Seasonal effect on nutrient intake in adults living in Southern Brazil

Efeito da sazonalidade sobre a ingestão de nutrientes em adultos residentes no Sul do Brasil

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Abstract

The objective of this study was to investigate the effect of seasonality on nutrient intake in healthy adults from the southernmost metropolitan area of Brazil. The dietary intake (24-hour dietary recall on six different days) in a sample of 162 adults (114 women), aged 20 to 69, was obtained during the year 2007. The nutrient intake was averaged for each season and adjusted for energy intake using the residual method. The effect of season on energy, macro and micro-nutrient intake was investigated based on the Generalized Estimate Equations (GEE) model. There were statistically significant differences between seasons for carbohydrate and total fat intake after controlling for gender, age, education, and interactions. In summer carbohydrate intake was higher than other seasons while the total fat intake was lower. These findings highlight the importance of considering seasonal variations not only for evaluating dietary intake but also nutrition and public health policy recommendations, particularly in adult populations living in temperate regions.

Eating; Nutrition Policy; Seasons

Introduction

The seasonal effect on health conditions has been documented in the literature [1,2,3]. Children from very poor areas of the world are at higher risk of diarrhea infections, weight loss, and malnutrition in the summer months [1,2]. Colder temperatures seem to influence the appearance of bulimia [3] and a form of recurrent depression or bipolar disorder known as seasonal affective disorder (SAD) [4].

Climate influences some physiological functions which may, in part, be related to changes in food intake. Metabolism is thought to be higher during the winter months [5] and this seasonal adaptation can be influenced by age and gender [6]. Other studies associate seasonality with changes in serum levels of nutrients such as vitamin D [7] and cholesterol [8]. According to Minghelli et al. [9], lower availability of food during the summer has led to weight reduction, loss of muscle mass, and lower diet-induced thermogenesis in adult Gambians. The seasonal differences in nutrient intake, mainly vitamins and minerals, depend on the availability of foods [10]. A study carried out on farm workers and non-farm families from Washington State documented that the consumption of vegetable and fruits varied across seasons according to the harvest period [11].

As in many countries, the production of fruits, vegetables, and meats is strongly influenced by the climate in Brazil [12]. Although most of Brazil is situated in the tropics (below the Equator) with very little climatic change, the southernmost region of the country is in the temperate zone with marked seasonal (subtropical) climates. Data from the *Brazilian Household Budget Survey* 2002-2003 (POF 2003) [13] showed differences of household food availability among the five major Brazilian regions. The relative participation of meat, wheat meal and dairy products in diets in the South Region was high, but household bean consumption was lower than others regions. Although fruits, vegetables and legumes in the diet were below the recommended daily intake, the Southern diet showed higher relative participation of these items compared with the North, Northeast and Center-West regions [14].

Despite the existence of four clearly defined seasons during the year in the South of Brazil and the peculiarities of the eating habits of this population, to the best of the authors' knowledge no studies regarding this subject have been carried out. The purpose of the present study was to investigate the effect of seasonality on food intake in healthy adults from the southernmost metropolitan area of Brazil.

Methods

The data of the present analysis comes from a large study aimed at constructing and validating a food frequency questionnaire (FFQ) [15] developed by the Universidade do Vale do Rio dos Sinos (UNISINOS). It is a longitudinal study carried out in the metropolitan region of Porto Alegre in the state of Rio Grande do Sul, Southern Brazil. A total of 162 volunteers were recruited through advertisements in local newspapers and the distribution of pamphlets. This sample size was estimated for the FFQ validity study [16]. To be eligible to participate in the study the subjects had to be between 20 and 69 years of age, free of sicknesses (diabetes, hypertension, renal insufficiency, gastro-intestinal diseases), could not be on any kind of diet, and should not be pregnant or nursing. The age was categorized as 20 to 39 years old and 40 to 69 years old, guided by previous studies carried out in São Leopoldo, Rio Grande do Sul State, that identified changes in dietary patterns of women aged 40 and above [17].

