

Calibration of the dietary data obtained from the Brazilian center of the *Natural History of HPV Infection in Men* study: the HIM Study

Calibração dos dados dietéticos obtidos no centro brasileiro do estudo *Natural History of HPV Infection in Men*: o Estudo HIM

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Abstract

The objective of this study was to estimate the regressions calibration for the dietary data that were measured using the quantitative food frequency questionnaire (QFFQ) in the Natural History of HPV Infection in Men: the HIM Study in Brazil. A sample of 98 individuals from the HIM study answered one QFFQ and three 24-hour recalls (24HR) at interviews. The calibration was performed using linear regression analysis in which the 24HR was the dependent variable and the QFFQ was the independent variable. Age, body mass index, physical activity, income and schooling were used as adjustment variables in the models. The geometric means between the 24HR and the calibration-corrected QFFQ were statistically equal. The dispersion graphs between the instruments demonstrate increased correlation after making the correction, although there is greater dispersion of the points with worse explanatory power of the models. Identification of the regressions calibration for the dietary data of the HIM study will make it possible to estimate the effect of the diet on HPV infection, corrected for the measurement error of the QFFQ.

Dietary Surveys; Questionnaires; Cohort Studies

Introduction

Quantitative food frequency questionnaires (QFFQ) are one of the most commonly used methods for evaluating habitual dietary intake in large-scale epidemiological studies, given their low cost and ease of application ^{1,2}. However, the errors present in the measurements of the questionnaire may attenuate the estimates of the relative risks that are found, and thus diminish the statistical power of studies evaluating the relationship between diet and disease ^{2,3}.

Knowing that error is inherent in food intake measurements, methodological strategies have been developed in an attempt to make the measurements obtained through the QFFQ closer to the quantities actually consumed, which are estimated through reference methods that are supposedly error-free ^{4,5}. This methodology is called calibration and it basically can be seen as a scale adjustment to the questionnaire measurements ⁶. Among parametric methods, calibration by means of linear regression is considered to be the standard ⁷. Through this methodology, the consumption measured using the reference method is modeled as a function of the QFFQ measurement ^{3,7}. The linear regression models obtained through calibration studies can be used to estimate food intake that is closer to reality, taking the QFFQ values as the basis ⁸.

Twenty-four-hours recall (24HR) is the primary instrument used in dietary surveillance ⁹

and is commonly used as the reference method in calibration studies. When it is assumed that the random errors in the questionnaire and in the reference method are independent from each other [$\text{Cov}(\varepsilon_R, \varepsilon_Q) = 0$], it is not expected that the errors in the reference method will cause erroneous estimates for calibration coefficients¹⁰. However, studies have shown that energy intake on these self-reported instruments is underreported and this fact appears to be selective according to personal characteristics^{9,11,12,13}.

The *Natural History of HPV Infection in Men* study (the HIM Study) is a prospective multicenter cohort study that analyzes, among other factors, participants' diets by seeking to identify nutrients and/or foods that are involved in the evolution of human papillomavirus (HPV) infection in men and in the development of diseases related to HPV. The QFFQ was the method chosen for measuring the food intake of the Brazilian population of the HIM study.

This study aimed to estimate the regressions calibration for the QFFQ used in the HIM study in Brazil through multiple linear regression models, taking three 24HR as the reference. As part of the objective, the effect of calibration was verified by comparing the calibrated data of QFFQ with the reference method.

Methods

Study population

The design of the HIM study, funded by the National Institutes of Health (NIH), was presented in a more detailed manner in a previous paper¹⁴. For the HIM study, conducted from 2005 to 2013, around 1,427 men from Tampa, USA; 1,429 from Cuernavaca, Mexico and 1,443 from São Paulo, Brazil, aged between 18 and 70 years were selected using convenience sampling.

Out of the 153 participants who performed the visit between January and September 2007 for the Brazilian cohort, the first 120 individuals who agreed to participate in the calibration study comprised the sub-sample. Individuals with energy consumption less than 500kcal or greater than 4,000kcal were excluded and thus 98 men were included in the sub-sample for the calibration study¹⁶.

