Diet quality index adjusted for energy requirements in adults

Índice de qualidade da dieta ajustado pela necessidade energética em adultos

Patricia Constante Jaime [1]
Daniel Henrique Bandoni [1]
Ana Clara da Fonseca Leitão Duran [1]
Regina Mara Fisberg [1]

[1] *Faculdade de Sáude Pública, Universidade de São Paulo, São Paulo, Brasil.*

Correspondence
P. C. Jaime
Departamento de Nutrição, Faculdade de Saúde Pública, Universidade de São Paulo.
Av. Dr. Arnaldo 715, 2º andar, São Paulo, SP 01246-904, Brasil.
constant@usp.br

Abstract

This study aimed to develop a diet quality index (DQI-a) adjusted for energy requirement. Dietary intake of adults was assessed using 24-hour food recall. The DQI was developed for scores evenly distributed across ten items characterizing different aspects of diet: food groups, nutrients, and variety. The components categorized under the food groups from the Dietary Guide for Brazilians were adjusted according to the estimated energy requirements of the population studied. Index consistency and correlation with nutrients of the diet was analyzed by Cronbach's alpha. A total of 737 individuals were assessed and energy requirements ranged from 1,800 to 2,500kcal among women and 2,500 to 3,400kcal in men. The food group with greatest variation in total portions was cereals and tubers. Cronbach's alpha of the DQI-a was 0.643 and the index correlated with most of the nutrients. The DQI-a can be considered a valuable instrument for assessing diet quality of the Brazilian population.

Diet; Food Consumption; Nutrition; Adult

Introduction

In recent years, several studies have confirmed the link between diet and non-communicable diseases. This research has provided solid evidence of the action of some nutrients and specific food groups (such as saturated fats, fruit, vegetables) as either risk factors or protective factors for diseases [1,2]. However, this relationship is highly complex since foods and nutrients are not consumed separately [3].

Therefore, indexes to access overall characteristics of diets have been proposed as a means of assessing food intake in terms of proportions, moderation and variety, according to recommendations for prevention of non-communicable diseases and conditions [4]. The use of dietary indexes based on nutritional recommendations or dietary guidance are centered on established knowledge of healthy eating. Given the use of scoring systems to classify foods, these instruments are easy to interpret and are consequently more intelligible for the population [5].

A number of indexes for assessing overall dietary quality are available including the healthy eating index (HEI) and the diet quality index, based on recommendations for the American population [6,7]. More recently, indexes based on specific diets have been developed such as the Mediterranean diet scale, developed for populations with a typical Mediterranean diet [8], while others are for use in general populations of spe-

cific countries [9,10]. In Brazil, Fisberg et al. [11] published an adaptation of the HEI using the food portions proposed for the Brazilian population.

However, the majority of the indexes available fail to take into account the association of index with energy requirements. Adjusting the overall diet quality index for estimated energy requirements is a valuable strategy for assessing population groups with heterogeneous sociodemographic profiles and/or greater variance in energy requirements due to, for example, the pattern of physical activity among the individuals in the study population.

Over the past few years, a number of modifications have been proposed for adjusting indexes of different energy requirements, such as the inclusion in the HEI of an adjustment for three ranges of energy requirement for men and women [12]. Another study have adapted the HEI for an American population, creating the HEI-2005, an index based on recommendations proposed in the *MyPyramid Food Guidance System* and incorporating correction for energetic density of the food group-related components [10].

In 2005, following publication of the Dietary Guide for Brazilians [13], adherence of groups of the Brazilian population to the nutritional recommendations contained in the guide have been a major focus of study. The use of indexes that reflect overall diet quality can represent a valuable methodological approach in this process.

In this context, the aim of the present study was to develop an index of diet quality adjusted for energy requirements and to apply the index in a sample of Brazilian adults.

Method

This was a methodological study which used baseline information from an intervention carried out in four São Paulo city companies, entitled *Impact of an Intervention for Weight Gain Prevention in the Workplace*. All employees of the companies studied were invited to take part in the present study.

Questionnaires collecting sociodemographic data (schooling, gender, age, marital status etc.) and habitual physical activity were applied in individuals who agreed to participate in the study.

Food intake was assessed by 24-hour food recall (24hR) telephone interview applied by previously trained nutrition students. A total of 751 individuals were studied, 14 were excluded because their mean daily energy intake was less than 669kcal or greater than 3.971kcal, the cutoff points the 1st and 99th energy intake percentiles in the population [14].

