

Are there differences in nutrient intake of Brazilian adults according to weight status?

Há diferenças na ingestão de nutrientes de adultos brasileiros segundo a condição de peso?

Marina Campos Araujo (<https://orcid.org/0000-0002-7980-6618>)¹

Camilla de Chermont Prochnik Estima (<https://orcid.org/0000-0002-5410-3940>)²

Edna Massae Yokoo (<http://orcid.org/0000-0002-3513-2084>)³

Taís de Souza Lopes (<http://orcid.org/0000-0002-6308-6214>)⁴

Rosângela Alves Pereira (<http://orcid.org/0000-0002-9886-9796>)⁴

Rosely Sichieri (<http://orcid.org/0000-0001-5286-5354>)²

Abstract *It was assessed the intake and prevalence of inadequate nutrient intake according to weight status among Brazilian adults from urban areas (n=16,198) evaluated in the Brazilian National Dietary Survey (NDS – 2008-2009), that obtained food records from two non-consecutive days. The prevalence of inadequate nutrient intake according to weight status was estimated based on Brazilian and international recommendations, in which usual intake was estimated applying the National Cancer Institute method. From 14 nutrients evaluated, six differed according to weight status in men, and only two among women. For men, the mean proportion of energy derived from lipids and saturated fat and mean intake of cholesterol, zinc, and vitamin B12 were greater among those with excess weight compared to those with normal weight; the inverse was observed for dietary fiber. Mean sodium intake was greater and proportion of energy from added sugar intake was lower among obese women compared to overweight ones. Strategies to encourage food consumption with high micronutrient density should be targeted to adult population regardless of their weight status.*

Key words *Nutrients, Obesity, Diet surveys, Diet records*

Resumo *Avaliou-se a ingestão e a prevalência de ingestão inadequada de nutrientes segundo a condição de peso em adultos brasileiros de áreas urbanas (n = 16.198) investigados no Inquérito Nacional de Alimentação (INA 2008-2009), que obteve o registro alimentar de dois dias não consecutivos. A prevalência de inadequação da ingestão de nutrientes foi estimada segundo a condição de peso e com base em recomendações brasileiras e internacionais, sendo a ingestão usual estimada pelo método do National Cancer Institute. Dos 14 nutrientes avaliados, seis diferiram segundo a condição de peso em homens e apenas dois entre as mulheres. Para os homens, a proporção média de energia proveniente dos lipídios e da gordura saturada e a ingestão média de colesterol, zinco e vitamina B12 eram mais elevadas para aqueles com excesso de peso do que entre os que tinham peso normal; o inverso foi observado para fibra dietética. A ingestão média de sódio foi maior e a proporção de ingestão de energia proveniente do açúcar de adição foi menor entre as mulheres obesas comparadas àquelas com sobrepeso. Estratégias para incentivar o consumo de alimentos com alta densidade de micronutrientes devem ser dirigidas à população adulta independentemente da sua condição de peso.*

Palavras-chave *Nutrientes, Obesidade, Inquéritos sobre dietas, Registros de dieta*

¹ Escola Nacional de Saúde Pública Sérgio Arouca, Fiocruz. R. Leopoldo Bulhões 1480/803, Bonsucesso. 21041-210 Rio de Janeiro RJ Brasil. mcamposaraujo@gmail.com

² Departamento de Epidemiologia, Instituto de Medicina Social, Universidade do Estado do Rio de Janeiro. Rio de Janeiro RJ Brasil.

³ Departamento de Epidemiologia e Bioestatística, Universidade Federal Fluminense. Niterói RJ Brasil.

⁴ Departamento de Nutrição Social e Aplicada, Universidade Federal do Rio de Janeiro. Rio de Janeiro RJ Brasil.