Assessment of food consumption

The sub-sample answered one 24HR and one QFFQ in the baseline. After six months another 24HR and QFFQ was answered. One year later than the first interview the participants answered

a last 24HR and QFFQ, all of them by personal interview. This study used three 24HR and the last QFFQ. The dietary methods were completed on the same day, the QFFQ first and then the 24HR¹⁷. The interviews last for approximately 35-45 minutes per person. For each dietary method, a manual of standardized procedures was developed.

• QFFQ: test method

The methodology for developing the QFFQ that was used in the HIM study in Brazil is available in a previously published paper¹⁸. This questionnaire was developed based on the dietary intake of a representative sample in the city of São Paulo that had been identified in a population-base study¹⁹. In the HIM study in Brazil, the questionnaires were answered during an interview and, for each of the 54 food items listed, the participants indicated their frequency of consumption (from 0-10 times a day, week, month or year) and the portion consumed (small, medium, large or extra large). A spreadsheet containing the nutritional composition of each food item, created using the Nutrition Data System for Research (NDSR) software, 2007 version (University of Minnesota, Minneapolis, USA), was used for calculating the energy and nutrient intake.

• 24HR: reference method

The three 24HR were answered by means of face-to-face interviews, using a standard form that was filled out using the multiple-pass method^{20,21}. This method consists of three elements: rapid listing, detailed description and review. In the HIM study in Brazil, the subjects were asked to describe all the foods and drinks consumed during the preceding day, from the first to the last item consumed before going to bed. After the foods consumed had been reported, the subjects were asked about the times and quantities. The data were critically reviewed by a nutritionist and undergraduate nutrition students in order to identify any discrepancies related to the descriptions of the foods or preparations consumed, or their portioning and quantification. The energy and nutrient intakes were calculated using the NDSR software. The distribution of the consumption was adjusted for within-person variability (deattenuation) by means of the method proposed by Iowa State University, using the PC-SIDE software (personal computer version of the Software for Intake Distribution Estimation, version 1.0, Department of Statistics, Iowa State University, Ames, USA).

Variables tested in the linear regression models

It is well accepted that some personal characteristics have influence in the report of dietary intake^{9,11,12,13}. In this study there was an attempt to minimize these effects with the inclusion of socio-demographic variables in the models. The variables tested as adjustments in the multiple linear regression models that were developed for energy and each of the nutrients were: body mass index (BMI; calculated as the weight in kilograms divided by the square of the height in meters); age (years); income, schooling and physical activity (categorized).

BMI and age were tested in the regression models as continuous quantitative variables. Income and schooling were transformed into dichotomous variables. Income was categorized as "0" when the total family income was less than \$ 1,608 and "1" when greater than or equal to this value. The variable schooling was categorized as "0" when the participant had less than 12 years of study and "1" when greater than or equal to this value.

The study participants answered the *International Physical Activity Questionnaire* (IPAQ; short version)²². From the data thus obtained, they were classified as "sedentary", "insufficiently active B", "insufficiently active A", "active" or "very active"²³.

To the physical activity variable were created two dummy variables. Physical activity I representing the active level of physical activity in relation to sedentary/insufficiently active A and B and physical activity II representing the very active level of physical activity in relation to sedentary/insufficiently active A and B.

Statistical analysis

• Linear regression models

The data on the nutrients measured by the QFFQ and 24HR were transformed into natural logarithms and adjustments for energy were made using the residuals method²⁴.

Taking \mathcal{E}_R to be the independent random errors presented by the QFFQ measurements (Q) and assuming a linear relationship between the questionnaire measurements and the true intake levels (24HR), an estimate was made for the intake level predicted by the reference measurement in relation to the measurement QFFQ ($E[R|Q]$), in which R was the dependent variable (Y) and Q was the independent variable (X)¹⁰.

$$Y = \beta_0 + \beta_1 X + \varepsilon_R \Leftrightarrow \quad (1)$$

$$\hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 X \Leftrightarrow \quad (2)$$

$$R = \hat{\beta}_0 + \hat{\beta}_1 Q \quad (3)$$

$\hat{\beta}_1$, which is the slope of the straight line estimated from the regression analysis, is called the calibration coefficient and is known as λ . The literature suggests that calibration using linear regression models should be done with adjustments for possible variables (C_i) that would influence the R measurements^{9,11,12,13}.

$$R = \beta_0 + \lambda Q + \beta_i C_i \quad (4)$$

In this study, the variables of BMI, age, income, schooling and physical activity were selected to be tested in the multiple models. For energy and each nutrient within the R measurement, univariate linear regression analysis was performed and, from the above variables, the ones that presented $p < 0.20$ in the multiple models were selected. Next, a regression function between the R and Q measurements was produced and the selected variables were included in multiple models.

