetic patients living in Maceió City - AL, Brazil.

METHODS

Developing the Food Frequency Questionnaire (FFQ)

Dietary information available in the database of 1,603 24-HDRs collected in a previous dietary study titled "Eating habits, nutrient intake and consumption of food items associated with cardiovascular protection and risk in hypertensive patients living in Maceió City - AL" were used to prepare the FFQ.

All 576 food items mentioned in the 1,603 24-HDRs were listed as cited. This number was narrowed down to 284 food items because many of them referred to the same product, although with different names (e.g., stew chicken, cooked chicken). The final list comprised all mentioned foods, except for those presenting caloric contribution lower than 0.01% of the total energy value. In addition, some food items were grouped because they presented similar nutritional value (e.g., Chunkey banana and Cavendish banana; apple and pear). Finally, food items that were not spontaneously mentioned in the 24-HDRs but that were known to contribute to the total caloric value of the diet (sugar, olive oil), as well as seasonal food items (cashew and guava), were incorporated to the FFQ. Thus, the final list comprised 126 items organized into 14 food groups: (1) fruits, (2) fruit juices, (3) green vegetables, (4) tubers and derivatives, (5) cereals and pasta, (6) condiments, (7) oils and fats, (8) milk and dairy products, (9) legumes, (10) meats, (11) sausages, (12) sweets, (13) soups and (14) beverages. Other issues associated with individuals' eating habits and preferences, such as the number of meals a day, oil/fat type often used to prepare meals, intake of visible fat from meat and inclusion of non-listed food items in the diet were also included in the analysis.

The portion sizes of each food item in the FFQ were classified as small, medium (reference portion) and large, based on references in the photo album[29] and on home measurement tables.[30] Food intake frequency was classified as daily, weekly, monthly and yearly basis. Options regarding the number of times (0 to > 10) a given food was often consumed were included in each of these categories.

Sample

The sample comprised individuals registered in Sistema de Controle da Hipertensão Arterial e do Diabetes Mellitus do Ministério da Saúde do Brasil (SISHIPERDIA-MS - Arterial Hypertension and Diabetes Mellitus Control System of the Brazilian Ministry of Health), Maceió City, Alagoas State, in 2011, who were part of the previously mentioned study population.

Adult individuals (20-60 years old) diagnosed with hypertension and/or diabetes mellitus, who were registered in HIPERDIA and agreed to participate in the research were included in it. Patients who did not complete data collection (socioeconomic, anthropometric and demographic data, three FFQs and three 24-HDRs), elderly individuals (older than 60 years) and those who did not agree to participate in the research were excluded from the study.

Seventy-three (73) individuals (16 men and 57 women) were initially selected to answer the first interview, which comprised the socioeconomic questionnaire, the elaborated FFQ, 24-HDR and anthropometric data collection. Fifty-one (51) of them (12 men and 39 women) participated in the second interview, which comprised the second FFQ application and the second 24-HDR; only 40 individuals (12 men and 28 women) completed the third interview, which encompassed the third FFQ application and the third 24-HDR, which, in its turn, corresponded to Sunday. Thus, the final sample of 40 individuals corresponded to 61.5% of the initial sample.

The research was approved by Comitê de Ética e Pesquisa da Universidade Federal de Alagoas (Research Ethics Committee of Federal University of Alagoas), process n. 23065.018588 / 2010-89. All participants signed the informed consent form.

Data collection

Data collection took place in three meetings in which (1) the socioeconomic and anthropometric questionnaire, as well as the first FFQ and the first 24-HDR were applied; (2) the second FFQ and the second 24-HDR were applied; and (3) the third FFQ and the third 24-HDR were applied. The total of three FFQs and three IDR24H were applied, the last application was carried out on Monday to assure that one of the 24-HDRs corresponded to Sunday in order include the weekend day of food intake. The mean interval between the first and second applications was 29.62 ± 11.13 days, and 28.02 ± 9.79 days between the second and third applications, which enabled reaching the recommended interval of 15-to-45 days.[31]

Both dietary surveys were applied on the same day; however, the FFQ was always applied before the 24-HDR in order to meet a requirement for this study type.[15] Based on the photo album, participants reported, in detail, the size and volume of the portions consumed by them, the brands of the products and the adopted food preparation method.

Socioeconomic data and nutritional status assessment

Participants' socioeconomic data were collected in the first interview and their profile was featured based on Critério de Classificação Econômica do Brasil (CCEB - Brazilian Economic Classification Criterion),[32] as well as on participants' income data; nutritional status was assessed based on participants' body mass index - BMI (kg/m²) and waist circumference - WC (cm).

Energy and nutrient intake estimates

The Nutrition Support Software (NUTWIN®) version 1.5, 2002, added with data collected from chemical composition tables and home measurements,[30,33-36] was used to calculate energy, macronutrient (carbohydrates, proteins and lipids), micronutrient (vitamins C, E, B_6 and B_{12}, calcium, magnesium, potassium and sodium) and dietary fiber intake, based on 24-HDRs and FFQs, which were transformed into values corresponding to daily food intake. Based on NUTWIN®, data were exported to Excel® 2007 spreadsheet and, then, to SPSS software version 18.0, for subsequent statistical analysis. All FFQ and 24-HDR data were inserted in double-entry table.

