Clinical Nutrition ESPEN 33 (2019) 91–97

Contents lists available at ScienceDirect

Clinical Nutrition ESPEN

journal homepage: http://www.clinicalnutritionespen.com

Original article

Usual intake and dietary sources of Selenium in adolescents: A cross-sectional school-based study

Anabelle Retondario [a, *], Amanda de Moura Souza [b], Ricardo Fernandes [a, 1], Liliana Paula Bricarello [a], Mariane de Almeida Alves [a, 2], Lúcia A.Z. Ramos Zeni [c], Erasmo B.S. de Moraes Trindade [c], Francisco de Assis Guedes de Vasconcelos [c]

[a] Post Graduate Program in Nutrition, Universidade Federal de Santa Catarina (UFSC, Federal University of Santa Catarina), Florianópolis, Brazil
[b] Institute of Collective Health Study, Universidade Federal do Rio de Janeiro (UFRJ, Federal University of Rio de Janeiro), Rio de Janeiro, Brazil
[c] Nutrition Department, Post Graduate Program in Nutrition, Universidade Federal de Santa Catarina (UFSC, Federal University of Santa Catarina), Florianópolis, Brazil

ARTICLE INFO

Article history:
Received 29 December 2018
Accepted 3 July 2019

Keywords:
Diet, food, and nutrition
Selenium
Adolescent
Eating
Recommended dietary allowance

SUMMARY

Background and objectives: Selenium is a mineral that constitutes selenoproteins and, therefore, has been studied, especially in cardiovascular diseases. Some risk factors for the development of these diseases, such as obesity, hypertension and dyslipidemia, have been observed early in life, including in childhood and adolescence, and food and nutrient intake is an important associated factor for their development. The aim of this study was to assess usual intake of selenium (Se) and dietary inadequacies regarding the consumption of this mineral, and to identify the main dietary sources of Se among 12–17 year-old Brazilian adolescents.

Methods: Data from the Study of Cardiovascular Risk in Adolescents, performed countrywide in the years 2013 and 2014, were used to estimate inadequate Se dietary intake. The National Cancer Institute's method was used, considering two days of 24 h dietary recall (24hR). The contribution of each food group to the total intake of Se was determined using a single 24hR, and was defined as a ratio between the total intake of Se and the percentage of Se in each food group, until reaching 95%. Food mentioned by adolescents were categorized into 39 food groups, according to macronutrient similarities.

Results: Data from 76,957 adolescents aged from 12–17 years (49.7% girls) from public and private schools were assessed. Selenium intake was according to recommendation levels. Mean Se intake ranged from 84.3 to 105.9 μg among sex and age groups. Considering the whole sample, meat, pasta, poultry, and fish were the food groups that contributed with the greatest amount of Se (representing 57.9% of total Se). Brazil nuts are consumed in bigger quantity only by 14–17 year-old girls, contributing to 1.6% of the Se in their diets.

Conclusion: Brazilian adolescents have an adequate Se intake because of the high consumption of meat, pasta, and poultry. Although Brazil nuts are the most important dietary source of Se, adolescents consume them in very small amounts, leading to a small contribution in the total intake.

1. Introduction

Selenium (Se) is an essential mineral with a large intake variation worldwide [1]. It is a component of Glutathione peroxidase (GPx), and can reduce cellular inflammation and lipid peroxides, as well as it is involved in T4-to-T3 conversion, and in the protection against harmful heavy metals and the action of xenobiotics [2,3]. Albeit a low Se intake may lead to deficiencies (such as Keshan and Kashin-Beck diseases), a high intake of this mineral could,

* Corresponding author. Post Graduate Program in Nutrition, Universidade Federal de Santa Catarina (UFSC, Federal University of Santa Catarina), Trindade, Florianópolis, 88040-900, Santa Catarina, Brazil. Fax: +55 48 3721 9542.
E-mail address: profe.anabelle@gmail.com (A. Retondario).
[1] Present address: Health Sciences College, *Universidade Federal de Grande Dourados* (UFGD, Federal University of Grande Dourados), Brazil.
[2] Present address: Public Health Faculty. *Universidade de São Paulo* (USP, University of São Paulo), São Paulo, Brazil.

https://doi.org/10.1016/j.clnesp.2019.07.002
2405-4577/

conversely, cause toxicity i.e. hair and nail loss, skin disorders, poor dental health, nervous system disorders and paralysis [4]. Its role in human health has been studied, especially in the scope of cardiovascular diseases (CVD) [1,5]. A meta-analysis concluded that Se was inversely associated with CVD in observational studies, but not in randomized trials, whose findings were considered inconclusive [6].

Some risk factors for the development of CVD, such as obesity and hypertension, have been observed early in life, including in adolescence. A literature review about metabolic syndrome in children and adolescents included studies conducted in eight different countries, with the prevalence of high triglycerides ranging from 4.9% to 75% of the sample, the prevalence of low HDL-c ranging from 8.1% to 42.2%, the prevalence of central obesity ranging from 4.9% to 27.7%, and the prevalence of hypertension ranging from 5.4% to 23.8% [7]. A Brazilian study reported a prevalence of 14.5% of pre-hypertension, 9.6% of hypertension, 17.1% of overweight, and 8.4% of obesity in adolescents countrywide [8].

