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Original Research Article

A cross-sectional survey of urinary iodine status in Latvia

Ilze Konrade [a,b,*], Lolita Neimane [a], Marina Makrecka [a,c], Ieva Strele [a], Edgars Liepinsh [c], Aivars Lejnieks [a,b], Parsla Vevere [d], Ugis Gruntmanis [e], Valdis Pīrāgs [f,g], Maija Dambrova [a,c]

[a] Riga Stradins University, Riga, Latvia
[b] Department of Medicine, Riga East Clinical University Hospital, Riga, Latvia
[c] Latvian Institute of Organic Synthesis, Riga, Latvia
[d] Clinic of Medical Genetics, Children's University Hospital, Riga, Latvia
[e] Department of Medicine, University of Texas, Southwestern Medical Center and North Texas Veterans Affairs Medical Center, Dallas, TX, USA
[f] Department of Medicine, University of Latvia, Riga, Latvia
[g] Pauls Stradins Clinical University Hospital, Riga, Latvia

ARTICLE INFO

Article history:
Received 24 September 2013
Accepted 22 April 2014
Available online 27 June 2014

Keywords:
Iodine
Deficiency
Iodized salt
Thyroid stimulating hormone

ABSTRACT

Background and objective: A nationwide survey of schoolchildren was conducted to detect regional differences in urinary iodine excretion in Latvia and to compare the results with data from the newborn thyroid-stimulating hormone (TSH) screening database as well with the results of a similar study performed in Latvia 10 years ago.

Materials and methods: We conducted a cross-sectional school-based cluster survey of 915 children aged 9–12 years in 46 randomly selected schools in all regions of Latvia. Urine samples, questionnaires on the consumption of iodized salt and information on socioeconomic status were collected. TSH levels in newborns were also measured.

Results: The median creatinine-standardized urinary iodine concentration (UIC) in our study was 107.3 μg/g Cr. UIC measurements indicative of mild iodine deficiency were present in 31.6%, moderate deficiency in 11.9% and severe deficiency in 2.8% of the participants. The prevalence of iodine deficiency was the highest in the southeastern region of Latgale and the northeastern region of Vidzeme. The prevalence of TSH values >5 mIU/L followed a similar pattern. The self-reported prevalence of regular iodized salt consumption was 10.2%. Children from urban schools had a significantly lower UIC than children from rural schools.

Conclusions: Our findings suggest that although the overall median UIC in Latvian schoolchildren falls within the lower normal range, almost 50% of the schoolchildren are iodine

* *Corresponding author at*: Department of Endocrinology, Riga East Clinical University Hospital, Hipokrata 2, 1038 Riga, Latvia.
E-mail address: drkonrade@inbox.lv (I. Konrade).

Peer review under responsibility of Lithuanian University of Health Sciences.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.medici.2014.06.003

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deficient, especially in urban schools and in the eastern part of Latvia. The absence of a mandatory salt iodization program puts a significant number of children and pregnant women at risk.

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1. Introduction

Iodine is an essential micronutrient required for adequate thyroid hormone production, and even a mild iodine deficiency during early childhood and pregnancy has the potential to impair neurological development. In adults, mild-to-moderate iodine deficiency appears to be associated with higher rates of more aggressive subtypes of thyroid cancer and increases the risk of diffuse goiter, nontoxic and toxic nodular goiter and associated hyperthyroidism [1]. Although the prevalence of iodine deficiency in Europe has been reduced by almost 30% over the past decade, it still remains the leading cause of preventable intellectual impairment [2,3] and is the primary motivation behind the current worldwide drive to eliminate iodine deficiency.

Iodine is obtained from the diet and is primarily absorbed by the gastrointestinal tract in the inorganic anionic form of iodide. Several studies have suggested that proximity to the sea and seaweed abundance are factors that maintain an adequate iodine supply [4]. Nevertheless, iodine cycling from seawater in many regions is slow and incomplete, leaving soils and drinking water iodine depleted. Therefore, populations in coastal regions can be iodine deficient [5]. Given that the country's Baltic Sea coast extends for 531 km, iodine is a largely overlooked nutrient in Latvia.