Statistical analysis

SPSS software version 18.0 was initially used to apply the Naperian logarithmic transformation to all nutrients, since they did not present Gaussian distribution, as tested through the Kolmogorov-Smirnov test. Means and standard deviations were calculated for the 24-HDR and FFQs. Paired sample t-test was used to analyze differences between each FFQ and the mean of three 24-HDR - significant differences were set at $p \leq 0.05$.

Pearson's correlation coefficient (PCC) for symmetric data and Spearman's correlation coefficient (SCC) for asymmetric data among FFQs 1, 2 and 3 were calculated. The mean of three 24-HDR and the intraclass correlation coefficient (ICC) were calculated for FFQs. Correlation coefficients based on crude, adjusted and deattenuated data were used to analyze FFQs' validity for mean food intake in the three 24-HDRs. Correlation coefficients ranging from 0.4 to 0.7 indicated good agreement between FFQ and 24-HDR, and between FFQs.[15]

The t-test was applied to variables "age" and "anthropometric data" to enable comparisons between sexes; significant results were set at $p \leq 0.05$. The Epi Info software version 3.5.2 (2010) was used to create a database for variables "age", "sex", "anthropometric data", "marital status", "schooling", "occupation", "diagnosis (SAH and/or DM)" and "economic class" to enable further descriptive analysis in Excel® 2007 software based on distribution rates.

RESULTS

Developed FFQ

After the methodological preparation stages were finished, the herein developed quantitative FFQ was structured and had its validity and reproducibility tested.

Featuring the investigated sample

Forty individuals participated in the current study: 12 (30%) of them were 38-to-59-year-old men (mean age = 52.58 ± 5.63 years) and 28 (70%) were 31-to-60-year-old women (mean age = 47.18 ± 9.74 years); 65% (n = 26) of them had SAH, 25% (n = 10) had SAH and DM, and 10% (n = 4) had DM. With respect to participants' marital status, 87% were married or lived in stable union, 10% were single and the remaining ones were widow(er). Only 35% of them had regular income, most individuals in the sample were housewives (47.5%) belonging to economic class D (80%), as shown in Table 1.

Table 1. Sociodemographic and anthropometric data about the investigated individuals. Maceió City - AL, 2011.

	Total	%	Sex		*P*
			Male	Female	
	(n= 40)		(n=12)	(n=28)	
Features					
Age (years) Mean (SD*)	48.80 (8.99)	-	52.58 (5.63)	47.18 (9.75)	0.347[1]
Age (minimum and maximum)	31-60		38-59	31-60	
Anthropometric Assessment					
Weight (kg) Mean (SD*)	75.33 (12.97)	-	74.30 (10.43)	75.77 (14.07)	0.656[2]
BMI[†] (kg/m²) Mean (SD*)	30.19 (5.24)	-	24.63 (2.18)	32.57 (4.26)	0.211[2]
WC[‡] (cm) Mean (SD*)	100.08 (12.85)	-	99.50 (10.56)	100.36 (14.11)	0.787[2]
Marital status					
Single	4	10	1	3	0.121[3]
Stable union	12	30	1	11	
Maried	23	57.5	10	13	
Widow(er)	1	2.5	-	1	

Table 1. Sociodemographic and anthropometric data about the investigated individuals. Maceió City - AL, 2011.(Continues)

	Total	%	Sex		*P*
			Male	Female	
	(n= 40)		(n=12)	(n=28)	
Schooling					
Illiterate/unfinished primary school	14	35	4	10	0.905[3]
Primary school/unfinished secondary school	15	37.5	4	11	
Secondary school /unfinished high school	5	12.5	2	3	
High school /unfinished higher education	6	15	2	4	
Ocupation					
Housewife	19	47.5	-	19	< 0.001[3]
General services / cleaning lady	4	10	-	4	
Watchman / doorman	3	7.5	3	-	
Retired / beneficiary	6	15	5	1	
Self-employed	3	7.5	2	1	
Unemployed	1	2.5	-	1	
Others	4	10	2	2	
CCEB[¦]					
C1	1	2.5	4	12	0.528[3]
C2	6	15	3	9	
D	32	80	3	2	
B2	1	2.5	2	5	

[1]Mann-Whitney test; [2] T test for independent samples; [3] Fisher's exact test.

*SD: standard deviation; [†]BMI: body mass index; [‡]WC: waist circumference; [¦]ECCB: economic classification criteria used in Brazil.

With respect to participants' anthropometric profile, 85% of them were overweight or obese, and 76.67% of men and 96.42% of women had abdominal obesity. There was not significant difference in variables "age", "weight", "BMI" and "WC" between sexes.

Table 2. Energy and nutrient intake based on 24-hour dietary recall (24-HDR) surveys 1, 2 and 3, on the mean (X) of three 24-HDRs, as well as on food frequency questionnaires (FFQ) 1, 2 and 3, and on the mean (X) of three FFQs. Maceió City -AL, 2011.

