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ORIGINAL CONTRIBUTION

Excessive iodine intake in schoolchildren

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Abstract

Purpose Inadequate iodine intake may result in iodine deficiency disorders (IDD). Thus, for more than 50 years, policies for the regulation of salt fortification with iodine have existed in Brazil. In 2003, a study on 6–14-year-old schoolchildren from regions of the state of São Paulo showed a median urinary iodine concentration of 360 μg/L. The objective of the present study was to assess the iodine nutrition status among schoolchildren.

Methods The study was conducted on 828 schoolchildren aged 4–13 years from eight schools in the interior of the state of São Paulo. A casual urine sample was collected from each volunteer for iodine determination by the adapted method of Sandell-Kalthoff.

Results Only 1.9% ($n = 16$) of the children evaluated had low values of urinary iodine (<100 μg/L), while 24.6% had urinary iodine excretion values between 200 and 300 μg/L, and 67.1% had values above >300 μg/L.

Conclusions The results show that the iodine nutritional status of the schoolchildren studied is characterized by a high urinary iodine excretion, which might reveal an increase in iodine consumption by this population.

Keywords Urinary iodine · Schoolchildren · Iodine · Salt

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Introduction

Iodine is a fundamental element for the hormones synthesized by the thyroid gland of mammals [1]. It occurs in large quantities in seawater, about 50 μg/L in the form of iodide [2]. Due to the high iodine concentration in the oceans, populations that live near the sea and frequently eat seafood usually ingest a little more than double the amount ingested by other populations [3]. In some countries, foods such as milk, eggs and bread are also sources of iodine due to iodine-containing compounds used in agriculture and to the use of iodized salt in food preparation [1, 4]. A study from Spain found an increase in milk iodine concentration in recent years, and the urinary iodine concentrations were significantly associated with the frequency of milk intake, especially skimmed milk [5].

After the discovery of the relation between goiter and iodine insufficiency, iodine supplementation was found to be able to prevent this disease. On this basis, Switzerland and the United States were the first countries to implement a mass prophylactic program against goiter in the 1920s by means of salt iodization [1].

In the 1980s, the World Health Organization (WHO) performed the first global estimate of the prevalence of goiter which revealed that 20–60% of the world population had iodine deficiency and/or goiter, with most cases being diagnosed in developing countries [1].

Insufficient iodine intake has been the major cause of goiter in the Brazilian population since colonial times and is considered to be the main cause of brain damage in fetuses and children, possibly also being responsible for psychomotor retardation [6].

In Brazil, since 1953, there have been policies for the iodization of salt for human consumption in order to promote adequate consumption of this nutrient by the population [7, 8]. In 2003, the National Agency for Sanitary Surveillance (ANVISA in the Portuguese acronym) established a norm for iodine concentration of 20–60 mg/kg in kitchen salt. In South America, iodine nutritional status improved considerably, with excessive iodine intake currently occurring in countries like Brazil, Chile and Colombia [9, 10].

This scenario indicates a transition in the nutritional profile of iodine in the population. In a study conducted in Colombia on schoolchildren, 43% of them were found to have excessive urinary excretion of iodine, while 29% had insufficient iodine intake [10]. In a study conducted in six different Brazilian states, 86% of the schoolchildren evaluated were found to have urinary iodine excretion of more than 300 μg/L, which is considered to be excessive [11].

The WHO states that excessive iodine consumption for a prolonged period of time can be harmful by increasing the prevalence of chronic autoimmune thyroiditis, known as Hashimoto thyroiditis, mainly among individuals genetically susceptible to autoimmune diseases. In addition, also according to the WHO, excessive iodine intake is related to the development of hyperthyroidism, a condition that affects the elderly, who usually present thyroid nodules that favor the onset of the disease [8].

The iodine intake recommended by the WHO is 90 μg/day for children up to 5 years of age, 120 μg/day for children aged 6–12 years, 150 μg/day for those older than 12 years, and 250 μg/day for pregnant and nursing women [12].

The study of the nutritional iodine profile of a population is important in order to determine the insufficient or sufficient intake of this nutrient. Thus, the objective of the present study was to assess the nutritional iodine profile of schoolchildren in the interior of the state of São Paulo.

