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Citation

Rossato, S L, M T A Olinto, R L Henn, L B Moreira, S A Camey, L A Anjos, V Wahrlich, W Waissmann, F D Fuchs, and S C Fuchs. 2015. "Seasonal Variation in Food Intake and the Interaction Effects of Sex and Age Among Adults in Southern Brazil." European Journal of Clinical Nutrition 69 (9) (April 1): 1015–1022. doi:10.1038/ejcn.2015.22.

Published Version

doi:10.1038/ejcn.2015.22

Seasonal variation in food intake and the interaction effects of sex and age among adults in southern Brazil

Seasonal food intake and interaction

Sinara Laurini Rossato [1,2§], Maria Teresa Anselmo Olinto [3], Ruth Lianne Henn [1,3], Leila B. Moreira [1,6], Suzi Alves Camey [1], Luiz Antônio dos Anjos [4], Vivian Wahrlich [4], William Waissmann [5], Flavio D. Fuchs [1], Sandra C. Fuchs [1,6]

[1] Postgraduate Studies Program in Epidemiology, School of Medicine, Federal University of Rio Grande do Sul, Rua Ramiro Barcelos 2600, 90035-003, Porto Alegre, RS, Brazil

[2] Department of Nutrition, Harvard School of Public Health, Room 300, 677 Huntington Avenue, Boston, MA, zip code 02115.

[3] Postgraduate Program in Collective Health, University of Vale do Rio dos Sinos, Avenida Unisinos 950, 93022-00, São Leopoldo, RS, Brazil

[4] Nutritional and Functional Assessment Laboratory, Department of Social Nutrition, Fluminense Federal University, Rua Mário Santos Braga 20, 415, 24020000, Niterói, Rio de Janeiro, Brazil

[5] Oswaldo Cruz Foundation. Sergio Arouca National School of Public Health. Workers' Health and Human Ecology Research Center. Rua Leopoldo Bulhões 1480, 21041210, Manguinhos, Rio de Janeiro, RJ, Brazil.

[6] Postgraduate Studies Program in Cardiology, School of Medicine, Federal University of Rio Grande do Sul, Rua Ramiro Barcelos 2600, 90035-003, Porto Alegre, RS, Brazil

[§] Corresponding author:
Harvard School of Public Health, Department of Nutrition.
677 Huntington Avenue, Room 300. Boston, MA, zip code 02115.
Phone and Fax number +1 617-432-2435
E-mail address: sinara.lrossato@gmail.com

Disclosure of conflict interest:

The authors declare no conflict of interest

Acknowledgement:

This study was supported by: CAPES – Brazilian Federal Agency for Support and Evaluation of Graduated Education; PROCAD 01/2005 nº 0257052, PROSUP nº 097/2007; National Council for Scientific and Technological Development – CNPq; nº 308833/2006, nº 308489/2009-8, nº

311801/2006-4, nº 70/2008, and nº 211521/2013; Studies and Projects Finance Organization – FINEP; Supporting the Program for Centers of Excellence – PRONEX; and HCPA-FIPE nº 00-176.

ABSTRACT

Background/Objective: Because studies have evidenced variations in nutrient intake, further investigation of the interaction between demographic characteristics and the seasons is necessary. We aimed to test the differences in food intake throughout the seasons and the interaction between the seasons and sex and age.

Methods: This study included 273 individuals. Food intake was evaluated with 24-hour dietary recalls, and the reported food items were sorted into food groups. We performed the test on the differences in intake of food groups throughout the seasons with repeated measures and on the interaction by using the Generalized Estimate Equation (GEE).

Results: Intake of fruits and natural fruit juices and sweetened beverages was lower, while that of grains and derivatives was higher in the winter. The intake of leafy vegetables and fish and seafood was lower in the autumn. The consumption of coffee and eggs was higher in the spring. Ingestion of chocolate powder and sugar, salt, and lean poultry was higher in the winter. The variation in consumption of grains and derivatives, eggs, fatty poultry, and processed meat over the seasons was more likely to be modified by sex. Age interacted with the seasons for leafy vegetables, beans and lentils, lean beef, lean poultry, low fat milk and light yogurt, vegetable oil and unsalted margarine, chocolate powder and sugar, and processed meat.