Energy and nutrients	Mean intake (standard deviation)							
	24-HDR 1	24-HDR 2	24-HDR 3	X 24-HDR	FFQ 1	FFQ 2	FFQ 3	XFFQ
Energy (Kcal)	1,687.07 (795.32)	1,927.16 (949.49)	1,700.93 (723.11)	1,771.72 (715.63)	2,641.53 (1152.89)	2,390.57 (1042.72)	2,568.92 (1194.28)	2,533.67 (129.14)
Carbohydrate (g)	218.55 (94.68)	252.52 (159.08)	227.32 (116.18)	232.79 (103.51)	366.28 (166.15)	331.41 (157.02)	353.39 (172.72)	350.36 (17.63)
Lipid (g)	50.59 (36.41)	58.85 (30.56)	50.73 (25.56)	53.39 (24.26)	79.30 (43.60)	71.86 (37.04)	77.41 (47.98)	76.19 (3.87)
Protein (g)	89.39 (55.70)	96.87 (46.18)	83.77 (41.18)	90.00 (40.64)	115.67 (50.68)	104.55 (56.21)	114.66 (57.75)	111.63 (6.15)
Fiber (g)	8.70 (10.59)	8.32 (9.74)	10.09 (8.66)	9.03 (7.44)	16.85 (8.73)	15.81 (11.18)	16.25 (7.53)	16.30 (0.52)
Vit C (mg)	133.61 (243.61)	139.96 (282.81)	89.32 (108.96)	120.96 (138.52)	528.54 (669.97)	393.32 (327.53)	551.27 (593.73)	491.04 (85.39)
Vit E (mg)	3.78 (2.91)	4.72 (3.25)	5.96 (6.45)	4.78 (2.89)	8.80 (4.81)	7.87 (4.91)	8.66 (5.68)	8.44 (0.50)

Table 2. Energy and nutrient intake based on 24-hour dietary recall (24-HDR) surveys 1, 2 and 3, on the mean (X) of three 24-HDRs, as well as on food frequency questionnaires (FFQ) 1, 2 and 3, and on the mean (X) of three FFQs. Maceió City -AL, 2011.(Continues)

Energy and nutrients	Mean intake (standard deviation)							
	24-HDR 1	24-HDR 2	24-HDR 3	X 24-HDR	FFQ 1	FFQ 2	FFQ 3	XFFQ
Vit B6 (mg)	1.25 (0.86)	1.42 (1.06)	1.28 (0.89)	1.31 (0.82)	1.95 (0.73)	1.74 (0.77)	1.91 (0.76)	1.87 (0.11)
Vit B12 (mcg)	5.75 (19.35)	12.05 (39.08)	3.31 (5.90)	7.04 (15.57)	9.51 (5.73)	12.99 (14.08)	13.34 (11.02)	11.95 (2.12)
Calcium (mg)	421.98 (256.45)	496.73 (354.71)	411.74 (244.03)	443.48 (225.07)	980.26 (536.17)	907.52 (553.24)	1078.96 (1215.39)	988.91 (86.05)
Magnesium (mg)	175.95 (82.90)	209.91 (139.11)	211.20 (120.28)	199.02 (96.15)	289.57 (98.57)	263.67 (112.88)	281.94 (134.49)	278.39 (13.31)
Potassium (mg)	1,999.17 (1425.09)	2,289.60 (2064.07)	2,094.71 (1588.99)	2,127.83 (1443.29)	3,374.88 (1218.59)	3003.06 (1384.78)	3,354.49 (2010.07)	3,244.14 (209.03)
Sodium (mg)	887.87 (686.31)	1,009.01 (778.26)	858,92 (608,94)	918.6 (537.12)	1,448.69 (1019.11)	1,228.54 (776.77)	1,400.61 (959.00)	1,359.28 (115.75)

Table 2 shows participants' energy and nutrient intake based on the 24-HDR and FFQs. The intake of energy and most nutrients in FFQs 1, 2 and 3 was higher than the mean of the three 24-HDRs. Paired sample t-test was applied to these differences (FFQ versus the mean of three 24-HDRs) in each of the three FFQs. Results have shown statistically significant differences in energy, macronutrient, fiber and micronutrient intake ($p < 0.05$), but not in protein intake between FFQ2 and the mean of the three 24-HDRs ($p > 0.05$). (Table 3)

Table 3. Difference between the usual energy and nutrient intake data collected though the food frequency questionnaire (FFQ) and the mean (X) of three 24-hour dietary recall (24-HDR) surveys, based on each FFQ (1, 2 and 3). Maceió City - AL, 2011.

Energy and Nutrients	Mean intake (standard deviation)		
	Difference between FFQ 1 and X 24-HDR	Difference between FFQ 2 and X 24-HDR	Difference between FFQ 3 and X 24-HDR
Energy (Kcal)	869.81 (615.05) ***	618.85 (437.59) ***	797.20 (563.71) ***
Carbohydrate (g)	133.48 (94.39) ***	98.62 (69.73) ***	120.60 (85.28) ***
Lipid (g)	25.91 (18.32) ***	18.47 (13.06) ***	24.02 (16.99) ***
Protein (g)	25.66 (18.14) ***	14.54 (10.28)	24.65 (17.43) *
Fiber (g)	7.81 (5.52) ***	6.78 (4.79) ***	7.22 (5.10) ***
Vit C (mg)	407.57 (288.19) ***	272.36 (192.59) ***	430.30 (304.27) ***
Vit E (mg)	4.02 (2.84) ***	3.09 (2.18) ***	3.88 (2.74) ***
Vit B6 (mg)	0.64 (0.45) ***	0.41 (0.30) ***	0.59 (0.42) ***
Vit B12 (mcg)	2.47 (1.75) ***	5.96 (4.21) ***	6.30 (4.46) ***
Calcium (mg)	536.78 (379.56) ***	464.04 (328.12) ***	635.48 (449.45) ***
Magnesium (mg)	90.55 (64.03) ***	64.65 (45.71) ***	82.93 (58.64) ***
Potassium (mg)	1,247.05 (881.80) ***	875.24 (618.89) ***	1,226.66 (867.38) ***
Sodium (mg)	530.09 (374.83) ***	309.94 (219.16) **	482.01 (340.83) **