Food intake is an important associated factor for the development of CVD [9]. In the global scenario, few studies have investigated the dietary intake of Se in adolescents and its relationship with CVD [10,11]. In Brazil, some studies have shown that the dietary habits of adolescents are based on traditional foods, such as rice and beans, and that the intake of sugary drinks and ultra-processed foods is high, causing an excessive intake of saturated fat, sugar, and sodium [12–14]. Considering the role of Se in CVD, it is relevant to investigate the dietary intake of this micronutrient in Brazilian adolescents.

The aim of this study was to assess the usual intake of Se and investigate the dietary inadequacy of the mineral, besides identifying the main food sources of Se among 12–17 year-old Brazilian adolescents.

2. Methods

This research is part of the *Estudo de Riscos Cardiovasculares em Adolescentes* (ERICA, Study of Cardiovascular Risks in Adolescents), a multicenter school-based countrywide cross-sectional study conducted in all of the 26 Brazilian States and the Federal District between 2013 and 2014, and representative of Brazilian adolescents from medium- and large-size cities (>100,000 residents) in national and regional reach, as well as for the state capitals [15]. The study sample was selected using a multistage design. The present study included adolescents with a full list of details of their dietary intake, in a total of 76,957 adolescents between 12 and 17 years-old. The ERICA research protocol, design, rationale, sample, and data collection has been previously published [15,16]. Data used in this research are briefly described below.

The adolescents answered a self-administered questionnaire supported by a personal digital assistant (PDA), LG GM750Q® model, where social and demographic information (sex, age, type of school, and macroregion) were collected [16].

To investigate dietary intake, a single 24hR was applied by trained interviewers, using a software developed specifically for the study: the ERICA-REC24h [17]. This software contains a list of foods usually consumed by Brazilian population [18,19], allowing foods that were not in the list and were reported by the adolescents to be added by the researchers. The multiple-pass method (MPM) [20] was used to minimize memory bias, which is intrinsic to this food survey method. Firstly, adolescents were asked by the interviewers about the food they ate the day before. Then they were asked about items which are not usually remembered, such as chewing gum, candy, snacks, and soft drinks. After that, the adolescents were asked about the time of consumption for each item they listed as consumed the day before the interview. After that, they were encouraged to minutely describe food quantities, reviewing information about time and occasion of consumption. In this step, interviewers could access a software tool where images of common household measures were available for adolescents to choose from, to accurately measure serving size. Lastly, interviewers conducted a final review of all listed food, probing about consumed and not reported items [17,20]. The use of Se and/or other nutrients supplements was not investigated.

In a random subsample of two students per class (about 7% of total sample), a second 24hR was applied to estimate within-person variability. Data from both 24hR were used to determine the usual intake of Se. According to the National Cancer Institute (NCI), using a 24hR on the whole sample and a second one on a subsample is acceptable if the subsample is large enough [21].

2.1. Inadequate dietary intake of Selenium

To determine inadequate Se dietary intake, sample weight and complexity of sample design were taken into account, applying the technique of replication called Fay-modified Balanced Repeated Replication (Fay-BRR) [22].

The usual dietary intake of Se was estimated using statistical modelling techniques, based on data from both 24hR. Within-person variability was estimated by the NCI method, in order to find the percentile distribution of intake: first, running a logistic regression model to estimate the probability of Se consumption, and next, running a linear regression model to estimate the consumed amount of Se [23].

Prevalence of inadequate Se dietary intake is defined as the proportion of adolescents whose Se intake was below the estimated average requirement (EAR). It was determined applying the EAR as a cut-off point method [24]. The Institute of Medicine established EAR by age: 35 μg/day for 12–13 years-olds, and 45 μg/day for 14–17 years-olds, for both sexes [3].

2.2. Dietary sources of Selenium intake

A dataset with 1128 foods was obtained from the first 24hR. Due to the large amount of dietary intake data, these foods were grouped according to the similarity of macronutrient composition, resulting in 39 food categories (Table 1). This procedure was based on a grouping carried out in a previous publication from ERICA, according to similar macronutrient profiles [12].

The contribution of each food group to the total intake of Se was determined using a single 24hR. The tool was applied using the software ERICA-REC24h [17], which contained a nutritional composition table of foods usually consumed by the Brazilian population [18,19]. The method proposed by Block, Dresser, Hartman & Carroll [25] was applied, considering a ratio between the total intake of Se and the percentage of Se contribution provided by each food group, until reaching about 95%. These results were presented in graphs, arranged by sex, age group, and macroregion.

2.3. Statistical procedures

The statistical analyses were performed using the STATA® (Statistical Software for Professionals, Texas) software, version 13.1, and SAS® (Statistical Analysis System, North Carolina) software version 9.4. The command survey (*.svy*) was used to consider the sample weight and survey design.

The sample's social and demographic characteristics (sex, age, type of school, and macroregion) were presented in proportions with the corresponding 95% confidence interval (95% CI).

Selenium intake distribution was presented in percentiles (p10, p50, p90) with the corresponding 95% CI of p50 arranged by sex,

Table 1
Categorization of foods according to a similar macronutrient profile. Brazil, ERICA 2013–2014.

