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### REFERÊNCIA

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# Validation of a quantitative food frequency questionnaire developed to under graduate students

## *Validação de um questionário quantitativo de frequência alimentar desenvolvido para universitários*

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## **Abstract**

A validity test of a Food Frequency Questionnaire was carried out using 50 students of health occupation in São Paulo, Brazil. Therefore, a three day dietary record was used as reference method and variables such as energy, macronutrients and dietary fiber were analyzed. The accordance between the Food Frequency Questionnaire and average data from dietary record was tested with kappa statistics and intra-class correlation coefficients (ICC). Limits of agreement were estimated by the Bland-Altman's method. Better results were found for calories (ICC 0.43; 95%CI 0.17 – 0.63) and non-energy-adjusted nutrients, except dietary fiber (ICC 0.34; 95%CI 0.07 – 0.56). The percentage of individuals classified in the same category of consumption was nearly half (49.8%), while only 16% of them were classified in opposite categories. With the exception of lipids, other analyzed variables tended to be overestimated by the Food Frequency Questionnaire. The Food Frequency Questionnaire is recommended as a method of assessing food intake of university students in studies which focus on calorie estimates and also intend to classify groups into intake categories.

**Keywords:** Food consumption. Questionnaires. Validation Studies. Student Health Services.

## Resumo

Validou-se um Questionário Quantitativo de Frequência Alimentar em 50 graduandos em Saúde de São Paulo, Brasil. Considerou-se o registro alimentar de 3 dias como referência e variáveis energia, macronutrientes e fibras alimentares. A concordância entre o Questionário Quantitativo de Frequência Alimentar e a média dos registros alimentares de 3 dias foi avaliada pela estatística kappa, pelo coeficiente de correlação intraclassa (ICC) e percentual de concordância. Os limites de concordância foram examinados pelos gráficos de Bland-Altman. Melhores valores de coeficiente de correlação intraclassa foram encontrados para calorias (ICC 0,43; IC95% 0,17 - 0,63) e para nutrientes não ajustados por calorias, com exceção das fibras (ICC 0,34; IC95% 0,07 - 0,56). O percentual de concordância mostrou uma minoria classificada em terços opostos (16%) e aproximadamente metade classificada no mesmo terço (49,8%). Houve tendência à superestimação nos dados do Questionário Quantitativo de Frequência Alimentar para calorias e nutrientes, exceto gorduras. Recomenda-se a utilização deste instrumento em população universitária em estudos que visem à estimativa de calorias, bem como à classificação dos indivíduos em categorias de consumo.

**Palavras-chave:** Consumo de alimentos. Questionários. Estudos de validação. Serviços de Saúde para Estudantes.

## Introduction

Epidemiological studies provide evidence able to identify risk factors and the importance of the diet in the prevention of non-transmissible chronic diseases (NTCDs)<sup>1-3</sup>.

The quantification and assessment of the diet are difficult tasks, although vital to the relationship between nutrients and NTCDs and in the monitoring of individual and populational dietetic behavior<sup>4,5</sup>. Those studies belong to the nutritional epidemiological area<sup>6</sup>.

Several types of instruments are used to assess both the present and previous diet: the 24 hour dietary recall (R24h), food-intake record (FR), and the food frequency questionnaire (FFQ). All of those instruments show either advantageous or limiting results<sup>7</sup>.

Presently, the FFQ is the most useful instrument in epidemiological studies, intended to assess the relation between diet and disease, since it enables the access to information about the food intake level before the disease and also, from the scientific point of view, a much less expensive method<sup>5</sup>. The instrument is structured in away it can consider the dietary intake recording frequency in time-units and it might be subject to two types of errors: random and systematic ones<sup>8</sup>. Systematic errors occur when there is a difference between the measured value and the real one, and thus, interfering in the instrument validity<sup>9</sup>. In order to minimize such results, more investigative studies on instrument validation are necessary.

A validation study should be conducted in order to improve the FFQ application within a specific population<sup>10</sup>, and to avoid missinterpretations, improve accuracy and reduce bias levels related to diet-disease occurrences<sup>7,11,12</sup>. As a result, the instrument's characteristics will be better acknowledged and, whenever necessary, its calibration should be suggested.

The assessment of dietary intake by college students of the health area is justified, considering the important role they will play in relation to people's education in health practices, health promotion and disease prevention. This way, reliable instruments are needed in order to correctly measure the dietary pattern

of the university's population. Since no golden-standard is known to exist, related to a dietary intake assessment, this study was intended to verify the relative validity of a quantitative food frequency questionnaire, especially built for college students of the healthcare area.