Data collection was carried out at two research units located in São Leopoldo and Porto Alegre, 30km from one another, during the year 2007.

The study consisted of six interviews per individual throughout the year, and in each one, a 24-hour dietary recall (24hR) was applied. On the first visit, demographic characteristics such as gender, age and education (described in complete years of formal schooling) were obtained using standardized questionnaires. All interviews were conducted by intensively trained interviewers. A photographic food album especially produced for this study was used to facilitate the identification of the foods ingested and their portion size. The album contains 224 photos showing foods with different sizes and presentations. It was based on the foods more frequently eaten by adults in a household survey [18]. Field work quality was controlled by conducting continuous training sessions, supervision of the field work, and periodic meetings.

The months considered for each season are: Summer (December, January and February), Autumn (March, April, May), Winter (June, July, August) and Spring (September, October, November). However, no data were collected in May, June and December.

Calculation of nutrient intake

The mean daily consumption of macro- and micronutrients was obtained by computing the food intake (in grams), versus the nutrient content for 100 grams of food as described in the Brazilian Food Composition Table (TACO, version 2. Núcleo de Estudos e Pesquisas em Alimentação, Universidade Estadual de Campinas, Campinas, Brazil). Alternatively, the USDA National Nutrient Database for Standard Reference – Release 20 tables (United States Department of Agriculture. Food search for Windows, version 1.0, database SR20. http://www.ars.usda.gov/Services/docs.htm?docid=5720, accessed on 12/Nov/2007) was used for the foods not found in the Brazilian table. The third alternative was the Table for the Assessment of Food Consumption and Portion Sizes [19], and food labels was consulted as the last option. The analysis of nutritional composition based on the TACO table includes 276 out of 1,358 analyzed foods (20%), the USDA table accounts for 202 (15%), and the Table for the Assessment of Food Consumption and Portion Sizes only 18 (1%). The search for data on nutritional composition in food labels was performed for 63 (5%) foods analyzed. Many of the foods listed were recipes, homemade mixtures or preparations. To calculate the nutritional composition of these foods, it was necessary to break down the recipes and calculate the ingredients one by one; this was necessary for 779 (59%) foods. The nutritional composition from these recipes was computed based on previously mentioned tables, with similar proportions as described above.

The components included in analysis were energy (kcal), proteins (g), lipids (g), carbohydrates (g), fiber (g) retinol (mcg of retinol), cholesterol (mg), vitamin C (mg), calcium (mg), and iron (mg).

Statistical analysis

Absolute and relative numbers were used to assess the distribution of repeated measures of 24hR according to the seasons and demographic characteristics of the sample.

The means of nutrient intakes were adjusted for energy by computing the regression model residuals with the energy intake as the independent variable and the nutrient intake as the dependent variable [16]. As the linear regression analysis assumes that the distribution of the dependent variable must be normal, the normality was tested using the Kolmogorov-Smirnov test [20]. All nutrients showed asymmetric distribution ($p < 0.001$), thus they were transformed into natural logarithms before the analysis.

The Generalized Estimate Equation model (GEE) was used with an unstructured correlation matrix to assess the effect of seasons on nutrient intake. The nutrient intake was included in the model as dependent variable and the seasons as predictor. The log link function was employed since the relationship between the dependent variable and predictor was not linear. The analysis was performed unadjusted and then controlled for age, gender and schooling. One at a time, the interactions were added (gender/seasons, age/seasons and schooling/seasons) and assessed the goodness of fit. The comparisons were based on pairwise contrast using sequential Bonferroni adjustment for multiple comparisons. GEE display quasi-likelihood under the independence model criterion (QIC) for choosing the best correlation structure and the best subset of predictors. The level of significance considered was 5%. The data were analyzed using SPSS for Windows, version 16.0 (SPSS Inc., Chicago, USA).