National school-based surveys in children aged 9–12 are routinely used to classify a population's iodine status [6,7]. Urinary iodine concentration (UIC) adjusted for creatinine concentration (μg iodine/g creatinine) fully reflects urinary iodine concentration, μg iodine/L [8]. According to the World Health Organization (WHO) guidelines, the median UIC in iodine-sufficient populations should be greater than 100 μg/g Cr, and less than 20% of the population can have UIC below 50 μg/g Cr [9]. Accordingly, mild iodine deficiency as urinary iodine excretion of 50–99 μg/g Cr, moderate deficiency as 20–49 μg/g Cr, and severe deficiency as less than 20 μg/g Cr [10].

A previous nationwide cross-sectional school-based cluster survey on iodine deficiency disorders (IDDs) in Latvia was performed in 2000, when 587 schoolchildren were tested. The median UIC 59 μg/L found by the survey was indicative of mild iodine deficiency; severe iodine deficiency was observed in 19.2% (n = 115) of the participants [11]. Despite these findings, the introduction of a mandatory salt iodization program in Latvia was rejected. Instead, the voluntary iodine fortification of foods was promoted. Preventive measures to eliminate IDDs were limited to a focused distribution of leaflets promoting voluntary iodine salt consumption in the population and vague measures to influence industry to use iodized salt in the production of industrially processed foods. The aim of the present study was to establish the efficacy of voluntary preventive measures and to assess the current prevalence of iodine deficiency in regions of Latvia.

2. Materials and methods

2.1. Study design

Samples were obtained from a cross-sectional school-based 46-cluster survey of children aged 9–12 years in 46 randomly selected schools (28 urban and 18 rural) in all regions of Latvia. A total of 915 urine samples and questionnaires on diet, consumption of iodized salt and indicators of socioeconomic status were collected. In addition, the origin of food (commercial and/or home-grown) and consumption of both sea-food and multivitamins were recorded. Samples of urine collected during the early morning were obtained in October 2010 (n = 504) and April 2011 (n = 411) to account for seasonal differences in UIC [12]. Assessment of elevated (cut-off point of 5 mIU/L) TSH in the Latvian Neonatal screening program (n = 31,274) was performed.

2.2. Laboratory measurements

An assay to detect urinary iodine using ammonium persulfate was adapted from methods described previously [13]. Absorption measurements were obtained at 405 nm after 30 min incubation at room temperature using a μQuant^{TM} Microplate Spectrophotometer (BioTek). The urinary creatinine concentration was measured using the Jaffe method [14] with the intention that iodine concentration adjusted for creatinine concentration (I/Cr) could be calculated.

2.3. Newborn screening TSH assay

The heel-prick blood samples from newborns were collected at least 48 h after birth as a part of a routine neonatal screening program. Whole blood samples spotted onto filter paper (grade 903 Schleicher and Schuell, Germany) were sent to the Clinic of Medical Genetics, Children's University Hospital (Riga, Latvia). TSH was measured by fluorometric enzyme immunoassay (Ani Labsystems Ltd., Finland) performed on a Fluoroskan Ascent (Thermo Labsystems, Helsinki, Finland) analyzer.

In total, there were TSH data on 40,386 newborns (98.8% of live births in 2009–2010, according to the Central Statistics Bureau of Latvia [15]). Of those, 4.9% had implausible test results, and 18.3% of blood draws were suspected to be collected earlier than 48 h after birth. The final number of TSH samples included in the analysis was 31,274 (76.5% of live births in 2009–2010).

2.4. Statistical analyses

The results are expressed as medians with interquartile range (IQR), as well as percentage of participants in the study. The Mann–Whitney *U*-test or Kruskal–Wallis tests were used to compare UIC between two or more subgroups, respectively. Differences between prevalence estimates were tested by the Chi-squared test in addition to calculation of 95% confidence intervals around prevalence estimates. *P* values below 0.05 were considered statistically significant. The data were analyzed using SPSS 19.0 statistical software (SPSS, Chicago, IL, USA) and Confidence Interval Analysis (CIA) software.

Table 1 – Distribution of participants with a decreased urinary iodine concentration (UIC) according to established severity categories in various regions of Latvia.

