Seasonal variation of food intake of adults from Niterói, Rio de Janeiro, Brazil

Variação sazonal na ingestão alimentar de adultos de Niterói, Rio de Janeiro

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Abstract

The measurement of usual food intake (FI) is necessary to accurately establish the relationship between diet and disease. In most studies data are collected at one particular time of the year, which may influence the interpretation of the results. The purpose of this study was to investigate the effect of seasonality on FI in a sample of adults from Niterói, RJ, Brazil. A total of 102 healthy subjects (69 women) aged between 20 and 69 years were interviewed to obtain six 24-hour dietary recalls, three in summer and three in winter. In both seasons, the intake of energy (EI) and 23 nutrients was determined and the percent of subjects who met the recommendations for the nutrients were computed. The data of FI were deattenuated considering the within-person variability and adjusted for energy. The intake of energy and some nutrients were significantly different between men and women. EI did not differ between seasons, for both sexes, but the intake of macro and micronutrients was different. The results of this study suggest that the seasonality in the measurement of FI should be considered in order to improve the methods and instruments used in population dietary surveys.

Keywords: Nutritional epidemiology. Diet. Diet Surveys. Food consumption. Seasons. Nutrition policy.

Resumo

A aferição da ingestão alimentar (IA) usual é necessária para estabelecer, com acurácia, a relação entre a dieta e o aparecimento de doenças. Na maioria dos estudos, os dados de IA usual são coletados referentes ao período de um ano, sem considerar a estação do ano em que o estudo ocorre. O objetivo do presente estudo foi verificar o efeito da sazonalidade na IA de adultos de Niterói, RJ. Um total de 102 sujeitos (69 mulheres) saudáveis, com idade entre 20 e 69 anos, responderam a seis recordatórios dietéticos de 24 horas, três no verão e três no inverno. Em ambas as estações do ano, foi determinada a ingestão energética (IE) e de 23 nutrientes, além do percentual de indivíduos que alcançavam as recomendações dos mesmos. Os dados finais foram deatenuados pela variabilidade intraindividual e ajustados pela energia. A IE e de alguns nutrientes foram significativamente diferentes entre os homens e as mulheres. A IE não se diferenciou entre as estações, para ambos os sexos, porém a ingestão de proteínas, fibras, magnésio, tiamina, piridoxina e niacina foi diferente entre as estações para ambos os sexos. Os resultados do presente estudo sugerem que a sazonalidade seja considerada na aferição da IA, servindo de base para a adequação dos métodos e instrumentos utilizados nos inquéritos dietéticos populacionais.

Palavras-chave: Epidemiologia nutricional. Dieta. Inquéritos sobre dietas. Consumo de alimentos. Estações do ano. Recomendações nutricionais.

Introduction

Data on food intake (FI) assessed with Food Frequency Questionnaires (FFQ) are usually collected at a particular time. Information bias could occur if the reference period for the information about FI includes the 12 previous months. As an example, if the FFQ is applied during summer, interviewees could involuntarily overestimate the foods typically consumed at this time of the year, to the detriment of foods consumed during winter. On the other hand, if the FFQ include a shorter period of time, such as three months, the information could be affected by the actual variation in the seasonal FI. This fact has been well documented and it has received significant attention in the literature[1,2]. Similarly, this could occur when other FI assessment instruments are applied, such as the dietary record or 24-hour dietary recall (24hR). The latter can be more or less affected by the seasons, depending on the number of assessments throughout the year.

There are controversies about the seasonal effect on FI. Some studies suggest that, as an example, the daily energy intake (EI) varies significantly according to the season of the year[1,2]. Others did not find such variation in EI[3,4], but identified differences in the eating pattern between seasons[5]. However, the majority of seasonal differences in the FI is found in regions where seasons are well defined, thus influencing the availability of certain foods throughout the year[1,6,7].

Considering the previously mentioned aspects, the present study aimed to assess the seasonal effect on the energy and macro- and micronutrient intakes of a sample of adults of the city of Niterói, RJ, Southeastern Brazil, where the climate is tropical.