The study was approved by the Institutional Review Board of the UNISINOS. Written informed consent was obtained from all participants prior to participation.

Results

A total of 792 24-hour recalls were applied for 162 participants. The characteristics of the sample and the number of 24hR conducted in each season are shown in Table 1. The participants were predominantly women (70.4%) and the mean age was 38.45 years (95%CI: 36.3-40.6). This sample had high education, averaging 11 years of study. Table 1 shows that an inferior number of 24hR were answered during spring (17.8%).

Table 2 shows the differences in energy and nutrient intake between seasons. The results were based on estimated mean nutrient intake adjusted for energy [16]. Only carbohydrate and total fat intake showed differences after adjustment. The carbohydrate intake was higher in summer compared to autumn, winter and spring, respectively, 15.8, 18.1 and 18.3g. The opposite was observed for total fat: the intake was always lower in summer compared with other seasons, respectively, -8.1, -6.3 and -8g.

The best QIC were reached when the interaction schooling/seasons was removed from the model. When the interaction between seasons and gender was considered (Table 2) we found that gender changed the effect of the seasons in energy, carbohydrate and total fat intake and showed a borderline significance for calcium ($p = 0.061$). When we analyzed differences within gender groups, among men we found higher total fat intake in autumn and in spring compared to summer, and a higher carbohydrate intake in summer (Figure 1). Although the p-values for multiple comparisons showed a significant interaction between season and gender for energy (Table 2), no statistical significance was observed within the gender groups (Figure 1).

The interaction between seasons and age was present for energy, protein, carbohydrate, total fat

Table 1

Sample description of repeated measures and economic and demographic characteristics. South of Brazil (n = 143).

Variables	n	%
Total number of repeated measures	792	
Seasons		
Summer	214	27.0
Autumn	227	28.7
Winter	210	26.5
Spring	141	17.8
Gender		
Female	114	70.3
Male	48	29.7
Age (years old)		
20-39	92	55.6
40-69	70	44.4
Education (years of study)		
Less than 8	34	12.8
9-11	44	28.9
More than 12	84	58.3

Table 2

Mean differences in energy and nutrient intake between seasons and statistical significance (p-value). South of Brazil (n = 143).

Nutrient intake	Summer						Winter	
	Autumn		Winter		Spring		Spring	
	Mean difference	p-value	Mean difference	p-value	Mean difference	p-value	Mean difference	p-value
Energy (kcal)	98.68	1.000	34.21	1.000	81.90	1.000	47.69	1.000
Protein (g)	0.52	1.000	-3.06	1.000	-0.81	1.000	2.25	1.000
Carbohydrate (g)	15.79	**0.019**	18.08	**0.007**	18.32	**0.007**	0.24	1.000
Total fat (g)	-8.09	**0.001**	-6.38	**0.004**	-8.00	**0.001**	-1.62	1.000
Cholesterol (mg)	-12.17	1.000	-38.02	0.917	-5.33	1.000	32.68	1.000
Total fiber (g)	-0.56	1.000	-1.36	0.977	0.23	1.000	1.59	0.977
Calcium (mg)	50.26	0.826	80.35	0.087	57.74	0.826	-22.61	1.000
Iron (mg)	0.77	1.000	0.49	1.000	0.21	1.000	-0.28	1.000
Vitamin C (mg)	6.45	1.000	0.13	1.000	8.20	1.000	8.07	1.000
Retinol * (mcg retinol)	-20.63	1.000	-12.62	1.000	-32.37	0.829	-19.75	1.000

