Diet quality among older adults: What the Index Associated with the Digital Food Guide and the Brazilian Healthy Eating Index-Revised Reveal

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Abstract *The aim of the present study was to compare the Diet Quality Index-Digital Food Guide (DQI-DFG) to a more widely used measure in the literature: the Brazilian Healthy Eating Index-Revised (BHEI-R). A cross-sectional population-based study was conducted with 822 older adults (≥ 60 years) from the city of Campinas/SP, Brazil. The BHEI-R resulted in a higher overall score compared to DQI-DFG (62.9 vs. 47.7). For the BHEI-R, mean scores increased with age and were worse among smokers and individuals with a higher level of schooling. Regarding the DQI-DFG scores, no significant associations with age, schooling or smoking were detected; however, scores were higher in higher income segments. The components with the worst scores were whole grains, sodium and milk (BHEI-R); fruits, whole grains, roots/tubers, milk, refined cereals and red meat/processed (DQI-DFG). Divergences were found in the global scores and components of the indicators, reflecting important methodological differences. Studies of this nature constitute an opportunity to increase awareness regarding indicators of particular aspects of diet.*

Key words *Aged, Food consumption, Health survey*

Introduction

Population aging has been occurring at a rapid rate throughout the world[1]. Healthy eating plays a fundamental role in the aging process as well as the prevention and control of chronic noncommunicable diseases[2-4]. Therefore, the assessment of eating patterns in older adults is important and can be facilitated with the use of diet quality indicators, which are methods founded on traditional eating patterns or dietary guidelines for the prevention of disease[5].

Diet quality indicators enable a more comprehensive analysis of eating practices and associations with health, going beyond the reductionism of the assessment of dietary intake based on isolated nutrients and foods[5]. The most recent edition of the *Dietary Guide for the Brazilian Population* states that the beneficial effects of a healthy diet are attributed more to the combination of foods that compose eating practices as well as the interaction of nutrients with each other and with other components of the dietary matrix than individual foods and nutrients[6].

Among the proposed national indicators, the Brazilian Healthy Eating Index-Revised (BHEI-R)[7] is composed of 12 components, nine of which are food groups (total fruits; whole fruits; total vegetables; dark green/orange vegetables and legumes; meat, eggs and beans; milk and dairy; total grains; whole grains; oils), two nutrients (sodium and saturated fat) and one that unites solid, saturated and *trans* fats, alcohol and added sugar. The BHEI-R is derived from the US Healthy Eating Index (HEI-2005)[8]. This measure has been adapted for use in Brazil based on the recommendations of the *2006 Dietary Guide for the Brazilian Population*, which determined the number of portions and energy value per portion of the food groups in a diet with 2000 kcal/day[9]. The dietary guidelines are recommended for individuals over than two years of age and were defined based on a revision of the guidelines of the US food pyramid adapted for Brazil[10]. Regarding nutrients, the definition of the cutoff points was based on the recommendations of the US Institute of Medicine (sodium), the Brazilian Cardiology Society and World Health Organization (saturated fat)[7].

Published in 2019, the *Diet Quality Index Associated to the Digital Food Guide* (DQI-DFG)[11] has 11 groups, seven of which are denominated "adequacy components" (poultry, seafood and eggs; whole grains, tubers and roots; fruits; vegetables; legumes and nuts; milk and dairy; oils and

fats) and four dispensable food groups denominated "moderation components" (sugars and sweets; beef, pork and processed meats; refined grains; and processed fats). The framework of the DQI-DFG is founded on the dietary guidelines proposed by the Department of Nutrition of the Harvard School of Public Health with adjustments made to value foods that are part of the eating habits of the Brazilian population. The energy value of the portions and food intake ranges were determined based on the creation of a reference diet that meets the nutritional requirements of adults established by the US Institute of Medicine (macronutrients, vitamins, minerals, linoleic acid and alpha-linolenic acid) and Brazilian Cardiology Society (saturated, monounsaturated and polyunsaturated fatty acids)[11].

Considering improvements in the measurement process of diet quality and the fact that instruments of this nature enable a better understanding of the dietary practices of individuals and collectivities, the aim of the present study was to compare the DQI-DFG to a more widely used indicator in the literature (BHEI-R) for the assessment of the diet of older adults.

Methods

A cross-sectional study was conducted using data from the Health Survey and Nutrition Survey, which were population-based studies conducted in the city of Campinas, state of São Paulo, Brazil, between 2014 and 2016. Data were collected from non-institutionalized individuals 60 years of age or older, residents of permanent private homes in urban areas of the city of Campinas.

The Campinas Health Survey defined a minimum sample of 1000 older adults, which would enable estimated a proportion of 0.50 (maximum sample variability), with a 95% confidence level, 4-5% sampling error and a design effect of 2. The sample was obtained through probabilistic cluster sampling in two stages: census sector and household. In the first stage, 70 census sectors were randomly selected with probability proportional to the number of households counted in the 2010 census. The sectors were visited in the field for the establishment of an updated list of households[12].