The nutritional values of foods reported on the 24hR were analyzed using the computer program for performing nutritional calculations – Nutwin – Nutrition Support Program – version 1.5 (Departmento de Informática em Saúde, Universidade Federal de São Paulo, Brazil). The foods database was updated using reference information from the Brazilian Food Composition Table (TACO, version 2. Núcleo de Estudos e Pesquisas em Alimentação, Universidade Estadual de Campinas, Campinas, Brazil) and the USDA National Nutrient Database for Standard Reference version 19 (Agricultural Research Service, United States Department of Agriculture, Washington DC, USA). Prior to performing calculations, the different food recipes were standardized (such as sandwiches, pizzas, filled pastries and juices) and their respective constituent ingredients entered separately into the nutritional calculation program. Foods were classified into the groups contained in Dietary Guide for Brazilians [13].

Development of the diet quality index

The diet quality index (DQI-a) adjusted for estimated energy requirements was developed based on the HEI [6] with scores distributed evenly across ten components, each measuring different aspects of a healthy diet. The DQI-a developed in this study comprises the following components:
a) Components 1-6: food groups (grains; vegetables; fruit; milk and dairy products; meats and legumes). This is a measure of the degree of conformance in consumption of each food group, as established by the Dietary Guide for Brazilians [13].
b) Components 7-9: nutrients present in the diet (total fat, saturated fat and sodium). This is a measure of the degree of moderation in consumption, according to the recommendations in the guide.
c) Component 10: variety of diet. Variety was measured taking into account the different food types consumed during one day, categorized into six food groups (grains; vegetables; fruit; milk and dairy products; meats and legumes), where each food item had to attain at least half the portion size recommended by the dietary guide [13] for its respective food group.

Each component was scored on a continuous scale from 0 to 10, commensurate to the individual's intake as per the equation below:

$$\text{Component score} = [10/(VMax-VMin)].(X-VMin),$$

where, VMax: maximum value of the component, corresponding to recommended intake; Vmin: minimum value of the component, corresponding to non-consumption for components 1-6, fat

consumption ≥ 45% of total caloric value of the diet, saturated fat ≥ 15%, sodium consumption ≥ 4.800mg and insufficient variety in component 10; X: amount consumed by the individual.

Individuals with intakes equal to the recommended level for each item are assigned 10 points, giving a maximum possible score of 100. High scores indicate intake which is close to the recommended intervals or amounts, whereas low scores indicate lower conformance with the recommendations.

In contrast to the HEI, the components categorized into the six food groups were adjusted according to the estimated energy requirements of the population studied.

Predictive equations for use in populations that were developed for individuals with a normal weight and overweight and which were adopted by the Institute of Medicine [15] were employed to estimate energy requirements of the participants of this study. Levels of both occupational and leisure-time physical activity were used to estimate the required physical activity in the equation, and assessed by the questionnaire developed by Baecke et al. [16] adapted to the Portuguese language [17].

After calculating the estimated energy requirements of the study participants, the sample was divided into terciles by gender. The median value was used as a reference for energy recommendation in each of the six population groups for which the index was designed. Thus, the calculation of the number of portions of the food groups for each tercile studies was based on the recommendations for a 2.000kcal diet stated in the Dietary Guide for Brazilians [13].

The distribution of portions was set according to the guidelines for a healthy diet and to Brazilian eating habits, with emphasis on foods comprising the staple diet (grains, vegetables and fruit groups) and the legumes group [13].

Measures of central tendency, dispersion and proportion were used in the descriptive analysis of data for the overall DQI-a and its components. To evaluate the consistency of the DQI-a and each component was used Cronbach's alpha.

Also, the correlation between the DQI-a and total energy, macronutrients, saturated fat, fibers, cholesterol and sodium were assessed by Pearson's correlation coefficient. Given the correlation between the DQI-a and total energy intake, the correlation with the nutrients studied was adjusted by total energy in the diet using the residuals method [18].

Finally, the DQI-a was categorized into terciles, with analysis by sociodemographic characteristics of the population, namely: gender (male or female), age group (18 to 29 years, 30 to 39 years, and greater than 40 years), schooling (categorized as > 12 years of schooling and ≥ 12 years of schooling), and body mass index (BMI – categorized as BMI < 25kg/m² or ≥ 25kg/m²). Differences in dietary quality terciles and sociodemographic characteristics were assessed using the chi-squared test.