Interactions between the variables that remained in the final model were tested, but no significant interaction was observed. The assumed linear relationship between the variables was evaluated by means of the graphs on the residuals, and these showed that the models were adequate.

The QFFQ data were calibrated using the equations estimated from the regression analyses. The geometric means and respective 95% confidence intervals (95%CI) were calculated for the QFFQ data after adjustment for energy and after calibration. Likewise, they were calculated for the 24HR after deattenuation and adjustment for energy. The Mann-Whitney U test was used to identify differences between the means of the 24HR and of the QFFQ calibrated and non-calibrated.

Dispersion graphs between the 24HR and QFFQ measurements corrected by the calibration were produced in order to assess whether there was any increase in the correlation between the instruments, with regard to protein, thiamin and phosphorous. These nutrients were chosen because of the increase in statistical power observed with the inclusion of adjustment variables in the multiple models used for the calibration.

P values < 0.05 were considered statistically significant, and all analyses were performed using the Stata software release 10 (Stata Corp., College Station, USA).

Ethical issues

This study was approved by the Research Ethics Committees of the Reference and Training Center in Sexually Transmitted Diseases and in Acquired Immune Deficiency Syndrome (CRT-DST/AIDS) and of the School of Public Health of the University of São Paulo. Participation in the study was conditional on signing the free and informed consent statement.

Results

Representativeness and characterization of the sample

The participants in the calibration study presented characteristics that resembled those of the participants in the Brazilian cohort. There were no differences between the groups regarding age. Within the subsample, the mean age was 35.8 ± 10.0 years, compared with 37.7 ± 11.9 for the sample of the whole cohort ($p = 0.27$). The BMI was similar between the groups, with a mean of $25.6 \pm 4.4 \text{ kg/m}^2$ for the subsample and a mean of $26.1 \pm 3.6 \text{ kg/m}^2$ for the whole cohort ($p = 0.10$). The participants in the subsample and whole cohort presented equivalent schooling and income levels ($p = 0.84$ and $p = 0.54$, respectively). This group had a mean BMI indicating overweight and most had attended school for more than 12 years and had a family income of between R\$ 1,001 and R\$ 3,000 (between US\$ 543 and US\$ 1,627) per month. In relation to levels of physical activity, 52.2% of participants were considered active, 33.7% sedentary, insufficiently active B or A, and 14.1% very active.

Calibration of the nutrient intake data

The regression coefficients ($\hat{\beta}_1$), in simple linear regression analysis, ranged from 0.06 for total fat to 0.45 for fiber. In the regressions calibration, the variable of income was the one associated with the greatest number of nutrients, followed by physical activity and age. The power of the multiple models (R^2a) ranged from 0.02 for mono-unsaturated and polyunsaturated fat to 0.33 for phosphorous and these models presented better explanatory power in relation to simple analyses (Table 1).

The geometric means and 95%CI for energy and nutrients measured using 24HR and QFFQ are presented in Table 2. Comparing the data from the 24HR (deattenuated and adjusted for energy) with the data from the QFFQ (adjusted for energy), the means are statistically equal for

saturated fat, trans fat, cholesterol, vitamin C and calcium. The geometric means for the deattenuated and energy-adjusted 24HR measurements and for the calibration-corrected QFFQ measurements were statistically equal for energy and all the nutrients studied.

The dispersion graphs (Figure 1) between the QFFQ and 24HR values demonstrate increased correlation between the instruments after making the correction for the data calibration, although there is greater dispersion of the points with worse explanatory power of the multiple linear regression models (R^2a).

Discussion

The HIM study is the first cohort study in Brazil for which regressions calibration were calculated to enable correction of the estimated effect measurements. Although there is debate in the current literature regarding the performance of the food frequency questionnaire^{25,26,27}, thereby indicating that calibration studies are needed, studies using calibration methodology are not common. The stimulus for conducting calibration studies is that they generate deattenuation factors for the relative risk (RR) estimates that are found in studies evaluating the relationship between diet and disease²⁵, particularly in the case of questionnaires that have been developed and are being used for the first time, as is the case of the Brazilian QFFQ of the HIM study²⁸.