In the second stage, the number of households necessary to reach the minimum sample size was calculated based on the older adult/household ratio. Thus, 3157 households were selected considering a 20% non-response rate. All

older residents (≥ 60 years of age) of the selected homes were asked to participate in the study. Further information on the sampling design of the survey has been published elsewhere[12].

The questionnaire for the Campinas Health Survey addresses broad themes and was organized into blocks to investigate morbidities and disabilities, the use of healthcare services, preventive practices, health-related behaviors, sociodemographic characteristics, etc. The data were obtained at the homes by trained interviewers who administered the questionnaire with the aid of an electronic device (Samsung Galaxy table, model GT-P5200).

The Campinas Nutrition Survey was performed concomitantly to the Campinas Health Survey. The older people who participated in the health survey were asked (upon the second visit to the home) to answer a questionnaire on food intake. Trained interviewers began the interviews with the completion of a 24-hour recall (24HR) using the Multiple-Pass Method[13]. With this method, the 24HR is applied in five steps with the aim of stimulating the respondent's memory and improving the quality of the information[14]. Only one 24HR was applied per participant. The interviewers visited the field every day of the week and every month of the year. A total of 88.5% of the 24HRs represented food consumption from Monday to Friday. A photographic album was used to assist in the completing of the 24HR[15].

Trained nutritionists subsequently performed the revision of the content of the 24HRs to correct possible mistakes as well as to quantify the foods and meals recorded in home measurements[16-18], on food labels and from consumer services. The data from the 24HRs were entered into the *Nutrition Data System for Research* (NDS-R) software, version 2015 developed by the Nutrition Coordinating Center of the University of Minnesota, Minneapolis, USA. The NDS-R software is updated annually and has more than 18 thousand foods and 170 nutrients. Meals not in the NDS-R database were developed based on standard recipes and inserted into the *User Recipe Module*. The data from all 24HRs were checked to ensure the consistency of the information.

Among 1168 older adults identified at the selected domiciles, 986 were interviewed for the Campinas Health Survey (14.0% refusals and 1.5% other losses). Among these 986 individuals, 138 declined to participate in the Campinas Nutrition Survey and 26 declined to answer the 24HR. Thus, the sample was composed of 822 older adults.

Variables of interest

The quality of the diet was assessed using two indicators: *Brazilian Healthy Eating Index-Revised* (BHEI-R)[7] and *Diet Quality Index Associated to the Digital Food Guide* (DQI-DFG)[11]. The DQI-DFG is comprised of a set of "adequacy components" (essential for the maintenance of health and the prevention of chronic noncommunicable diseases) and "moderation components" (foods that increase the risk of developing chronic diseases if consumed in excess). Although the BHEI-R was developed based on the HEI-2005[8], which classifies adequacy and moderation components, the authors opted not to adopt this denomination[7].

The BHEI-R has 12 components, which are presented in Chart 1. For components 1 to 9, the scores ranges from zero (not consumed) to five or ten points (consumption that meets or exceeds the recommended value). Components 10 to 12 receive scores ranging from zero (consumption that surpasses the maximum recommended limit) to ten or twenty points (meets established consumptions levels). Intermediate intake values are calculated proportionally. The total BHEI-R score is the sum of the 12 components and ranges from zero (worst quality) to 100 points (best quality)[7].

The DQI-DFG comprises 11 components – seven adequacy components (items 1 to 7) and four moderation components (items 8 to 11). The maximum score (5, 7.5, 10, 12.5 or 15 points) is attributed when consumption reaches the recommended number of portions or when it falls within the range of the established portions. Adequacy components receive an increasing proportional score (consumption below the minimum portion limit), decreasing proportional score (consumption up to twice the maximum limit of portions for items 2, 3 and 6) and no points (null consumption of components 1 to 7 or more than double the maximum limit of portions for items 2, 3 and 6). The other adequacy components (1, 4, 5 and 7) remain at the maximum score if surpassing the determined number of portions, as there is no evidence of health risks. Moderation components are attributed a decreasing proportional score (up to double the upper limit of the range of portions) and no score (more than double the upper limit)[11]. The total DQI-DFG is the sum of the 11 components and ranges from zero (worst quality) to 100 points (best quality) (Chart 1).

Diet quality was assessed considering the independent variables: sex (male and female), age group (60 to 69, 70 to 79 and 80 or more years

Chart 1. Components of BHEI-R and DQI-DFG, examples of foods and scoring criteria.