Food group	Description
Rice/Rice dishes	Rice, rice with vegetables, sushi and other rice-based preparations
Corn/Corn dishes	Corn, cornmeal, *polenta* (cornmeal boiled into a porridge) and other corn-based preparations
Beans and other legumes	Beans, soy meat and other types of beans
Vegetables	Leafy greens and legumes
Tubers	Potatoes, not including their industrialised forms (chips), cassava, yams and other tubers
Fruits	Fruits and fruit salads
Nuts	Peanuts, cashews, almonds and others
Breakfast cereals	Oats, frosted flakes, Granola bars and other types of cereals
Pasta/Pasta dishes	Pasta, ravioli, lasagna and other pasta-based preparations
Soups	Soups and broths
Breads	White, wholegrain and toasted breads
Cakes, pies and pastries	Desserts and pastries in general
Cookies	Sweet and filled cookies
Diet/light cakes, cookies, pies and pastries	Diet/light cakes, sweet and filled biscuits, and pastries
Crackers	Biscuits and chips (potato or corn)
Meat/Meat dishes	Meat, meat-based preparations and other meats
Pork/Pork dishes	Pork and pork-based preparations
Poultry/Poultry dishes	Chicken, chicken-based preparations and other fowl
Fish/Fish dishes	Fish and fish-based preparations
Processed meats	Ham, salami, mortadella, sausage and other processed meats
Eggs	Eggs and egg-based preparations
Milk	Whole and skimmed milk
Milk based dishes	Milk-based preparations
Flavoured dairy drinks	Dairy drinks sweetened with artificial or natural flavourings, and fermented milk
Milk substitutes	Soy milk, soy-based beverages, and other kinds of vegetable-based milk
Juices and fruit drinks	Natural and processed fruit juices
Soft drinks	Regular soft drinks
Low sugar or light fat soft drinks	Diet and light soft drinks
Coffee	Coffee, cappuccino, latte and other coffee-based drinks
Tea	Teas
Alcoholic beverages	Wine, beer, and others
Cheeses and other dairy products	Cheeses and yoghurts
Sweets and desserts	Sweets, fruit-based desserts, chocolate and other candies
Sugar, honey and jellies	Sugar, honey and jellies
Diet or light sweets and desserts	Diet or light sweets, desserts, cakes, pastries and cookies
Oils and fats	Vegetable oils, olive oil, butter, margarine, sauces and condiments
Pizza	Pizzas and calzones
Deep-fried and baked snacks	Chicken pastry, pie, cheese-bread and other snacks
Sandwiches	Hamburgers and other sandwiches

Souza et al. [12].

age group, macroregion and type of school (public or private). The prevalence of inadequate intake was arranged by sex, age group, macroregion and type of school (public or private).

2.4. Ethics procedures

ERICA was approved by the Research Ethics Committees of the Institute of Collective Health Studies at the *Universidade Federal do Rio de Janeiro* (UFRJ, Federal University of Rio de Janeiro) (Report n.01/2009, Process n.45/2008) and by the Research Ethics Committees in all states and in the federal district. All participants of the present study signed an informed consent form prior to participating.

3. Results

A total of 76,957 adolescents were assessed. Of these, 49.7% were girls, 64.9% were 14–17 years-old, and 82.7% studied in public schools. More than half of the sample lived in Southwest region of Brazil (50.5%) (Table 2).

Inadequate intake of Se was not found in this population, regardless of sex, age groups, macroregions, and type of school (public or private), according to the EAR cut-off method. The mean Se intake ranged from 84.3 μg (girls 12–13 years) to 105.9 μg (boys 14–17 years). The results show statistically significant differences of Se intake between groups. Boys had a higher intake of Se than girls independent of age and type of school. Considering the national means, in the 12–13 year-old age group, boys had a Se intake of 98.3 μg, against 84.3 μg in girls group. Likewise, in the 14–17 year-old age group, boys consumed 105.9 μg against 91.1 μg from girls. Girls in the 12-13 year-old age group from public schools consumed statistically less Se than boys from the same age and type

Table 2
Social and demographic characteristics of adolescents. Brazil, Study of Cardiovascular Risks in Adolescents (ERICA) 2013–2014.

Characteristic	N	%	CI95%
Sex			
Girls			
12-13 years-old	11,756	17.3	15.4–19.3
14-17 years-old	30,962	32.4	30.1–34.7
Boys			
12-13 years-old	9,556	17.8	16.0–19.6
14-17 years-old	24,683	32.5	30.7–34.3
School type			
Public	60,553	82.7	78.1–87.4
Private	16,404	17.3	12.6–21.9
Macroregions			
North	15,401	8.4	7.3–9.4
Northwest	23,884	21.5	18.3–24.7
Southwest	17,644	50.5	45.9–55.1
South	9,881	11.9	9.1–14.7
Midwest	10,147	7.8	6.5–9.0

CI95%: confidence interval of 95%.

of school (85.7 μg *versus* 95.4 μg). In all groups the p10 of Se intake distribution was above of the EAR for this mineral (Table 3).

Food groups that contributed with the highest percentiles of Se were meat (20.9%), pasta (14.9%), poultry (12.8%), and fish (9.2%), representing 57.8% of the total consumption of Se for the whole sample. Analysing by sex, for girls, the meat, pasta and poultry food groups reached 47.4% in the 12-13 year-old age group and 47.7% in the 14-17 year-old age group. Brazil nuts are at the back of the 14-17 year-old food list, contributing with 1.6% of the total amount of Se. For boys, the meat, pasta and fish food groups reached 45.9% in the 12-13 year-old age group and the meat, pasta and poultry food groups reached 50.9% in the 14-17 year-old age group (Fig. 1).

Among the country's macroregions, the meat food group was the main source of Se, except in the South, where the main source was the pasta food group. Meat, pasta and poultry were the food groups that contributed with the highest percentiles of Se in the Northwest (50.9%), Midwest (55.7%), Southwest (49.5%), and South (50.7%) regions. In the North, the food groups that contributed the most were meat, fish and poultry (55.6%) (Fig. 2).