Nutrient intake	Autumn				p-value to multiple comparisons **		
	Winter		Spring				
	Mean difference	p-value	Mean difference	p-value	Season ***	Gender #	Age ##
Energy (kcal)	-64.47	1.000	-16.79	1.000	0.710	**0.002**	**0.016**
Protein (g)	-3.58	1.000	-1.33	1.000	0.650	0.105	**0.041**
Carbohydrate (g)	2.29	1.000	2.53	1.000	**0.003**	**0.005**	**0.003**
Total fat (g)	1.70	1.000	0.09	1.000	**< 0.001**	**0.001**	**0.001**
Cholesterol (mg)	-25.84	1.000	6.84	1.000	0.551	0.703	0.571
Total fiber (g)	-0.80	1.000	0.79	1.000	0.441	0.544	0.430
Calcium (mg)	30.08	0.928	7.48	1.000	0.110	0.061	**0.026**
Iron (mg)	-0.28	1.000	-0.56	1.000	0.487	0.338	0.847
Vitamin C (mg)	-6.32	1.000	1.76	1.000	0.937	0.107	0.193
Retinol * (mcg retinol)	8.01	1.000	-11.73	1.000	0.503	0.502	0.752

* Retinol without outliers;

** All analyses were adjusted for gender, age, schooling and interaction (gender/seasons, age/seasons);

*** Comparison among seasons;

Analysis for interaction between gender and seasons;

Analysis for interaction between age and seasons.

and calcium intake (Table 2). Differences within age groups were seen only for carbohydrate and total fat, and only among younger individuals. Subjects aged from 20 to 39 years had higher carbohydrate intake in summer than autumn (p = 0.005) and higher total fat intake in autumn and winter than in summer (Figure 2).

Discussion

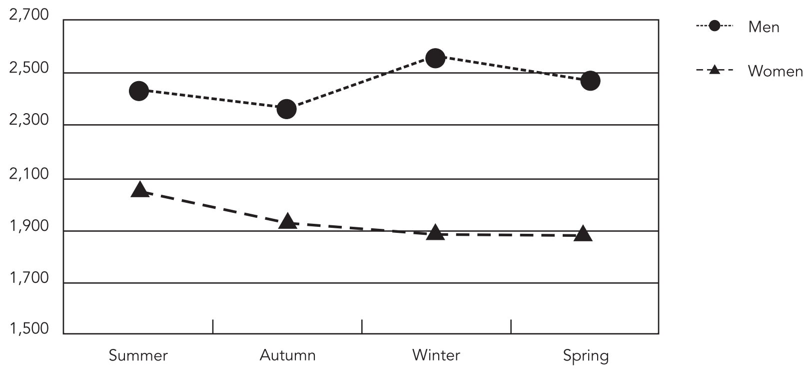
This is an exploratory study aimed at evaluating the seasonal effect on energy and nutrient intake of adults living in the Metropolitan area of Porto Alegre. Porto Alegre is located in the temperate zone, and because of the marked seasonal variations in climate, differences in dietary intake were expected. In general, the results showed differences in intake according to seasons for carbohydrate and total fat, after controlling for gender, age, education, and interactions between season and gender, and season and age. In summer the carbohydrate intake was higher than other seasons while the total fat intake was lower.

Seasonal variation of dietary intake has been studied in convenience samples throughout the world. Hebert et al. [21] found large inter-person

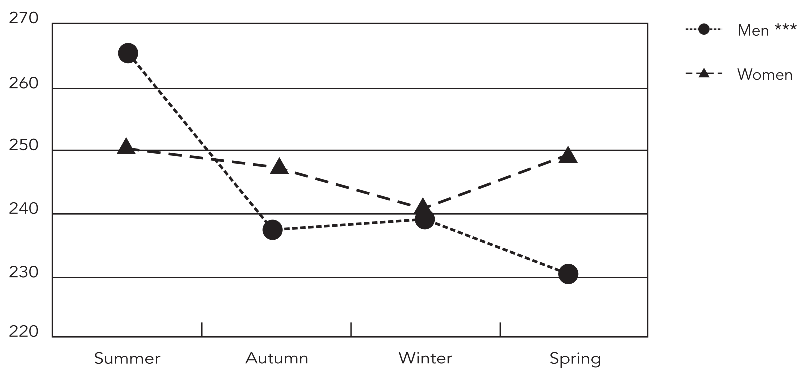
Figure 1

Interaction between seasons and gender *. South of Brazil (n = 143).