The models for calibrating the QFFQ for use in the HIM study in Brazil were estimated by means of multiple linear regression, in which regression was performed on three 24HR as a function of QFFQ and specific adjustment variable for each nutrient. According to Rosner et al.³, the ideal would be for the intercepts (β_0) to be close to zero and for the straight-line slope (β_1) to be close to one, in order to be able to affirm that bias was absent from the questionnaire. Since bias is known to be present in the questionnaire, the straight-line slope of the regression is, in practice, less than one. It was observed that the slopes of the straight lines estimated by the simple linear regression in the Brazilian HIM study were between 0.06 for total fat and 0.45 for fibers. Similar intercept values were observed by other authors in international cohort studies, in relation to calcium, iron and fiber, although for the other nutrients, the values obtained in these studies were closer to one. In the *European Prospective Investigation into Cancer and Nutrition* (EPIC), the values of the calibration coefficients ranged from 0.30 to 0.59 for Swiss men and from 0.23 to 0.56 for Norwegian women, for the same

Table 1

Simple and multiple linear regression models considered for calibrating the quantitative food frequency questionnaire (QFFQ) data. *Natural History of HPV Infection in Men: the HIM Study, Brazil, 2007-2008.*

	Simple linear regression			Multiple linear regression: regression calibration									
	β_1 (95%CI), in log, adjusted by energy	p-value *	R ²	λ (95%CI), in log, adjusted by energy	β_0	Income	Physical activity I	Physical activity II	Age (years)	Schooling	BMI (kg/m ²)	p-value *	R ^{2a}
Energy (kcal)	0.28 (0.15; 0.41)	0.00	0.16	0.21 (0.08; 0.34)	6.46 *	-	0.08	0.06	-	-	-0.014 *	0.00	0.24
Nutrients													
Protein (g)	0.15 (0.04; 0.26)	0.01	0.07	0.17 (0.07; 0.27)	3.92 *	0.02 *	-	-	-0.003 *	-0.04 *	-	0.00	0.24
Carbohydrate (g)	0.25 (0.09; 0.41)	0.00	0.09	0.20 (0.03; 0.37)	4.50 *	-0.01	-	-	0.002 *	-0.04	-	0.00	0.15
Dietary Fiber (g)	0.45 (0.26; 0.63)	0.00	0.19	0.45 (0.26; 0.63)	1.55 *	-	-	-	-	-	-	0.00	0.19
Total fat (g)	0.06 (-0.10; 0.21)	0.49	0.00	0.03 (-0.14; 0.21)	4.27 *	-	0.17	0.07 *	-	0.04	-	0.09	0.05
Saturated fat (g)	0.18 (0.02; 0.34)	0.03	0.05	0.18 (0.02; 0.34)	2.75 *	-	-	-	-	-	-	0.03	0.05
Monounsaturated fat (g)	0.10 (-0.04; 0.23)	0.15	0.02	0.10 (-0.04; 0.23)	3.06 *	-	-	-	-	-	-	0.15	0.02
Polyunsaturated fat (g)	0.21 (-0.06; 0.48)	0.13	0.02	0.21 (-0.06; 0.48)	2.38 *	-	-	-	-	-	-	0.13	0.02
Trans fat (g)	0.15 (-0.00; 0.30)	0.05	0.04	0.19 (0.01; 0.37)	0.10 *	-	0.04	0.17	-	-	-	0.05	0.05
Cholesterol (mg)	0.13 (0.03; 0.23)	0.01	0.07	0.10 (-0.00; 0.20)	5.22 *	0.04 *	-	-	-0.005 *	-	-	0.00	0.13
Vitamin A (IU)	0.20 (0.08; 0.31)	0.00	0.10	0.16 (0.04; 0.28)	7.13 *	0.09 *	-	-	0.003	-	-	0.00	0.17
Thiamin (mg)	0.16 (-0.03; 0.35)	0.09	0.03	0.19 (0.00; 0.37)	0.41 *	-	0.02	-0.09 *	-	-	0.005 *	0.00	0.14
Riboflavin (mg)	0.30 (0.17; 0.43)	0.00	0.18	0.30 (0.17; 0.43)	0.46 *	-	-	-	-	-	-	0.00	0.18
Niacin (mg)	0.17 (0.03; 0.31)	0.01	0.06	0.17 (0.03; 0.31)	2.61 *	-	-	-	-	-	-	0.01	0.06
Folate (mg)	0.28 (0.13; 0.43)	0.00	0.13	0.24 (0.09; 0.39)	4.86 *	-	-	-	-	-0.05	-	0.00	0.13
Vitamin C (mg)	0.31 (0.13; 0.48)	0.00	0.11	0.25 (0.05; 0.45)	3.10 *	0.13 *	0.20	0.17	-	-	-	0.00	0.14
Vitamin E (mg)	0.31 (0.12; 0.50)	0.00	0.10	0.31 (0.12; 0.50)	1.45 *	-	-	-	-	-	-	0.00	0.10
Calcium (mg)	0.43 (0.30; 0.55)	0.00	0.32	0.43 (0.30; 0.55)	3.83 *	-	-	-	-	-	-	0.00	0.32
Phosphorous (mg)	0.36 (0.24; 0.49)	0.00	0.25	0.35 (0.21; 0.48)	4.80 *	0.02 *	-	-	-0.003 *	-	-	0.00	0.33
Iron (mg)	0.40 (0.22; 0.58)	0.00	0.16	0.37 (0.18; 0.56)	1.92 *	-	0.02	-0.10 *	-	-	-	0.00	0.21