Regarding the type of school (public or private), the meat, pasta and poultry food groups contributed with 48.9% in public schools and 47.8% in the private ones (data not shown).

4. Discussion

The aim of this study was to assess the usual intake and the main dietary sources of Se among Brazilian adolescents. The main results show that Brazilian adolescents have an adequate intake of Se, mostly due to the consumption of meat, pasta, and poultry.

The intake of Se was according to recommendation levels. A previous investigation in the Brazilian population identified an intake of Se above the EAR in 5.7% of 10–13 year-old boys, in 8.5% of 14–18 year-old boys, in 4.4% of 10–13 year-old girls and in 12.1% of 14–18 year-old girls [19].

The mean Se intake found in this study was higher than the findings of the *Programa Orçamento Familiar* 2008–2009 (POF, Brazilian Household Budget Survey 2008–2009), the latest national survey conducted in Brazil. In this survey, the mean intake of Se by adolescents ranged from 76.8 μg (10–13 year-old girls) to 93.9 μg (14-18 year-old boys) [19]. In the United States, a study with children and adolescents showed that the intake of Se ranged from 88.0 μg (14–18 year-old girls) to 127.0 μg (14–18 year-old boys), when analysing nonusers of dietary supplements [26]. Comparing by age group, the North American Se intake was higher for 9-13 year-old boys (108.08 μg), for 14–18 year-old boys (127.0 μg), and for 9-13 year-old girls (90.0 μg). For 14–18 year-old girls, the intake of Se was slightly lower (88.0 μg) than the intake observed in our study.

Selenium intake is affected by the Se concentration in the soil, which depends on geological factors and proximity to the ocean [27–29]. Thus, the dietary intake of Se has a large variation worldwide. It seems to be less than 10 μg/day in Chinese areas where Keshan disease is endemic, and could reach 350 μg/day in areas with extreme Se levels in the soil, such as Venezuela [5]. Moreover, the bioavailability of Se is affected by the form of the mineral. Even though absorptive pathways have not been fully elucidated, inorganic forms (such as selenate and selenite) seem to be very well absorbed, but less well retained by the human body than the organic ones (such as selenomethionine and selenocysteine). Selenomethionine is predominant in cereals, while non-Se-accumulating plant foods have selenate, selenomethionine, and small quantities of selenocysteine. Se in animal-derived foods seems to be major selenomethionine and selenocysteine, besides selenite and selenate have been detected in fish [30–32]. An insufficient Se intake (<12 μg/d) for a long period of time could cause Keshan disease, a cardiopathy described by Chinese scientists in a Chinese area where Se deficiency is endemic [33]. On the other hand, selenosis could be observed in diets with an >800 μg/d intake, affecting nails, hair, teeth, skin, the gastrointestinal tract, and the nervous system [34].

The results found in this study show statistically significant differences of Se intake between girls and boys. This finding was expected, since Brazilian boys have a higher energy intake compared to girls [12], whereas the recommendation of Se intake is the same for boys and girls in the same age group [3].

Table 3
Nutritional recommendation and percentiles 10, 50 and 90 of Se intake according to sex, age group, macroregions, and type of school (public or private). ERICA, Brazil, 2013–2014.

	Girls									
	12–13 years old					14–17 years old				
	EAR	p10	p50	p90	CI95%	EAR	p10	p50	p90	CI95%
Brazil	35 μg	62.5	84.3	111.8	80.6–88.0[a]	45 μg	68.0	91.1	120.2	86.8–95.4[b]
North		71.8	97.3	129.9	92.2–102.4[c]		71.2	96.9	129.3	92.6–101.2
Northwest		64.4	87.6	117.8	84.9–90.3[c,d]		66.2	90.2	120.5	87.5–92.9[e]
Midwest		67.6	92.0	123.2	89.8–94.2		68.2	92.9	124.3	90.9–94.9
Southwest		64.7	88.1	117.4	80.1–96.1		66.8	90.9	121.2	84.0–97.8
South		69.7	94.9	127.0	92.7–97.1[d]		70.1	95.4	127.6	93.4–97.4[e]
School type										
Public		63.0	85.7	114.0	82.8–88.6[f]		66.8	90.4	120.2	86.3–94.5
Private		70.8	96.3	128.3	87.9–104.7		71.0	96.4	128.7	89.7–103.1
	Boys									
Brazil	35 μg	73.6	98.3	129.1	93.4–103.2[a]	45 μg	79.7	105.9	138.6	100.4–111.4[b]
North		71.1	96.5	128.7	92.8–100.2		70.9	96.3	128.6	93.0–99.6
Northwest		62.3	92.2	123.1	89.1–95.3		69.9	95.0	126.3	91.3–98.7
Midwest		68.9	94.0	125.6	91.7–96.4		70.1	95.1	127.2	92.2–98.0
Southwest		69.1	93.6	124.9	87.5–99.7		71.2	96.4	128.1	91.7–101.1
South		70.2	95.0	127.3	91.7–98.3		70.4	95.5	127.7	91.0–100.0
School type										
Public		70.8	95.4	126.6	89.7–101.1[f]		74.7	100.5	133.0	93.4–107.6
Private		70.3	95.8	128.4	89.5–102.1		70.7	96.0	128.4	91.3–100.7

EAR, Estimated Average Requirement; CI95%, confidence interval of 95%. Statistically significant differences between groups are indicated by identical letters following CI95% in each line or column.