Methods

The present study used a prospective cohort originated from the research project entitled “Construction and Validation of an Instrument to Assess the Food Intake of a

Population"*, aimed at constructing and validating a FFQ[8]. The sample comprised of 150 adult individuals who lived in the city of Niterói, RJ, Brazil. Individuals were contacted by telephone, according to a list of participants of a household survey conducted in a probabilistic sample of adults living in the city of Niterói[9], based on the following criteria: being aged between 20 and 69 years; having completed at least ten years of school in the three lowest income strata or four years in the remaining income strata; not being obese or underweight, a criterion assessed with a body mass index (BMI) higher than or equal to 30 kg.m^{-2} and lower than 18.5 kg.m^{-2}, respectively; reporting not having or not being undergoing treatment for diabetes mellitus, kidney diseases, cardiovascular diseases (CVD), gastrointestinal diseases, thyroid disorders or any other diseases that could interfere with the eating pattern; not being pregnant or breast-feeding; and not being on a diet.

Individuals who agreed to participate in the study were invited to be present at the LANUFF (Nutritional and Functional Assessment Laboratory of the Fluminense Federal University) on a particular morning while fasting. They were given detailed explanations about their participation and subsequently signed an informed consent form. Socio-demographic data were obtained with a standard questionnaire, aiming to categorize socioeconomic classes[10]. Body mass and stature measurements were obtained while individuals were wearing standard clothes, following the methods described by Lohman et al.[11]. With these measurements, BMI was calculated and participants' nutritional status was classified as either normal ($18.5 \leq BMI < 25$ kg.m^{-2}) or overweight ($25 \leq BMI < 30$ kg.m^{-2})[12].

After these measurements were obtained, a 24hR was performed with the use of a photo album especially designed for this research project, which was provided for individuals to take home. On this occasion, three non-consecutive days were set up through telephone calls to perform this 24hR (two weekdays and one weekend day). Six months after the first dietary recall was performed, individuals were contacted again and the procedures used to obtain three more 24hR were repeated. Data collection was performed between the summer of 2007 and 2008 (January through April) and winter of 2007 (July through October).

The nutrient content of these dietary recalls were primarily obtained from the Brazilian Food Composition Table (TACO)[13]. Foods that were not present in the TACO were obtained from other sources[8]: the USDA National Nutrient Database for Standard Reference – Release 20[14]; Eating Pattern Assessment Table in Cooking Measures[15]; and, lastly, in very specific cases (such as nutritional supplements and fast--food restaurant preparations), the nutrition facts from food labels.

Within- and between-person variances were estimated according to the three 24hRs per season, as were the individual energy and macro- and micronutrient intakes deattenuated for within-person variability (WV) using the PC-SIDE software[16]. The PC-SIDE software predicts the transformation of dietary variables to enable the symmetry of distribution before the within- and between-person variances are calculated and provides individual deattenuated values for WV in the original scale[17,18].

Prior to deattenuation, the three summer 24hRs were compared to each other (non-normal distribution) and as there were no significant differences among them (Kruskal-Wallis H-test with $p > 0.05$), they were included in the same season of the year (summer). This procedure was also performed for the three winter 24hRs.

The WV deattenuated values were used to calculate the percentage of individuals who met the recommendations (% IAR) of FI. Energy recommendations were estimated by multiplying the basal metabolic rate (BMR)

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– calculated by the equations suggested by the Food and Agriculture Organization (FAO)[19] – according to the physical activity level of 1.4, as recommended for this population[20]. The acceptable macronutrient distribution range of the Dietary Reference Intakes (DRI)[21] was used as recommendations for protein, carbohydrate and total fat intakes. The recommendations from the Brazilian Cardiology Society[22] for saturated, mono- and polyunsaturated fats were used for these dietary components. The recommendations for fibers, calcium, manganese, sodium and potassium were based on adequate intake values, according to the DRI. The recommended dietary intake values for magnesium, phosphorus, iron, copper, zinc, retinol, thiamin, riboflavin, pyridoxine, niacin and vitamin C were used[21,23-27].

The intake of macro- and micronutrients, deattenuated for WV, was adjusted for EI, using the residue method[28]. The objective of the adjustment for EI was to remove possible confounding factors that could occur with the total EI and this is a requirement for studies on nutrient intake assessment[28].