*p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001. (paired sample t-test)

Validity

With respect to the validity of the FFQs regarding mean food intake in the three 24-HDRs, gross values have overall shown lower correlation to FFQ3 and higher correlation to FFQ2. In absolute values, validity ranged from 0.04 (vitamin C in FFQ2) to 0.55 (calcium in FFQ2). Pearson's correlation coefficients recorded the lowest values for fiber and potassium (0.15 and 0.17 in FFQ 1), and for vitamin C (0.04 in FFQ2 and 0.12 in QFA3); as well as the highest values for lipids (0.53 in FFQ2) and calcium (0.55 in FFQ2 and 0.46 in FFQ1), as shown in Table 4.

Based on the comparison of correlation values recorded for crude, deattenuated and adjusted energy data (table 4), values recorded for crude and adjusted data were overall remarkably close, if not equal, to each other. On the other hand, deattenuated data overall recorded the highest values. The analysis of data generated in these three treatments has shown acceptable correlation values (> 0.4) recorded for energy and for 58% (n = 7/12) of the analyzed nutrients, namely: carbohydrates, lipids, proteins, vit B_6, vit B_{12}, calcium and sodium. However, there was not uniform correlations between food survey applications; the second application presented the best performance. It is essential highlighting the FFQ validity for calcium intake in all applications (Table 4).

Table 4. Correlation coefficients of energy and nutrient intake between food frequency questionnaires (FFQ) 1, 2 and 3 and the mean of three 24-hour dietary recall (24-HDR) surveys based on crude, deattenuated and adjusted data. Maceió City - AL, 2011.

Energy and Nutrients	Correlation coefficients between intake data								
	24-HDR *vs* FFQ 1			24-HDR *vs* FFQ 2			24-HDR *vs* FFQ 3		
	Cr	Deat	Adjust	Cr	Deat	Adjust	Cr	Deat	Adjust
Energy (Kcal)	**0.48**[1]		**0.48**[1]	**0.52**[1]		**0.52**[1]	0.32[1]		0.32[1]
Carbohydrate (g)	0.38[1]	**0.43**	0.38[1]	**0.41**[1]	**0.47**	**0.42**[1]	0.22[1]	0.25	0.22[1]
Lipid (g)	**0.51**[1]	**0.58**	**0.51**[1]	**0.53**[1]	**0.60**	**0.53**[1]	0.13[2]	0.15	0.13[2]
Protein (g)	0.24[2]	0.27	0.24[2]	**0.45**[1]	**0.51**	**0.45**[1]	0.14[1]	0.16	0.15[1]
Fiber (g)	0.15[1]	0.17	0.15[1]	0.22[1]	0.25	0.22[1]	0.38[1]	0.43	0.37[1]
Vit C (mg)	0.22[1]	0.24	0.19[1]	0.04[1]	0.05	0.06[1]	0.12[1]	0.13	0.14[1]
Vit E (mg)	0.30[1]	0.34	0.27[1]	0.29[1]	0.32	0.26[1]	0.25[1]	0.29	0.21[1]
Vit B6 (mg)	0.29[1]	0.33	0.29[1]	0.35[1]	**0.4**	0.35[1]	0.38[1]	**0.44**	0.38[1]
Vit B12 (mcg)	0.33[1]	0.37	**0.44**[2]	0.28[1]	0.31	0.19[2]	0.26[1]	0.29	0.23[2]
Calcium (mg)	**0.46**[1]	**0.52**	**0.46**[1]	**0.55**[1]	**0.63**	**0.55**[1]	**0.41**[1]	**0.46**	**0.41**[1]
Magnesium (mg)	0.18[1]	0.20	0.19[1]	0.29[1]	0.33	0.29[1]	0.26[1]	0.3	0.26[1]
Potassium (mg)	0.17[1]	0.20	0.18[1]	0.30[1]	0.34	0.29[1]	0.39[1]	0.44	0.38[1]
Sodium (mg)	**0.46**[1]	**0.53**	**0.47**[1]	**0.45**[1]	**0.51**	**0.45**[1]	0.19[1]	0.21	0.20[1]

[1] Pearson's correlation; [2]Spearman's correlation

*Cr: crude data; [†]Deat: Deattenuated data; [‡]Adjust: Adjusted data

Correlation values > 0.4 are highlighted in bold

Reproducibility

Most intraclass correlation coefficients (Table 5) ranged from 0.4 to 0.7, therefore, they were within the recommended levels and attributed good reproducibility to the tested instrument; potassium was the only

exception, since it recorded ICC equal to 0.28 between FFQs 1 and 3. The best correlations were found between FFQs 2 and 3, which recorded ICC higher than 0.7 for energy (0.8) and vitamin C (0.77).