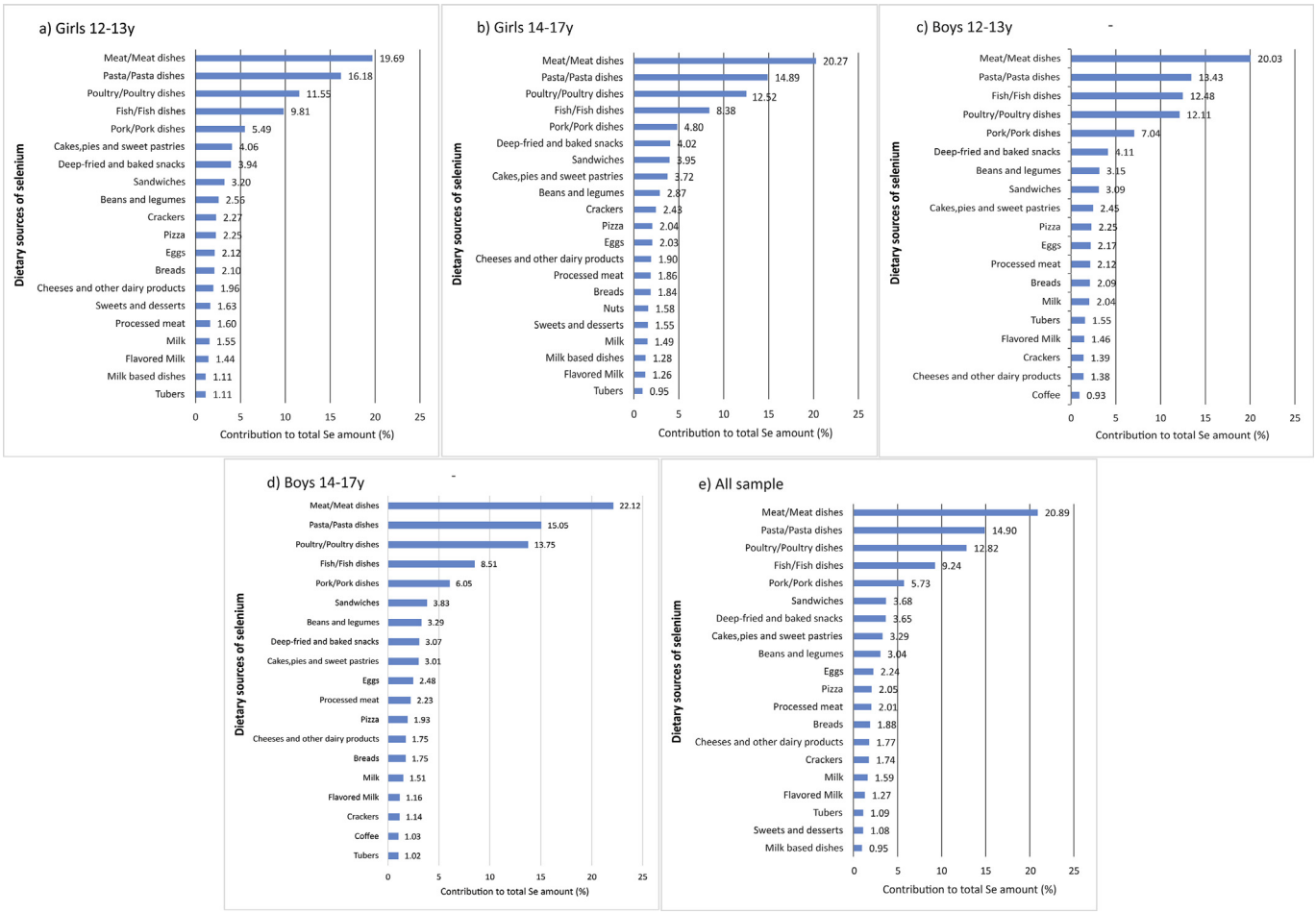

Fig. 1. Food groups contributing to 95% of total intake of Se arranged by sex and age group. ERICA, Brazil, 2013–2014.

The Northwest region had a lower mean intake than the South. In the South, the consumption of pasta by girls is higher than in the Northwest. This could lead to an increase in the intake of Se in Southern girls, because wheat and wheat-derived products may contribute significantly to the intake of Se by the population [35].

The main dietary sources of Se are presented in Fig. 1, arranged by sex and age groups. Wheat and wheat-derived products are a good source of Se [35], as well as seafood [18]. Meat probably contribute to a high amount of this mineral because its consumption is also high. Data from POF 2008–2009 showed that red meat was the fifth most consumed food by adolescents in Brazil (46.5% of the subjects). Poultry (25.6%) and pasta (19.0%) were also among the most consumed food groups in this age group [36]. Unpublished data from the same sample (ERICA 2013–2014) found a mean consumption of 100.1 g of meat, 62.8 g of pasta and 56.9 g of poultry. These amounts are more significant than the amount of Se-rich food groups consumed, such as seafood (18.8 g, including fish) and nuts (0.27 g).

On the other hand, nuts and animal giblets/innards, foods with a high amount of Se, were seldom consumed by Brazilian adolescents. Brazil nuts are considered the main food source of Se, with the highest concentration of this mineral of all edible nuts, besides having a high bioavailability [37–39]. In our results, nuts only appear as main dietary source of Se for 14-17 year-old girls, contributing to 1.6% of total Se intake of this group. Unpublished data from the same sample (ERICA 2013–2014) found a mean consumption of 0.3 g of nuts, highlighting the low consumption of this item.

