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Effect of Iodized Salt on Thyroid Volume of Children Living in an Area Previously Characterized by Moderate Iodine Deficiency*

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ABSTRACT

It is well established that an adequate iodine intake prevents iodine deficiency disorders. Prophylaxis through iodized salt is able to correct urinary iodine deficiency and to prevent goiter endemia, but scanty data are available about its effect on decreasing the thyroid size in goitrous children born before prophylaxis.

The prevalence of goiter was evaluated by ultrasound in the schoolchildren population of an area of Eastern Tuscany (Tiberina Valley) characterized by moderate iodine deficiency in 1985. At present, after the implementation of voluntary iodized salt consumption, iodine urinary excretion was borderline sufficient (median, 98 μg/L). Goiter prevalence was higher at ultrasound (17%) than by palpation (10%). The median thyroid volume ranged from 3.1 mL in 7-yr-old children to 9.2 mL in 14-yr-old children. In the 7–10 yr age class (*i.e.* in children born after iodine prophylaxis), no statistical difference in thyroid volume was found with respect to controls. In older children (11–14 yr) born before the institution of iodine prophylaxis, the median thyroid volume was significantly higher than that in age-matched controls. Moreover, in this cluster of subjects, the median thyroid volume in nongoitrous children was higher than that in controls.

In conclusion, the data of the present study indicate that the iodized salt prophylaxis is able to prevent the development of goiter in children born after the implementation of iodized salt consumption and to further control thyroid enlargement in older children, but is less effective (or rapid) in reducing goiter size in children exposed to iodine deficiency in the first years of life. (*J Clin Endocrinol Metab* **82:** 1136–1139, 1997)

IN DEVELOPING countries where iodine deficiency and goiter endemia is severe, oral or parenteral administration of iodized oil was shown to be an effective method of iodine prophylaxis, leading to eradication of goiter and cretinism in the new generations (1–5). Moreover, a few months after the administration of iodized oil, a significant decrease in goiter size was obtained in goitrous patients (2). In industrialized countries, the most convenient method of iodine prophylaxis is the use of iodized salt in the daily diet. A large series of controlled studies demonstrates a rapid increase in urinary iodine excretion and a dramatic decline in goiter in children born after iodized salt prophylaxis (6–11). Nevertheless, no data are available about the effect of iodized salt supplementation on the thyroid volume of children born before prophylaxis.

Thyroid ultrasonography is a cheap and reliable method for the evaluation of thyroid volume. In the epidemiological surveys, the use of this technique is at present strongly recommended to define the goiter endemia in areas of mild iodine deficiency (12–16). In fact, although in severe iodine-deficient areas neck palpation provides a careful estimation of thyroid size (17–21) in mild iodine-deficient areas, as in Italy, where most goitrous subjects have a small goiter (11), thyroid palpation has proven to be inaccurate, especially in children who are commonly examined in epidemiological surveys (12–15).

The aim of the present study was to measure thyroid volume and evaluate the prevalence of endemic goiter by ultrasound criteria in the schoolchildren population living in an extra urban area of East Tuscany (Tiberina Valley). This area, characterized by moderate iodine deficiency in 1985, is at present borderline iodine sufficient after the implementation of voluntary iodized salt consumption.

Materials and Methods

This study was carried out in the 7- to 14 yr-old schoolchild population of three villages (Badia Tedalda, Sestino, and Caprese Michelangelo) of a well defined geographic area of Eastern Tuscany (Tiberina Valley). The altitude of the villages ranges between 545–850 m above sea level. In 1985, before the beginning of iodine prophylaxis, the median urinary iodine excretion in this area was 22 μg/L, and goiter prevalence by palpation was 51% (22).

Two hundred and eighty subjects, representing 96% of the entire schoolchild population, were studied. Urinary iodine excretion was measured in extemporary samples by a colorimetric assay using an Autoanalyzer (Technicon, Tarrytown, NY) according to the method of Zak, and results were expressed as micrograms of iodine per L urine (23, 24).

Thyroid size was estimated by palpation separately by two expert examiners and scored according to the WHO criteria (grade 0, no palpable or visible goiter; grade 1, an enlarged thyroid that is palpable but not visible when the neck is in a normal position; grade 2, a palpably enlarged thyroid visible when the neck is in a normal position) (25). When the estimations did not coincide, the lowest score was chosen. The thyroid ultrasound examination was performed with a portable real-time instrument (Aloka SSD-500, Tokyo, Japan), using a 7.5-MHz linear

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transducer. Thyroid volume was calculated using the formula of a rotation ellipsoid model: width × length × thickness × 0.52 for each lobe.