Materials and methods

Study place and group

This is a cross-sectional survey, which was conducted at two major cities from the interior of the state of São Paulo, Ribeirão Preto and Botucatu, from 2004 to 2007. The two cities represent two different regions of the state. The schools were selected randomly among all institutions that represented the reality of each city. Due to the characteristics of these cities, both urban and rural state schools were selected. All healthy children and adolescents from eight schools of both genders and aged 4–13 years, with no diagnoses of renal disorders or pathological changes that might compromise the results of the study were included in the investigation. A total of 828 schoolchildren participated in the study, which was approved by the Research Ethics Committee of HCFMRP–USP and FMRP–USP (protocol no, 12466/2004). The parents or persons responsible for the schoolchildren gave written informed consent to participate. A descriptive analysis of the data was performed.

Collection of urine samples

A casual urine sample was collected from each child and adolescent studied.

Methodology for the evaluation of urinary iodine excretion

The Sandell-Kalthoff reaction was used for urinary iodine determination, with chloric acid being replaced with ammonium persulfate [13]. The standard curve was constructed using a potassium iodate solution with known amounts of 5, 10, 15, 20 and 30 μg/L ($r = 0.99$). For each sequence of analyses, a concentration from the standard curve was repeated as a quality control of the study.

The classification of iodine nutrition in schoolchildren was based on the criteria established by the WHO/UNICEF/ICCIDD [14], which consider median urinary iodine to be iodine deficiency or an insufficient iodine intake when the value is less than 100 μg/L, adequate iodine nutrition or intake when the value is 100–199 μg/L and above requirements when the value is 200–299 μg/L. A value above 300 μg/L is considered to indicate excessive intake, which is related to the risk of adverse health consequences [15].

Results

Tables 1 and 2 show the levels of urinary iodine according to gender and age range, respectively. In most children and adolescents of both genders (75%), urinary iodine levels were above 200 μg/L. The median urinary iodine value for boys (348 μg/L) was a little higher than the value for girls (328 μg/L). Analysis by age range showed that most schoolchildren (75%) of all age ranges presented urinary iodine levels above 200 μg/L as well. The median value for children aged 11–13 years (345 μg/L) was higher than the

Table 1 Population distribution of urinary iodine values according to gender

Gender	n	Minimum	p5	p25	Median (μg/L)	p75	p95	Maximum
Female	443	43.00	166.60	266.00	328.00	383.00	465.00	803.00
Male	385	43.00	163.60	288.50	348.00	403.00	499.70	816.00

n Sample, *p* percentile

Table 2 Population distribution of urinary iodine values according to age range

Age range (years)	n	Minimum	p5	p25	Median (μg/L)	p75	p95	Maximum
4–7	47	43.00	96.80	266.00	342.00	430.00	481.60	491.00
8–11	442	45.00	160.45	267.75	334.00	384.00	443.00	500.00
11–13	339	43.00	181.00	291.00	345.00	395.00	647.00	816.00

n Sample, *p* percentile

values for the other age ranges, with the maximum value detected for this age range (816 μg/L) being much higher than those for the others. Twenty-five percent of the children aged 4–7 years had low urinary iodine values (96.80 μg/L).

Three of the eight schools evaluated (2, 7 and 8) presented urinary iodine values above 200 μg/L for practically all children and adolescents studied. Among the three schools, school no 2 presented the highest urinary iodine values in all percentiles, whereas in the remaining schools, 75% of the children had urinary iodine levels above 200 μg/L. The median urinary iodine values were above 300 μg/L for all groups except school no 5. In school no 1, only 25% of the schoolchildren presented values below 100 μg/L, as shown in Table 3.

Table 4 shows the population distribution of urinary iodine according to reference values and to schools. Overall, only 1.9% of the total number of children and adolescents evaluated ($n = 16$) presented urinary iodine values <100 μg/L, with 7.2% ($n = 5$) of them being from school 1. Regarding high concentrations of urinary iodine, 24.6 and 67.1% of the children and adolescents were found to present values between 200 and 300 μg/L and above 300 μg/L, respectively, with 92.2% ($n = 59$) of the children presenting excessive urinary iodine excretion in school 2, followed by schools 8 and 7, as shown in Table 4.