Components of BHEI-R	Examples of foods	Scoring range (minimum to maximum)	Minimum score criterion	Maximum score criterion
Total fruits	Fruits and fruit juice	0 to 5	No intake	1.0 portion/1000 kcal
Whole fruits	Fruits (excluding fruit juices)	0 to 5	No intake	0.5 portion/1000 kcal
Total vegetables[a]	All vegetables	0 to 5	No intake	1.0 portion/1000 kcal
Dark green and orange vegetables and legumes	Arugula, broccoli, watercress, salsa, spinach, collards, endive, chicory, beets, pumpkin, carrot, all types of beans, peas, chickpeas, soybeans, fava beans, lentils, soy-based products, such as tofu	0 to 5	No intake	0.5 portion/1000 kcal
Total grains (grains, roots and tubers)	Savory and sweet breads, pasta, cakes, pancakes, crackers, tapioca, rice, wheat, corn, potatoes, cassava	0 to 5	No intake	2.0 portions/1000 kcal
Whole grains	Whole wheat flour, cornmeal, whole-grain rice, oats, flax meal, breads and cakes made with whole grain flour	0 to 5	No intake	1.0 portion/1000 kcal
Milk and dairy	Milk and all milk byproducts and soy-based beverages	0 to 10	No intake	1.5 portion/1000 kcal
Meat, eggs and beans	Beef, pork, mutton, game meat, poultry, fish, eggs, nuggets and processed meats	0 to 10	No intake	1.0 portion/1000 kcal
Oils [b]	Vegetable oils, mayonnaise, salad dressings	0 to 10	No intake	0.5 portion/1000 kcal
Saturated fat	---	0 to 10	≥ 15% of TEV [c]	≤ 7% of TEV
Sodium	---	0 to 10	≥ 2.0g/1000 kcal	≤ 0.75g/1000 kcal
SoFAAS [d]	Margarine, butter, lard, hydrogenated vegetable fats, alcohol (calories from alcohol and respective carbohydrate), sugar added to juices, coffee, tea; sugar in carbonated soft drinks, sweetened juices, jams, processed foods	0 to 20	≥ 35% of TEV	≤ 10% of TEV
BHEI-R total		0 (worst) to 100 (best)		
Components of DQI-DFG		**Scoring range (minimum to maximum)**	**Minimum score criterion**	**Maximum score criterion**
Adequacy components Poultry, seafood and eggs	Poultry (chick, duck, turkey, gizzard), fresh, chilled, frozen seafood or preserved in oil or salt (sardines, hake, dogfish, salmon, cod, lobster, squid, octopus, oyster, mussels)	0 to 12.5	No intake	≥ 0.5 portion/1000 kcal

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of age), schooling (0 to 3, 4 to 8 and 9 or more years of study), family income *per capita* using the monthly minimum wage (MMW) as reference (< 1, ≥ 1 to < 2, ≥ 2 to < 3 to ≥ 3 times the MMW), smoking (never smoked, ex-smoker and smoker) and self-reported medical diagnosis of arterial hypertension and diabetes *mellitus* (yes or no). Smoking, hypertension and diabetes were selected to determine whether the indicators discriminate the quality of the diet in these groups, as smokers have a poor quality diet[19-21] and the presence of chronic disease requires the

Chart 1. Components of BHEI-R and DQI-DFG, examples of foods and scoring criteria.

Components of DQI-DFG		Scoring range (minimum to maximum)	Minimum score criterion	Maximum score criterion
Whole grains, tubers and roots	Rice (brown, negro, wild, 7 grains), oats, quinoa, brans, popcorn, whole grain breads and baked goods (French roll, oatmeal cookie), whole-grain toast, yam, cassava	0 to 5	No intake or > 6.0 portions/1000 kcal	≥ 2.0 to ≤ 3.0 portions/1000 kcal
Vegetables	Greens (Chinese cabbage, watercress, lettuce, spinach, endive, arugula, cabbage, parsley, collards), pumpkin, zucchini, broccoli, cauliflower, beets, palm heart, onion, garlic, tomato, pickles and canned onions	0 to 15	No intake or > 6.0 portions/1000 kcal	≥ 1.5 to ≤ 3.0 portions/1000 kcal
Legumes and nuts	Beans, chickpeas, lentils, soybeans, tofu, soy flour, soy milk without sugar, peanuts, almonds, cashews	0 to 15	No intake	≥ 2 portions/1000 kcal
Milk and dairy	Milk and natural yogurt – skim, low-fat, whole (excluding milk-based beverages with added sugars), cottage cheese, mozzarella, buffalo mozzarella, ricotta, ricotta cream, cream cheese, cheese spread	0 to 15	No intake	≥ 1.0 portion/1000 kcal
Oils and fats	Palm, olive and vegetable oils (soybean, peanut, corn, sunflower, coconut), butter, heavy cream	0 to 10	No intake or > 3.0 portions/1000 kcal	≥ 1.0 to ≤ 1.5 portion/1000 kcal
Moderation components	Sugar, honey, sweetener, chocolate milk, ultra-processed sweets (candy, ice cream, chocolate, cookies, cereal bars, condensed milk, jams, fruit in syrup, crystalized fruit), carbonated soft drinks, artificial juice, soy juice; Homemade desserts classified by item components	0 to 7.5	No intake	≥ 1.2 portion/1000 kcal
Sugars and sweets	*Chuck steak, ribs, rump steak, jerky, pancetta, mutton, boar, rabbit, liver, kidney, tongue, sausage, ham, bologna, hamburger, hotdog, steak*	0 to 5	> 1.0 portion/1000 kcal	No intake or ≤ 0.5 portion/1000 kcal
Beef, pork and processed meats	Rice, corn starch, canned corn, potato, sweet potato, cornmeal, pasta, instant pasta, bread (French roll, baguette, sliced bread, hamburger and hotdog buns, flatbread, ciabatta), sweet bread, toast, tapioca, sago, crackers, cookies, packaged chips	0 to 5	> 1.0 portion/1000 kcal	No intake or ≤ 0.5 portion/1000 kcal
Refined grains	*Bacon, pork lard, mayonnaise, margarine, whipped cream, vegetal cream, peanut butter without sugars, readymade sauces (ketchup, mustard, salad dressing, soy sauce, Worcestershire sauce, tomato sauce/paste)*	0 to 5	> 2.0 portions/1000 kcal	No intake or ≤ 1.0 portion/1000 kcal
Processed fats		0 to 5	> 1.0 portion/1000 kcal	No intake or ≤ 0.5 portion/1000 kcal
DQI-DFG total		0 (worst) to 100 (best)		