Regions	No. of participants	UIC < 100 μg/g Cr, % (*n*)	UIC < 50 μg/g Cr, % (*n*)	UIC < 20 μg/g Cr, % (*n*)
Kurzeme	203	37.9 (77)	9.4 (19)	1.5 (3)
Latgale	159	46.3 (83)	25.2 (40)	5.7 (9)
Riga	212	47.6 (101)	12.3 (26)	1.9 (4)
Vidzeme	177	53.1 (94)	19.8 (35)	5.6 (10)
Zemgale	164	42.1 (69)	9.1 (15)	0 (0)
Latvia	915	46.3 (424)	14.7 (135)	2.8 (26)

3. Results

The median UIC in Latvian schoolchildren was 107.3 (IQR 69.1–161.7) μg/g Cr. Children from urban schools ($n = 522$, median 102.5 μg/g Cr, IQR 66.8–151.2) had lower UIC compared to children from rural schools ($n = 393$, median 111.9 μg/g Cr, IQR 71.2–173.8; $P = 0.006$). There was no difference between the median UIC of boys and girls.

Similar to the findings of the previous Latvian nation-wide IDD survey in 2000 [11], the median UIC in this study differed significantly between regions ($P < 0.001$) (Fig. 2). The lowest UIC was observed in the Vidzeme and Latgale regions (96.0 μg/g Cr and 95.5 μg/g Cr, respectively), while the highest UIC was found in the Kurzeme (126.6 μg/g Cr) region, the closest to Baltic Sea. The highest percentage of school children with UIC < 100 μg/g Cr were in Vidzeme (53%), while school children with UIC < 50 μg/g Cr were in the Latgale region (25.2%) (Fig. 1 and Table 1).

Analysis of questionnaires showed no significant association between UIC and consumption of iodized salt, seafood or multivitamins (Table 2). The self-reported incidence of regular iodized salt consumption by Latvian schoolchildren was 10.2%. We found significant differences in consumption habits of iodized salt ($P = 0.014$) between regions. It was used by 13% (95% CI, 8.5–21.5) of respondents in Riga, 12.4% (95% CI, 7.4–19.8) in Zemgale, 12.3% (95% CI, 7.8–20.1) in Kurzeme, 7.8% (95% CI, 3.5–11.4) in Latgale and only 3.9% (95% CI, 1.1–5.0) in Vidzeme.

The highest UIC was found in school children who reported consuming home-grown food and children attending rural schools. The schoolchildren from urban schools ($n = 522$, median 102.5 μg/g Cr, IQR 66.8–151.2) had significantly lower UIC then participants from rural schools ($n = 393$, median 111.9 μg/g Cr, IQR 71.2–173.8; $P = 0.006$). There were no statistical differences between urban and rural children consuming foods from supermarket or mixed origin (Table 3). The socioeconomic status of the parents was not associated with UIC (data not shown).

Analysis of the data from the Latvian Neonatal TSH screening program showed that 8.2% (95% CI, 7.8–8.7) had TSH concentrations >5 mIU/L in 2009 and 9.3% (95% CI, 8.8–9.7) had TSH concentrations >5 mIU/L in 2010. This is suggestive of mild iodine deficiency in Latvia. The average prevalence of TSH > 5 mIU/L was 8.7% (95% CI, 8.4–9.1), the highest proportion of infants with TSH indicative for iodine deficiency was in Latgale (13.1%; 95% CI, 12.1–14.1), the lowest was found in coastal Kurzeme (5.8%; 95% CI, 5.1–6.6) (Fig. 2). The interregional differences of TSH > 5 mIU/L prevalence estimates were statistically significant ($P < 0.001$) (Fig. 2). Despite the observed regional differences, the prevalence of elevated neonatal TSH, as well as the lower limit of the 95% CI of the estimate, exceeded 3% even in Kurzeme, the coastal region of Latvia.

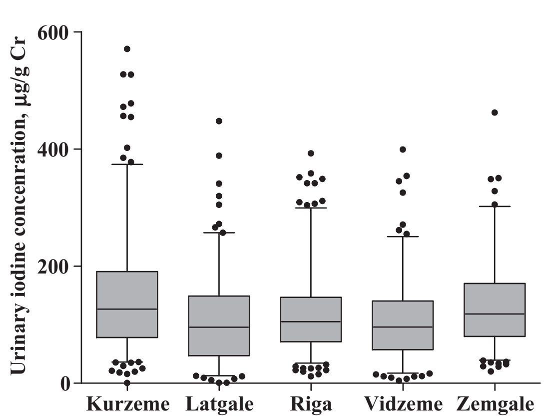

Fig. 1 – Regional differences in the median urinary iodine concentration in different regions of Latvia. Data are presented as medians (95% CI). Kruskal–Wallis test for global comparison of all regions, $P < 0.001$.