A Belgian study found similar results in adults: despite Brazil nuts, fish and seafood, eggs, poultry, cheese, mushrooms and pasta being the foods with the highest amounts of Se, the major sources were meat and meat dishes, fish and seafood, and pasta and rice [40].

When analysing by macroregion, only in the South of Brazil the main source of Se was not meat, but pasta. In the North, fish was the second main source of Se. These differences could be explained by local food habits. Brazil is a continental country, colonized by several European cultures which influenced customs and traditions, including the population's dietary habits. In the South, there is a significant expression of Italian colonization, reflected by a higher consumption of pasta. In the North, the colonization process had encountered more resistance by the native indigenous, being that food habits strongly represent their traditions and preferences, reflected by a higher consumption of fish.

As limitations of this study, it is considered that the amount of Se in food is affected by the content of Se in the soil. Despite having used a national food composition table [18], some data from this tool could be imported from international bodies. In addition, the use of Se and/or other nutrients supplements was not investigated. Although the limitations regarding food reports, such as a possible recall bias or an interviewer bias, and multiple days required to assess usual intake [41], the choice of a 24hR is observed as a strength in this study. The application of a second 24hR in a subsample is highlighted, which enabled researchers to estimate within-person variability to calculate inadequate intake. The NCI states that, in large samples, applying a second 24hR on a

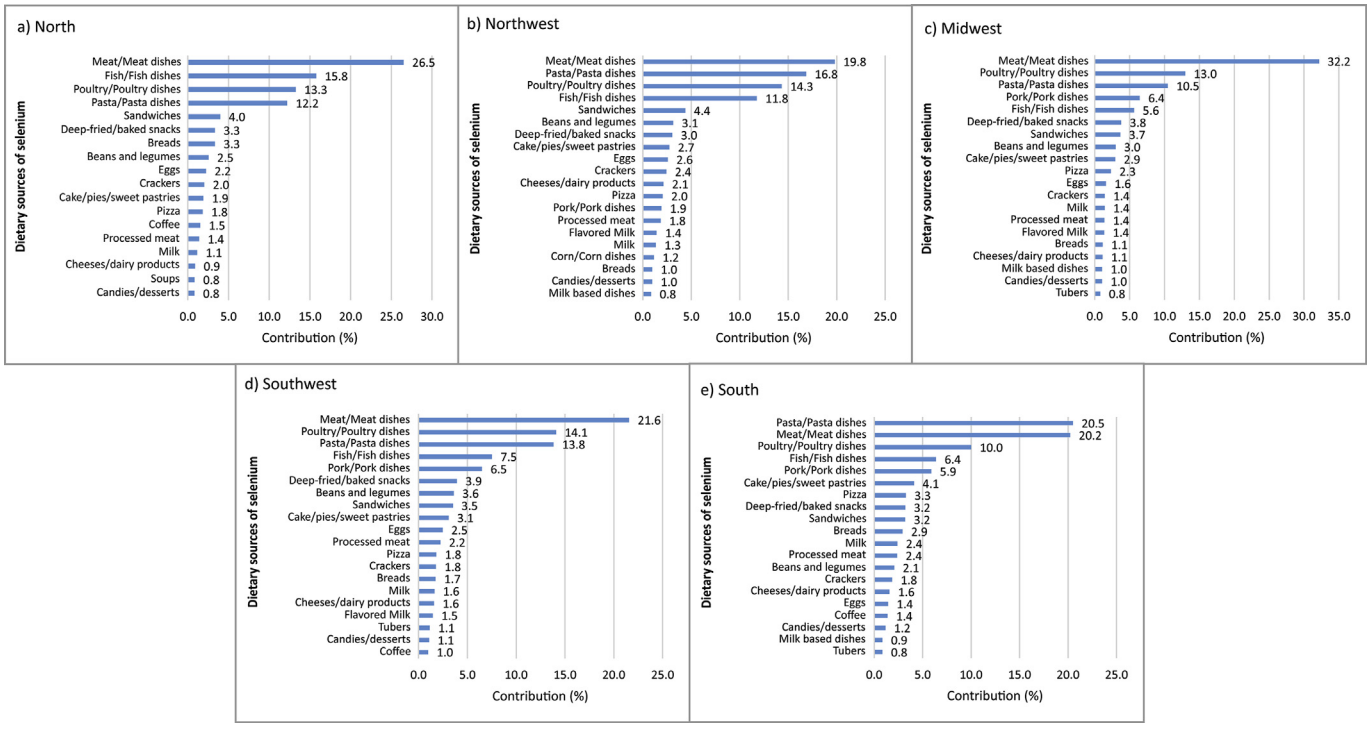

Fig. 2. Food groups contributing to 95% of total intake of Se according to the macroregions. ERICA, Brazil, 2013–2014.

subsample is statistically acceptable [21]. Moreover, the probabilistic sample needs to be highlighted as a strength, reaching a regional and national representative sample of 12–17 year-old Brazilian adolescents.

It is suggested that future studies investigate the association between the intake of Se and health outcomes in adolescents, such as the occurrence of CVD and their risk factors. Asking participants about the use of supplements should be considered in the design of future studies, in order to improve data quality.

5. Conclusions

It is concluded in this study that Brazilian adolescents have an adequate intake of Se, mainly because of the consumption of meat, poultry, fish and pasta. The few differences observed between each of the macroregions were explained by cultural and local habits. Although Brazil nuts are the most important dietary sources of Se, their consumption is very low, therefore not significantly contributing to the intake of Se.