Discussion

The biomarker recommended to assess iodine nutrition in the population is urinary iodine concentration, which is an excellent indicator of recent iodine intake [15, 16]. According to the WHO, in children, median urinary iodine concentrations between 100 and 299 μg/L define a population that has no iodine deficiency or an insufficient iodine intake [15].

In a study on 153 schoolchildren aged 8–10 years on the island of Tanna, Vanuatu Republic, Li et al. [17] observed that 51% of them had iodine insufficiency, as shown by urinary iodine excretion below 50 μg/L.

Mazzarella et al. [18], in a study of 9–13-year-old schoolchildren in various Italian provinces, observed that median iodine excretion was always below 100 μg/L, demonstrating that half the children evaluated had at least a mildly insufficient iodine intake.

In Nepal, Gelal et al. [19] detected a 22% rate of iodine insufficiency in a group of schoolchildren aged 6–11 years, finding urinary iodine concentrations below 100 μg/L.

Benoist et al. [20] reported that 31.5% of world schoolchildren have insufficient iodine intake, most of them living in some regions of Europe (52.4%) and of the Oriental Mediterranean (48.8%), whereas a smaller percentage of children with insufficient iodine intake was found in the Western Pacific (22.7%) and in the Americas (10.6%).

In the present study, insufficient iodine intake (<100 μg/L) was detected in only 1.9% of the subjects, in agreement with the prevalence rate of <5% accepted by the WHO [8]. However, information about excessive intake of this nutrient is also available in the literature. Gelal et al. [19] also observed schoolchildren with iodine insufficiency, as mentioned earlier, while 21.7% presented excessive iodine intake.

In a study on 6–14-year-old schoolchildren from regions of the state of São Paulo, Duarte et al. [21] detected iodine excretion of more than 300 μg/L in 53% of the subjects and excretion of more than 600 μg/L in 21%, characterizing a more than sufficient iodine intake in these regions. The present study, in which 24.6% of the schoolchildren evaluated presented more than adequate iodine intake and 67.1% presented excessive intake, agrees with the report by Duarte et al. [21].

The nutritional profile of iodine is currently going through a period of transition, with the concomitant

Table 3 Population distribution of urinary iodine values according to each school

School	*n*	Minimum	p5	p25	Median (μg/L)	p75	p95	Maximum
1	69	43.00	68.00	257.00	338.00	437.00	495.00	500.00
2	64	77.00	261.25	363.00	497.05	650.75	802.50	816.00
3	89	98.00	178.00	255.50	311.00	361.50	437.00	460.00
4	114	56.00	155.75	292.00	354.00	394.25	462.00	487.00
5	146	43.00	134.85	217.00	269.00	322.25	390.95	434.00
6	37	150.00	151.80	282.50	338.00	380.50	431.10	432.00
7	117	55.00	212.40	287.00	353.00	384.00	443.00	457.00
8	192	138.00	239.25	325.00	357.50	398.50	439.35	452.00

n Sample, *p* percentile

Table 4 Population distribution of urinary iodine values according to reference urinary iodine values and school

School	Deficient <100 μg/L		Adequate 100–200 μg/L		More than adequate 200–300 μg/L		Excessive >300 μg/L		Total	%
	n	%	n	%	n	%	n	%		
1	5	7.2	6	8.7	15	21.7	43	62.3	69	100
2	1	1.6	0	0.0	4	6.3	59	92.2	64	100
3	1	1.1	7	7.9	34	38.2	47	52.8	89	100
4	2	1.8	6	5.3	26	22.8	80	70.2	114	100
5	3	2.1	23	15.8	63	43.2	57	39.0	146	100
6	0	0.0	4	10.8	7	18.9	26	70.3	37	100
7	4	3.4	0	0.0	33	28.2	80	68.4	117	100
8	0	0.0	6	3.1	22	11.5	164	85.4	192	100
Total	16	1.9	52	6.3	204	24.6	556	67.1	828	100

n Sample

occurrence of insufficient and excessive intake, or with the prevalence of excessive over insufficient consumption of this nutrient.