Conclusion: This study shows that food intake may change seasonally and that seasonal variation depends on sex and age, which might aggregate a specific co-variation component.

Key words: Seasonal variation, interaction effect, food intake variation.

INTRODUCTION

Nutrient (1) and food intake (2, 3) hardly remain constant over the seasons and differ with sex and age (4). Differences related to season in the intake of cereals, milk products, oils and fats, vegetables, fruits, alcoholic and non-alcoholic beverages, and water have already been described (3, 5). Japanese men and women have presented a higher intake of vitamin C in the summer and autumn in comparison with the overall intake per year (6). In developing countries, out-of-season fruits and vegetables are usually more expensive and may not be accessible to low-income families and regions (7). A recent study has shown a different progression of food intake with aging in men and women. For men, there was a linear reduction in the consumption of poultry, protein-mixed dishes, coffee and tea, and spreads; however, for women, the differences were not linear with age (20-39, 40-49, and 60 + years old, respectively). There was a linear and significant increase of vegetable intake for women, whereas the variation was non-linear and of lesser magnitude for men (4).

Food intake variation throughout the seasons, sex, and age might be relevant if the variation increases the likelihood of diseases (8, 9), but it is even more relevant if it introduces measurement bias (10, 11). Since they represent a source of variation and a potential bias, the seasons can influence patterns of health. Deaths by myocardial infarction were associated with a seasonal pattern (9) in Israeli industrial employees. This association could also be attributed to an increased consumption of fat in the winter (12), changes in plasma lipid levels among the seasons (13), or to other cardiovascular risk factors.

In addition to detection, the seasonal, sex, and age differences in food intake require rigorous methodological handling because they lead to a measurement bias. To prevent or control such sources of bias, sampling across the seasons and a proper statistical analysis were required (10, 11). In southern Brazil, an evident variation in food intake throughout the seasons was detected (1), but the overall energy from diet remained constant, even with differences in carbohydrate and fat intake. A sampling frame among seasons was recommended (11), and statistical modeling was developed to handle the seasonal variation (10, 14). The differences in food intake according to sex, age and seasonal variation have already been demonstrated separately; however, the interaction effect among them in dietary surveys has been neglected thus far.

We aimed to assess the seasonal variation in food intake and the interaction effect of sex and age on this variation.

METHODS

To expand coverage of food intake and the seasons as well as the external validity, data from two dietary studies were pooled. Dietary assessment was carried out in two cross-sectional studies conducted in southern Brazil, with adults with ages ranging from 18 to 90 years. In the first study, conducted in 2004 in Porto Alegre (Latitude: 30º 01’ 59” S Longitude: 51º 13’ 48” W; average temperature range from 3°C in the winter to 22°C in the summer), 112 adults (≥ 20 years) were selected and interviewed at home, using two sequential 24-hour dietary recalls (24hDR), as a subsample of the SOFT Study (Syndrome of Obesity and Risk Factors for Cardiovascular Disease) (15). In the second study, a convenient sample of 161 adults were interviewed at two health care centers located in Porto Alegre and São Leopoldo (Latitude: 29º 45’ 37” S Longitude: 51º 08’ 50” W), a town 34 kilometers from Porto Alegre. Six non-consecutive 24hDRs were conducted mainly in the summer (three) and winter (three) of 2007. The response rate in the first study was 100 percent. In the second study, the response rate was 85 percent in the first three interviews and 71 percent in the last three interviews. Both studies excluded pregnant women and people on diets. Double data entry and validation procedures were performed using the Epinfo (version 6.0; *Centers for Disease Control and Prevention*, Atlanta, United States), and details are described elsewhere (1, 15, 16).

Both studies used photographic albums, however with different presentations, to gather information on food portions. The albums for the first study were produced by a research team from the Nutrition and Dietetics Laboratory of the University of Vale do Rio dos Sinos (18), and for the second study, by a research team from the Nutritional and Functional Assessment Laboratory of the Fluminense Federal University (LANUFF).

Trained research assistants using the same protocol in both studies collected anthropometry measures, such as weight and height. Body mass index (BMI) was calculated by weight (kg) divided by height squared (m) (19). The cutoff age at 45 years old was defined after sensitivity analysis tested different cutoffs. The decision was based on the proportion of individuals in each age group that could result in minimal loss of statistical power, usually caused by stratification.