[a] includes legumes only after maximum score of meat, eggs and beans is reached; [b] includes monounsaturated and polyunsaturated fats and fats from nuts and fish; [c] VET: total energy value; d energy percentage from saturated and trans fats, alcohol and added sugar.

Source: BHEI-R - Previdelli et al. (2011); DQI-DFG - Caivano *et al.* (2019).

search for health care, which increases the opportunity to receive nutritional counseling and make healthy eating choices[19,22].

Data analysis

Means and 95% confidence intervals (CI) were estimated for each component of the BHEI-R and DQI-DFG and transformed into percentages in relation to the maximum score of the component. Next, global means of the BHEI-R and DQI-DFG were estimated according to the categories of the independent variables using simple and multiple (adjusted by sex and age) linear regression models considering a 5% significance level. Means of the components were also calculated according to age group to determine the behavior of the two diet quality instruments with the increase in age. The statistical analyses were performed using the *survey* module of the Stata 15.1 program, which considers weights and the sampling design of the study.

Ethical considerations

The Campinas Health Survey (certificate number: 37303414.4.0000.5404) and Campinas Nutrition Survey (certificate number: 26068214.8.0000.5404) received approval from the institutional review board of *Universidade Estadual de Campinas* and the National Research Ethics Committee (CEP/CONEP system). The procedures of the study were only conducted after agreement on the part of the participant through a signed statement of informed consent.

Results

The present study involved the analysis of information on 822 older adults who answered a 24HR. Mean age was 71.0 years (95% CI: 70.2-71.9) and women predominated in the sample (60.5%).

Regarding the BHEI-R components, very low scores (not reaching even 50% of the maximum score) were found for whole grains, milk and dairy (which means less consumption), and sodium (greater intake). For the DQI-DFG, the components with the worst scores were fruits, whole grains, roots and tubers, milk and dairy (low intake), refined grains, and red and processed meats (high consumption) (Table 1).

The total BHEI-R score was higher than the total DQI-DFG score (62.9 *versus* 47.5). No dif-

ferences were detected in the mean diet quality scores with regards to sex and arterial hypertension with either measure. Unlike the DQI-DFG, the BHEI-R identified differences per age, schooling and smoking; diet quality was better among long-lived older adults and worse among older adults with less schooling and smokers. BHEI-R scores were lower in the highest income stratum, but this difference lost its statistical significance in the adjusted analysis. In contrast, mean DQI-DFG scores were higher in higher income segments. According to both indicators, diabetics had a diet of better quality (Table 2).

According to the BHEI-R, individuals between 70 and 79 years of age had higher scores for total fruits, whole grains and sodium compared to those 60 to 69 years of age; the mean milk and dairy score increased with the advance in age. According to the DQI-DFG, the mean fruits score was higher among individuals 70 to 79 years of age and the milk and dairy score was higher among individuals 80 years of age or older compared to younger age groups; the processed fat score increased with age, reflecting a reduction in intake (Table 3).

Discussion

The differences found in the global score of the indices used in the present study are partially explained by divergences in the scoring criteria and the definition of the energy value of the portions of foods recommended for a diet of 1000 kcal and intake ranges linked to the maximum score. For instance, the maximum fruit score corresponds to an intake of 70 kcal on the BHEI-R (≥ 1.0 portion of 35 kcal for total fruits and ≥ 0.5 portion of 35 kcal for whole fruits) and between 97.5 and 195 kcal on the DQI-DFG (1.5 to 3.0 portions of 65 kcal); for milk and dairy, the maximum score is equivalent to 180 kcal on BHEI-R (≥ 1.5 portion of 120 kcal) and between 200 and 300 kcal on the DQI-DFG (1.0 to 1.5 portion of 200 kcal). Moreover, the DQI-DFG discriminates the energy value of the milk and dairy component in milk/yogurt (120 kcal) and cheeses (80 kcal), considering the greater concentration of fat and sodium in cheeses.

For grains, the BHEI-R confers the maximum score for intake equal to or greater than 2.0 portions of total grains (including roots and tubers) and 1.0 portion of whole grains (150 kcal each portion). The DQI-DFG takes a different approach by uniting whole grains with roots and

Table 1. Mean scores of BHEI-R and DQI-DFG components and respective percentages in relation to maximum scores among older adults, 2015-16 Dietary Intake Survey of city of Campinas, SP, Brazil.