The adjustment for EI did not lead to satisfactory results for the intake of retinol in women and men and that of copper and riboflavin in men. For this reason, these data were not shown.

The means (and standard deviations – SD) of the most adequate unit of measurement and the % IAR were estimated for the energy and macro- and micronutrient intakes in the summer and winter for both sexes. The mean intakes, deattenuated for WV only and deattenuated and adjusted for EI, were compared between sexes and seasons of the year. The difference between means was tested using the non-parametric test (Wilcoxon), as variables did not show a normal distribution. In all statistical tests, the value of $\alpha = 0.05$ was used to determine the significance.

The data analysis was performed with the Statistical Analysis System (SAS) version 9.1, Software for Intake Distribution Estimation (PC-SIDE) version 1.0 and Statistical Package for the Social Sciences (SPSS) version 13.0[16,29,30].

The research project was approved by the Research Ethics Committee of the Medical School of the Fluminense Federal University under number 163/06. There were no conflicts of interest during the development of the study.

Results

A total of 102 individuals (69 women) completed the present study. Approximately 54% of the sample belonged to socioeconomic class B, the majority was aged between 40 and 49 years (25.5%) and had normal BMI (63.7%), and the prevalence of overweight was higher in men (51.5%) than women (29.0%) (Table 1).

The majority of losses was due to individuals' refusal to participate in the second stage of the study and those who were lost to follow-up had similar characteristics to the ones who remained in the analysis: the majority were women (56.3%) and aged between 40 and 49 years (31.3%), belonged to socioeconomic class B (45.5%), and had a higher prevalence of overweight compared to men.

The intake of energy and of certain nutrients (protein, fat, carbohydrate and pyridoxine) was significantly different between men and women for the WV-deattenuated EI-adjusted values. In general, EI and nutrient intake were higher in men than in women. There were no differences between seasons of the year for the mean WV-deattenuated EI both in women and men (Tables 2 and 3).

Protein intake among men was higher during summer than winter (Table 2). Among women, the highest intake occurred during winter, although only for proteins adjusted for EI (Table 3). There were no differences in fat intake of men between seasons of the year; however, this intake adjusted for EI was different between summer and winter among women. EI-adjusted carbohydrate intake was greater during winter, compared to summer in men (Table 2), whereas the intake of carbohydrates by

Table 1 - *Distribution of socioeconomic and demographic variables, and nutritional status of adults from Niterói, Rio de Janeiro, Brazil, 2007-08.*
Tabela 1 - *Distribuição das variáveis socioeconômicas, demográficas, e estado nutricional de adultos de Niterói, RJ, Brasil, 2007-08.*

Characteristics	N (%)		
	Men (n = 33)	Women (n = 69)	Total (n = 102)
Age (in years)			
20 to 29	4 (12.1)	13 (18.8)	17 (16.7)
30 to 39	10 (30.3)	13 (18.8)	23 (22.5)
40 to 49	11 (33.3)	15 (21.7)	26 (25.5)
50 to 59	2 (2.1)	19 (27.5)	21 (20.6)
≥ 60	6 (18.2)	9 (13.0)	15 (14.7)
Socioeconomic class*			
A	4 (12.1)	14 (20.3)	18 (17.7)
B	19 (57.6)	36 (52.2)	55 (53.9)
C	9 (27.3)	18 (26.1)	27 (26.4)
D	1 (3.0)	1 (1.4)	2 (2.0)
BMI ($kg.m^{-2}$)**			
Normal	16 (48.5)	49 (71.0)	65 (63.7)
Overweight	17 (51.5)	20 (29.0)	37 (36.6)

* Brazilian Economic Classification Criterion of the Brazilian Association of Market Research Companies[10].
** Critério de Classificação Econômica Brasil da Associação Brasileira de Empresas de Pesquisa[10].*
** Body mass index = body mass (kg) / stature^2 (m). A BMI between 18.5 and 24.9 $kg.m^{-2}$ = normal; A BMI equal to or higher than 25.0 $kg.m^{-2}$ = overweight[12].
*** Índice de massa corporal = massa corporal (kg) / estatura^2 (m). IMC de 18,5 até 24,9 $kg.m^{-2}$ = normal; IMC igual ou maior a 25,0 $kg.m^{-2}$ = sobrepeso[12].*

women was not different between seasons of the year, both for WV-deattenuated values and those adjusted for EI (Table 3).