To determine whether subjects consumed iodized salt, an appropriate questionnaire was distributed to the parents. The answers documented that 70% of the families had regularly used iodized salt.

Two thousand six hundred and ninety-three children born and living in urban (Bologna, Pisa, Lucca, and Grosseto) iodine-sufficient areas of northern and central Italy were used as controls (11). The median urinary iodine excretion in the control population was 110 μg/L. The prevalence of goiter was 6.1% by palpation and 3.9% by ultrasound (16).

Statistical analysis

Urinary iodine excretion was expressed as a median. Statistical evaluation was performed by χ^2 and Student's t tests for unpaired data.

Results

In the schoolchild population of the Tiberina Valley, the median urinary iodine excretion was 98 μg/L, and goiter was found in 28 of 280 (10%) subjects by palpation (Table 1). All goitrous children had grade 1 according to the WHO classification recently proposed (25). Urinary iodine excretion ranged from 22–223 μg/L. The analysis of distribution of the data showed values lower than 100 μg/L in 43% of subjects; 23% of these had urinary iodine excretion lower than 50 μg/L.

The prevalence of goiter at ultrasound (*i.e.* thyroid volume, >2 SD of the mean thyroid volume of age-matched controls) was 48 of 280 children (17%), significantly higher ($\chi^2 = 4270$; $P < 0.0001$) than that found in the control area (105 of 2693, 3.9%). Median urinary iodine excretion in the 48 goitrous children was 75 μg/L, significantly higher ($P < 0.001$) than that observed in nongoitrous children (101 μg/L). All but 2 goitrous children came from the families that did not use iodized salt. It is worth noting that in the area examined in the present report, goiter prevalence at ultrasound was higher than that found by palpation, whereas in the control area, goiter prevalence was lower at ultrasound than that observed by palpation (Table 2). The median thyroid volume progressively increased from 3.1 mL in 7-yr-old children to 9.2 mL in 14-yr-old children (Table 3). In older children (11–14 yr), thyroid volume was greater than that in age-matched controls, whereas younger children did not differ from controls, for either median or mean values (Fig. 1 and Table 3). In 12- to 14-yr-old groups, a highly significant difference in mean values was found by the use of Student's t test, as reported in Table 3. The thyroid volume of older children (11–14 yr old) was larger than that in controls in children from Badia Tedalda, where the median urinary iodine excretion was superimposable to that of control areas (Table 4). Even excluding subjects with goiter at ultrasound, children in the 11–14 yr age class living in the Tiberina Valley had a median thyroid volume higher than that of age-matched controls, although still in the normal range. No significant difference was found between the median thyroid volume in the study population and that in the control group in younger (6–10 yr) age classes (Fig. 2).

TABLE 1. Prevalence of goiter and urinary iodine excretion (UIE) in Tiberina Valley

Villages	No. of subjects	Goiter[a] (%)	UIE (μg/L) median
Badia Tedalda	107	6.0	109
Caprese M.lo	96	12.5	82
Sestino	77	12.0	60
General study population	280[b]	10.0	98

The data refer to the schoolchildren population both of the single villages and of the whole area.

[a] By palpation.

[b] 96% of schoolchildren population.

TABLE 2. Prevalence of goiter at ultrasound and by palpation in Tiberina Valley and control areas

	Ultrasound		Palpation	
	n	%	n	%
Tiberina valley	48/280	17.0	28/280	10.0
Control areas	105/2693	3.9	165/2693	6.1

The data refer to the entire schoolchildren population.

Discussion

Many studies demonstrate a rapid increase in urinary iodine excretion and a dramatic decrease in goiter prevalence in children born and living in iodine-deficient areas after the implementation of iodized salt (7, 8–10) and oral or parenteral iodized oil administration (1–5, 26–30). The use of salt supplemented with iodide appears to be the method of choice for eradicating iodine deficiency in industrialized countries (6–11), whereas iodized oil is the most effective method to prevent iodine deficiency disorders in countries where iodized salt is difficult to distribute (26, 27). The effectiveness of iodized salt prophylaxis to correct iodine deficiency and reduce goiter prevalence is reported in several studies. No data are available about the effect of iodized salt consumption on the thyroid volume of children exposed to iodine deficiency in the first years of life. Thyroid ultrasonography was used in the present study, as it is more accurate than palpation to assess goiter prevalence in the schoolchild population living in mild iodine-deficient areas (12–16, 31). The median thyroid volume in children living in Tiberina Valley was similar to that in age-matched controls in the younger age groups (6- to 10-yr-old children), whereas it was higher in the older group (11–14 yr old). Moreover, in addition to the evidence of goiter in a minority of subjects, a large majority of 11- to 14-yr-old children showed a subtle enlargement of the thyroid gland even in the absence of goiter at ultrasound (*i.e.* thyroid volume above the mean ± 2 SD of age-matched controls). This slight increase in thyroid size cannot be noticed by palpation, but it is detectable by ultrasound. These findings suggest that the exposure to mild to moderate iodine deficiency in childhood causes a subtle enlargement of the thyroid gland in the juvenile population that may persist after correction of iodine deficiency. Thus, the correction of iodine deficiency through the implementation of iodized salt consumption prevents goiter in children born after iodine prophylaxis and is able to prevent further increase in thyroid size in older children, but fails to induce a quick regression of the thyroid enlargement in children previously exposed to iodine deficiency. The pivotal role of the lingering effect of earlier iodine deficiency is suggested by the evidence that the thyroid volume of older children was higher with respect to controls in Badia Tedalda, although

