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Daily dietary selenium intake of selected Brazilian population groups

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Due to its essential characteristics, the daily dietary selenium intake of individuals should be monitored accurately. In the current work, daily selenium intake of different Brazilian population groups based on duplicate portion diet analysis was evaluated and compared with the new estimated average requirement values (EAR), to assess if selenium deficiency or excess could be observed in these groups. Selenium content was determined by neutron activation analysis (NAA). The average daily dietary selenium intake found was 26.3 (±8.3) μg/day for children from the city of São Paulo, 37.4 (±16.0) μg/day for children from Belém, 107 (±107) μg/day for children from Macapá, 28.4 (±7.5) μg/day for institutionalized elderly, 32 (±6) μg/day for non-institutionalized elderly and 37 (±17) μg/day for university students from São Paulo. Most daily dietary selenium intake range observed were below the EAR values. The values obtained for children groups from Belém and Macapá cities, whose intake levels were much higher than the recommendation, were an exception.

Introduction

Although considered as an essential element, selenium can be toxic for humans and animals, depending on its intake level. Its beneficial effect occurs in a small range. Below this range, selenium cannot perform its essential function and above it, becomes toxic. Selenium is involved in a large number of biological processes in the human body. Its necessity in the formation of selenocysteine as part of the active center of glutathione peroxidase is well known. The antioxidant effect of this enzyme prevents cells from damage caused by free radicals. The role of selenium in the detoxification from heavy metals such as mercury and lead is also important for the human body. Low levels of selenium intake are reported to cause disease such as Keshan disease. Certain selenium compounds have been claimed to prevent carcinoma, slow the aging process, enhance sexual activities, etc.[1]

The levels, species and biovailability of selenium in foods depend greatly on the geochemical environment in which they are grown. Variation in geochemical conditions cannot only lead to certain diseases in animals but also influence the selenium body burden in humans. For these reasons, there is an increasing interest in monitoring selenium levels in foods and diets.[2]

Although the understanding of the nutritional significance of selenium increases, many questions relating to its role, requirements, metabolism, and links between dietary intakes and health remain unanswered. There is an evidence from the epidemiological studies that high dietary selenium intakes and high selenium status in people are associated with lower cancer mortality[3] and other degenerative diseases.[4] However, contradictory informations have been found in some prospective studies.

Selenium present in cereals, wheat, and most vegetable foods, mainly as selenomethionine, has a higher biovailability (85–100%) than that observed in dairy products and meats (10–15%). The Se content of fish is high, presenting a relative bioavailability (20–50%) while in dairy products it presents the lowest bioavailability, 7% in cow milk.[3] In general, the status of Se content in foods of vegetal origin are highly variable and depend mainly on the soil conditions where they were grown and on the nature of plants cultivated in them in relation to their capacity to accumulate Se from the soils.

The difficulty for measuring the Se uptake from the diet is one of the principal problems in analytical epidemiological studies. One of the ways to estimate are the direct determination of selenium content in meals (duplicate portion sampling), although this method is not used in large disease studies.[4]

Many studies have been performed in different countries throughout the world, which summarize the recent literature on Se intake for healthy adults. The Se intakes ranges from <10 μg/day in Se-deficient area to approximately 5000 μg/day in those where there exists an endemic selenosis.[4]

Estimates of essential and other trace element intake through the daily diets of different population groups are being carried out periodically by the Activation Analysis Laboratory of IPEN/CNEN in collaboration with the Department of Food and Experimental Nutrition of the University of São Paulo.[5–10] In these studies the diets were collected by the duplicate portion method, which is considered the most appropriate when a small group is evaluated.

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In this work, Se daily dietary intakes were evaluated in some duplication portion samples of different Brazilian population groups: 3 pre-school children groups from different Brazilian regions, groups of institutionalized and non-institutionalized elderly and university students.

Diets were collected by the duplicate portion method and the selenium concentration was determined by neutron activation analysis (NAA).

Experimental

Subjects

Children: Three groups of pre-school children (3 to 7 years) were studied. These children remained the whole day in the nurseries in the cities of São Paulo (SP), Macapá (AP) and Belém (PA). The children from São Paulo had two complete meals and snacks and the others, four complete meals in the nurseries. In the total 19 children in São Paulo, 44 in Macapá and 88 children in Belém participated in the present study.

University groups: The study was carried out during the years 1998–1999 in two groups of students from São Paulo University (aged 20 to 24 years), each consisting of nine women and ten men.

Elderly: Two groups of elderly were studied: one of them was selected from a private institution (23 individuals which age ranging from 70 to 95 years), and another group consisted of thirty non institutionalized healthy elderly women (age ≥60 years), from the urban region of São Paulo. This group did not have vitamin-mineral supplementation.

Sampling

In all of these groups, duplicate portion technique was used for collecting the diets.

Children from São Paulo, elderly people and students: The individual samples of each participant were collected during 3 days. The 3 day-diet was prepared and analyzed separately.

Children from Macapá and Belém: The diets from Amazon region were composed by typical foods from this region. The meals of seven days were collected separately and the fresh weight was determined.

In all diets the inedible portions (like bone, peel of fruits) were discarded and the equivalent of the food consumed was weighed and stored in a refrigerator. Two different drying processes were carried out: (a) the student's diets were dried in a ventilated oven at 60 °C until constant weight. Afterwards the diet samples were pulverized and homogenized in a stainless steel knife mill and kept at 4 °C before analysis; (b) the other diets were freeze-dried for about 48 hours and, thereafter, were homogenized in a domestic blender, which was coated with Teflon and equipped with titanium blades. After this, the diets were kept at 4 °C before analysis.