Cholesterol intake was different between seasons of the year in men only and this intake was higher during summer (Table 2), whereas the intake of saturated fats adjusted for EI was only different among women and it was higher during winter (Table 3). With regard to monounsaturated fats, again there were only differences in intake among women, which was higher during winter (Table 3). There were no differences in the intake of polyunsaturated fats in men between seasons (Table 2). In contrast, among women, this difference occurred in both types of adjustment (Table 3).

In general, both men and women had higher fiber intake adjusted for EI during winter, when compared to the summer. Concerning the differences in intake of minerals and vitamins between seasons, there was a higher intake of calcium, magnesium, phosphorus, copper, potassium, thiamin and pyridoxine during winter by women (Tables 2 and 3).

The majority of women and men did not meet the recommendations of calcium, magnesium, potassium, retinol and polyunsaturated fats. In addition to these nutrients, a higher percentage of men did not meet the recommendations for protein (winter), pyridoxine (winter), monounsaturated fats (winter), thiamin (summer), fibers and vitamin C (both seasons) (Figure 1a). Among women, the corresponding nutrients were fibers (summer), monounsaturated fats (summer), iron and pyridoxine (both seasons) (Figure 1b).

Discussion

Several studies assessed possible sources of variability capable of interfering with

Table 2 - Mean intake (standard deviation – SD) of energy, macro and micronutrients, in the summer and winter, deattenuated by within-person variation and adjusted for energy, of men from Niterói, Rio de Janeiro, Brazil, 2007-08.
Tabela 2 *- Médias de ingestão (e desvio-padrão – DP) de energia, macro e micronutrientes, no verão e no inverno, deatenuadas pela variabilidade intraindividual e ajustados pela energia, de homens de Niterói, RJ, Brasil, 2007-08.*

Intake of energy, macro- and micronutrients	Deattenuation for within-person variability[17,18]		Adjustment for energy[28]	
	Summer	Winter	Summer	Winter
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD
Energy (kcal)	2801.3 ± 680.2	2666.4 ± 832.1	-	-
Protein (g)	131.2 ± 39.4*	110.5 ± 34.3	131.4 ± 19.9*	115.0 ± 21.6
Fat (g)	90.2 ± 34.4	84.5 ± 38.8	91.3 ± 22.3	89.3 ± 26.6
Carbohydrate (g)	342.5 ± 92.7	362.2 ± 141.6	343.7 ± 41.9*	383.4 ± 58.7
Fiber (g)	24.5 ± 7.9	29.2 ± 11.0	25.7 ± 6.9*	30.7 ± 8.1
Calcium (mg)	828.1 ± 395.2	697.4 ± 289.8	827.8 ± 342.4	729.7 ± 209.2
Magnesium (mg)	339.0 ± 78.8	363.8 ± 119.2	339.4 ± 47.9*	378.2 ± 78.2
Manganese (mg)	3.4 ± 1.4	3.0 ± 1.5	2.9 ± 1.2*	2.0 ± 0.9
Phosphorus (mg)	1587 ± 377.3	1433.7 ± 509.1	1588.1 ± 211.1	1498.9 ± 309.1
Iron (mg)	14.4 ± 2.7	12.9 ± 5.2	15.1 ± 2.0*	12.8 ± 2.8
Sodium (mg)	3065.2 ± 1340	3173.2 ± 1247.4	3065.7 ± 873.5	3304.8 ± 940.0
Potassium (mg)	3009.0 ± 726.5	3121.9 ± 1078.3	3009.8 ± 441.0	3253.9 ± 712.5
Copper (mg)	1.3 ± 0.3	2.3 ± 2.6	NA	NA
Zinc (mg)	16.8 ± 2.9*	14.9 ± 4.5	16.7 ± 2.0*	14.6 ± 2.8
Retinol (μg)	287.6 ± 185.1	1853.7 ± 3676.8	NA	NA
Thiamin (mg)	1.5 ± 0.6*	1.8 ± 0.6	2.6 ± 0.5*	0.9 ± 0.6
Riboflavin (mg)	1.4 ± 0.4	1.7 ± 0.8	NA	NA
Pyridoxine (mg)	1.5 ± 0.4	1.4 ± 0.2	0.5 ± 0.3*	1.0 ± 0.2
Niacin (mg)	34.2 ± 17.8*	23.5 ± 7.1	35.3 ± 14.7*	24.5 ± 6.7
Vitamin C (mg)	69.8 ± 42.4	67.7 ± 35.2	69.6 ± 40.8	67.9 ± 34.7
Cholesterol (mg)	402.5 ± 108*	343.5 ± 97.3	402.7 ± 72.3*	355.5 ± 70.4
SFA (g)	34.0 ± 10.9	30.3 ± 14.5	32.9 ± 7.6	33.2 ± 10.9
MUFA (g)	28.8 ± 10.1	26.7 ± 11.5	28.0 ± 7.3	28.2 ± 8.0
PUFA (g)	16.1 ± 8.3	15.3 ± 4.6	15.5 ± 6.1	14.8 ± 3.7