95%CI: 95% confidence interval; BMI: body mass index; log: natural logarithm.

* p < 0.05: the variable is statistically significant.

Table 2

Geometric means and 95% confidence interval (95%CI) for quantitative food frequency questionnaire (QFFQ) and 24-hours recall (24HR) values with the deattenuated nutrient data, adjusted for energy and after correction by the calibration. *Natural History of HPV Infection in Men: the HIM Study, Brazil, 2007-2008.*

	24HR		QFFQ		
	Geometric means (95%CI)		Geometric means (95%CI)		
	Deattenuated and adjusted by energy	Adjusted by energy	p-value *	Adjusted by energy and calibrated	p-value *
Energy (kcal)	2,340.4 (2,235.2; 2,450.5)	2,111.8 (1,976.4; 2,256.5)	0.02	2,350.2 (2,255.1; 2,449.3)	0.80
Nutrients					
Protein (g)	96.6 (94.8; 98.4)	78.1 (75.5; 80.8)	0.00	96.4 (95.5; 97.3)	0.73
Carbohydrate (g)	288.6 (282.0; 295.4)	260.7 (253.4; 268.1)	0.00	289.2 (286.2; 292.3)	0.70
Dietary Fiber (g)	19.0 (18.0; 20.0)	22.9 (21.7; 24.1)	0.00	19.0 (18.6; 19.4)	0.81
Total fat (g)	85.7 (84.0; 87.5)	81.1 (79.0; 83.2)	0.01	85.8 (85.3; 86.3)	0.97
Saturated fat (g)	28.8 (28.0; 29.7)	28.0 (27.0; 29.1)	0.33	28.8 (28.6; 29.0)	0.26
Monounsaturated fat (g)	29.4 (28.8; 30.0)	27.9 (27.0; 28.8)	0.03	29.4 (29.3; 29.5)	0.78
Polyunsaturated fat (g)	19.8 (19.0; 20.5)	17.8 (17.3; 18.3)	0.00	19.8 (19.6; 19.9)	0.81
Trans fat (g)	3.7 (3.5; 3.9)	3.9 (3.7; 4.2)	0.10	3.7 (3.6; 3.8)	0.59
Cholesterol (mg)	270.3 (257.3; 283.9)	229.4 (207.9; 253.1)	0.06	267.0 (261.6; 272.6)	0.65
Vitamin A (IU)	6,386.1 (5,948.4; 6,856.0)	8,583.3 (7,634.8; 9,649.6)	0.00	6,409.0 (6,197.2; 6,628.0)	0.97
Thiamin (mg)	1.9 (1.8; 1.9)	1.6 (1.5; 1.6)	0.00	1.9 (1.9; 1.9)	0.48
Riboflavin (mg)	1.9 (1.8; 1.9)	1.7 (1.6; 1.8)	0.00	1.9 (1.8; 1.9)	0.77
Niacin (mg)	22.2 (21.8; 22.7)	18.1 (17.5; 18.6)	0.00	22.2 (22.1; 22.4)	0.64
Folate (mg)	538.8 (524.1; 554.0)	394.2 (380.5; 408.4)	0.00	541.0 (535.2; 546.8)	0.57
Vitamin C (mg)	86.0 (76.2; 97.0)	100.5 (88.1; 114.8)	0.07	85.9 (81.1; 90.9)	0.83
Vitamin E (mg)	7.3 (7.1; 7.6)	5.8 (5.6; 6.0)	0.00	7.3 (7.2; 7.4)	0.76
Calcium (mg)	795.1 (758.8; 833.1)	774.5 (728.1-823.9)	0.41	795.9 (776.0; 816.4)	0.83
Phosphorous (mg)	1,327.0 (1,297.9; 1,356.8)	1,232.7 (1,195.4; 1,271.2)	0.00	1,325.3 (1,307.7; 1,343.2)	0.83
Iron (mg)	17.8 (17.4; 18.3)	13.4 (13.0; 13.8)	0.00	17.8 (17.6; 18.1)	0.96