Instrumental neutron activation analysis

The concentration of selenium in the diets was determined by INAA technique. The samples were irradiated for 8 hours in a thermal neutron fluence rate of 10^{13} $n \cdot cm^{-2} \cdot s^{-1}$ in the IEA-R1 research reactor at IPEN. Primary selenium standard and biological reference materials were simultaneously irradiated with the diet samples for standardization and quality control purposes.

All diet samples, selenium primary standard and reference materials were measured using a counting system with an Ortec EG&G high resolution solid state Ge detector (POP TOP Model 20190) with a resolution of 1.9 keV for the 1332 keV γ-ray peak of ^{60}Co. This detector was coupled to an EG&G Ortec ACE8K card and associated electronics. Spectrum analysis was performed using the VISPECT2 software.

Results and discussion

The validation of the analytical method applied in this work was carried out by analysis of NIST biological reference materials. The results obtained showed good agreement with the certified values (Table 1).

Based on the ISO/IUPAC,[11] the concentration of Se determined was converted into *z*-score (Fig. 1). In all of the reference materials analyzed, the *z*-score values were $|z| \leq 1$, showing that the results were considered satisfactory, in the 99% confidence interval of the target value.

Table 1. Results of Se in the NIST reference materials by INAA (in $\mu g/g^{-1}$)

Reference material	Average ± SD (*n*)	Certified values
Apple Leaves –NIST 1515	0.055 ± 0.010 (3)	0.050 ± 0.009
Whole Milk Powder –NIST 8435	0.132 ± 0.009 (2)	0.131 ± 0.014
Bovine Liver – NIST 1577b	0.68 ± 0.03 (5)	0.73 ± 0.06
Wheat Flour – NIST 1567[a]	1.18 ± 0.02 (8)	1.1 ± 0.2

n: Number of individual determination.

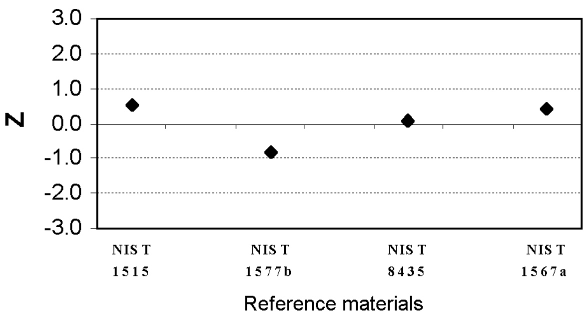

Fig. 1. Control chart (*z*-score)

Table 2 presents the average daily intake and the range of selenium in the different samples. The average daily intakes of selenium for both elderly groups and the student group were below the EAR values (45 μg/day).[12] In previous studies,[5–10] diets from São Paulo state showed low selenium level, mainly due to low concentration of this element in soil.

The average daily intakes of selenium obtained for pre-school children from São Paulo were adequate. However, the values obtained for children groups from Belém and Macapá were higher than the new estimated average requirement (25 μg/day).[12] These results reveal surprisingly high selenium concentrations in the children diets of the Amazon region that contain Brazil nuts (Castanha do Pará), and further investigation are advised to determine the sources to avoid negative effects of undesired overdoses. Typical symptoms of selenium toxicity (selenosis), like the loss of hair and nails, or the odor of garlic in the breath, were not observed.

The risk of selenium intake above the UL (tolerable upper intake level) for the USA and Canadian populations appears to be small. There have been no cases of selenosis in the high-selenium areas in the USA.[13] These authors note that the selenium intake exceed 400 μg/day in 12 subjects, with the highest intake being 724 μg/day. Even at this level, toxic effects would be unlikely, since the LOAEL (lowest-observed-adverse effects level) is about 900 μg/day, and many people would not be affected even at this level of intake. Although intakes above the UL (400 μg/day for adults and 90–280 for children) indicate an increased level of risk, these high intakes, if below the LOAEL, would, nevertheless, be unlikely to result in observed clinical disease.[12]

Conclusions

In general, the daily Se intake obtained from Amazon region was higher than of the São Paulo region. Three children groups from different regions of Brazil were studied and the daily Se intake was 26.3 μg/day for children from São Paulo, 37.4 μg/day for children from Belém, 107 μg/day for children from Macapá. The daily dietary selenium intake for institutionalized elderly (28.4 μg/day), for non-institutionalized elderly (32 μg/day) and for university students (37 μg/day) from São Paulo presented values below EAR values, showing a deficiency of selenium in the diets form this region. The values obtained for diets from Macapá were much higher than EAR values. It probably happens due to the fact that these diets contain Brazil nuts which are known to have elevated Se levels. Despite high intakes, no health changes were observed in the children due to this excess of selenium. However, further investigations should be carried out to monitor the nutritional status on selenium in pre-school children from Macapá and the consumption of Brazil nuts should be lowered to avoid children to be intoxicated.

Table 2. Average daily intake of selenium in the different Brazilian group diets

Group	Daily intake average, μg/day	Range, μg/day	EAR, μg/day	RDA, μg/day
Children from São Paulo city (*n*=19)	26.3 ± 8.3	15.9–39.7	23	30
Children from Macapá city (*n*=44)	107 ± 107	21.7–27.9	23	30
Children from Belém city (*n*=88)	37.4 ± 16.0	13.4–58.9	23	30
Institutionalized elderly (*n*=23)	28.4 ± 7.5	10.7–57.0	45	55
Non institutionalized elderly women (*n*=30)	32 ± 6	9.3–110	45	55
Male university students (*n*=10)	41 ± 19	21–111	45	55
Female university students (*n*=9)	29 ± 10	17–52	45	55

n: Number of individuals.

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