Components of BHEI-R [a]	Mean score	95% CI [b]	Percentage in relation to maximum score
Total fruits	2.60	2.38-2.82	52.2
Whole fruits	2.79	2.55-3.03	55.8
Total vegetables	4.52	4.44-4.61	90.4
Dark green and orange vegetables and legumes	4.01	3.86-4.16	80.2
Total grains	4.61	4.53-4.68	92.2
Whole grains	0.62	0.48-0.76	12.6
Milk and dairy	4.21	3.90-4.53	42.2
Meat, eggs and beans	8.73	8.53-8.93	87.3
Oils	9.32	9.09-9.55	93.2
Sodium	2.06	1.85-2.27	20.8
Saturated fat	6.70	6.38-7.02	67.0
SoFAAS [c]	12.74	12.1-13.3	63.6
Components of DQI-DFG [d]	**Mean score**	**95% CI**	**Percentage in relation to maximum score**
Fruits	5.34	4.80-5.87	35.6
Vegetables	9.73	9.20-10.27	64.9
Whole grains, roots and tubers	0.52	0.39-0.66	10.4
Milk and dairy	2.69	2.30-3.08	26.9
Poultry, seafood and eggs	6.66	6.00-7.32	53.3
Legumes and nuts	8.23	7.62-8.84	54.9
Oils and fats	6.64	6.49-6.80	88.5
Refined grains	0.58	0.43-0.73	11.6
Sugars and sweets	2.57	2.26-2.88	51.4
Beef, pork and processed meats	1.63	1.46-1.81	32.6
Processed fats	2.85	2.56-3.13	57.0

[a] BHEI-R: Brazilian Healthy Eating Index-Revised. [b] 95% CI: 95% confidence interval. [c] SoFAAS: energy percentage from fats (saturate and trans), alcohol and added sugar. [d] DQI-DFG: Diet Quality Index Associated to Digital Food Guide.

Source: Inquérito de Consumo Alimentar do Município de Campinas, SP (ISACamp-Nutri 2014-2016).

tubers (except potato) and classifying refined grains as a moderation component. The number of portions recommended was established to restrict the consumption of refined grains (≤ 1.0 portion of 200 kcal) and prioritize whole grains, roots and tubers (2.0 to 3.0 portions of 260 kcal) in the daily diet.

The indicators also differed in terms of the maximum scores of the components. The DQI-DFG attributes higher scores for foods such as fruits, vegetables, legumes and nuts (15 points) and poultry, seafood and eggs (12.5 points) and lower scores (5 points) for beef, pork and processed meats, sugars and sweets, and processed fats (margarine, mayonnaise, lard and ready-made salad dressings); these 5-point groups are considered moderation components (foods for

which consumption is discouraged). On the BHEI-R, the fruits and vegetables components each total 10 points, whereas 10 points is conferred for saturated fat and another 20 points is conferred for SoFAAS (calories from saturated and trans fat, alcohol and added sugars). The adequacy components of the DQI-DFG account for 80% of the total score (100 points), resulting in a refinement in the detection of a diet of better quality.

The DQI-DFG is more discerning regarding the selection of foods that compose some of the components. The BHEI-R allows the inclusion of crackers/cookies, packaged crisps, cakes and sweet breads in the total grains group, sweetened yogurts, milk-based ice creams and soy-based beverages in the milk and dairy group, and pro-

Table 2. Mean BHEI-R and DQI-DFG scores according to sociodemographic variables, chronic diseases and smoking among older adults, 2015-16 Dietary Intake Survey of city of Campinas, SP, Brazil.