The strategy most commonly used to control iodine insufficiency in the population is the monitoring of salt iodization [12]. In Brazil, since 1974, there has been concern about the standardization of the amount of iodine to be added to salt as a supplement. At that time, the supplementation with 10 mg iodine/kg salt was established. In 1998, ANVISA established a range of iodine concentrations in salt for human consumption of 40–100 mg/kg salt. However, this range was revised in 2003 and reduced to 20–60 mg iodine/kg salt [8].

Iodine nutritional status among schoolchildren varies depending on hydration and also on the eating habits in countries in which public policies use salt iodization to avoid iodine insufficiency. For this reason, in Brazil, the intake of foods containing iodized salt in their preparation can influence the nutritional status of iodine, because it is known that most of the iodine ingested is excreted into the urine [15, 16]. In addition, the cities included in the survey are located in different regions with different climates, with possible changes in the state of hydration occurring in the population. The schoolchildren studied in the present investigation belonged to different age groups, and a difference in iodine intake was expected to occur among them. However, this did not necessarily affect the hydration status as these healthy children.

An important limitation of this study is the daily variation in urinary iodine excretion. Determination of median urinary iodine values from a casual urine sample is well accepted for assessing the iodine status of a population, but not of an individual. It would be possible to adjust the urinary iodine concentrations according to creatinine excretion, but the use of iodine values not adjusted for creatinine excretion is well accepted, because there are some disadvantages such as protein intake adequacy and malnourished status which can influence creatinine excretion. Therefore, this measure would be unreliable for estimating iodine concentration from a spot sample [15, 16].

Another important aspect to be emphasized and that may explain the situation of excessive iodine intake detected in the present study is the daily salt intake by the population.

Pontes et al. [22] analyzed quantitatively the amount of iodine present in salt samples from the residencies of 180 schoolchildren and observed that no sample contained more than 60 mg iodine/kg salt [7].

Nevertheless, data from the Brazilian Association of Salt Extractors and Refiners (ABERSAL, 2008) have shown that the mean daily salt intake of Brazilians represents double the amount (12.34 g/day) [8] recommended by the Brazilian Society of Hypertension, which is 6 g salt/day or 100 m Eq sodium [23].

Costa and Machado [24], in a study conducted on 81 schoolchildren, detected a mean salt consumption per family member of 7.66 g. In the same study, the authors also evaluated the intake of sodium-rich foods and observed that 82.7% of the 81 schoolchildren had the habit of eating salty snacks, 63% ate sausages, 54.3% ate cheeses, 54.3% ate hot dogs, and 53.1% ate pizza, habits that contribute to an increased indirect consumption of salt.

In another study, Navarro et al. [25] also detected excess salt (NaCl) intake among 6–12-year-old children from the interior of the state of São Paulo. In the urban school, salt consumption reached values exceeding 10 g/day among some children.

The excessive salt consumption detected in these studies agrees with the findings of excessive iodine consumption, since kitchen salt is the medium most frequently used to guarantee iodine consumption by the population studied.

Conclusion

The present study shows that most of the schoolchildren evaluated had a urinary iodine excretion above 300 μg/L, which corresponds to an excessive iodine intake that might lead to a risk of adverse iodine-induced consequences for health. These results also demonstrate a possible transition in the nutritional iodine profile. Further studies are necessary to investigate the factors that influence the nutritional iodine profile in these areas and to evaluate schoolchildren from other Brazilian states.