## Methods

### Quantitative Food Frequency Questionnaire construction

The study included 104 volunteers from the healthcare area, attending to the Students' Nutrition Ambulatory of the Universidade Federal de São Paulo (UNIFESP). This self-administered quantitative FFQ included 77 items at its initial stage. The food list was based in informed food and preparations for a 3-days dietary report (3dDR)<sup>13</sup>. In addition to that, information about home measurements were changed to grams and mL, with the help of centesimal composition charts<sup>14-16</sup>, and calculated by the Nutritional Support software of UNIFESP<sup>17</sup>. The charts were then organized according to the percentage contribution for the total energy value informed, and selected and assembled according to their nutritional similarity and also according to the food that responds to the 95% of the energy intake. Based on the distributive percentage related to each weighted portion in grams, it was possible to define as a small portion (S) the one with value equal or lower than 25%; the medium portion (M) at 50% and the large one (L) at 75% or more. Following the development of a pilot project, the instrument was restructured as to include 70 food items. In addition to the food list, the FFQ presents a blank to be filled with the type of food absent from the initial list but pertaining to the dietary habits of the voluntary participant. Thus, their consumption frequency, of at least once a week, was considered valid<sup>5</sup>.

### Study validity

The instrument used to assess the amount of food items consumed was tested in university students of both genders. The inclusion

criteria were the absence of any interfering condition related to the usual food intake (such as pregnancy, lactation etc.), no previous nutritional orientation and the student being enrolled in the health care area of UNIFESP.

Convenient samples were attained by invitation, in the classrooms, to participate in the project. All students interested in the project were directed to the Students' Ambulatory of Health Service, where their personal informations were collected. At first, 108 students were recruited, but at the end only 50 of them — from the several health area Graduation courses — comprised the total sample. Participants were asked to sign an Informed Consent form and the investigation was approved by the Ethics and Research Committee from UNIFESP (CEP 1152/09).

The validation study sought to compare results attained by the study-test-method and results obtained by a reference method, considered of superior quality. The 3dDR instrument was used in order to avoid errors co-related to FFQ<sup>5,7</sup>.

The FFQ was filled before the 3dDR in order to estimate the usual diet as suggested by Cade et al.<sup>12</sup>. Data collection was performed by trained nutritionists — dietitians attending the Public Health Specialization in Nutrition course at UNIFESP.

Literature suggests that the applied methods should be in consonance with the period of time in which they are to be conducted<sup>12</sup>. Thus, FFQ data collection was approved for a period of six months. This same period was considered for the reference method (3dDR) data collection. Food items in the 3dDR home measurements were converted to grams /day using the Nutritional Support software of UNIFESP<sup>17</sup> and the composition tables for food items<sup>14-16</sup>. As for the FFQ, it was conducted in a previous phase, dealing with the changes occurred in the food intake in grams /day using an Excel<sup>®18</sup> spreadsheet, in which frequency was multiplied by the size of the informed portion, while the product was divided by the number of month-days. The following dietetic variables were considered: total energy (kcal), macronutrients (carbohydrates, lipids, and proteins - in grams) and total dietary fiber (in grams).

## Statistical analysis

Data were analyzed by the SPSS software, version 15.0, for Windows<sup>19</sup>, considering a significance level of 5%. In a previous analysis on the validity of FFQ, the Student's *t*-test was done in pairs, intending to verify the existence of statistically significant differences. In addition the residual method was performed for energy adjustment previous to intra-class correlation coefficient (ICC) estimate as proposed by Willett and Stampfer<sup>20</sup>. Relative validity was assessed using ICC for raw nutrients and adjusted by energy<sup>21</sup>.

The Kappa index was used to assemble dietetic variables related to consumption's thirds of each method. In this case, the assessment was carried out with the total proportion of participants correctly classified in the same consumption category<sup>22</sup>. Information divergences were examined in a graphic developed by Bland and Altman<sup>23</sup>, allowing trend verification on sub- or- over data estimation, presented by the test-method.

## Results

Most participants were female (74%). The sample consisted of students of medicine (44%), nursing students (22%), nutrition students (18%) and others (16%). From the initial sample, which included 108 participants, 53.7% of them were presented with incomplete documents or desistance and so, only 50 participants were approved for the validation study. Table 1 shows data related to energy and nutrients obtained by both dietary inquiries. As for the

percentage of macronutrient contributions, increased values were shown by the FFQ for carbohydrates and proteins when compared to those of 3dDR.