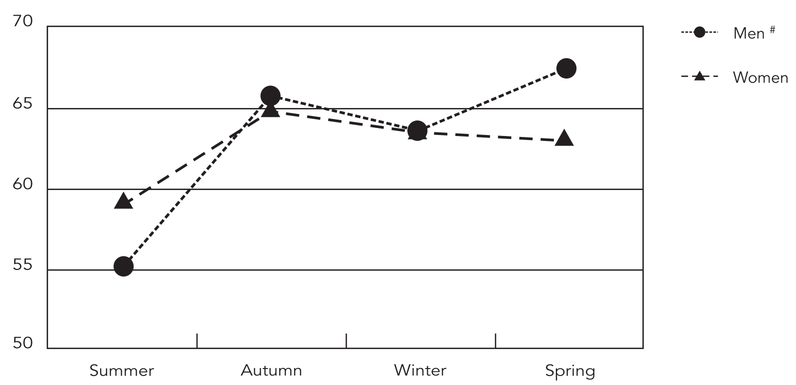
1a) Mean energy intake (kcal) **



1b) Mean carbohydrate intake (g)



1c) Mean total fat intake (g)



* Analysis controlled for gender, age, education and interactions;

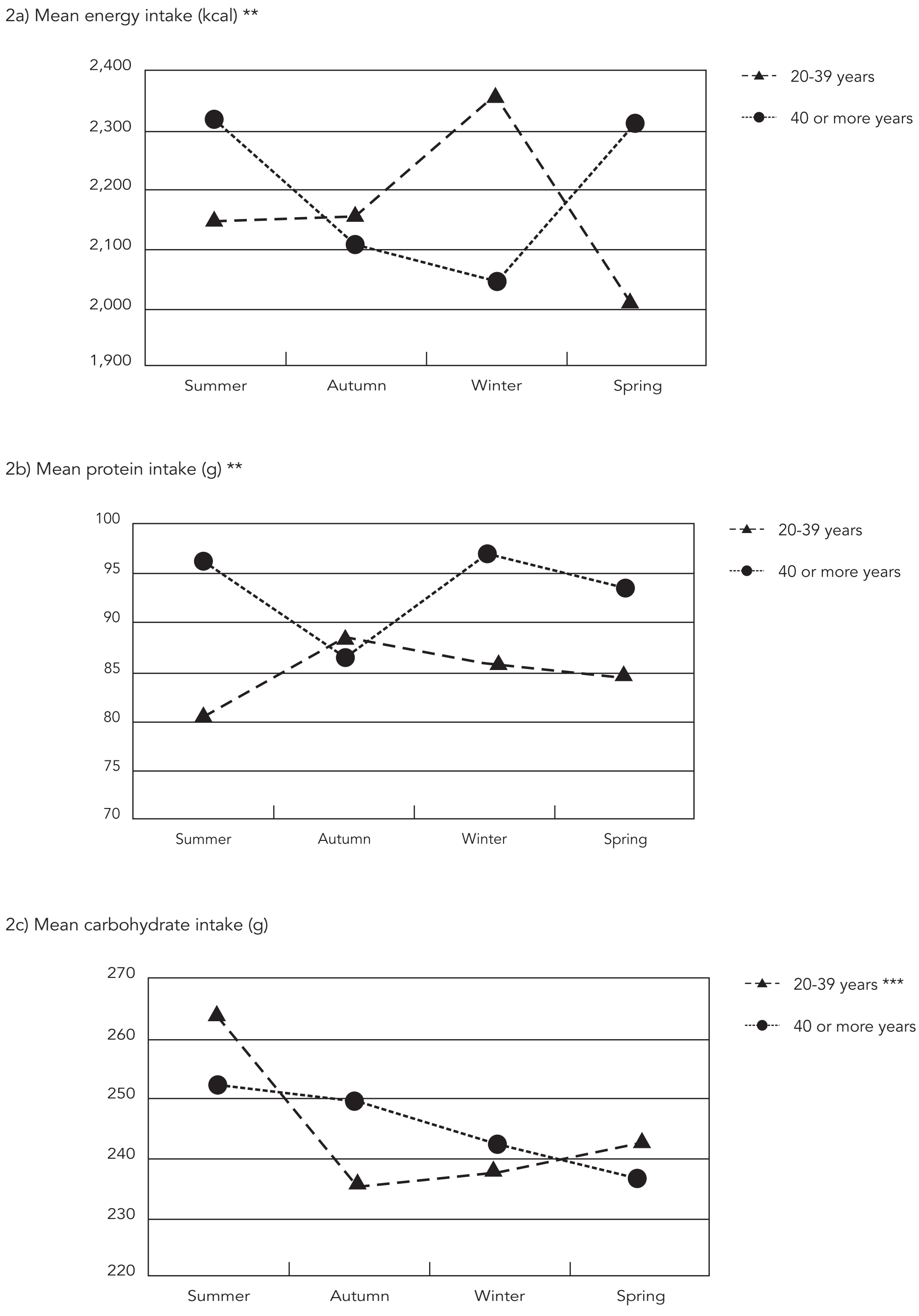
** Note: there was no statistical difference within groups;