Introduction

The World Health Organization recognizes the obesity epidemic as an important target for the prevention and control of non-communicable diseases (NCD)¹. National survey data from the United States found lower intakes of micronutrients and higher prevalence of nutrient inadequacy among overweight and obese adults compared to normal weight ones². Also, specific nutrients have been associated with obesity, such as blood deficiency of iron, zinc, or vitamins A, C and E^{3,4}. Low blood concentrations of zinc, vitamin A or C in humans, for example, may decrease leptin expression, an adipokine connected with satiety³, and increase insulin resistance⁴, both effects that are related to adiposity. Iron and vitamin E were inversely associated with insulin and C-reactive protein⁴ and C-reactive protein has been directly associated with obesity in adults⁵. Moreover, García *et al.*⁶ reviewed the impact of micronutrient deficiencies on obesity and stated that antioxidants, such as vitamin C, vitamin E and β -carotene, were predictors of the levels of leptin, which is closely related to obesity. However, this association may not represent a causal relationship and most guidelines have recommended reduced energy intake to prevent obesity regardless of diet composition⁷.

Considering that nutrient biomarkers may be associated with obesity, we hypothesized whether nutrient intake and micronutrient intake inadequacy were different according weight status believing that overweight and obese adults have greater micronutrient intake inadequacy compared to normal weight individuals. We evaluated nutrient intake and inadequacies according to weight status in a large population based study, the first Brazilian National Dietary Survey (2008-2009) that showed important prevalence of micronutrient inadequate intake throughout all age groups⁸⁻¹¹.

Subjects and Methods

The National Dietary Survey (NDS) carried out in 2008-2009 was the first Brazilian nationwide survey of individual dietary intake. Design and sampling procedures are described elsewhere¹². Briefly, a two-stage cluster sampling design was used. First, the primary sampling units, census tracts, were selected by systematic sampling and, afterwards households, the secondary sampling units, were selected by simple random sampling.

Individuals aged 10 years or older ($n = 34,003$) living in 13,569 households from all five Brazilian Regions and urban and rural areas were included in the dietary survey. For this paper, only adults aged 20-59 years old from urban areas were included, excluding pregnant and lactating women ($n = 781$), yielding a final sample of 16,198 Brazilian adults. The present study was approved by the local ethics committee.

Food records from two non-consecutive days were used to estimate food intake. Food nutritional composition was obtained in the Brazilian Table of Food Composition and in the Nutrient Data System for Research, version 2008 (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN, USA)¹³. The nutrient intake data did not include the consumption of supplements and/or medications.

Body weight was measured using a portable electronic scale with capacity of 150 kg and height was assessed using a portable stadiometer. Weight status was classified using the body mass index ($BMI = \text{weight in gram/height in cm}^2$) classified according to the World Health Organization (WHO) criteria¹⁴.

Data analyses

The National Cancer Institute (NCI) method was used to estimate usual intake of energy, energy from protein, energy from carbohydrate, energy from added sugar, energy from lipids, energy from saturated fat, dietary fiber, cholesterol, calcium, iron, zinc, vitamins B12, A, C and sodium. The NCI method was also used to estimate the prevalence of nutritional inadequacy. This method estimates the usual intake after adjusting for within-person variance using the linear mixed effects model¹⁵. The technique of balanced repeated replication (BRR) was used to estimate standard errors¹⁶.

The prevalence of micronutrients inadequacy (except sodium and iron) was assessed through the Estimated Average Requirement (EAR) cut-off point method¹⁷⁻²⁰, in which inadequacy denotes the proportion of population that consumed less than the median requirement. For sodium intake, inadequacy denotes excessively high intake [over the Tolerable Upper Intake Level (*UL*)]²¹. For iron intake, the probability approach method was used²². The cut-off point for total cholesterol and energy from saturated fat followed the Brazilian Society of Cardiology recommendations²³. Dietary Reference Intakes (DRI) were used to assess energy from protein, carbohydrates and

lipids²⁴ and WHO recommendation were used for energy from added sugar²⁵. For dietary fiber intake, we adopted a value of 25 g/d considering a diet of 8368 kJ (2000 kcal), as recommended by the Brazilian Ministry of Health²⁶. Nutrient intake means and inadequacy prevalence were estimated according to weight status.