* p < 0.05: there is difference between geometric means from 24HR and QFFQ.

nutrients investigated^{29,30}. Direct comparison of the data obtained in calibration studies such as the current study on the QFFQ for the HIM study in Brazil, with data from previous investigations, should be done cautiously because of the variations in the data analysis methodology. The EPIC studies cited above used the same instrument as the reference method (24HR), but the number of repetitions, the sample sizes and the nature of the population groups differed^{29,30,31}.

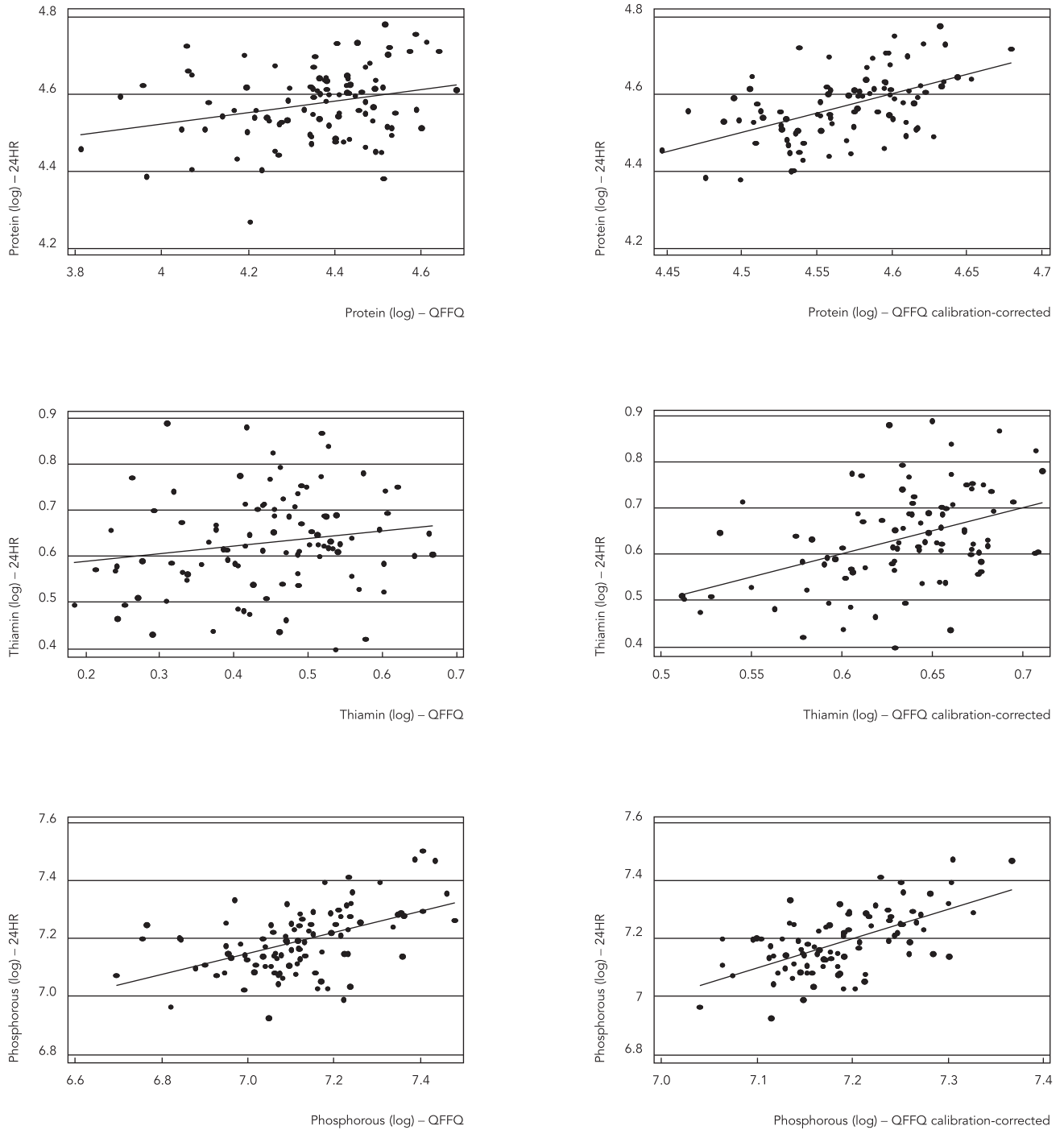
The models obtained in the multiple regression analyses can be applied to correct the RR obtained in the main study³². The observed attenuation of the regression coefficients values (β_1) may have been a reflection of the presence of random errors in the QFFQ measurements used in the HIM study in Brazil³³. This attenuation may also have occurred through violation of the theoretical assumptions of the calibration method¹⁶. For the calibration coefficients, considered