*** p-value for differences between summer and autumn intake (p = 0.040), p-value for differences between summer and spring intake (p = 0.002);

p-value for difference between summer and autumn intake (p = 0.019), p-value for difference between summer and spring intake (p = 0.011).

Figure 2

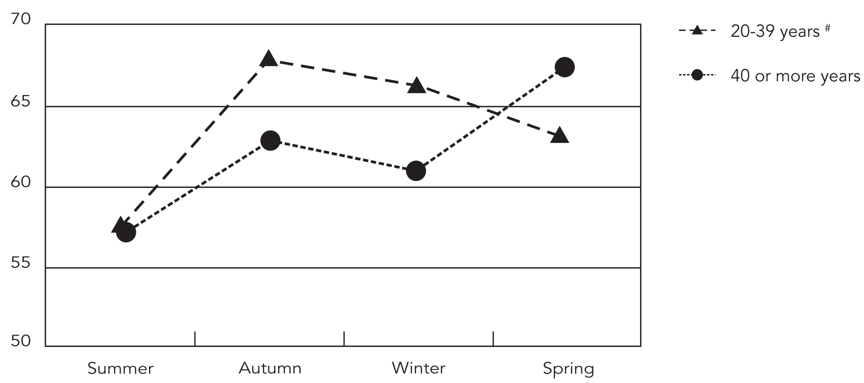
Interaction between seasons and age groups *. South of Brazil (n = 143).



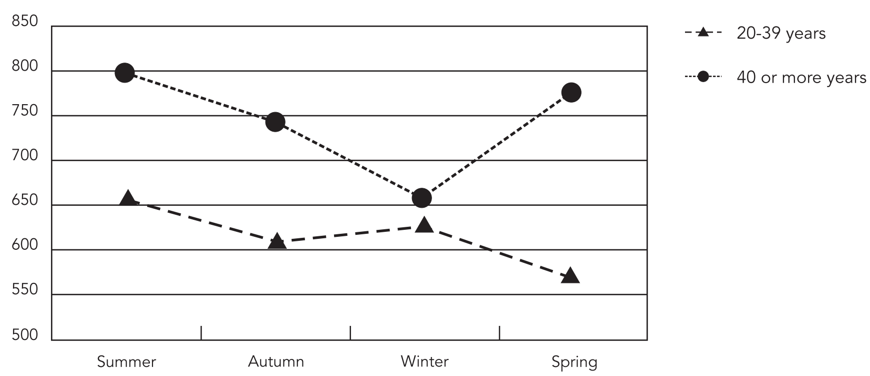
(continues)