Variables and categories	n	BHEI-R [a]		DQI-DFG [b]	
		Mean [unadjusted] (95% CI) *	Mean [adjusted] (95% CI) *	Mean [unadjusted] (95% CI) *	Mean [adjusted] (95% CI) *
Sex					
Male [#]	323	62.9 (61.5-64.3)	61.7 (59.7-63.6)	47.9 (46.2-49.5)	47.6 (45.7-49.5)
Female	499	62.9 (59.5-66.3)	61.6 (57.5-65.5)	47.2 (43.3-51.1)	47.1 (42.9-51.2)
Total	822	62.9 (61.8-64.1)		47.5 (46.2-48.7)	
Age group (in years)					
60 to 69 [#]	430	61.6 (59.6-63.5)	61.7 (59.7-63.6)	47.3 (45.5-49.1)	47.6 (45.7-49.5)
70 to 79	266	**64.1 (59.7-68.4)**	**64.2 (59.8-68.5)**	48.7 (44.2-53.2)	49.0 (44.4-53.6)
80 or older	126	**64.7 (59.9-69.4)**	**64.8 (60.0-69.6)**	45.3 (39.7-51.0)	45.7 (39.9-51.4)
Schooling (in years)					
0 to 3 [#]	293	64.5 (63.0-65.9)	63.1 (60.8-65.5)	47.1 (45.8-49.5)	47.3 (45.0-49.5)
4 to 8	351	63.6 (59.8-67.3)	62.5 (58.0-67.1)	48.3 (43.6-53.0)	48.3 (42.8-53.9)
9 or more	172	**60.5 (56.2-64.6)**	**59.5 (54.3-64.8)**	47.5 (43.8-51.3)	47.5 (42.8-52.2)
Family income per capita (MMW)					
< 1 [#]	247	64.5 (63.1-65.9)	63.3 (61.1-65.4)	45.4 (43.4-47.5)	45.3 (42.6-48.0)
≥ 1 and < 2	308	63.2 (59.8-66.5)	62.0 (57.8-66.1)	47.6 (42.7-52.5)	47.5 (42.0-53.0)
≥ 2 and < 3	146	61.8 (56.7-66.8)	61.0 (55.3-66.6)	48.7 (43.2-54.2)	**48.9 (42.7-55.0)**
≥ 3	121	**61.6 (57.6-65.7)**	60.5 (55.5-65.4)	**48.5 (43.5-53.5)**	**48.3 (42.6-54.0)**
Diabetes mellitus					
No [#]	594	61.9 (60.4-63.4)	60.7 (58.5-62.9)	46.6 (45.2-48.0)	46.9 (44.8-48.9)
Yes	218	**66.0 (61.6-70.4)**	**64.8 (59.7-69.8)**	**49.9 (46.3-53.4)**	**50.1 (45.8-54.3)**
Hypertension					
No [#]	326	62.2 (60.5-64.0)	61.2 (58.8-63.6)	48.0 (46.5-49.5)	48.1 (46.2-50.1)
Yes	486	63.4 (59.9-66.9)	62.0 (58.0-66.0)	47.1 (43.7-50.4)	46.9 (43.1-50.8)
Smoking					
Never smoked [#]	542	63.5 (62.2-64.7)	62.2 (60.0-64.3)	47.8 (46.4-49.3)	48.3 (45.9-50.8)
Ex-smoker	185	63.1 (59.6-66.5)	62.0 (57.7-66.3)	46.6 (42.9-50.4)	46.8 (41.9-51.7)
Smoker	89	**59.3 (55.1-63.4)**	**58.7 (53.6-63.7)**	46.3 (41.8-50.9)	46.6 (41.2-52.1)

n: number of individuals in unweighted sample. [a] BHEI-R: Brazilian Healthy Eating Index-Revised. [b] DQI-DFG: Diet Quality Index Associated to Digital Food Guide. MMW: monthly minimum wage. * Means obtained by simple and multiple linear regression (adjusted for sex and/or age); 95% CI: 95% confidence interval; bold type: p-value < 0.05; # reference category used for comparison.

Source: Inquérito de Consumo Alimentar do Município de Campinas, SP (ISACamp-Nutri 2014-2016).

cessed meats in the meats, eggs and beans group, which is contrary to the current recommendations of the *Dietary Guide for the Brazilian Population* to avoid the consumption of ultra-processed foods.[6] The guide offers a change in the paradigm incorporated by the DQI-DFG by classifying the majority of ultra-processed foods as moderation components.

Another important difference between the indicators regards the definition of specific groups for legumes and nuts, poultry, seafood and eggs, and beef, pork and processed meats, as presented in the DQI-DFG. The BHEI-R unites meat, eggs and beans into a single component. If the maximum score for this component were reached (10 points = 1 portion of 190 kcal) and the energy from legumes remains, it is transferred to two other components: total vegetables and dark green/orange vegetables. This method does not consider differences in the nutritional values of proteins[23] or the risk of red/processed meats for the development of chronic diseases[24,25] and overestimates the vegetable scores (raw and cooked vegetables). This difference between the

Table 3. Mean scores of BHEI-R and DQI-DFG components according to age group among older adults, 2015-16 Dietary Intake Survey of city of Campinas, SP, Brazil.

Components of BHEI-R [a]	Age group (in years)			p-value* (2)/(1)	p-value (3)/(1)
	60 to 69 (1)	70 to 79 (2)	≥ 80 (3)		
Total fruits	2.41	2.80	2.77	**0.044**	0.328
Whole fruits	2.63	3.01	2.83	0.097	0.601
Total vegetables	4.46	4.56	4.65	0.409	0.093
Dark green and orange vegetables and legumes	3.93	4.18	3.90	0.102	0.883
Total grains	4.62	4.58	4.62	0.692	0.950
Whole grains	0.49	0.84	0.58	**0.046**	0.562
Milk and dairy	3.48	4.81	5.24	**< 0.001**	**0.001**
Meat, eggs and beans	8.77	8.74	8.60	0.919	0.520
Oils	9.22	9.32	9.64	0.672	0.082
Sodium	1.95	2.36	1.85	**0.020**	0.704
Saturated fat	6.65	6.72	6.84	0.864	0.676
SoFAAS [b]	12.97	12.18	13.17	0.166	0.793