Table 5. Mean energy and nutrient intake based on food frequency questionnaires (FFQs) and on intraclass correlation coefficients between FFQs. Maceió City - AL, 2011

Energy and Nutrients	Mean intake (standard deviation)			CCI*		
	FFQ 1	FFQ 2	FFQ 3	FFQ 1 and FFQ 2	FFQ 1 and FFQ 3	FFQ 2 and FFQ 3
Energy (Kcal)	2,641.53 (1,152.89)	2,390.57 (1,042.72)	2,568.92 (1,194.28)	0.63	0.69	**0.8**
Carbohydrate (g)	366.28 (166.15)	331.41 (157.02)	353.39 (172.72)	0.49	0.69	0.7
Lipid (g)	79.3 (43.60)	71.86 (37.04)	77.41 (47.98)	0.7	0.69	0.61
Protein (g)	115.67 (50.68)	104.55 (56.21)	114.66 (57.75)	0.66	0.59	0.7
Fiber (g)	16.85 (8.73)	15.81 (11.18)	16.25 (7.53)	0.6	0.57	0.67
Vit C (mg)	528.54 (669.97)	393.32 (327.53)	551.27 (593.73)	0.52	0.51	**0.77**
Vit E (mg)	8.8 (4.81)	7.87 (4.91)	8.66 (5.68)	0.64	0.58	0.65
Vit B_6 (mg)	1.95 (0.73)	1.74 (0.77)	1.91 (0.76)	0.7	0.56	0.69
Vit B_{12} (mcg)	9.51 (5.73)	12.99 (14.08)	13.34 (11.02)	0.4	0.44	0.54
Calcium (mg)	980.26 (536.17)	907.52 (553.24)	1078.96 (1215.39)	0.62	0.62	0.73
Magnesium (mg)	289.57 (98.57)	263.67 (112.88)	281.94 (134.49)	0.49	0.41	0.56
Potassium (mg)	3,374.88 (1,218.59)	3,003.06 (1,384.78)	3,354.49 (2,010.07)	0.45	**0.28**	0.59
Sodium (mg)	1,448.69 (1,019.11)	1,228.54 (776.77)	1,400.61 (959.00)	0.68	0.58	0.49

*ICC: intraclass correlation coefficient
Correlation values < 0.4 and > 0.7 are highlighted in bold

DISCUSSION

The validity and reproducibility of the quantitative FFQ developed for hypertensive and/or diabetic individuals was tested in a sample mostly composed of adult hypertensive and obese women, who were housewives, married or living in stable union, with complete primary education or incomplete secondary education, and who belonged to economic class D.

Based on the assessment of intake data collected in the applied surveys, it was possible observing that energy and most nutrients recorded higher intake rates among FFQs than in the three 24-HDRs (Table 3). Similar results were found in studies conducted by Marques-Vidal et al.,[37] Pakseresht & Sharma,[38] Kusama et al.,[39] Rodríguez et al.,[40] Fatihah et al.,[41] Papazian et al.,[42] Cantin et al.[43] and Moghames et al.[44] The likely overestimation attributable to FFQ, or the underestimation attributable to 24-HDR, observed in the present study could result from features inherent to the adopted instruments themselves. In the case of the herein developed FFQ, both the size of the food item list and the intake frequency options - which ranged from 0 to > 10 - were within the recommended range.[8]

FFQ reproducibility recorded higher correlations than its validity; this outcome was consistent with other studies.[2,10,11,45] The time elapsed between applications of the two FFQs is an important aspect influencing reproducibility, which can be overestimated when FFQ application intervals are too short because participants would remember the answers given in the first questionnaire. On the other hand, exceedingly long intervals would reduce correlations due to changes in participants' diet pattern.5 The mean time (one month) elapsed between the application of three FFQs in the present study was enough to avoid real changes in participants' diet and to stop them from remembering their previous answers. Thus, it is possible concluding that the strong correlation between FFQ applications corresponded, in fact, to its satisfactory reproducibility.

On the other hand, validity (Table 4) presented correlation coefficients similar to the ones recorded in other studies based on similar methodology.[10,37-39,41,46,47] Values recorded for non-adjusted WCs were comparable to macronutrient data available in the literature and were higher than values recorded for some micronutrients. The energy-based adjustment did not change, or even reduced, correlation coefficient values, as reported in another study.[18] According to Willett,[8] the energy-based adjustment tends to increase correlation coefficient values when nutrient intake variability is associated with energy intake; however, correlation coefficient values can decrease when nutrient variability results from systematic under or overestimation errors in food intake reports. As the present study found post-adjustment decrease in some correlation coefficients, it is possible speculating that these errors may have happened in reports of both methods.

The day-to-day variation in intra-individual food intake in the three 24-HDRs was corrected[17] by taking into consideration that the random intra-individual error in the measurement of variables subjected to comparisons tends to reduce correlation coefficients to zero. Thus, energy-based deattenuated and adjusted correlation coefficients between FFQs and the reference method were calculated - FFQ2 recorded the highest values after de-attenuation.

Although the intrapersonal variability in the herein investigated recalls was corrected, FFQs recorded deattenuated values lower than 0.4 for micronutrients; this outcome may be explained by variability in individual dietary intake. This fact points toward the need of carrying out more reference method applications to enable analyzing the intake of these micronutrients in a more accurate way.[18]

The herein analyzed data have shown greater correlation among information collected in the FFQ applied in the second research stage (FFQ2). Thus, it is possible raising two hypotheses: the first one is that interviewees were more familiar with the instrument and with its application form at the time they answered the FFQ2, a fact that would make them able to quantify the ingested portions;[48] whereas the second hypothesis referred to the incidence of the Hawthorne effect, i.e., participants would have changed their diet in the interval between interviews because of the research.[18,49] However, the same process was not observed in FFQ3 results.