Figure 2 (continued)

2d) Mean total fat intake (g)



2e) Mean calcium intake (mg)



* Analysis controlled for gender, age, education, and interactions;

** There was no statistical difference within groups;

*** p-value for difference between summer and autumn intake (p = 0.005), p-value for difference between summer and winter intake (p = 0.058);

p-value for difference between summer and autumn intake (p < 0.001), p-value for difference between summer and winter intake (p = 0.032).

variability but very little of the variance in dietary intake could be ascribed to season in a study in two regions in rural India using 24hR. In the dietary calibration studies for the Shanghai Health Study, the total variation derived from the seasonal effect and the variation due to methodological issues such as the day of the week and the sequence of interviews was less than 5%, and did not represent an important source of variation in food intake. This study was based on 24hR administered biweekly during 1 year in a sample of healthy urban Chinese men (n = 96) [22] and women (n = 200) [23]. In another similar study conducted with a Japanese population, the contribution of the season on total variation ranged from 0.1 to 2.7% [24].

In a similar tendency to our study, Fowke et al. [25] compared the average nutrient intake in each season with the annual average intake and observed an increase in fat and reduction in carbohydrate intake in winter. However, different from our findings, they also found differences for protein between seasons.

In our study, we found an interaction between season and gender to energy intake but there were no differences within gender groups. However, the increase of 200kcal in winter in relation to autumn in the men group deserves attention because it can be considered clinically relevant. In a study by Fowke et al. [25] with 74,958 individuals that aimed to investigate the effect of season on FFQ administration, statistically significant differences were found only for women. For them, there was an increase in energy intake from summer to winter. In contrast, Westerterp et al. [26] found increased energy intake in winter in comparison to summer in a sample of 27 dietitian women. In another study carried out in northwest Spain, comparing summer and winter, there was a statistically significant increase in energy intake in winter only in men [27]. Similar results were observed in 94 male Israeli industrial employees, but they were not statistically significant [28].

Interaction between season and gender also was observed for carbohydrate intake, but statistically significant differences were found only for men. The intake was lower in autumn and spring in relation to summer. In contrast, in the study conduced for Cappita & Alonso-Calleja [27] in Spain, men consumed less carbohydrate in summer.

Similar to carbohydrate, gender changed the effect of season in total fat intake and differences were found only for men too. The total fat intake was lower in summer when compared to autumn and spring. Shahar et al. [29] also observed lower total fat intake in summer for men, when comparing with winter. According to the authors, the increase in fat intake in winter was attributed to higher consumption of meat, dairy product and eggs.

The energy, protein, carbohydrate, total fat and calcium intakes in the seasons also varied according to age groups. Studies testing the seasonal effect on nutrient intakes according to age were not found, which did not permit comparisons with our results.

Although differences within each age group were not significant, it is noteworthy that the young subjects did not reach the minimum recommended intake of calcium in any season [30]. Moreover, the reduction of approximately 100mg of calcium intake from summer to winter among the 40 and more year-old group may represent a risk.

The comparison between this and other studies developed around the world is relevant, but it is important to consider that there is a large difference in several aspects influencing all findings. One of these aspects relates to statistical analyses conducted in each study. Different to all other studies identified, in our study the analysis was based on GEE [31], an extension of the General Linear Model, especially used for analyses of repeated measures with non-normal distribution data. The GEE is a statistical method still underutilized in nutritional epidemiology, but it is increasingly being used to perform analyses of correlated data in longitudinal studies. On the other hand, it is difficult to conduct comparisons between nutrient intakes observed in the South of Brazil and in other parts of the world, because cultural habits and availability of foods are very different. Hence, other studies in this region are necessary to allow more comparisons, since differences were found.

One of the strengths of the current study was the methodological care required to reduce potential errors in dietary intake reported by the subjects. There was a photo album to assist in determining the size of servings of each ingested food. All researchers were well trained in the research instruments and all subjects were free of medical conditions that could interfere with normal eating habits. One weekend day was included, in accordance with recommendations for food surveys, in order to obtain information from an atypical day and help represent the dietary habits of the individuals [16].