References

1. Zimmermann MB (2009) Iodine deficiency. Endocr Rev 30:376–408
2. Goldschmidt VW (1954) Geochemistry. Oxford University Press, Oxford
3. Institute of Medicine (IOM), Academy of Sciences (2001) Dietary reference intakes for vitamin A, Vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Washington, DC: National Academy Press. http://www.nap.edu/openbook.php?record_id=10026. Accessed 31 August 2010
4. Alvarez-Pedrerol M, Ribas-Fitó N, García-Esteban R, Rodriguez A, Soriano D, Guxens M, Mendez M, Sunver J (2010) Iodine sources and iodine levels in pregnant women from an area without known iodine deficiency. Clin Endocrinol (Oxf) 72:81–86
5. Soriguer F, Gutierrez-Repiso C, Gonzalez-Romero S, Olveira G, Garriga MJ, Velasco I et al (2011) Iodine concentration in cow′s milk and its relation with urinary iodine concentrations in the population. Clin Nutr 30:44–48
6. Nimer M, Silva ME, Dutra de Oliveira JE (2002) Associações entre iodo no sal e iodúria em escolares, Ouro Preto, MG. Rev Saúde Pública 36:500–504
7. Pontes AAN, Rocha AM, Leite DFB, Lessa AF, Adan LFF (2009) Iodação do sal no Brasil, um assunto controverso. Arq Bras Endocrinol Metab 53:113–114
8. Medeiros-Neto G (2009) Iodine nutrition in Brazil: where do we stand? Arq Bras Endocrinol Metab 53:470–474
9. Agência Nacional de Vigilância Sanitária (ANVISA) (2003) Resolução-RDC no 130, de 26 de Maio de 2003. http://portal.anvisa.gov.br. Accessed 31 August 2010
10. Gallego ML, Loango N, Londoño AL, Landazuri P (2009) Niveles de excreción urinaria de yodo en escolares del Quindío, 2006–2007. Rev Salud Pública 11:952–960
11. Rossi AC, Tomimori E, Camargo R, Medeiros-Neto G (2001) In our experience…searching for iodine deficiency disorders in schoolchildren from Brazil: the thyromobil project. Thyroid 11:661–663
12. World Health Organization (WHO), United Nations Children's Fund, International Council for the Control of Iodine Deficiency Disorders (2007) Assessment of iodine deficiency disorders and monitoring their elimination, 3rd edn. Geneva
13. Pino S, Fang S-L, Braverman LE (1996) Ammonium persulfate: a safe alternative oxidizing reagent for measuring urinary iodine. Clin Chem 42:239–243
14. WHO, UNICEF, ICCIDD (1999) Progress towards the elimination of iodine deficiency disorders (IDD). In: World Health Organization, Geneva, WHO Document WHO/NHD/99.4
15. World Health Organization (2007) Assessment of iodine deficiency disorders and monitoring their elimination: a guide for programme managers, 3rd edn
16. Zimmermann MB (2008) Methods to assess iron and iodine status. Br J Nutr 99(Suppl 3):S2–S9
17. Li M, McKelleher N, Moses T, Mark J, Karen Byth, Ma G, Eastman CJ (2009) Iodine nutritional status of children on the island of Tanna, Republic of Vanuatu. Public Health Nutr 12:1512–1518
18. Mazzarella C, Terracciano D, Di Carlo A, Macchia PE, Consiglio E, Macchia V, Mariano A (2009) Iodine status assessment in Campania (Italy) as determined by urinary iodine excretion. Nutrition 25:926–929
19. Gelal B, Aryal M, Lal Das BK, Bhatta B, Lamsal M, Baral N (2009) Assessment of iodine nutrition status among school age children of Nepal by urinary iodine assay. Southeast Asian J Trop Med Public Health 40:538–543
20. Benoist B, McLean E, Andersson M, Rogers L (2008) Iodine deficiency in 2007: global progress since 2003. Food Nutr Bull 29:195–202
21. Duarte GC, Tomimori EK, Boriolli RA, Ferreira JE, Catarino RM, Camargo RYA, Medeiros-Neto G (2004) Avaliação ultrasonográfica da tireóide e determinação da iodúria em escolares de diferentes regiões do estado de São Paulo. Arq Bras Endocrinol Metab 48:842–848
22. Pontes AAN, Costa ADM, Benício AL, Silva CRA, Morais RM, Pedrosa C et al (2002) Prevalência de doenças da tireóide em uma comunidade do nordeste brasileiro. Arq Bras Endocrinol Metab 46:544–549

23. Sociedade Brasileira de Hipertensão (SBH) (2010) III Consenso Brasileiro de Hipertensão Arterial. Available at: http://www.sbh.org.br. Accessed August 31, 2010
24. Costa FP, Machado SH (2010) O consumo de sal e alimentos ricos em sódio pode influenciar na pressão arterial das crianças? Ciência Saúde Coletiva 15:1383–1389
25. Navarro AM, Oliveira LA, Ferreira JF, Braga Costa TM, Dutra de Oliveira JE, Marchini JS (2009) Excreção urinária de sódio em crianças e adolescentes de área urbana e rural. Alim Nutr Araraquara 20:657–661