NA: non-adjusted. / *NA: Não ajustado.*
SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid.
SFA: lipídio saturado; MUFA: lipídio moinsaturado; PUFA: lipídio poliinsaturado.
* Means significantly different from those found during winter for each adjustment (Wilcoxon test; p < 0.05).
** Médias significativamente diferentes em relação ao inverno para cada ajuste (teste de Wilcoxon; p < 0,05).*

the measurement of FI of populations, such as seasonality[1-7]. The effect of seasonality on FI depends on cultural, ecological, geographic and meteorological factors and the industrialization level of a country[31], apart from factors intrinsic to individuals (sex and age).

In the present study, the assessment of the energy and macro- and micronutrient intakes was obtained in two seasons of the year: summer and winter, using more than one statistical adjustment. The data shown here were corrected for WV, thus enabling the intake distribution to be exclusively influenced by the differences among individuals. Fluctuations in individual daily intake

Table 3 - Mean intake (standard deviation – SD) of energy, macro and micronutrients, in the summer and winter, deattenuated by within-person variation and adjusted for energy, of women from Niterói, Rio de Janeiro, Brazil, 2007-08.
Tabela 3 *- Médias de ingestão (e desvio-padrão – DP) de energia, macro e micronutrientes, no verão e no inverno, deatenuadas pela variabilidade intraindividual e ajustados pela energia, de mulheres de Niterói, RJ, Brasil, 2007-08.*