Dietary analysis

Food intake data from the 24hDRs of both studies were pooled and converted to weight and volume based on the Table of Portion Sizes for the Assessment of Food Consumption (20) and specialized culinary websites. The 24hDRs provided 900 recipes prepared at home or consumed in traditional restaurants, which were broken down to obtain the usual intake of foods such as vegetable oil, sugars, sweeteners, salt, and salt-based spices. Based on the weight (g), volume (ml), and description of the recipe, the relative content of each ingredient was estimated. Food intake, measured in grams per day, and total daily energy intake were calculated. We performed the quality control by comparing our estimates with those obtained from similar recipes found in food composition tables that list the components (TACO and USDA) (20, 21). A five percent variation was accepted for at least three of the four macronutrients analyzed (energy, carbohydrate, total fat, and proteins, as references). These comparisons were made for recipes with potato chips; baked, grilled and fried foods; sauces; risottos; and soups. Food items were sorted into groups according to the DASH (Dietary Approaches to Stop Hypertension) dietary eating plan (18 items), and 14 additional food groups were created (22) (**Supplemental Table**). Salt added in salads or recipes was considered an isolated food group. The ethics committees of both institutions (*Clinic Hospital of Porto Alegre* and UNISINOS Institutional Review Boards) approved the projects and all participants signed a consent form to participate.

Statistical analysis

Comparisons in the mean intake of food groups (g/day) amid the seasons were performed with the Generalized Estimate Equation (GEE). The food group was entered in the model as a dependent variable, the seasons as predictors, and the 24-hour dietary recalls as repeated measures in a nested format of the data set. The exchangeable working correlation matrix was applied to take into account the different correlations made in both studies, due to the data collection methods. The Tweedie distribution and log link function were used to support the "zero" intake observed in some of the food groups, the non-linearity between the dependent variables and predictor, and non-normal distribution of food intake (23 - 25). We tested the differences among seasons by simple contrasts adjusted for the Bonferroni sequential, using the season with the lowest intake as the reference category. The model was adjusted for sex, age (as continuous), and BMI. We evaluated the interaction effect of season with sex and age (as dichotomous: 1 – 20 to 44 years, 2 – 45 to 90 years). The level of significance was five percent for differences in simple comparisons and interaction effect. Data analysis was carried out using the *Statistical Package for Social Sciences* (SPSS Inc., Chicago, USDA, version 16.0).

RESULTS

Participants

The overall survey included 273 participants and a total of 762 24-hour dietary recalls throughout the four seasons, which were evaluated by repeated measure statistical procedures. **Table 1** shows that the participants were 27 percent males, 43.6 (SD=16.2) years old, and had a mean body mass index of 24.6 (SD=3.7) kg/m^2. In both surveys, women and girls were the majority. While the first survey had less young (20-40 years old) individuals (30%), the second they were preponderant (69%); what conferred to the overall sample a balance (53% of younger individuals). Body mass index was higher in the first survey. The second survey had a larger number of 24-hDR replicates and a more proportional distribution through the seasons, except for spring that had most individuals evaluated in the first survey (85 vs. 15%). Again, the differences between both surveys pondered for overall survey.

Food intake according to sex and age

Table 2 presents the average intake of food groups according to sex and age. For individuals older than 45, we evidenced a significantly higher intake of vegetable oil and unsalted margarine (+1.2 g/d), whole milk and yogurt (+40.7 g/d), and eggs (+2.9 g/d) and a lower intake of sweets of all types (-17.6 g/d), sweetened beverages (-105.3 mL/d), fried foods of all kinds (-14.3 g/d), and processed meat (-6.4 g/d). Men had a higher intake of leafy vegetables (+10.8 g/d) and lean beef (+14.3 g/d), which might infer a health food pattern. However, they also had a higher intake of sweetened beverages (+60.7 mL/d) and fried foods of all kinds (+10.90 g/d). Such results may suggest a likely improvement in diet quality with age yet may be controversial for sex in this survey.