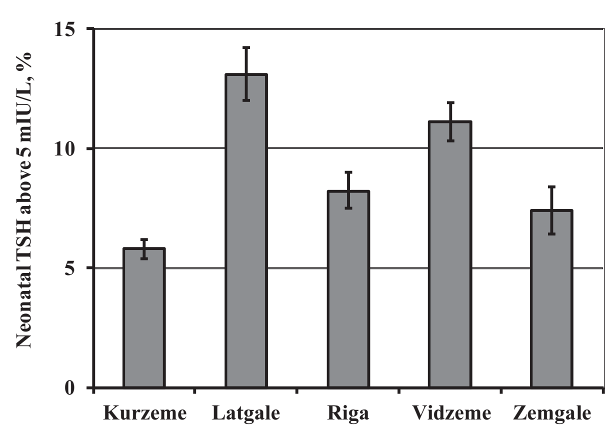

Fig. 2 – Percentage of neonatal TSH above 5 mIU/L by region of birth (combined data from 2009 and 2010). Data are presented as percentage of participants (95% CI).

Table 2 – Urinary iodine concentration (UIC) according to the self-reported consumption of iodized salt, seafood, and multivitamins.

	Participants, % (*n*)	UIC, median (IQR) (μg/g Cr)	UIC < 100 μg/g Cr, % (*n*)	UIC < 50 μg/g Cr, % (*n*)	P*
Use of iodized salt (*n* = 899)					
Always	10.2 (92)	114.3 (77.2–166.9)	39.1 (36)	13.0 (12)	
Sometimes	45.4 (408)	105.1 (68.3–164.2)	48.8 (199)	15.4 (63)	0.580
Never	32.5 (292)	108.8 (68.5–157.6)	45.5 (133)	14.7 (43)	
No opinion	11.9 (107)	115.0 (72.1–161.7)	43.0 (46)	11.2 (12)	
Consumption of sea fish (*n* = 898)					
2–3 times a week	2.8 (26)	91.1 (63.4–160.2)	57.7 (15)	11.5 (3)	
Once a week	33.0 (296)	99.0 (65.5–153.2)	51.4 (152)	17.2 (51)	0.075
Once a month or less	64.1 (579)	113.6 (71.9–165.8)	42.7 (247)	13.1 (76)	
Use of multivitamins (*n* = 886)					
Regularly	11.9 (105)	100.5 (64.9–161.4)	49.5 (52)	15.2 (16)	
Few months annually	59.1 (524)	110.9 (72.3–163.9)	43.3 (227)	14.5 (76)	
Short-term†	21.7 (192)	102.5 (64.3–170.2)	49.0 (94)	16.1 (31)	0.844
Never	7.3 (65)	106.0 (70.0–145.5)	49.2 (32)	4.6 (3)	

* P value Kruskal–Wallis one-way analysis of variance.
† Short-term: <1 month, during illness/sickness.

4. Discussion

The present 10-year follow-up cross-sectional school-based survey in children found that in the absence of a mandatory salt iodization program, the median inter-seasonal creatinine-standardized UIC in Latvian schoolchildren was 107.3 μg/g Cr, a value within the lower normal range. It can be considered an improvement compared with the median UIC of 59 μg/L found in the previous nationwide cross-sectional school-based cluster survey on IDDs [11]. Nevertheless, the results of the present study suggest that a degree of iodine deficiency is present in 49% of Latvian schoolchildren, especially in urban schools and in the Latgale and Vidzeme regions (Tables 1 and 3).

Maternal iodine transfer to the fetus in the later weeks of gestation is essential for fetal and neonatal brain development, and the degree of impairment of thyroid function in the neonate is more important than in adults [16]. Accordingly, we also analyzed the Latvian Neonatal TSH screening data from 2009 to 2010 for different regions of Latvia. The prevalence of neonatal TSH > 5 mIU/L in less than 3% of newborns is a recognized indicator of iodine nutrition adequacy [9]. We found increased levels of TSH to be present in 8.7% of neonates. This finding indicates inadequate iodine nutrition but is significantly better than the rate of 16.5% found in Latvian Neonatal TSH screening in 2000–2002, which provided the first evidence that Latvia was an iodine-deficient region [17]. At the time, it also confirmed that the severity of iodine deficiency was highest in inland regions (the south-eastern Latgale region and the northeastern Vidzeme region) and lowest in regions along the Baltic Sea [17]. In the present study, the newborn TSH screening results are in agreement with the measures of iodine status determined by UIC analysis.