The Goldberg method adapted by Black²⁷ was used to define misreporting. Basal Metabolic Rates (BMR) were estimated²⁸ and the ratios between reported energy intakes and BMRs (rEI:BMR) were calculated along with the 95% confidence limits. Acceptable reporters were defined as having a rEI:BMR in the range 1.00 to 2.42, under-reporters as a ratio <1.00, and over-reporters as a ratio > 2.42²⁷.

NCI models used to estimate usual nutrient intake and prevalence of nutritional inadequacy included energy, age and misreporting as covariates. Macronutrient intake was analyzed a proportion of total energy intake and not considered energy intake as covariate.

Statistical significance analysis was performed by comparing the 95% confidence intervals. All statistical analyses were performed using survey procedures from SAS release 9.3 (2011, SAS Institute) to take into account weighting and the sample design effect considering the primary and secondary sampling units.

Results

Overall prevalence of overweight was 35%, while that of obesity was 15%. The prevalence of overweight was higher among men (40%) than among women (29%), whereas the prevalence of obesity was higher in women (17%) than in men (13%) (Table 1).

In both sexes, mean proportion of energy from protein was slightly higher among obese people. Among men, mean proportion of energy derived from total lipids and saturated fat total and mean intake of cholesterol, zinc, and vitamin B12 were greater among obese men compared to overweight and normal weight men. The inverse was observed for fiber intake. The mean of sodium intake was higher among obese women compared to overweight one. However, mean of added sugar intake was lower for obese compared to non-obese subjects. (Table 2).

Prevalence of inadequacy intake equal to or greater than 60% were observed for proportion of energy from added sugar, dietary fiber, calcium, sodium, and vitamin A among both men

Table 1. Prevalence of weight status and mean age among Brazilian adults (20–59 years old) from urban areas: The 2008-2009 National Dietary Survey.

	Total		Men		Women	
	n = 16 198		n = 7 441		n = 8 757	
Age (years)	37.7	0.2	37.9	0.2	38.1	0.2
[mean, standard error: SE]						
Overweight (BMI 25-29.9 kg/m ²) [%, SE]	34.9	0.6	40.5	0.9	29.5	0.8
Obesity (BMI ≥30 kg/m ²) [%, SE]	14.8	0.5	12.8	0.6	16.8	0.7

and women regardless of weight status. The prevalence of inadequacy of energy from total lipids and saturated fat, cholesterol, and dietary fiber intake was greater among obese men compared to non-obese men. Alternatively, the prevalence of inadequate intake of zinc and vitamin B12 was lower among obese men compared to their counterparts. The prevalence of inadequacy of added sugar intake was lower among obese women compared to overweight and normal weight women (Table 3).

Discussion

Our hypothesis was not confirmed since the findings of this exploratory analysis showed that there were almost no differences in nutrient intake according to weight status, which suggests that nutrient inadequate intake might not be contributing to the development of obesity among Brazilian adults. Although obese men had excessive fat and low fiber intake compared to men of other weight status and obese women had excessive sodium intake compared to overweight, the mean values are close, and the prevalence of inadequate fat intake was low independently of weight status.

The higher zinc and vitamin B12 intake among obese men might be related to higher protein intake, mainly animal protein intake, since proportion of energy from protein was slightly higher among obese people. Brazilian national data of food intake showed that prevalence of all meat intake (beef, pork meat, chicken, processed meat) were greater among men than women²⁹⁻³¹

Table 2. Adjusted mean intake* according to weight status among Brazilian adults (20–59 years old) from urban areas: The 2008–2009 National Dietary Survey.