Intake of energy, macro- and micronutrients	Deattenuation for within-person variability[17,18]		Adjustment for energy[28]	
	Summer	Winter	Summer	Winter
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD
Energy (kcal)	2170.1 ± 520.4	2265.5 ± 575.0	-	-
Protein (g)	103.7 ± 30.1	111.3 ± 28.3	104.1 ± 17.7*	111.6 ± 17.3
Fat (g)	67.5 ± 24.7	74 ± 23.5	68.2 ± 12.7*	74.2 ± 12.2
Carbohydrate (g)	284 ± 67.9	291.2 ± 87.7	283.3 ± 35.4	290.3 ± 41.5
Fiber (g)	23.4 ± 7.8	26.6 ± 10.7	22.9 ± 6.9*	26.6 ± 9.0
Calcium (mg)	802.7 ± 381.8*	919.0 ± 400.3	802.4 ± 286.3*	920.0 ± 309.4
Magnesium (mg)	291.2 ± 79.9*	345.7 ± 133.2	291.2 ± 52.9*	346.2 ± 100.6
Manganese (mg)	2.8 ± 0.8*	3.6 ± 1.8	3.3 ± 0.7	3.2 ± 1.3
Phosphorus (mg)	1345.0 ± 434.7*	1493.2 ± 444.9	1345.7 ± 239.8*	1492.9 ± 244.8
Iron (mg)	10.9 ± 2.6	12.1 ± 4.7	10.9 ± 1.6	11.4 ± 3.0
Sodium (mg)	2624.9 ± 653.9	2487.9 ± 753.7	2625.6 ± 476.4	2487.2 ± 571.1
Potassium (mg)	2828.2 ± 704.2*	3277.1 ± 1112.5	2827.2 ± 419.6*	3276.8 ± 801.8
Copper (mg)	1.8 ± 0.9	1.7 ± 1.0	1.7 ± 0.7*	2.7 ± 0.9
Zinc (mg)	11.8 ± 3.6*	14.1 ± 4.6	12.1 ± 2.5	13.2 ± 3.3
Retinol (µg)	869.8 ± 1554.8	363.4 ± 217.4	NA	NA
Thiamin (mg)	1.7 ± 0.6	1.7 ± 1.0	0.7 ± 0.5*	1.9 ± 0.8
Riboflavin (mg)	1.5 ± 0.4	1.5 ± 0.5	2.3 ± 0.3	2.4 ± 0.3
Pyridoxine (mg)	1.1 ± 0.4*	1.3 ± 0.6	2.0 ± 0.3*	2.2 ± 0.5
Niacin (mg)	28.8 ± 10.0*	23.6 ± 6.8	28.2 ± 7.7*	23.5 ± 5.8
Vitamin C (mg)	138.6 ± 138.1	147.0 ± 115.0	139.3 ± 135.3	146.9 ± 114.9
Cholesterol (mg)	320.8 ± 112.7	325.1 ± 105.8	320.1 ± 76.9	325.2 ± 73.7
SFA (g)	25.3 ± 9.8	27.6 ± 9.7	25.2 ± 5.1*	27.5 ± 5.3
MUFA (g)	21.1 ± 7.0*	24.1 ± 8.4	21.3 ± 4.1*	24.0 ± 4.8
PUFA (g)	12.0 ± 4.4*	13.5 ± 3.6	11.0 ± 3.4*	13.3 ± 2.7

NA: non-adjusted. / *NA: Não ajustado.*
SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid. / *SFA: saturated fatty acid (lipídio saturado); MUFA: monounsaturated fatty acid (lipídio moinsaturado); PUFA: polyunsaturated fatty acid (lipídio poliinsaturado).*
* Means significantly different from those found during winter for each adjustment (Wilcoxon test; $p < 0.05$). / ** Médias significativamente diferentes em relação ao inverno para cada ajuste (teste de Wilcoxon; p < 0,05).*

can change the results and its adjustment allows the reduction in estimates of variability such as standard deviation and error[32,33]. Furthermore, these results were adjusted for EI, enabling the intake of women and men to be compared in both seasons of the year, without being influenced by the supply of energy[31].

The EI was not different between seasons for the WV-deattenuated results for both sexes, showing that the EI remains the same in the sample of adults of the city of Niterói throughout the year. Consequently, the intake of different types of food will not change the EI in general, but that of certain micronutrients will, confirming that the