in this study as the regressions calibration (the complete model), to provide a valid correction of the relative risk estimates, it needs to be assumed that the errors in the reference method (in this case, 24HR) and in the QFFQ are not correlated^{3,29,32,34}. However, the errors in the two instruments probably do have a positive correlation, and this causes diminishment of the correlation coefficients²⁹. To estimate the regressions calibration in the HIM study in Brazil, data from the 24HR and QFFQ were used with adjustments for energy as a means of reducing the correlation between the errors^{16,29}.

When there is a strong correlation between the consumption of a nutrient and energy, the true relationship between this nutrient and a given disease cannot be identified from analysis of the results obtained³⁵. The adjustment for energy is made with the aim of estimating the consumed quantity of a specific nutrient, independent of

Figure 1

Dispersion graphs between the deattenuated energy-adjusted 24-hour recall (24HR) values and the energy-adjusted calibration-corrected quantitative food frequency questionnaire (QFFQ) values, for protein, thiamin and phosphorous. *Natural History of HPV Infection in Men: the HIM Study, Brazil, 2007-2008.*



the quantity of energy consumed. As expected, after adjustment for energy in the present study, it was observed that there was no change in the geometric mean consumption: only the confidence interval decreased, thereby suggesting that the precision in estimating the value increased (data not presented).

The method used as the reference for calibrating the QFFQ for the HIM study in Brazil has the characteristic of high within-person variability, because of the unstable nature of individuals' diets. Nonetheless, it is commonly used in this type of study¹⁰. The variability may be diminished through increasing the number of repetitions of the reference method and the sample size^{10,36}. One precaution taken in the present calibration study was to make the measurements of the reference method as close as possible to the habitual intake, before including them in the model. By using the 24HR three times, it was possible to adjust the energy and nutrient consumption for the within-person variability. These adjustments were made in an attempt to minimize the errors through correcting for the distribution of the consumption. The method used for this adjustment has been indicated as one of the most efficient methods for estimating habitual intake³⁷. Therefore, it was assumed that the number of repetitions of the 24HR that were performed, together with the deattenuation of the data, was sufficient to diminish the within-person variation.