Table 3 displays the differences in average intake of food groups (g/day) according to the seasons. The consumption of fruits and natural fruit juices, leafy vegetables, sweetened beverages, and eggs was statistically significantly different among all the seasons compared with the reference season. The intake of fruits and natural fruit juices and sweetened beverages was lower in the winter than in the summer, while the intake of leafy vegetables was 36 percent lower in the autumn than in the spring, when there was the highest intake of eggs. The intake of a few food groups varied in just one season compared with the season of reference. Intake of vegetable oil and unsalted margarine was 25 percent lower in the autumn than in the spring. Lean poultry intake was higher in the winter. Consumption of whole cheese, cottage cheese, and cream was higher in the autumn. The intake of chocolate powder and sugar, salty baked goods, and salty industrialized foods was more likely to decrease in the summer. Salt intake was 54 percent higher in the winter than in the autumn, and there were no significant differences in intake in the other seasons.

Interaction effect

The interaction effect of sex on seasonal food intake was detected for the intake of four (out of 30) groups and presented a markedly different direction of the seasonal effect on food intake **(Figure 1)**. Intake of grains and derivatives for men was lower in the autumn than in the winter, but for women it was lower in the spring and similarly high in the summer, autumn, and winter. The intake of eggs was lower in the winter for women and in the summer for men. For egg intake in the winter for women, low variability occurred because most women did not consume eggs, and those who did, had a low intake. Contrary to what was observed in women, the intake of fatty poultry was lower in the winter and higher in the summer and spring for the men. Also, processed meat intake was higher for women and lower for men in the summer. The differences in intake of food groups among seasons were statistically significant only for egg intake among women ($P=0.04$).

Figure 2 shows the interaction effect between age and seasons. Among younger adults (20-44 years), intake of leafy vegetables increased linearly over the seasons. In contrast, this intake among participants between the ages of 45 to 90 was non-linear. Consumption of beans and lentils was lower in the summer and higher in the other three seasons among the younger adults. Lean beef intake became gradually higher from summer to spring for younger adults and non-linear for the older adults. The highest intake of lean poultry was in the autumn for the younger adults and in the winter for the older adults. Contrary to what we observed in older adults, younger adults had a lower intake of vegetable oil and margarine in the autumn and of low fat milk and light yogurt in the winter. While the intake of chocolate powder and sugar and processed meat did not change significantly among the seasons for the younger adults, the intake of these food groups varied significantly among the seasons for the older adults.

DISCUSSION

Our study presents a distinct standpoint in relation to the co-variation of seasonal food intake and the interaction effect of sex and age on seasonal food intake. To our knowledge, the interaction effect of sex and age on seasonal food intake had not been investigated previously. The results illustrate that the inclusion of the interaction term as co-factor in the statistical analysis should be taken into account, although our study could not clarify the mechanisms involved. Despite some limitations, as discussed below, the aggregation of surveys helped to improve the external validity, statistical power and pondered categories of age, seasonal distribution and BMI.

Our results confirm that there is a food intake variation throughout the seasons in southern Brazil and demonstrate that those variations depend on sex and age. For the overall survey, we detected a higher intake of fruits and natural fruit juices, leafy vegetables, fish and seafood as well as that of eggs, vegetable oil and margarine, and sweetened beverages in the spring and summer. In the wintertime, there was an increased intake of lean poultry and added salt. The intake of fruits and natural fruit juices, leafy vegetables, and sweetened beverages may be related to high temperatures and increased physical activity (26). There was a reduction in intake of fruits and natural fruit juices in the winter in the entire survey and in women. Somewhat similar results were observed for fruit intake in Spain, with increases of 5.3 and 12.6 percent in women and men, respectively, in the summer (2). Chinese women had a 3.8 percent decrease in fruit intake in the winter, compared with the annual mean (3). In Japan, the greatest source of variation in nutrient intake was observed for carotene and vitamin C intake. Carrots and spinach contributed to 50 percent of the total carotene intake; cabbage and tomato contributed with 10 to 15 percent of the total vitamin C intake. The highest contribution to total vitamin C intake was observed in the intake of vegetables and fruits (5).