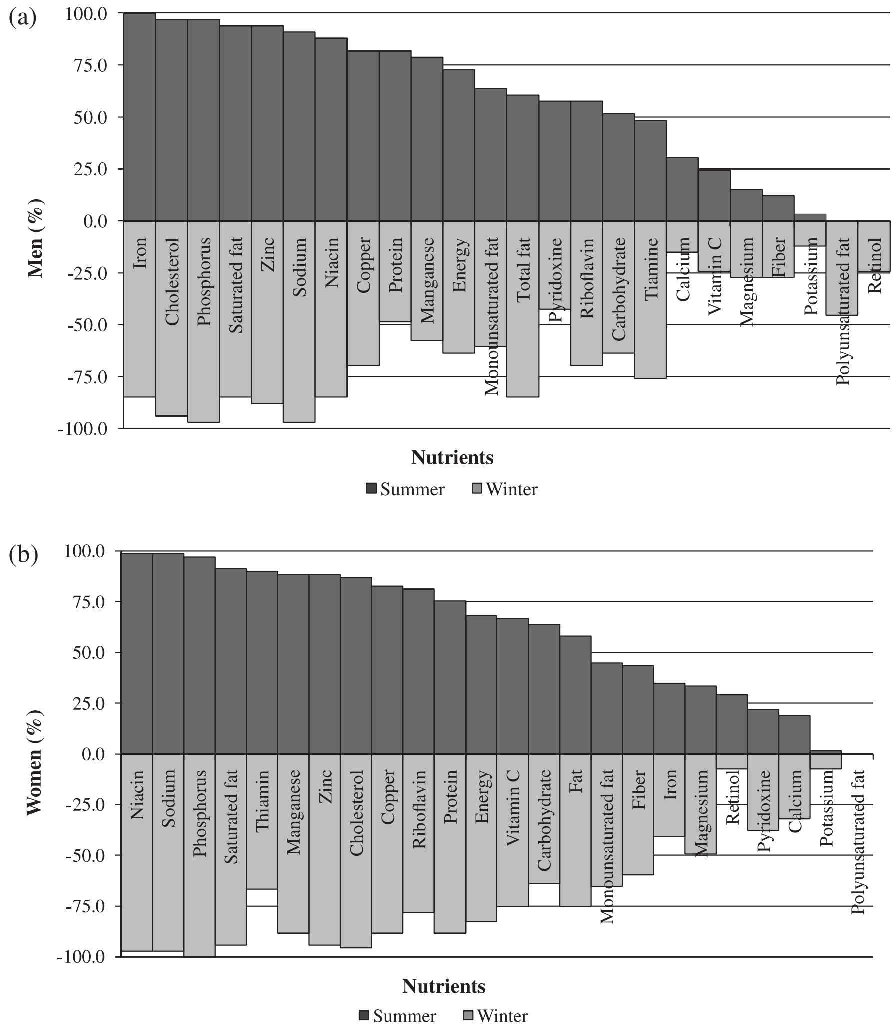

Figure 1 - Percentage of adult men (a) and women (b) whose intakes, deattenuated by within-person variation[17,18], reached the recommendation for energy, macro and micronutrients intakes, in summer and winter, according to the Dietary Reference Intakes and the Brazilian Society of Cardiology[21-27]. Niterói, Rio de Janeiro, Brazil, 2007-8.

Figura 1 *- Percentual de homens (a) e mulheres (b) adultos cujas ingestões, deatenuadas pela variabilidade intraindividual[17,18], alcançam a recomendação de ingestão energética, de macro e micronutrientes, no verão e no inverno, segundo a Dietary Reference Intakes e a Sociedade Brasileira de Cardiologia[21-27]. Niterói, RJ, Brasil, 2007-8.*

quality of foods characterizing the dietary pattern of individuals is different throughout the year. This corroborates other studies that have used 24hRs[2,34] and FFQs[3,35].

In Brazil, studies that assess the seasonal variations in FI are rare. In general, the sources of variation in the FI of Brazilians studied are limited to methodological variations intrinsic to individuals. There were two studies[36,37] that showed results associating seasonality and FI in Brazil. In the first one, a variation was found in the eating behavior of workers with fixed shifts in the city of São Paulo between summer and winter by applying dietary recalls for three days. The diet of workers had a higher amount of energy, carbohydrates and fats during winter, showing the influence of seasonality on the FI of the sample of men.

Rossato et al.[37] analyzed the seasonal variation in FI of healthy adults living in the state of Rio Grande do Sul, Southern Brazil, using six 24hRs throughout the year. The intake of carbohydrates adjusted for EI was higher during summer, compared to other seasons, contrary to what was observed for fats, whose intake was higher during winter. According to the present study, there were no differences in EI in both sexes between seasons, strengthening the hypothesis that what changes throughout the year is in fact the dietary pattern.

However, in international studies, different EI values were found throughout the year. When the FI of American women aged between 51and 86 years was assessed with a questionnaire of assessment of seasonal dietary patterns, Lee et al.[38] found higher EI during winter than summer. Based on data from a cohort study conducted in Shanghai, China, Fowke et al.[6] found higher EI during winter than summer in healthy women, using a FFQ. Likewise, Westerterp et al.[7] found higher EI by Dutch adults during winter than summer, as assessed with a seven-day dietary recall. Nonetheless, Kuhnlein et al.[39] did not find differences in EI originated from industrially processed foods, known as "market foods", when compared to traditional unprocessed foods in Canadian women aged between 40 and 70 years, assessed during six moments of the year.