Some studies have shown that personal and socioeconomic characteristics have an influence on food consumption reports. Underreporting has been shown to be more prevalent among women, rather than men and seems to be more common among older people than among younger. Overweight is also associated with underreporting^{9,38,39,40} as well as year of study and education appear to be independent predictors of underreporting³⁸. When comparing underreporters with those people who report accurately, underreporters tend to report being less physically active⁴⁰. Because of these factors it was decided to test and include adjustment variables in the multiple linear regressions, thereby enabling better estimates of the regression calibration and increasing the explanatory power of the models^{41,42,43,44}. One example can be given by the correction of the protein consumption data of the QFFQ through the calibration: the simple linear regression between the deattenuated 24HR data and the energy-adjusted QFFQ data produced an estimated regression coefficient of 0.15 (95%CI: 0.04-0.26), with an explanatory power for the model of 0.07 (R^2). When other variables were included the power of the model increased to

0.24 (R^2 a). When the equation from multiple regression on the QFFQ data was applied, it was seen from the dispersion graph that a clear adjustment of the data had occurred in relation to the 24HR. The inclusion of other variables in the model made it possible for the QFFQ values to be brought close to those of the reference model, thereby indicating the importance of evaluating the model in its entirety, in interpreting the data, and not just the regression coefficients or calibration factors. However, the explanatory power of the models was not presented in other calibration studies, which made comparisons impossible.

Both for energy and for all the nutrients evaluated, the confidence interval of the QFFQ data decreased after the correction according to the calibration, while statistical differences between calibrated data and data from the reference method disappear. Just as in studies in other countries, the same behavior in relation to standard deviations was described in a study on adolescents in Brazil^{45,46,47}. This adjustment of the distribution occurred through correction of the classification errors among individuals. Extreme values were especially affected because this was a linear regression to which the instruments were subjected⁵.

A limitation that can be pointed out is that the sample of the calibration study was selected by convenience. The principal problem of this kind of sampling is that it can lead to a group that is not representative of the population under study. The representativeness of the sub-sample was tested and the participants of the calibration study represent the population of the HIM study as they do not show statistical differences regarding age, body mass index, education and income.

The use of dietary data generated by the QFFQ in epidemiological studies without any type of correction may explain the conflicting results or inconsistencies presented in some of them^{3,16}, including studies that evaluated the influence of diet on the process of infection by HPV and the development of lesions relating to the virus. However, after correction of QFFQ data based on linear regression analyses in which the reference method is as much based on reports as the QFFQ is, and is subject to similar errors, the relative risks may be biased^{48,49}. Biomarkers can be used to make consumption measurements more accurate and consequently also the relative risk estimates. However, only a limited number of biomarkers are known and, even so, their use in large-scale studies is not viable because of the high costs involved⁵⁰. In any event, the use of reference methods based on reports for calibrating dietary data is still more attractive than using the

crude data in studies that evaluate the relationship between diet and disease³².

Conclusion

In the present study, the results from the calibration of the QFFQ that was used in the HIM study in Brazil were presented. The minimization of the measurement errors through correcting the data according to the calibration was expected. However, to analyze the relationships between dietary factors and the history of HPV infection in men, data with and without correction by the calibration should be used comparatively.

Resumo

O objetivo foi estimar as regressões de calibração dos dados dietéticos mensurados pelo questionário quantitativo de frequência alimentar (QQFA) utilizado no Natural History of HPV Infection in Men: o Estudo HIM. Uma amostra de 98 indivíduos do estudo HIM respondeu, por meio de entrevista, a um QQFA e três recordatórios de 24 horas (R24h). A calibração foi feita por meio de análise de regressão linear, tendo os R24h como variável dependente e o QQFA como variável independente. Idade, índice de massa corporal, atividade física, renda e escolaridade foram utilizadas como variáveis de ajuste nos modelos. As médias geométricas dos R24h e do QQFA corrigido pela calibração são estatisticamente iguais. Os gráficos de dispersão entre os instrumentos demonstraram aumento da correlação após a correção dos dados, porém observa-se maior dispersão dos pontos de acordo com a piora do poder explicativo dos modelos. A identificação das regressões de calibração dos dados dietéticos do estudo HIM permitirá a estimativa do efeito da dieta sobre a infecção por HPV, corrigida pelo erro de medida do QQFA.

Inquéritos sobre Dietas; Questionários; Estudos de Coorte

Contributors

J. A. Teixeira participated in the analysis and interpretation of the data, and in the write up of the article. M. L. Baggio collaborated on the project and conception of the article. R. M. Fisberg contributed towards the project and article conception and approved the final version for publication. D. M. L. Marchioni also participated in the project and article conception, data interpretation and critical review of the relevant content.

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