Components of DQI-DFG [c]	Age group (in years)			p-value* (2)/(1)	p-value (3)/(1)
	60 to 69 (1)	70 to 79 (2)	≥ 80 (3)		
Fruits	4.93	6.27	4.57	**0.012**	0.698
Vegetables	9.75	10.25	8.56	0.361	0.148
Whole grains, roots and tubers	0.54	0.54	0.41	0.854	0.407
Milk and dairy	2.39	2.69	3.62	0.291	**0.003**
Poultry, seafood and eggs	7.03	6.64	5.55	0.558	0.059
Legumes and nuts	8.79	7.77	7.59	0.075	0.234
Oils and fats	6.70	6.69	6.37	0.936	0.196
Refined grains	0.58	0.58	0.71	0.630	0.494
Sugars and sweets	2.61	2.36	2.91	0.222	0.345
Beef, pork and processed meats	1.48	1.78	1.81	0.253	0.305
Processed fats	2.53	3.11	3.21	**0.001**	**0.013**

[a] BHEI-R: Brazilian Healthy Eating Index-Revised. Means obtained through simple linear regression; * bold type: p-value < 0.05. (1) reference category; (2)/(1) 70 to 79 years in relation to reference category; (3)/(1) ≥ 80 years in relation to reference category. [b] SoFAAS: energy percentage from fats (saturates and trans), alcohol and added sugar. [c] DQI-DFG: Diet Quality Index Associated to Digital Food Guide.

Source: Inquérito de Consumo Alimentar do Município de Campinas, SP (ISACamp-Nutri 2014-2016).

two methods may explain why the percentage of the mean in relation to the maximum score of the meat, eggs and beans component was high on the BHEI-R (87.3%) and low on the DQI-DFG (32.6%) for the beef, pork and processed meats component.

Unlike the BHEI-R, the DQI-DFG did not detect poorer global diet quality among smokers. The association between smoking and poor diet quality has been identified in other studies using the BHEI-R[19,20]. Among older residents of Brazilian state capitals and the Federal District, smokers were more likely to have abusive alcohol use (odds ratio = 2.94) and inadequate diet (odds ratio = 1.51) evaluated using an index that reflects the frequency of the consumption of fruits, vegetables, beans, milk, sweets, red meat and sweetened beverages[26]. A study conducted in the United States using data from 3-day diet records found that smokers had lower intakes of energy, polyunsaturated fatty acids, omega-3, dietary fiber and several micronutrients, such as calcium, iron, magnesium and vitamins A, C and E, in comparison to non-smokers[21].

The scoring rules for the DQI-DFG are more rigorous compared to those of the BHEI-R, considering the establishment of consumption ranges that protect the diet from an excess of saturated fat, refined carbohydrates, fructose and sucrose. Seven of the 11 DQI-DFG components receive

a decreasing proportional score or no points if intake surpasses the establish range of portions. The maximum DQI-DFG score is linked to portions with higher energy value for milk, fruits and vegetables; the fruits and vegetables score is not split into subgroups and has a higher value; and the classification of foods is more refined, as exemplified by specific groups for red and processed meats, white meats and eggs, legumes, and sugars and sweets. These differences may explain why the DQI-DFG did not identify significant associations with smoking, age or schooling. Moreover, the means of the components are quite distant from each maximum score, as demonstrated in Table 1.

Income and schooling have been associated with better diet quality, as reported in studies conducted in Australia[27], the Unites States[28] and Brasil[29] and partially confirmed in the present sample, as older people with greater purchasing power had higher DQI-DFG scores. However, the BHEI-R indicated that poorer diet quality was associated with a higher income and level of schooling, which contrasts findings from other studies and may be due to the particularities of the index mentioned above.

Dietary indices are useful tools for assessing and monitoring food intake on the individual and collective levels, as such measures unite different food groups and/or nutrients, enabling a better understanding of eating practices. Such measures constitute a more appropriate way for assessing diet quality in comparison to studies of a reductionist nature that analyze a single food/ nutrient.[5] The advance of studies in the field of nutrition has demonstrated that the beneficial effects of eating patterns on health are not the result of individual foods, but rather how foods are combined, prepared and consumed[5,6]. An example is the Mediterranean diet, which is characterized by high intake of fruits, vegetables, whole grains, nuts and legumes, moderate intake of dairy, fish, poultry and olive oil, and low consumption of red meats[30]; several studies have demonstrated the protective role of this traditional eating pattern regarding cardiovascular disease, diabetes and premature death[30-32].

Studies conducted in Brazil show that older people generally have a healthier, more traditional diet compared to younger groups. A study investigating the most widely consumed foods in Brazil using data from the National Diet Survey, which was part of the 2008-2009 Family Budget Survey, found that only older people cited more than one fruit and raw vegetable and soup/broths among the 20 most prevalent foods and, unlike adolescents and adults, did not report carbonated soft drinks or fried and baked snack foods[33]. The findings of the 2013 National Health Survey revealed that, compared to adults, older people had higher rates of the recommended intake of fruits and vegetables and fish (≥ 1 day per week)[34] as well as lower frequency of the regular consumption (≥ 5 days per week) of red meat and chicken with excess fat, carbonated soft drinks and sweets[35]. A study involving Brazilian older adults and employing cluster analysis found that the majority had a healthy eating pattern, with the greater consumption of vegetables, chicken, milk, fruits and fruit juices[36]. However, the diet quality of the older adults in the present study was not considered adequate, revealing that the use of indices offers more robust information on diet as a whole.