	Normal weight †		Overweight †		Obesity †	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
Men (n = 7441)	(n = 3643)		(n = 2824)		(n = 974)	
Energy (kJ) ‡	8870	8643; 9097	8995	8791; 9199	9164	8735; 9592
Energy from protein (%)	16.9	16.6; 17.1	17.4	17.0; 17.7	17.4	17.1; 17.8
Energy from carbohydrate (%)	55.4	55.0; 55.8	54.3	53.8; 54.8	53.2	52.3; 54.1
Energy from added sugar (%)	13.0	12.5; 13.6	13.1	12.4; 13.9	12.5	12.2; 12.8
Energy from lipids (%)	26.9	26.7; 27.1	27.4	27.2; 27.6	27.9	27.6; 28.3
Energy from saturated fat (%)	9.1	9.0; 9.2	9.4	9.3; 9.4	9.7	9.6; 9.8
Cholesterol (mg)	272	267; 278	277	269; 285	295	287; 302
Dietary fiber (g/4184kJ)	11.1	10.8; 11.4	10.8	10.3; 11.3	10.2	9.8; 10.7
Calcium (mg)	548	521; 576	577	569; 584	582	561; 602
Iron (mg)	13.4	13.1; 13.6	13.6	13.2; 13.9	13.5	13.0; 13.9
Zinc (mg)	12.7	12.1; 13.2	13.2	12.8; 13.5	14.1	13.8; 14.3
Vitamin B12 (µg)	5.1	4.9; 5.3	5.5	5.3; 5.7	6.0	5.6; 6.3
Vitamin A (µg) §	435	405; 465	457	431; 482	451	409; 494
Vitamin C (mg)	119	111; 127	132	126; 137	136	116; 156
Sodium (mg)	3605	3560; 3650	3697	3598; 3797	3648	3576; 3721
Women (n = 8757)	(n = 4713)		(n = 2620)		(n = 1424)	
Energy (kJ) ‡	7216	6954; 7479	6985	6798; 7173	7113	6893; 7333
Energy from protein (%)	16.6	16.3; 16.9	16.4	16.2; 16.7	17.2	17.0; 17.4
Energy from carbohydrate (%)	56.2	56.0; 56.5	56.1	55.6; 56.6	55.7	55.2; 56.2
Energy from added sugar (%)	14.9	14.5; 15.3	14.7	14.2; 15.1	13.2	12.9; 13.5
Energy from lipids (%)	27.3	27.0; 27.6	27.6	27.4; 27.8	27.5	27.1; 27.8
Energy from saturated fat (%)	9.6	9.5; 9.8	9.7	9.6; 9.9	9.5	9.4; 9.6
Cholesterol (mg)	229	217; 242	218	212; 225	232	212; 252
Dietary fiber (g/4184kJ)	10.7	10.4; 10.9	10.6	10.4; 10.9	10.9	10.6; 11.3
Calcium (mg)	498	483; 512	463	433; 494	468	445; 490
(20–50 years)	499	479; 519	458	425; 492	447	428; 465
(51–59 years)	497	460; 534	481	437; 524	523	482; 563
Iron (mg)	10.2	9.8; 10.6	9.7	9.6; 9.8	10.2	9.7; 10.7
(20–50 years)	10.3	9.9; 10.8	9.8	9.7; 9.9	10.3	9.9; 10.7
(51–59 years)	9.3	9.0; 9.6	9.4	8.9; 9.9	10.0	9.2; 10.8
Zinc (mg)	9.9	9.6; 10.2	9.5	9.3; 9.8	10.3	9.6; 11.0
Vitamin B12 (µg)	4.2	4.0; 4.4	4.1	4.0; 4.1	4.3	4.0; 4.7
Vitamin A (µg) §	440	409; 471	433	416; 451	431	408; 454
Vitamin C (mg)	128	120; 137	123	115; 132	115	103; 126
Sodium (mg)	2811	2738; 2883	2735	2717; 2754	2907	2817; 2998

* Mean nutrient intake was adjusted for energy intake, except for nutrients described as percentages of energy intake. Both mean nutrient intake and prevalence of inadequate nutrient intake were adjusted for age and under- and over-reporting. † Normal weight = BMI <25kg/m²; Overweight = BMI 25–29.9kg/m²; Obesity = BMI ≥30 kg/m². ‡ 1 kJ = 0.239 kcal. § Calculated as retinol activity equivalents.

while men had lower prevalence of vegetables and fruit intake compared to women^{12,32}.