The current study presented the following limitations: (1) The use of 24-HDR as reference method to validate the FFQ, since error sources can be associated with each other because both methods depend on participants' memory[6] - although the evaluation period between both methods is different (24h for dietary recall vs. months to 1 year interval for the FFQ), errors in the current study may have been minimized. (2) The application of only three 24-HDRs may have posed limitations to measure participants' usual intake of most micronutrients (from 2 to 28 24-HDRs, according to Slater et al.[17]), although it was within the recommended range and compatible to other studies of the same nature. (3) The sample size, which can influence the record of higher correlation coefficients for some nutrients. According to some researchers,[5,8] samples used in validity studies should comprise from 50 to 100 individuals; however, it is just a recommendation. Studies available in the literature have used different numbers of individuals, which ranged from 20 to 42 participants.[50,51] (4) Features inherent to the adopted methods, such as difficulty in obtaining the exact size of food portions consumed by participants, dependence on interviewees' memory and the likelihood of variations in participants' eating habits throughout the study,[49] as previously mentioned.

CONCLUSION

The herein developed quantitative FFQ has shown satisfactory reproducibility for energy, fibers and all evaluated nutrients. It presented acceptable validity for energy and macronutrients, as well as for calcium and sodium, in most FFQs. Although at lower values, correlation coefficients recorded for the other nutrients were compatible to the ones reported in other studies similar to the present one.

Thus, the FFQ developed in the current study was effective in assessing the food intake of individuals with systemic arterial hypertension and/or diabetes mellitus, who used Sistema Único de Saúde (SUS) - Brazilian Unified Health System - in Maceió City – AL. Thus, it can be used in nutritional epidemiology studies applied to this target population. In addition, this instrument can be incorporated to protocols focused on assisting patients affected by these conditions in Unidades Básicas de Saúde (UBS) - Basic Healthcare Units - in the herein investigate city.

REFERENCES

1. Ocké MC, Bueno-de-mesquita HB, Goddijn HE, Jansen A, Pols MA, Van Staveren WA, et al. The Dutch EPIC food frequency questionnaire. I. Description of the questionnaire, and relative validity and reproducibility for food groups. Intern J Epidemiol 1997;26(1):S37-S48. DOI: https://doi.or/10.1080/09637486.2016.1268099
2. Willett W. Future directions in the development of food-frequency questionnaires. Am J Clin Nutr 1994;59:171S-174S. DOI: 10.1093/ajcn/59.1.171S
3. Sampson, L. Food frequency questionnaires as a research instrument. Clin Nutr 1985;4:171-8.
4. Ferro-Luzzia A. Individual food intake survey methods. In: Proceedings of International Scientific Symposium on Measurement and Assessment of Food Deprivation and Undernutrition, 2002; Rome, Italy. Rome: Food and Agriculture Organization of the United Nations. p. 101-125, 2002.
5. Cade J, Thompson R, Burley V, Warm D. Development, validation and utilization of food-frequency questionnaires: a review. Public Health Nutr 2002;5(4):567-87. DOI: 10.1079/PHN2001318
6. Slater B, Philippi ST, Marchioni DML, Fisberg RM. Validação de Questionários de Frequência Alimentar - QFA: considerações metodológicas. Rev. bras. epidemiol 2003;6(3). DOI: https://doi.org/10.1590/S1415-790X2003000300003
7. Nelson M, Hague GF, Cooper C, Bunkers VW. Calcium Intake in the elderly: validation of a dietary questionnaire. J Human Nutr Diet 1989;1:115-27. DOI: https://doi.org/10.1111/j.1365-277X.1988.tb00443.x
8. Willett W. Nutritional Epidemiology. 2nd ed. New York: Oxford University Press; 1998, p. 514.

9. Lima FEL, Slater B, Latorre MR, Fisberg RM. Validade de um questionário quantitativo de frequencia alimentar desenvolvido para população feminina no nordeste do Brasil. Rev. bras. epidemiol 2007;10(4):483-90. DOI: https://doi.org/10.1590/S1415-790X2007000400006

10. Salvo VLMA, Gimeno SGA. Reprodutibilidade e validade do questionário de frequencia de consumo de alimentos. Rev Saúde Públ 2002;36(4):505-12. DOI: https://doi.org/10.1590/S0034-89102002000400018

11. Ribeiro AC, Sávio KEO, Rodrigues MLCF, Costa THM, Schmitz BAS. Validação de um questionário de frequência de consumo alimentar para população adulta. Rev Nutr 2006;19(5):553-62. DOI: 10.1590/S1415-52732006000500003

12. Silva TA, Vasconcelos SML. Procedimentos metodológicos empregados em questionários de frequência alimentar elaborados no Brasil: uma revisão sistemática. Rev Nutr (Impresso) 2012;25:785-797. DOI: https://doi.org/10.1590/S1415-52732012000600010

13. Beaton G, Burema J, Ritenbaugh C. Errors in the interpretation of dietary assessments. Am J Clin Nutr 1994;65:1100-1007. DOI: 10.1093/ajcn/65.4.1100S