In Brazil, 72.6% of deaths in 2013 were caused by chronic noncommunicable diseases, especially cardiovascular disease, cancer, respiratory diseases and diabetes *mellitus*[37]. The prevalence and number of chronic diseases increase with age. Among Brazilian older adults, the prevalence of multimorbidity (presence of two or more diseases) was 58.8% among individuals 50 to 59 years of age, increasing to 73.4% (60-69 years), 79.0% (70-79) and 82.4% (≥ 80 years)[38]. Nutritional disorders affect a large portion of older women (18.2% of those underweight and 41.9% of those overweight) and older men (19.9% of those underweight and 31.6% of those overweight)[39]. Moreover, chronic low-grade inflammation (*inflamm-aging*), which is an inherent condition of aging, increases the risk of chronic diseases[40] and an unhealthy diet induces the inflammatory response[2].

The diet quality of the older adults in the present study was unsatisfactory and the lower DQI-DFG score reflects an assessment that approaches current national recommendations with regards to the classification of foods according to the degree of processing. The indicators analyzed present divergences regarding the scores of the components, which are explained by differences in scoring criteria, the energy value of the portion and the organization of the components. For instance, the total grains group on the BHEI-R includes foods that are classified in other groups on the DQI-DFG (refined grains; sugars and sweets; and whole grains, roots and tubers), as occurs with the meat, eggs and beans group (red and processed meats; poultry, seafood and eggs; and legumes and nuts) and milk and dairy

group (sugars and sweets). On the DQI-DFG, the moderation and adequacy (fruits; milk and dairy; and whole grains, tubers and roots) components received decreasing scores if consumed in excess, offering a more thorough method for the assessment of dietary quality.

Considering the methodological differences of the indices and the current epidemiological scenario in Brazil, the DQI-DFG is more aligned with the recommendations of the *Dietary Guide for the Brazilian Population*,[6] the aim of which is to protect and promote health. Nevertheless, the results point to the need for further studies that can adapt diet quality indicators to the specificities of what is expected as a quality attribute for this stage in life, considering the absence (to the best of our knowledge) of a specific assessment tool for the diet of older adults.

Among the limitations of the present study, it is necessary to consider possible errors resulting from the methods chosen to estimate food consumption. The application of a single 24-hour recall does not represent habitual consumption due to the variation in foods over the course of several days[41]. However, when administered on different days of the week and months of the year, information from a single 24HR is sufficient to estimate the average consumption of a group or differences between groups[42]. Moreover, the interviewees of the Campinas Nutrition Survey were trained to apply the 24HR using the Multiple-Pass Method, which helps the individual remember the foods and beverages consumed, making the record of information more precise. The interviewers also used a photographic album to assist the individual in defining the quantities of the foods.

The strengths of the present study include the use of a representative sample of the older population and the standardization of the collection procedures as well as the quantification and input of the dietary data. The review of the content of the 24HR and the quantification and input of the data to the NDS-R program were performed by trained nutritionists. To the best of

our knowledge, no previous national study has evaluated the results of diet quality indices applied to older adults.

Conclusion

Differences were found between the two diet quality indicators analyzed in the magnitude of the global quality scores as well as associations with sociodemographic variables and smoking. The following are the main characteristics that distinguish the DQI-DFG from the BHEI-R: energy value of the portions, which is high for foods such as milk, fruits and vegetables; the establishment of consumption ranges linked to the maximum score of the components to protect the diet from the excess of nutrients; a decreasing proportional score or no points for situations in which consumption surpasses the established range; maximum scores for components such as fruits, vegetables, legumes and nuts, poultry, seafood and eggs, and lower scores for red and processed meats, sugars and sweets, and processed fats; greater discernment regarding the organization of the components and the selection of foods that integrate the components. These characteristics denote greater refinement in the classification of a diet of better quality. However, the DQI-DFG does not address alcohol intake. Considering evidence in the literature on the use of alcohol and the increase in the risk of chronic diseases and premature death, this aspect can be considered a limitation of the measure, along with the lack of information on the proportion of fatty acids.

The development and improvement of novel diet quality indicators constitutes an opportunity to incorporate scientific advances in nutrition. The complexity of the aging process and implications for the dietary profile require the creation of specific instruments that include aspects such as the consumption of water, coffee, tea, a variety of foods and the use of spices, besides a likely adjustment in the portion criteria, with adequate energy quotas for this stage of life.

Collaborations

D Assumpção performed the analysis, literature review and writing of the manuscript. SA Caivano and LP Corona performed a critical revision of the manuscript. MBA Barros preformed a revision of the statistical analyses and critical revision of the manuscript. AA Barros Filho preformed a revision of the statistical analyses and critical revision of the manuscript. SMA Domene oriented the proposal of the study, contributed to the writing of the manuscript and performed a critical revision of the manuscript. All authors approved the final version to be published.

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