In relation to kappa statistics values when adjusted to energy, little concordance was observed of macronutrients when compared to FFQ and 3dDR data are shown in Table 2. Better results were seen for energy (ICC 0.32; 95%CI 0.1 – 0.55). Table 3 shows the resulting FFQ capacity in classifying individuals within the same thirds, adjacent thirds or opposite thirds, for each consumption variable, after the adjustment by energy.

It was observed that individuals classified in the opposite thirds are represented by the minority (16%), as approximately half of the participants were classified in the same thirds. However, results do not point to a valid agreement since the attained values for kappa were low, mainly for macronutrients, and varying from 0.05 for proteins to 0.14 for carbohydrates and lipids.

It was observed a tendency to overestimation in the FFQ value for energy and nutrients, except for lipids (Table 4). Bland and Altman's<sup>23</sup> proposed graphics were built in order to verify the divergences between both methods. Thus analysis of the difference between the nutrients and energy found the same results (Figure 1A and B). Figure 1A shows that higher deviation levels between data on energy obtained by FFQ and 3dDR were seen in intakes of more than 2000 kcal. Figure 1B shows trends of overestimation in the FFQ report, in relation to 3dDR for proteins as well as for other nutrients, whose results were similar.

**Table 1** - Crude values for energy and macronutrients from the Food Frequency Questionnaire and 3-days Dietary Report and the percentage contribution of macronutrients in relation to the total energy.

**Tabela 1** - Valores brutos de calorias e macronutrientes obtidos pelos Questionário de Frequência Alimentar e Registro Alimentar de 3 dias e percentual de contribuição de macronutrientes em relação ao valor calórico total.

Variable	FFQ			3dDR		
	Mean	SD	%	Mean	SD	%
Energy (kcal)	2070.22	578.45	–	2058.81	573.17	–
Carbohydrates (g)	294.76	83.18	56.95	279.16	89.25	54.24
Proteins (g)	97.1	27.89	18.76	77.91	23.42	15.14
Lipids (g)	61.49	23.86	26.73	71.31	20.62	31.17
Fiber (g)	19.23	5.89	–	15.28	5.47	–

FFQ: Food Frequency Questionnaire; 3dDR: 3-days Dietary Report; SD: standard deviation.  
FFQ: Questionário de Frequência Alimentar; 3dDR: Registro Alimentar de 3 dias; SD: desvio padrão.

**Table 2** - Weighted Kappa statistics values and interclass correlation coefficients with a 95% confidence interval between the Food Frequency Questionnaire and 3-days Dietary Reports' variables.

**Tabela 2** - Valores da estatística kappa ponderado e coeficiente de correlação intraclasse, com intervalo de confiança de 95% entre as variáveis do Questionário de Frequência Alimentar e do Registro Alimentar de 3 dias.

Variable	ICC	95%CI	Kappa	95%CI
Energy (kcal)	0.43	0.173 – 0.630	0.32	0.097 – 0.545
Carbohydrates (g)	0.35	0.08 – 0.569	0.05	0 – 0.2679
Proteins (g)	0.35	0.08 – 0.569	0.23	0.014 – 0.4476
Lipids (g)	0.38	0.112 – 0.591	0.28	0.063 – 0.489
Fiber (g)	0.28	-0.001 – 0.512	0.19	0 – 0.396
Carbohydrates*	0.22	-0.055 – 0.471	0.14	0 – 0.371
Proteins*	0.29	0.014 – 0.523	0.05	0 – 0.271
Lipids*	0,26	-0.016 – 0.501	0.14	0 – 0.366
Fiber*	0,34	0.068 – 0.580	0.23	0.024 – 0.438

\*adjusted for energy. ICC: interclass correlation coefficients.

\*ajustado para energia. ICC: coeficiente de correlação intraclasse.

**Table 3** - Percentual of thirds' classification and weighted Kappa after adjustment for energy.

**Tabela 3** - Classificação percentual dos participantes em terços e kappa ponderado após ajuste de energia.

Variable	Same Third (%)	Adjacent Third (%)	Oposit Third (%)	Kappa	p-value*
Energy (kcal)	54	32	14	0.32	0
Carbohydrates (g)	44	36	20	0.14	0.11
Proteins (g)	36	44	20	0.05	0.69
Lipidss (g)	42	40	18	0.14	0.2
Fiber (g)	40	52	8	0.23	0.32
Mean	49.8	40.8	16	–	–

\*for crude agreement.

\*para concordância bruta.