Results

Of the 737 participants comprising the final sample of the present study, most were women (59.7%), had ≥ 12 years of schooling (54.1%), a mean age of 33 years (SD = 9.23), and were predominantly overweight (BMI ≥ 25kg/m² – 55.1%). The mean estimated energy requirement of the overall population was 2,440kcal (SD = 581kcal), being 2,088kcal (SD = 311kcal) among women and 2,962kcal (SD = 487kcal) for men.

Table 1 shows the maximum scores for the components. The first six items related to food groups were adjusted for energy requirements, which ranged from 1,800 to 2,500kcal among the women and 2,500 to 3,400kcal in the men. As expected, the group associated with the greatest variation in total portions comparing the terciles was the grains group, representing for the highest energy contribution to the diet.

Women had a mean score of the DQI-a (59.2; SD = 11.4) slightly higher than men (56.7; SD = 10.5). The lowest mean component scores for both genders occurred in the legumes and fruit groups, whereas highest mean scores were found for total fat (Table 2).

Maximum scores on the various components of the DQI-a were attained only by a small portion of the population studied. However, 58.6% of the population achieved maximum scores for total fat consumption, 50% of men scored maximum points for saturated fat and 50% of women for sodium.

Cronbach's alpha of the index was 0.643, with no difference between genders. Milk and dairy products and saturated fat products made the lowest contribution to performance of the coefficient (Table 3).

Our results showed that the DQI-a correlated with the majority of the nutrients in the diet, even after adjusting for energy, including nutrients not comprising a direct part of the indicators such as fibers, carbohydrate and proteins (Table 4).

Older individuals with a normal weight (BMI < 25kg/m²) scored higher on the DQI-a, where 40% of these individuals were at the 3rd distribution tercile of the index (Table 5).

Table 1

Components of the diet quality index (DQI-a) adjusted for energy requirements in adults. São Paulo, Brazil, 2008.

Components	Female			Male		
	Energy requirement *			Energy requirement **		
	1st tercile	2nd tercile	3rd tercile	1st tercile	2nd tercile	3rd tercile
	1,800kcal	2,000kcal	2,500kcal	2,500kcal	2,800kcal	3,400kcal
Grains (portions) ***	5	6	7	7	9	12
Vegetables (portions) ***	3	3	4	4	4	5
Fruit (portions) ***	3	3	3	3	3	4
Milk and diary products (portions) ***	3	3	3	3	3	3
Meat (portions) ***	1	1	2	2	2	2
Legumes (portions) ***	1	2	2	2	3	4
Total fat (%) #		≤ 30			≤ 30	
Saturated fat (%) #		≤ 10			≤ 10	
Sodium (mg) *		≤ 2,400			≤ 2,400	
Variety (food types) *		≥ 8			≥ 8	

* Energy requirement for women: 1st tercile (< 1,900kcal), 2nd tercile (1,900 to 2,140kcal), 3rd tercile (> 2,140kcal);

** Energy requirement for men: 1st tercile (< 2,670kcal), 2nd tercile (2,670 to 3,140kcal), 3rd tercile (> 3,140kcal);

*** Score of 0 for food groups indicates 0 portions;

Score of 0 for intake of total fat ≥ 45%, saturated fat ≥ 15%, sodium ≥ 4,800mg and for variety of three or less food types.

Table 2

Scoring of adjusted diet quality index (DQI-a) and its components and proportion of maximum observed scores by gender. São Paulo, Brazil, 2008.

Components	Female		Male		Total	
	Mean (SD)	Observed scores of 10 (%)	Mean (SD)	Observed scores of 10 (%)	Mean (SD)	Observed scores of 10 (%)
Grains	5.53 (2.46)	7.72	4.74 (2.32)	4.38	5.21 (2.43)	6.37
Vegetables	4.81 (3.21)	13.63	4.08 (2.85)	5.72	4.51 (3.09)	10.45
Fruit	3.16 (3.48)	8.64	2.90 (3.48)	9.43	3.06 (3.49)	8.96
Milk and diary products	4.48 (3.04)	9.55	4.59 (3.20)	12.12	4.53 (3.11)	10.58
Meat and eggs	7.46 (3.30)	47.05	7.58 (2.97)	45.79	7.51 (3.17)	46.54
Legumes	2.75 (3.58)	11.59	3.01 (3.32)	6.73	2.86 (3.48)	9.63
Total fat	8.39 (2.47)	55.23	8.63 (2.44)	63.64	8.49 (2.46)	58.61
Saturated fat	8.09 (2.96)	48.64	6.40 (3.81)	54.21	7.06 (3.86)	50.88
Sodium	6.27 (3.33)	53.18	7.10 (3.01)	33.67	7.41 (3.43)	45.32
Variety	6.82 (3.96)	31.82	7.42 (3.68)	40.74	6.61 (3.23)	35.41
DQI-a	59.18 (11.37)	-	56.70 (10.49)	-	57.24 (12.43)	-