The finding that obese women have a lower intake of excessive added sugar compared to overweight and normal weight women indicates a possible substitution of added sugar for artificial sweeteners and/or low sugar products among obese women, since analyses were adjusted for

misreporting. Furthermore, the lower intake of added sugar among obese women was accompanied by quite similar energy intake across the weight status groups, indicating that the reduction of added sugar among obese women was offset by an increase in other energy sources.

Few studies compared nutrient intake across the categories of weight status. Agarwal *et al.*²

Table 3. Cut-off points to define inadequate intake*, and prevalence of inadequate nutrient intake according to weight status among Brazilian adults (20–59 years old) from urban areas: The 2008-2009 National Dietary Survey.

	Cut-off point	Prevalence of inadequacy					
		Normal weight †		Overweight †		Obesity †	
		%	95% CI	%	95% CI	%	95% CI
Men (n = 7441)							
Energy (kJ) ‡		-	-	-	-	-	-
Energy from protein (%)	<10%	0.2	0.1; 0.3	0.1	0.03; 0.2	0.1	0.05; 0.2
Energy from carbohydrate (%)	>65%	7	6; 7	5	4; 6	3	2; 4
Energy from added sugar (%)	>10%	67	64; 69	67	64; 71	63	59; 67
Energy from lipids (%)	>35%	4	4; 5	5	5; 6	7	6; 7
Energy from saturated fat (%)	>10%	33	31; 35	37	36; 38	42	40; 44
Cholesterol (mg)	>300mg	36	34; 38	37	34; 40	42	39; 45
Dietary fiber (g/4184kJ)	<12.5g/4184kJ	70	66; 74	74	69; 79	79	74; 84
Calcium (mg)	<800 mg	85	83; 88	82	81; 83	82	79; 84
Iron (mg)	-	5	-	5	-	4	-
Zinc (mg)	<9.4 mg	28	26; 31	27	24; 30	22	19; 25
Vitamin B12 (µg)	<2 µg	9	7; 10	7	5; 8	5	4; 5
Vitamin A (µg) §	<625 µg	82	79; 85	79	76; 83	80	76; 84
Vitamin C (mg)	<75 mg	49	46; 53	45	44; 46	44	40; 48
Sodium (mg)	>2300 mg	87	86; 87	88	87; 89	88	87; 89
Women (n = 8757)							
Energy (kJ) ‡		-	-	-	-	-	-
Energy from protein (%)	<10%	0.3	0.2; 0.4	0.3	0.2; 0.5	0.2	0.1; 0.3
Energy from carbohydrate (%)	>65%	8	7; 10	8	7; 9	7	6; 8
Energy from added sugar (%)	>10%	77	74; 80	76	74; 78	68	65; 70
Energy from lipids (%)	>35%	5	4; 6	6	5; 6	6	5; 7
Energy from saturated fat (%)	>10%	41	39; 44	43	41; 45	39	38; 41
Cholesterol (mg)	>300mg	21	17; 24	18	16; 21	23	16; 30
Dietary fiber (g/4184kJ)	<12.5g/4184kJ	75	72; 78	75	72; 78	72	68; 76
Calcium (mg)		-	-	-	-	-	-
(20-50 years)	<800 mg	82	81; 83	91	89; 94	92	91; 93
(51-59 years)	<1000 mg	96	94; 98	96	95; 98	95	94; 97
Iron (mg)		-	-	-	-	-	-
(20-50 years)	-	31	-	35	-	32	-
(51-59 years)	-	34	-	35	-	36	-
Zinc (mg)	<6.8 mg	20	19; 22	25	24; 26	21	18; 25
Vitamin B12 (µg)	<2 µg	12	10; 14	15	13; 18	13	11; 15
Vitamin A (µg) §	<500 µg	68	64; 72	69	67; 71	70	67; 73
Vitamin C (mg)	<60 mg	36	34; 38	38	35; 40	41	37; 46
Sodium (mg)	>2300 mg	70	68; 73	65	63; 67	68	66; 71