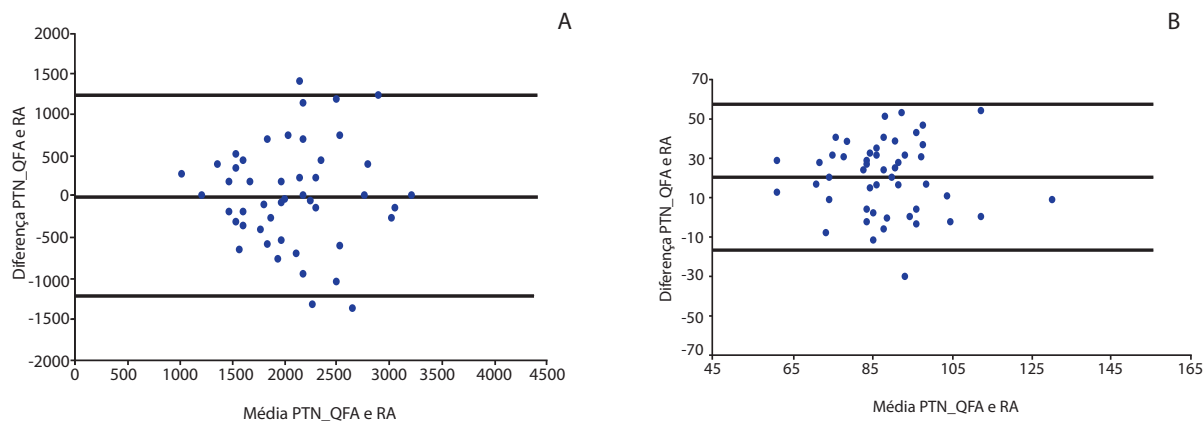
**Table 4** - Means and standard deviation of the difference of data gathered trough Food Frequency Questionnaire and 3-days Dietary Report adjusted for energy.

**Tabela 4** - Média e desvio padrão da diferença dos dados obtidos pelo Questionário de Frequência Alimentar e Registro Alimentar de 3 dias ajustados pela energia.

Variable	Average (FFQ-3dDR)	SD
Energy (kcal)	11.4	615.46
Carbohydrates (g)	17.42	35.02
Proteins (g)	20.57	18.42
Lipids (g)	-11.07	11.84
Fiber (g)	3.17	5.56

FFQ: Food Frequency Questionnaire; 3dDR: 3-days Dietary Report; SD: standard deviation.

FFQ: Questionário de Frequência Alimentar; 3dDR: Registro Alimentar de 3 dias; SD: desvio padrão.



**Figure 1** - Bland-Altman graphic for energy (A) and protein (B).

**Figura 1** - Gráfico de Bland-Altman para energia (A) e para proteína (B)

## Discussion

Assessing food intake is not an easy task, due not only by the absence of a golden standard but also by the fact that the existing methods are subject to variations and measurement errors<sup>24</sup>.

Both 3dDR and FFQ showed tendency to protein rich diets (Table 1), according to the WHO recommendations<sup>25</sup>, which are intended to prevent NTCs. The contributing percentage of proteins in relation to the total energy value was over 15%. As a consequence, an alteration occurs in the percentage of other participating macronutrients. The low intake of fibers (< 25 g/d)<sup>26</sup> reinforces the need for nutritional attention and surveillance toward this populational group. The mean levels for energy intake, fibers and macronutrients except lipids, were higher for FFQ in relation to those in 3dDR. Since the comparison between the mean of energy and nutrients between both methods provide limited information concerning the validity<sup>5</sup>, other statistical tests were carried out.

The ICC and the kappa index values were low and even furtherly reduced when energy was corrected (Table 2). This adjustment of nutrients using energy is seen as a methodological strategy developed to correctly try to estimate parameters and try to control any eventual confusion effect caused by energy in validation<sup>8,10</sup> studies. The Reduction of coefficient values after the adjustment by energy is useful to other studies<sup>27-31</sup>, which may evidence the presence of systematic errors on sub-or-super account of food consumption<sup>5,31</sup>.

A large number of validation studies used the Pearson's or the Spearman's correlation coefficient when comparing the methods<sup>9,27-30,32-40</sup> which turned results more difficult to be evaluated. In spite of the coefficient's attained values, the use of ICC was adopted for viewing the several publications which point to over-estimates association when using Pearson's correlation in samples with great inter-subject variability, which as a consequence, could lead to false conclusions concerning the method's validity<sup>23,41</sup>. High values for Pearson's correlation coefficient do not necessarily mean that both methods are consistent, since this

measurement is only directed to the strength relation between two variables<sup>23</sup>.