14. Fisberg RM, Marchioni DML, Colucci ACA. Avaliação do consumo alimentar e da ingestão de nutrientes na prática clínica. Arq Bras Endocrinol Metab 2009;53(5):617-624. DOI: https://doi.org/10.1590/S0004-27302009000500014

15. Silva TA, Vasconcelos SML. Validação de questionários de frequência alimentar: uma revisão sistemática. DEMETRA Alimentação, Nutrição & Saúde 2013;8:197-212. DOI: https://doi.org/10.12957/demetra.2013.5892

16. Thompson FE, Byers T. Dietary assessment resource manual. J NUTR 1994;124:2245S-2317S. DOI: 10.1093/jn/124.suppl_11.2245s

17. Slater B, Marchioni D, Fisberg RM. Estimando a prevalência da ingestão inadequada de nutrientes. Rev Saúde Públ 2004;38(4):599-605. DOI: 10.1590/S0034-89102004000400019

18. Zanolla AF, Olinto MTA, Henn RL, Wahrlich V, Anjos LA. Avaliação de reprodutibilidade e validade de um questionário de frequência alimentar em adultos residentes em Porto Alegre, Rio Grande do Sul, Brasil. Cad. Saúde Pública 2009;25(4):840-848. DOI: https://doi.org/10.1590/S0102-311X2009000400015

19. Dwyer J. Avaliação dietética. In Tratado de nutrição moderna na saúde e na doença, 2nd ed, p.937-59. [SHILLS, Maurice ; OLSON, James ; SHIKE, Moshe, editors]. São Paulo: Manole; 2003.

20. Anastasi A, Urbina S. Testagem psicológica. 7 ed. Porto Alegre: Artes Médicas; 2000.

21. Lee J, Kolonel L, Hankin J. On establishing the interchangeability of different dietary-intake assessment methods used in studies of diet and cancer. Nutr Cancer 1989;5:215-8. DOI: 10.1080/01635588309513798

22. Sichieri, R.; Everhart, J. E. Validation of a brazilian food frequency questionnaire against dietary recalls and estimated energy intake. Nutr Res 1998;1649-1659. DOI: https://doi.org/10.1016/S0271-5317(98)00151-1

23. Fornés NS, Stringhini MLF, Elias BM. Reproducibility and validity of a food-frequency questionnaire for use among low-income Brazilian workers. Public Health Nutrition 2003;6(8):821–827. DOI: https://doi.org/10.1079/PHN2003505

24. Galante AP, Colli C. Desenvolvimento e aplicação de um questionário semiquantitativo de frequencia alimentar on-line para estimar a ingestão de cálcio e ferro. Rev Bras Epidemiol 2008;11(3):402-10. DOI: https://doi.org/10.1590/S1415-790X2008000300007

25. Matarazzo HCZ, Marchioni DML, Figueiredo RAO, Slater B, Neto JE, Filho VW. Reprodutibilidade e validade do questionário de frequência de consumo alimentar utilizado em estudo caso-controle de câncer oral. Rev Bras Epidemiol 2006;9(3):316-24. DOI: https://doi.org/10.1590/S1415-790X2006000300006

26. Pereira GA; Genaro PS; Santos LC; Sarkis KS; Pinheiro MM; Szjenfeld VL; Schuch NJ; Martini LA. Validation of a food frequency questionnaire for women with osteoporosis. J Nutr Health Aging 2009;13(5):403-7. DOI: 10.1007/s12603-009-0075-0

27. Fumagalli F, Monteiro JP, Sartorelli DS, Vieira MNCM, BianchiMLP. Validation of a food frequency questionnaire for assessing dietary nutrients in Brazilian children 5 to 10 years of age. Nutrition 2008;24 (5):427-32. DOI: 10.1016/j.nut.2008.01.008

28. Cardoso, M. A. & Stocco, P. R. Desenvolvimento de um questionário quantitativo de frequencia alimentar em imigrantes japoneses e seus descendentes residentes em São Paulo, Brasil. Cad Saúde Pública 2000;16 (1):107-14. DOI: https://doi.org/10.1590/S0102-311X2000000100011

29. Zabotto CB, Vianna RPT, Gil MF. Registro fotográfico para inquéritos dietéticos: utensílios e porções. Goiânia: Nepa-Unicamp; 1996.

30. Pinheiro ABV, Lacerda EMA, Benzecry EH, Gomes MCS, Costa VM. Tabela para avaliação de consumo alimentar em medidas caseiras. 5ªed. Rio de Janeiro: Atheneu; 2000.

31. Burley V, Cade J. Consensus Documento on the development, validation and utilization of food frequency questionnaires. The fourth International Conference on Dietary Assessment Methods. Tucson, Arizona (USA); 2000.

32. ASSOCIAÇÃO BRASILEIRA DE EMPRESAS DE PESQUISA (ABEP). Critério de Classificação Econômica Brasil. 2014. [acessado 2017 Nov 04]; Disponível em: http:// www.abep.org

33. Philippi ST. Tabela de composição de alimentos: suporte para decisão nutricional. 2ªed. São Paulo; 2002.

34. Núcleo de Estudos e Pesquisas em Alimentação (NEPA) – UNICAMP. TACO - Tabela brasileira de composição de alimentos. 2ª ed. Campinas: 2006.

35. Instituto Brasileiro de Geografia e Estatística (IBGE). Tabela de Composição de Alimentos. 5. Ed. – Rio de Janeiro: IBGE; 1999.