Conflict of interest

The authors declare no conflicts of interest.

Author contributions

AR worked in all stages of the research, such as project design, analysis and interpretation of data, and writing the manuscript; AMS worked in data analysis and interpretation, writing and reviewing the manuscript; RF, LPB, MAA, LAZRZ e EBSMT contributed significantly with writing and reviewing the manuscript. FAGV guided all steps of the research, such as project design, collection, analysis and interpretation of data, manuscript idealization and revision of the final text. All the authors read and approved the final version of the manuscript.

Funding

This study was funded by the Post Graduate Program in Nutrition, *Universidade Federal de Santa Catarina* (UFSC, Federal University of Santa Catarina) - Social Demand Program/CAPES [Scholarship grant to Ms. Retondario, Mr. Fernandes and Ms. Bricarello]; the FAPESC [Scholarship to Ms. Alves]; the *Financiadora de Estudos e Projetos* (FINEP, Financer of Studies and Projects) [grant number 01090421] and the *Conselho Nacional de Pesquisa* (CNPq, National Research Council) [grant numbers 565037/2010-2, 405009/2012-7 and 457050/2013-6].

Acknowledgements

The authors would like to thank the Nutrition Post Graduate Program of the Federal University of Santa Catarina, Brazil, and the *Coordenação do Aperfeiçoamento do Pessoal do Ensino Superior* (CAPES, Coordination for higher Education Staff Development)/ Social Demand Program for the scholarship granted to the authors AR, RF, and LPB. We would also like to thank the *Fundação de Amparo à Pequisa e Inovação de Santa Catarina* (FAPESC, Santa Catarina State Foundation for Research and Innovation Support) for the scholarship granted to MAA.

References

[1] Rayman MP. Selenium and human health. Lancet 2012;379:1256–68.
[2] Sarmento RA, Silva FM, Sbruzzi G, Schaan BDA, Almeida JCD. Micronutrientes antioxidantes e risco cardiovascular em pacientes com diabetes: uma revisão sistemática. Arq Bras Cardiol 2013;101:240–8.
[3] Institute of Medicine. Dietary reference intakes for vitamin C, vitamin E, Selenium, and carotenoids. Washington, DC: Institute of Medicine; 2000.
[4] Johnson CC, Fordyce FM, Rayman MP. Symposium on 'Geographical and geological influences on nutrition': factors controlling the distribution of selenium in the environment and their impact on health and nutrition. Proc Nutr Soc 2010;69:119–32.
[5] Reilly C. Selenium in food and health. 2nd ed. New York, USA: Springer; 2006.