Related literature shows that correlations between the FFQ diet estimations and the method of reference are found between 0.3 and 0.7<sup>42</sup>, although other studies had been published about similar methodology validation with lower coefficients, than those seen here, for some nutrients<sup>16,31</sup>. Those studies showed a satisfactory reproducibility level and reasonable validity in relation to the studied nutrients.

The FFQ validity evaluation was also tested by comparing the individuals' classification within the consumption thirds for both methods. Results showed to be consistent with other studies in literature, regarding studies with similar methodology<sup>8,9,43,44</sup>, a higher percentage of individuals classified in the same category (43.2%) and a few individuals in opposite thirds (16%). The questionnaire's ability in classifying individuals, according to their intake level, contributed to attain a correct risk estimate<sup>31</sup>.

Mc Pherson et al.<sup>45</sup> stated that some self-administered dietary inquiries present overestimated results at the first contact with the instrument in relation to the second. In the present study, it could be observed that FFQ overestimated the dietary measurements, except when dealing with lipids. As for proteins and carbohydrates, a higher divergence level between the methods was observed. Other authors<sup>31,43</sup> found more coherent data during a second application of the FFQ and 3dDR methods and suggested a better participant preparation when answering on the changes of their dietary intake, during the period of the study. Krebs-Smith<sup>10</sup> emphasized an over-estimation trend related to dietary intake, which might be the result of a long food list, leading then to the responsive individuals' weariness. The food list was carefully developed and reformulated after the execution and inclusion of 70 food items in the pilot project.

Viewing to improve the results interpretation, the methodology proposed by Bland-Altman<sup>23</sup> was used for the graphic construction, based in



the consumption data, so then it was possible to observe that in lower energy intake cases, the agreement between methods turns to be more useful. Approximately over 200 kcal data shows to be more distant from the mean levels, even if ICC and higher kappa (0.43 and 0.42, respectively) had been found when compared to macronutrients and fibers.

Among this study's limitations, it is important to mention the higher number of female participants and the losses. Other Brazilian studies that considered the university population have also included larger number of female participants in relation to the number of males<sup>46,18</sup>, although this is a characteristic of the population of students<sup>46-48</sup> enrolled in the Graduation courses of UNIFESP (61.44% females, 2009). In relation to losses, it is possible that this high percentage might have influenced the results concerning the viewing the final sample small size. The reason for such losses, was the poor attendance for nutritional visits, absence of 3dDR, FFQ incorrect record filling, and/or lacking of the Informed Consent.

Literature suggests<sup>12</sup> that a minimum number (50) of participants may be adequate for a validation study<sup>12</sup>. Other studies on validation, conducted in Brazil, also presented losses to follow up, even though, with a lower percentage as seen in the present study (53.7%): Assis et al.<sup>49</sup> and Ribeiro et al.<sup>28</sup> with 14% and Zanolla et al.<sup>31</sup> with 27%. A study by Cardoso et al.<sup>27</sup> showed that from the initial sample of 255 nutritionists, the investigators remained with only 77 individuals for the reproducibility study. For validation, 52 participants were recruited. However, validation studies in Brazil may eventually include less than 50 participants<sup>9,22,29,30</sup>. In addition to that, it may be possible to emphasize a series of

limitations inherent to any FFQ as those related to memory, perception, lacking standardization, structure faults, and also due to chance<sup>42</sup>. Specifically, in relation to the tested FFQ, a possible biased record should be taken into consideration since this FFQ is self-administered, and subject to false interpretations, even with a previous pilot-study having been conducted and intended to minimize this effect. The low correlation coefficients levels — except those of calories and fibers — for the agreement methods, may occur mainly in the absence of a golden-pattern. Due to this finding, it was opted for the use of 3dDR, since this method depends on the memory and it may lead to less FFQ correlated errors<sup>5</sup>, and also to its possible application in the studied sample. However, the filling of 3dDR opens the space for possible changes in the present diet and as a consequence, not reflecting the real consumption. At the same time, the role played by the dietary intake variability within the course of time must be emphasized and also, one must not ignore the existence of a different scale in order to estimate the nutrient intake using the FFQ or 3dDR<sup>10</sup>.

The knowledge of the problems linked to the method enables the development of new studies which seek its correction and calibration. This way, it is recommended that the use of this instrument in university population in studies intended to estimate energy as well as in the classification of individuals in consumption categories. The use of adequate instruments may serve as the basis to develop adequate instruments, able to serve as the basis for strategies, development of new strategies, disease prevention, and also, to improve the quality of life and health promotion.

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