The reasons behind the seasonal influence on food intake and health patterns are not clear. Availability represents an important barrier for the intake of fruits and vegetables in some countries (6), and harvests might determine choice in intake of fruits and vegetables in others (8, 27). Health patterns such as normal blood pressure (28), absence of cardiovascular disease (9), and normal lipid levels (12, 13) are likely to be the result of lifestyle, genes, and environmental characteristics, but their relation to seasonal variation has not been clearly linked. Also, other conditions, such as mood disorders, are likely to affect eating habits significantly throughout the binge precipitation (29).

We observed an interaction effect of sex and age on seasonal food intake that forecasts the heterogeneity resulting from the seasonal effect, thereby confirming an interaction between seasonal food intake and sex and age, as in the previously reported case on nutrient intake (1). A recent study, which evaluated the diets of Brazilians and North Americans, also revealed a different progression of changes in food intake with age between men and women (4), but the interaction term was not tested in that study. Such different results may be attributed to some known reasons. Each population has different food habits (30), which could explain why the food groups for the interaction effects found were different between the populations. Additionally, we used two surveys, therefore, the first sample has a lower average income than the second, which may influence the variability of diet (31).

In other countries, the intake of fruits and vegetables is correlated to age and gender (29), but in our study, we observed an interaction effect only for leafy vegetables in relation to age. To our knowledge, the interaction of sex and age on food intake had not been tested so far, but there is at least one study that has evaluated nutrient intake. Zhang and colleagues identified an increase in phosphorous intake with aging, which was different in men and women. The interaction effect was confirmed by statistical tests (32). The discrepancy in food intake between men and women and for age groups may be explained by differences in body size, by women tending to have a healthier diet than men (33), and by expected changes in food habits through age (34). Södergren and collaborators evaluated differences in lifestyle between men and women and found that 72 percent of women lead a healthy lifestyle while only 53 percent of men do so (33). In general, the score generated by calculating the quality of diet based on *Healthy Eating Index-2005* classified North American women as having a better quality of diet than men in every age group, except for individuals from ages 31 to 50 (34). On the other hand, potential bias inherent to short report methods, which are influenced by age, sex, and others factors, must be considered. For instance, the fear of a negative evaluation, history of weight loss, and the percentage of energy derived from fatty foods are the most precise predictors of sub-report among women. For men, the main predictors are BMI, comparisons in physical activity levels among men of the same age, and frequency of food consumption (35). Studies have shown likely errors in the report due to age, yet the under-intake of food intake can easily be confounded with under-report (36).

The seasons have previously been considered to be confounding factors, and weighted analysis could be an appropriate approach (37, 38). However, the interaction effect might buffer or exacerbate the truth effect (39, 40). In addition to the possible influence on health patterns, the seasonal effect may have a methodological impact because of the variation in exposure throughout time (41, 42).

Strength and Limitations

The aggregation of studies that have similarities but are not identical may imply strength and a limitation. For age, BMI and seasons, the unification strengthens the study because it pondered the sample distribution; however it did not enhance the distribution according to sex. Both studies used similar interview methods but different photographic albums for data collection and food assessment, a different number of 24-hour dietary recalls. These distinctions may have been taken into account by the statistical method performed using the working correlation matrix and repeated measures method of analysis. Dissemblance between the photographic albums could not be taken into account; therefore, we cannot specify how much it influenced the results.

Final conclusion

This study evidences seasonal variation in food intake. We noted a high intake of fruits and natural fruit juices, vegetables, and leafy vegetables as well as of ultra-processed foods, such as sweetened beverages and sugar and chocolate powder, in the summer and spring. There was a higher intake of salt in the winter. Seasonal variation might influence health patterns, and further investigations that link these patterns, sex, and age to this variation are strongly encouraged. Methodologically, this study demonstrates the interaction between seasonal variation in food intake and sex and age, which could be considered in the design of forthcoming dietary studies and in statistical analyses.

Supplementary information is available at EJCN's website

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FIGURE LEGENDS

Figure 1 Interaction effect between season and sex on food intake (mean and CI95%).

Legend: X Women ◆ Men.

Abreviations: Summer (Sum); Autumn (Aut); Winter (Win); Spring (Spr) . P-values were described in table 1.

Figure 2 Interaction effect between season and age on food intake (mean and CI95%).

Legend: X 20 – 44 years ◆ 45 – 90 years.

Abreviations: Summer (Sum); Autumn (Aut); Winter (Win); Spring (Spr) . P-values were described in table 1.