[6] Flores-Mateo G, Navas-Acien A, Pastor-Barriuso R, Guallar E. Selenium and coronary heart disease: a meta-analysis. Am J Clin Nutr 2006;84:762–73.
[7] Moraes AC, Fulaz CS, Netto-Oliveira ER, Reichert FF. Prevalence of metabolic syndrome in adolescents: a systematic review. Cad Saúde Pública 2009;25:1195–202.
[8] Bloch KV, Klein CH, Szklo M, Kuschnir MC, Abreu GA, Barufaldi LA, et al. ERICA: prevalences of hypertension and obesity in Brazilian adolescents. Rev Saude Publica 2016;50(Suppl. 1).
[9] Perk J, De Backer G, Gohlke H, Graham I, Reiner Z, Verschuren M, et al. European guidelines on cardiovascular disease prevention in clinical practice (version 2012). The fifth joint task force of the European society of cardiology and other societies on cardiovascular disease prevention in clinical practice (constituted by representatives of nine societies and by invited experts). Eur Heart J 2012;33:1635–701.
[10] Holben DH, Smith AM, Ilich JZ, Landoll JD, Holcomb JP, Matkovic V. Selenium intakes, absorption, retention, and status in adolescent girls. J Am Diet Assoc 2002;102:1082–7.
[11] Velazquez-Lopez L, Santiago-Diaz G, Nava-Hernandez J, Munoz-Torres AV, Medina-Bravo P, Torres-Tamayo M. Mediterranean-style diet reduces metabolic syndrome components in obese children and adolescents with obesity. BMC Pediatr 2014;14:175.
[12] Souza AM, Barufaldi LA, Abreu GA, Giannini DT, de Oliveira CL, dos Santos MM, et al. ERICA: intake of macro and micronutrients of Brazilian adolescents. Rev Saude Publica 2016;50(Suppl. 1):5s.
[13] Barufaldi LA, Abreu GA, Oliveira JS, Santos DF, Fujimori E, Vasconcelos SM, et al. ERICA: prevalence of healthy eating habits among Brazilian adolescents. Rev Saude Publica 2016;50(Suppl. 1).
[14] Chermont Prochnik Estima C, da Costa RS, Sichieri R, Pereira RA, da Veiga GV. Meal consumption patterns and anthropometric measurements in adolescents from a low socioeconomic neighborhood in the metropolitan area of Rio de Janeiro, Brazil. Appetite 2009;52:735–9.
[15] Vasconcellos MT, Silva PL, Szklo M, Kuschnir MC, Klein CH, Abreu GA, et al. Sampling design for the study of cardiovascular risks in adolescents (ERICA). Cad Saúde Pública 2015;31:921–30.
[16] Bloch KV, Szklo M, Kuschnir MC, Abreu GA, Barufaldi LA, Klein CH, et al. The Study of Cardiovascular Risk in Adolescents–ERICA: rationale, design and sample characteristics of a national survey examining cardiovascular risk factor profile in Brazilian adolescents. BMC Public Health 2015;15:94.
[17] Barufaldi LA, Abreu GA, Veiga GV, Sichieri R, Kuschnir MC, Cunha DB, et al. Software to record 24-hour food recall: application in the study of cardiovascular risks in adolescents. Rev Bras Epidemiol – Braz J Epidemiol 2016;19:464–8.
[18] IBGE. Pesquisa de Orçamentos Familiares (POF), 2008–2009. Tabela de composição nutricional dos alimentos consumidos no Brasil. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística.; 2011.
[19] IBGE. Pesquisa de orçamentos familiares 2008-2009 : análise do consumo alimentar pessoal no Brasil. Rio de Janeiro: IBGE; 2011. p. 150.
[20] Conway JM, Ingwersen LA, Vinyard BT, Moshfegh AJ. Effectiveness of the US Department of Agriculture 5-step multiple-pass method in assessing food intake in obese and nonobese women. Am J Clin Nutr 2003;77:1171–8.
[21] NCI. In: Epidemiology and genomics research Program. Dietary assessment primer. Choosing an approach for dietary assessment, vol. 2018. NCI. Us Department of Health & Human Services; 2018.
[22] Barbosa F, Sichieri R, Junger W. Assessing usual dietary intake in complex sample design surveys: the National Dietary Survey. Rev Saude Publica 2013;47(Suppl. 1):171S–6S.
[23] Freedman LS, Guenther PM, Dodd KW, Krebs-Smith SM, Midthune D. The population distribution of ratios of usual intakes of dietary components that are consumed every day can be estimated from repeated 24-hour recalls. J Nutr 2010;140:111–6.
[24] Institute of Medicine. DRI dietary reference intakes: applications in dietary assessment: report of the subcommittee on interpretation and uses of dietary reference intakes and the standing committee on the scientific evaluation of dietary reference intakes. Washington (DC): Institute of Medicine; 2000.
[25] Block G, Dresser CM, Hartman AM, Carroll MD. Nutrient sources in the American diet: quantitative data from the NHANES II survey. I. Vitamins and minerals. Am J Epidemiol 1985;122:13–26.
[26] Bailey RL, Fulgoni 3rd VL, Keast DR, Lentino CV, Dwyer JT. Do dietary supplements improve micronutrient sufficiency in children and adolescents? J Pediatr 2012;161:837–42.
[27] Amouroux D, Liss PS, Tessier E, Hamren-Larsson M, Donard OFX. Role of oceans as biogenic sources of selenium. Earth Planet Sci Lett 2001;189:277–83.
[28] Baoyan M, Xuelin Z. Regional ecological risk assessment of selenium in Jilin province, China. Sci Total Environ 2000;262:103–10.
[29] Ortuño J, Ros G, Periago MJ, Martínez C, López G, Rodrigo J. Nutritional importance of selenium. Arch Latinoam Nutr 1997;47:6–13.
[30] Burk RF, Norsworthy BK, Hill KE, Motley AK, Byrne DW. Effects of chemical form of selenium on plasma biomarkers in a high-dose human supplementation trial. Cancer Epidemiol Biomark Prev 2006;15:804–10.
[31] Fairweather-Tait SJ, Collings R, Hurst R. Selenium bioavailability: current knowledge and future research requirements. Am J Clin Nutr 2010;91:1484S–91S.
[32] Rayman MP, Infante HG, Sargent M. Food-chain selenium and human health: spotlight on speciation. Br J Nutr 2008;100:238–53.
[33] Alfthan G, Xu GL, Tan WH, Aro A, Wu J, Yang YX, et al. Selenium supplementation of children in a selenium-deficient area in China: blood selenium levels and glutathione peroxidase activities. Biol Trace Elem Res 2000;73:113–25.
[34] Yang GQ, Wang SZ, Zhou RH, Sun SZ. Endemic selenium intoxication of humans in China. Am J Clin Nutr 1983;37:872–81.
[35] Peters K, Galinn S, Tsuji P. Selenium: dietary sources, human nutritional Requirements and intake across populations. 2016.
[36] Souza Ade M, Pereira RA, Yokoo EM, Levy RB, Sichieri R. Most consumed foods in Brazil: national dietary survey 2008–2009. Rev Saude Publica 2013;47(Suppl. 1):190S–9S.
[37] Thomson CD, Chisholm A, McLachlan SK, Campbell JM. Brazil nuts: an effective way to improve selenium status. Am J Clin Nutr 2008;87:379–84.
[38] Unicamp. Universidade Estadual de Campinas. Núcleo de Estudos e Pesquisas em Alimentação - NEPA. Tabela brasileira de composição de alimentos - TACO. 4th ed. Campinas, SP: Unicamp; 2011.
[39] Cardoso BR, Duarte GBS, Reis BZ, Cozzolino SMF. Brazil nuts: nutritional composition, health benefits and safety aspects. Food Res Int 2017;100:9–18.
[40] Waegeneers N, Thiry C, De Temmerman L, Ruttens A. Predicted dietary intake of selenium by the general adult population in Belgium. Food Addit Contam: Part A 2013;30:278–85.
[41] Shim JS, Oh K, Kim HC. Dietary assessment methods in epidemiologic studies. Epidemiol Health 2014;36:e2014009.