Discussion

The DQI-a adjusted the recommendations in the Dietary Guide for Brazilians for the energy requirements of the study sample, comprising of workers in the city of São Paulo. The use of specific guidelines for the Brazilian population enables reproducibility and use of the DQI-a on a larger scale in the context of overall assessment of diet.

The fact that the DQI-a was developed based on the distribution of the estimated energy requirements of the specific population studied and on gender, differentiated this instrument from other indexes available for assessing overall diet quality.

Table 3

Cronbach's alpha of adjusted diet quality index (DQI-a) and its components by gender. São Paulo, Brazil, 2008.

Components	Female	Male	Total
	Alpha without component	Alpha without component	Alpha without component
Grains	0.640	0.627	0.633
Vegetables	0.623	0.610	0.616
Fruit	0.629	0.592	0.613
Milk and diary products	0.665	0.661	0.661
Meat and eggs	0.643	0.626	0.635
Legumes	0.623	0.611	0.617
Total fat	0.621	0.601	0.612
Saturated fat	0.674	0.680	0.675
Sodium	0.596	0.582	0.590
Variety	0.618	0.592	0.608
DQI-a	0.650	0.635	0.643

Table 4

Correlation between energy and selected nutrients and adjusted diet quality index (DQI-a) in adults. São Paulo, Brazil, 2008.

Nutrients	r	p-value	Adjusted r *	p-value
Energy (calories)	0.175	< 0.01	-	-
Carbohydrates (% energy)	0.267	< 0.01	0.279	< 0.01
Proteins (% energy)	0.170	< 0.01	0.182	< 0.01
Fats (% energy)	-0.488	< 0.01	-0.516	< 0.01
Saturated fats (% energy)	-0.474	< 0.01	-0.500	< 0.01
Fiber (g)	0.535	< 0.01	0.456	< 0.01
Cholesterol (mg)	-0.075	0.04	-0.018	0.62

* Adjusted for total energy.

Adjustment for different estimated energy requirements, as well as the use of energy density, represents important advances in the revisions to the HEI [19]. Both updates to the HEI included some adjustments for energy, whereby the stratification of food portions into three pre-established ranges of energy requirement for men and women incorporated in the HEI-2005 [12] was considered a major improvement [19]. Moreover, the HEI-2005 was able to predict obesity better than the original index probably as a result of opting for adjustment by energy requirements which took account not only of gender and age but also level of physical activity [12].

The use of energy density in adjusting the diet quality index, as proposed by Guenther et al. [10], although advantageous for indexes which make no adjustments for energy, may introduce bias by under or overestimating diet quality because this measure is not based on individual estimates of energy requirements. Adjustment for density is recommended however, in cases when the energy needs of the study population cannot be determined e.g. when data on level of physical activity is unavailable.

When applied to populations with specific characteristics (such as those with differentiated levels of physical activity, pathology type or in particular phases of life), indexes which use reference values of energy consumption provided by dietary guides may lead to under or overestimation of scores, especially on components which are more highly correlated to energy consumption. For instance, the recommendations of number of food portions defined in the Dietary Guide for Brazilians are based on a diet of

Table 5

Distribution of study population according to sociodemographic features, nutritional status and tercile of adjusted diet quality index (DQI-a). São Paulo, Brazil, 2008.

Variables	DQI-a					
	1st tercile		2nd tercile		3rd tercile	
	43.3 (6.8) *		57.6 (3.3) *		70.7 (5.4) *	
	n	%	n	%	n	%
Gender						
Male	141	32.0	138	31.4	161	36.6
Female	104	35.0	108	36.4	85	34.6
Age (years) *						
18-29	122	38.7	117	37.1	76	24.1
30-39	75	31.4	74	31.0	90	37.6
≥ 40	48	26.2	55	30.1	80	43.7
Schooling (years)						
< 12	117	34.6	116	34.3	105	31.1
≥ 12	128	32.1	130	32.6	141	35.3
BMI (kg/m2) **						
< 25	99	29.9	98	29.6	134	40.5
≥ 25	146	36.0	148	35.5	112	27.6

BMI: body mass index.