Important seasonal differences were found for the intake of nutrients associated with nutritional diseases (iron-deficiency anemia) and non-communicable chronic diseases (hypercholesterolemia, CVD and osteoporosis) in the present sample of adults of Niterói. The intake of iron and cholesterol by men was higher during summer, whereas that of calcium by women was higher during winter. This fact should be emphasized, as the need for the regular intake of such nutrients throughout the year is known, so as to guarantee a high level of health.

Tokudome et al.[40] found results similar to those found in the present study, using dietary recalls with weighing during seven consecutive days, associated with the intake of potassium, calcium, magnesium, copper and saturated, mono- and polyunsaturated fats in Japanese women, which was significantly higher during winter. In Spain, Capita & Alonso-Calleja[1] also found higher intake of carbohydrate and fiber by men during winter and that of protein, fiber and polyunsaturated fats by women, using dietary records applied throughout one year.

The results of the present study showed a high percentage of adults that did not meet the recommendations for certain nutrients, including differences according to sex and seasons of the year and suggesting the need for distinct interventions in this population. The low iron intake by women was highly significant, while there was a low intake of fiber, niacin and vitamin C among men. The low iron intake of women could be associated with the occurrence of iron-deficiency anemia, a situation found in several studies conducted in samples of Brazilians[41-44], emphasizing the need for interventions in this group.

A higher percentage of men did not meet the recommendations of proteins and monounsaturated fats during winter. Among women, a higher percentage did not meet the recommendations for fiber and monounsaturated fats during summer. In this sample, a high percentage of women and men did not meet the recommendations of calcium, retinol and saturated fats in both seasons of the year, which could be associated with osteoporosis[45], hypovitaminosis A[46] and CVD, respectively[22].

On the other hand, the intake of sodium, cholesterol and saturated fats, well above the recommendations for women and men in both seasons of the year, can increase the risk of CVD, such as arterial hypertension and atherosclerosis, both highly prevalent in the Brazilian population[22,47]. Furthermore, the high percentage of men and women with higher than recommended EI should be emphasized. This finding is alarming, considering the high indices of overweight and obesity in the Brazilian population[20,22].

There are certain limitations when determining whether the recommendations have been met in population studies. The insufficient intake of calcium and fiber could be partly explained by the high nutritional recommendations proposed. The intake of other nutrients such as retinol and polyunsaturated fats could be underestimated, due to their high concentration in few foods. A high percentage of individuals who did not meet the recommendations could also be associated with the limitations of food composition tables, where foods and their nutritional values are insufficiently described, leading to the use of several sources and information about food preparations[48].

The present study had some limitations. The data were based on a convenient sample, not representative of the population studied, although sufficient to achieve the objective (validation of a FFQ) of the research project from which it originated. Additionally, there was a higher percentage of adults of the socioeconomic class A in the sample studied (17.7%), compared to the 5.1% estimated for the population of the metropolitan area of the city of Rio de Janeiro[10]. On the other hand, the majority of the population of the present study had a normal BMI, based on the inclusion criteria proposed, thus reducing the chances of underreporting of FI due to overweight and obesity[48]. Despite these limitations, the importance of seasonality in the measurement of FI of the population studied became clear.

To replicate the number of 24hRs used during different periods of the year and to include non-consecutive weekdays and weekend days, both of which were successfully achieved in the present study, are essential to plan dietary surveys, thus reducing possible sources of random errors. Measurement errors caused by seasonality can be equally diluted among individuals in the case of large samples; in contrast, lack of distortion cannot be guaranteed in the results of FI due to seasonality[2,49]. Additionally, although the city of Niterói does not have well defined seasons due to its tropical location, significant differences in FI were found in the present study.

In conclusion, although the majority of national and international studies have not included seasonality, the results shown here indicate that this source of variation should be taken into consideration, even in tropical regions.

Authors' contributions: LA Anjos, MTA Olinto and W Waissmann were responsible for planning the original research. AF Costa, LA Anjos and V Wahrlich supervised the field data collection. EM Yokoo and RL Henn helped with data analysis and manuscript writing. AF Costa analyzed the data, discussed the results and wrote the first version of the manuscript, which was subsequently reviewed and approved by all authors.

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