However, some details should be considered in interpreting our findings. This paper addresses nutrients instead of foods, so the seasonal variations could be attributed to the differences in the foods eaten, which was not assessed in the present analysis.

One should also consider the number of days of diet data to be collected. It is well established that food intake on a single day, most probably, does not capture the pattern of usual intake [16] of an individual. In our study this number ranged from 1 to 3. In each season, on average, 30 individuals completed one, 25 two, and 39 three 24hR. Although the number of recalls in each season was greater than one for most participants, we know that for some nutrients there is a wide variation in day-to-day intake and more days of dietary surveys would be needed. According to Tokudome et al. [24], the number of 24hR or food record replications necessary for estimating nutrient consumption per person within 20% of the true mean for female Japanese dietitians ranged from 3 to 9 for energy and for macronutrients, and from 4 to 160 for specific micro-nutrients.

The results of this study should be viewed with caution, since the sample used is non-probabilistic and is characterized by having a high level of education. About 60% of this sample had completed undergraduateor graduate courses. In accordance to the national survey conducted in 2000 (Brazilian Institute of Geography and Statistics. 2000 Demographic Census. http://www.ibge.gov.br), only 1.88% of the population were college laureated and less than 1% had graduate degrees.

Although we have not found differences between seasons for most nutrients, the seasonal variation observed for the intake of some nutrients should be viewed with concern, since the elements for maintaining a good level of health include the regular consumption of food in adequate quantity and quality [32]. This is especially important for energy and macro-nutrient intake because of increasing levels of obesity [32], and calcium intake among older people, due to the greater risk of developing osteoporosis [33], and for young people who are at the peak stage of bone mass formation [34]. Additionally, it is noteworthy that a recent study identified an inverse association between calcium intake and type 2 diabetes [35]. Thus, cyclic variation of this nutrient intake may represent an important public health problem.

In conclusion, these findings highlight the importance of considering seasonal variations not only for evaluating dietary intake but also nutrition and public health policy recommendations, particularly in energy and macro-nutrient intakes in adult populations living in the temperate zone. The effect of season on food intake depends on gender and age and the differences in climate between seasons.

Resumo

Avaliar o efeito da sazonalidade sobre a ingestão de nutrientes em adultos residentes em Porto Alegre e Região Metropolitana, no Sul do Brasil. A ingestão alimentar foi obtida por meio de recordatórios alimentares de 24 horas em uma amostra de 162 adultos, com idade entre 20 e 69 anos. A ingestão média de nutrientes para cada estação do ano foi ajustada pela energia total usando o método dos resíduos. O efeito das estações do ano sobre a ingestão de energia, macro e micro-nutrientes foi analisado com base no modelo de Equações de Estimação Generalizado (GEE). Houve diferenças estatisticamente significativas entre as estações do ano para a ingestão de carboidratos e gordura total após ajuste para sexo, idade, educação e interações. No verão a ingestão de carboidrato foi maior do que nas outras estações e a ingestão de gordura foi menor. Os resultados sugerem que o efeito da variação sazonal sobre a ingestão de nutrientes deve ser considerado em estudos de avaliação da ingestão dietética e recomendações, especialmente em adultos residentes em zonas temperadas como a região Sul do Brasil.

Ingestão de Alimentos; Recomendações Nutricionais; Estações do Ano

Contributors

M. T. A. Olinto participated in the coordination of the study, its planning and execution and the write up of the article. S. L. Rossato contributed with data collection and analysis and the article write up. R. L. Henn was involved in the planning, analysis and write up. L. A. Anjos participated in the planning, research supervision and write up. A. W. Bressan contributed in the supervision of the field work and review of the manuscript. V. Wahrlich supervised the field work and training and reviewed the article. The final version was approved by all authors.

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