* Mean (standard deviation) of terciles of DQI-a;

** Significant difference on chi-squared test ($p < 0.05$).

2,000kcal [13], i.e. a value close to the mean estimated energy needs of women (2,088kcal), yet far lower than the mean found for the men in our sample (2,962kcal).

In developing the DQI-a, the cholesterol component was replaced by the legumes group because beans are a typical food in the Brazilian diet and their consumption is encouraged by the dietary guide [13]. The same substitution was made in an earlier study involving adults from São Paulo State [20]. Moreover, a traditional Brazilian diet consisting mainly of rice and beans (main components of the grains and legumes groups, respectively) was deemed protective against weight gain of adults living in Rio de Janeiro [21].

Notably, recent studies have shown dietary cholesterol to play a lesser role compared to saturated or trans fats as risk factors for developing cardiovascular diseases [1,22].

In view of the high complexity of analyzing food variables, principally when involving nutrients and foods which are difficult to measure and are highly intercorrelated, we considered the Cronbach's alpha result satisfactory (0.643). This indicator is used to estimate the internal consistency of measuring scales, and also employed when different items make up a scale [23,24].

The DQI-a was found to correlate strongly with the majority of the nutrients studied, even those not part of its direct calculation such as fibers, thus proving to be a good indicator for overall assessment of diet. On the HEI, energy intake was higher in individuals whose diet adhered to the recommendations of the North-American food pyramid [6].

The correlation data observed was similar to that found for other indexes, particularly regarding energy, total and saturated fats, and fiber. It should be noted that few studies have made adjustments for energy [11,25,26].

The results of the present study were similar to those reported by other authors, showing that overweight individuals were classified into the lower terciles of the DQI-a [12]. Also, older individuals were found to have a better quality diet, corroborating results in a population sample from the Municipal district of São Paulo [20].

Our findings corroborate previous results described in analyses using other indexes, evidencing that our index adjusted for energy requirements was able to classify the individuals from the sample according to the quality of their diets. Therefore, the DQI-a has shown to be a good instrument for assessing the diet of populations.

Finally, a possible limitation of our study is a bias in energy consumption measurements. Some studies have shown that women and individuals who are overweight have a tendency to underestimate food intake [27]. In our population, the prevalence of overweight (BMI ≥ 25kg/m^2) was 55.1%, and may have led to underreporting of food consumption, possibly affecting the results of the adjustments incorporated into the DQI-a. However, this limitation applies to all studies attempting to assess food intake.

The DQI-a proposed in this study can be used in epidemiological surveys or studies assessing food behavior in Brazilian adults who have a similar level of schooling, physical activity and age. Thus, drawing on the results of our study, we recommend that whenever possible, index scores should be based on estimated energy requirements for the study population in question, enabling specific cut-off points to be defined for food portions and allowing more accurate classification and assessment of overall diet quality of participants.

Resumo

O objetivo foi desenvolver um índice de qualidade da dieta ajustado (IQD-a) pela necessidade energética. Avaliou-se o consumo alimentar de adultos por meio de recordatório alimentar de 24 horas. O IQD-a foi obtido por uma pontuação distribuída igualmente em dez itens caracterizando diferentes aspectos da alimentação: grupos de alimentos, nutrientes e variedade. Os componentes relacionados aos grupos de alimentos do guia alimentar para a população brasileira foram ajustados pela estimativa da necessidade energética da população estudada. Analisou-se a consistência do índice por meio do alfa de Cronbach e sua correlação com nutrientes da dieta. Foram avaliados 737 indivíduos e as necessidades energéticas variaram de 1.800 a 2.500kcal entre as mulheres, e de 2.500 a 3.400kcal entre os homens. O grupo de alimentos com maior variação no total de porções foi dos cereais e tubérculos. O alfa de Cronbach do IQD-a foi de 0,643 e o índice correlacionou-se com a maioria dos nutrientes. O IQD-a pode ser considerado um importante instrumento de avaliação da qualidade da dieta da população brasileira.

Dieta; Consumo de Alimentos; Nutrição; Adulto

Contributors

P. C. Jaime, D. H. Bandoni, A. C. F. L. Duran all worked on article conception, analysis and interpretation of the data, as well as writing and critical review of the manuscript. R. M. Fisberg assisted in the conception, writing and critical review of the article.

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