In our study, we found slightly higher UIC values in the western coastal Kurzeme region bordering the Baltic Sea than in the Latgale and Vidzeme regions. Due to the high iodine concentration in seawater and seaweed [4], populations that live near the sea and frequently eat seafood usually ingest slightly more than double the amount of iodine ingested by other populations [18]. However, there is a lack of data addressing the correlation between the distance from the sea and the UIC in populations. Denmark and Poland have implemented mandatory iodization programs, and iodine deficiency was successfully eliminated after these measures were adopted [19,20]. The Baltic countries bordering Latvia have been reported as mildly iodine deficient by WHO. Their iodine status was assessed in 1995, and the median iodine excretion was found to be 65 μg/L and 75 μg/L in Estonia and Lithuania, respectively [21]. Given that the situation in Latvia has improved during the past decade, similar tendencies should be expected in the results of more recent studies in other Baltic countries.

The increased intake of iodized salt could explain some of the improvement in the iodine status of the Latvian population. A survey in 1999 showed that less than 1% of all edible salt in Latvia was iodized [11], but the present study reports that the self-reported prevalence of iodized salt consumption was 10%. This result is in agreement with the data presented in the FinBalt observations from 2008, where 7.9% of men and 10.3% of women reported an intake of iodized salt [22]. Nevertheless,

Table 3 – Urinary iodine concentration (ICU) according to the main source of food in rural vs. urban schools.

Source of food products	ICU in urban schools Median (IQR) (μg/g Cr)	ICU in rural schools Median (IQR) (μg/g Cr)	P*
Mainly supermarket	93.2 (58.5–164.3)	113.8 (55.0–203.5)	NS
Mainly home-grown	98.2 (58.8–150.3)	119.8 (90.5–173.5)	**0.02**
Mixed	106.3 (70.8–150.9)	110.5 (69.6–176.7)	NS

* Mann–Whitney test. NS, not significant.

our study did not find a correlation between UIC and iodized salt consumption (Table 2), indicating that other sources of iodine could be important. Similar results have been reported from France and the UK [23]. An iodization program that includes mandatory iodized salt usage by mass catering services or in commercial bread production is more effective [24]. We also found no association between UIC and socio-demographic factors; this outcome was similar to the findings of a German population study [25] but in contrast to the National Health and Nutrition Examination Survey data from the United States [26]. Note, however, that the nutritional profile of children might differ from that of the adults included in the National Health and Nutrition Examination Survey study.

Current efforts aimed at preventing iodine deficiency not only stipulate iodization of all household table salts but also include other alternatives to increase consumption of additional iodine-fortified products (e.g., milk, mineral water) with standardized levels of iodine [27]. In addition, in certain countries, foods such as milk, eggs and bread are sources of iodine due to iodine-containing compounds used in agriculture and to the use of iodized salt in food preparation [10]. Cow's milk is considered as an important source of dietary iodine [22], and associations between low urinary iodine excretion and a low intake of milk have been reported [28]. In Latvia, a survey of dairy farmers regarding iodine-rich artificial feed did not provide an explanation for the observed regional differences in iodine status (data not shown).

5. Conclusions

In conclusion, a large fraction of the Latvian population has a suboptimal iodine intake and was found to be iodine deficient although the overall median UIC remained within the low normal range. The most affected are schoolchildren in the eastern part of Latvia (Latgale and Vidzeme). The present situation is most likely due to the absence of a mandatory salt iodization program in Latvia and is putting a significant proportion of children and pregnant women at unnecessary risk of IDDs. The results of our study show a critical need for the implementation of evidence-based recommendations for mandatory iodine supplementation in Latvia.

Conflict of interest statement

The authors state no conflict of interest.

Acknowledgments

This study was supported by the Latvian Association of Endocrinology, Latvian State Research Programme BIOMEDICINE and Ojars Veide Foundation. The authors thank A. Kuzjukevich (‘‘Diamedica’’) for providing the data from the Latvian Newborn TSH screening laboratory.

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