* Cut-off point was based on Estimated Average Requirement for calcium, zinc, vitamins B12, A, C, and sodium. The probability approach method was used for iron. Brazilian Society of Cardiology recommendations were used for total cholesterol and energy from saturated fat. Dietary Reference Intakes were used for energy from protein, carbohydrates and lipids. WHO recommendation were used for energy from added sugar. Brazilian Ministry of Health recommendation was used for dietary fiber intake. † Normal weight = BMI < 25kg/m²; Overweight = BMI 25-29.9kg/m²; Obesity = BMI ≥30 kg/m². ‡ 1 kJ = 0.239 kcal. § Calculated as retinol activity equivalents.

compared micronutrient intake according to weight status among adults from National Health and Nutrition Examination Survey (NHANES) 2001-2008. Different from our results, the authors found that obese adults had about 5% to

12% lower micronutrient intake and a significantly greater prevalence of inadequate intake of vitamin A, vitamin C, vitamin D, vitamin E, calcium, and magnesium intake compared to normal weight adults. However, most of stu-

dies analyzed diet quality or nutrient deficiency using blood biomarkers^{3,4,33-35}. Results from the 2008-2009 NDS, the same survey used in the present study, showed that low diet quality was characterized by processed foods with high energy and low micronutrient density, and reduced fruit and vegetables consumption³⁶. However, it was not investigated diet quality according to weight status. Recent studies have identified low diet quality, based on analysis of food and nutrient intake, among obese people from both sexes and of different ages, socioeconomic status and culture^{33,34,37}. Nonetheless, studies that focused on differences on micronutrient biomarkers blood levels and obesity or obesity inflammation markers are controversial. García *et al.*³ observed an inverse association between blood concentrations of vitamins C and E with BMI and adiposity and a direct association between serum vitamin A and leptin concentrations among Mexican women. In another study, García *et al.*⁴ found an inverse association between serum iron and vitamin E with insulin concentrations and resistance. In addition, Zavala *et al.*³⁵ found that zinc blood concentrations were inversely associated with inflammatory cytokines present in populations with high prevalence of obesity. While the same study have not shown any evidence of vitamins C and E blood concentrations related to obesity inflammation markers among rural Mexican women. Nevertheless, it is noteworthy that these findings were obtained in special population groups or in clinical settings. We could not directly compare our results with those results because they used nutrient blood concentrations and obesity inflammation markers.

Although our objective was evaluate diet quality, based on nutrient intake e nutrient inadequate intake, according to weight status, it is important to mention that nutrient intake may not reflect the blood concentrations of nutrients. Nutrient status is determined not only by its total intake, but also by a number of factors that include its food sources (chemical form), nutrients and components interactions, nutrient metabolism, and so on³⁸.

A limitation of this study was that our data were based mainly on an American food composition table. This table was used since some foods, recipes, cooking methods, and nutrients information were not available in Brazilian food composition table. We recognized that some nutrients intake could be over- or underestimated compared to actual Brazilian food composition. However, we did a detailed verification of discrepancies between both nutritional composition databases in order to minimize nutrient over- or underestimate. Detailed information about these critical analyses can be found elsewhere¹³. In addition, American recommendations were used as cut-off point for nutrient inadequacy intake since we do not have Brazilians values established.

This nationwide dataset from a large middle-income country suggests that nutrient intake and inadequacies of nutrient intake are independent of weight status. This can be particularly important in non-obese people, who are not the priority group for public health strategies focusing on decreasing prevalence of obesity. Strategies to encourage consumption of food with high micronutrient density should cover all adult population regardless of their weight status.

Collaborations

MC Araujo contributed to the analysis and interpretation of the data, manuscript conception and writing; CCP Estima and EM Yokoo contributed to the interpretation of the data and manuscript writing; TS Lopes contributed to the analysis; RA Pereira and R Sichieri contributed to the design of the study, analysis and interpretation of the data, and manuscript writing. All authors read and approved the final manuscript.

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