36. Pacheco M. Tabela de equivalentes, medidas caseiras e composição química dos alimentos. Rio de Janeiro: Rúbio; 2006.

37. Marques-Vidal P, Ross A, Wynn E, Rezzi S, Paccaud F, Decarl BI. Reproducibility and relative validity of a food-frequency questionnaire for French-speaking Swiss adults. Food Nutr Res 2011;55. DOI: 10.3402/fnr.v55i0.5905

38. Pakseresht M, Sharma S. Validation of a culturally appropriate quantitative food frequency questionnaire for Inuvialuit population in the Northwest Territories, Canada. J Hum Nutr Diet 2010;23(Suppl.1):75–82. DOI: 10.1111/j.1365-277X.2010.01105.x

39. Kusama K, Le DSNT, Hanh TTM, Takahashi K, Hung NTK, Yoshiike N, Yamamoto S. Reproducibility and Validity of a Food Frequency Questionnaire among Vietnamese in Ho Chi Minh City. J Am Coll Nutr 2005;24(6):466–473. DOI: https://doi.org/10.1080/07315724.2005.10719492

40. Rodriguez MM, Mendez H, Torun B, Schroeder D, Stein AD. Validation of a semi-quantitative food-frequency questionnaire for use among adults in Guatemala. Public Health Nutr 2002;5(5):691–698. DOI: https://doi.org/10.1079/PHN2002333

41. Fatihah F, Ng BK, Hazwanie H, Norimah AK, Nik Shanita S, Ruzita AT, Poh BK. 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):687-694. DOI: 10.11622/smedj.2015190

42. Papazian T, Hout H, Sibai D, Helou N, Younes H, El Osta N, Khabbaz LR. Development, reproducibility and validity of a food frequency questionnaire among pregnant women adherent to the Mediterranean dietary pattern. Clin Nutr 2016;35(6):1550-1556. DOI: 10.1016/j.clnu.2016.04.015

43. Cantin J, Latour E, Ferland-Verry R, Morales Salgado S, Lambert J, Faraj M, Nigam A. Validity and reproducibility of a food frequency questionnaire focused on the Mediterranean diet for the Quebec population. Nutr Metab Cardiovasc Dis 2016;26(2):154-61. DOI: 10.1016/j.numecd.2015.11.003

44. Moghames P, Hammami N, Hwalla N, Yazbeck N, Shoaib H, Nasreddine L, Naja F. Validity and reliability of a food frequency questionnaire to estimate dietary intake among Lebanese children. Nutr J 2016;15:4. DOI: 10.1186/s12937-015-0121-1

45. Mohammadifard N, Sajjadi F, Maghroun M, Alikhasi H, Nilforoushzadeh F, Sarrafzadegan N. Validation of a simplified food frequency questionnaire for the assessment of dietary habits in Iranian adults: Isfahan Healthy Heart Program, Iran. ARYA Atheroscler 2015;11(2):139-46.

46. Sharma S, Iwasaki M; Kunieda C; Cao X; Ishihara J; Hamada G; Miyajima NT; Tsugane S; Marchand LL. Development of a quantitative food frequency questionnaire for assessing food, nutrient, and heterocyclic aromatic amines intake in Japanese Brazilians for a colorectal adenoma case-control study. Int J Food Sci Nutr 2009;60(7):128-39. DOI: 10.1080/09637480902740790

47. Khalesi S, Doshi D, Buys N, Sun J. Validation of a short food frequency questionnaire in Australian adults. Int J Food Sci Nutr 2017;68(3):349-357. DOI: 10.1080/09637486.2016.1240763

48. Pietinen P, Hartman A, Haapa E, Rasamen L, Haapakoski J, Palmgren J, et al. Reproducibility and validity of dietary assessment instruments II. A qualitative food frequency questionnaire. Am J Epidemiol 1988;128:667-76.

49. Tsubono Y, Nishino Y, Fukao A, Hisamichi S, Tsugane S. Temporal change in the reproducibility of a self-administered food frequency questionnaire. Am J Epidemiol 1995;142(11):1231-5. DOI: https://doi.org/10.1093/oxfordjournals.aje.a117582

50. Nath SD, Huffman FG. Validation of a semiquantitative food frequency questionnaire to assess energy and macronutrient intakes of Cuban Americans. Int J Food Sci Nutr 2005;56(5):309-14. DOI: https://doi.org/10.1080/09637480500284993

51. Brunst KJ, Kannan S, Ni YM, Gennings C, Ganguri HB, Wright RJ. Validation of a Food Frequency Questionnaire for Estimating Micronutrient Intakes in an Urban US Sample of Multi-Ethnic Pregnant Women. Matern Child Health J 2016;20(2):250–260. DOI: 10.1007/s10995-015-1824-9

Contributors

Ataide-Silva T has developed the study idea, implemented the methodology (data collection, tabulation and analysis) and contributed to manuscript writing; Padilha CC and Amorim MF have contributed to data collection and tabulation, as well as to manuscript writing; Santos EA has contributed to data analysis and manuscript writing; Vasconcelos SML has helped developing the study idea, contributed to the critical analysis of manuscript writing and supervised the study.

Conflict of Interest: The authors declare no conflict of interest.

Received: July 24, 2019
Accepted: November 27, 2019