TABLE 3. Thyroid volume (milliliters) in schoolchildren from Tiberina Valley and control areas

Age (yr)	Tiberina Valley		Control areas		P^a
	Mean ± SD	Median	Mean ± SD	Median	
7	3.3 ± 1.4[b]	3.1	3.1 ± 1.3	3.1	
8	3.5 ± 1.1	3.2	3.3 ± 1.2	3.3	
9	3.9 ± 1.1	3.8	3.6 ± 1.3	3.8	
10	4.5 ± 1.6	4.6	4.0 ± 1.5	4.3	
11	5.2 ± 1.9	5.1	4.9 ± 1.5	4.7	0.35
12	7.0 ± 2.1	6.9	5.3 ± 1.4	5.2	<0.007
13	8.5 ± 2.9	7.8	6.1 ± 1.6	6.0	<0.001
14	9.3 ± 2.5	9.2	6.3 ± 1.5	6.4	<0.001

[a] Comparison of mean values was performed using Student's *t* test.
[b] In all age groups, thyroid volume had a normal distribution.

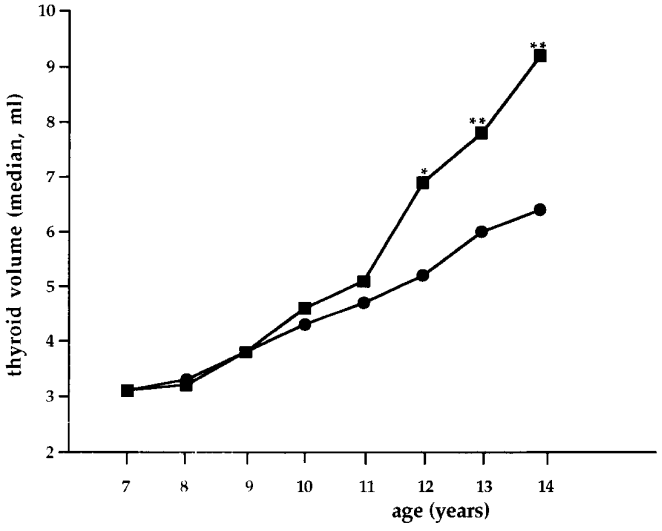

FIG. 1. Median thyroid volume (milliliters) in 7- to 14-yr-old children from the Tiberina Valley (■) and control areas (○). *, $P < 0.007$; **, $P < 0.001$.

TABLE 4. Median thyroid volume in older schoolchildren from Badia Tedalda and control areas, where the urinary iodine levels were superimposible

Age (yr)	11	12	13	14
TV Badia Tedalda (mL)	5.0	6.9	8.0	9.4
TV control areas (mL)	4.7	5.2	6.0	6.4
P^a	0.0003	0.0008	0.0001	0.0001

[a] Comparison of thyroid volumes was performed using Student's *t* test.

the median urinary iodine excretion in this village was superimposable to that in the control areas.

Thus, the knowledge of the previous status of iodine intake in a population is mandatory to understand the apparent discrepancy between a high goiter prevalence and a borderline low/normal iodine intake. This conclusion about the importance of the history of iodine deficiency is also supported by the high prevalence of nodular goiter in the adults living in the area studied in the present report (32).

In conclusion, the data of the present study indicate that iodized salt prophylaxis is able to increase urinary iodine excretion, to keep the progression of goiter endemia in the children born before the implementation of prophylaxis, and to prevent the development of goiter in the children born after prophylaxis. However, it seems to be less effective (or rapid) in reducing thyroid size in children previously exposed to iodine deficiency.

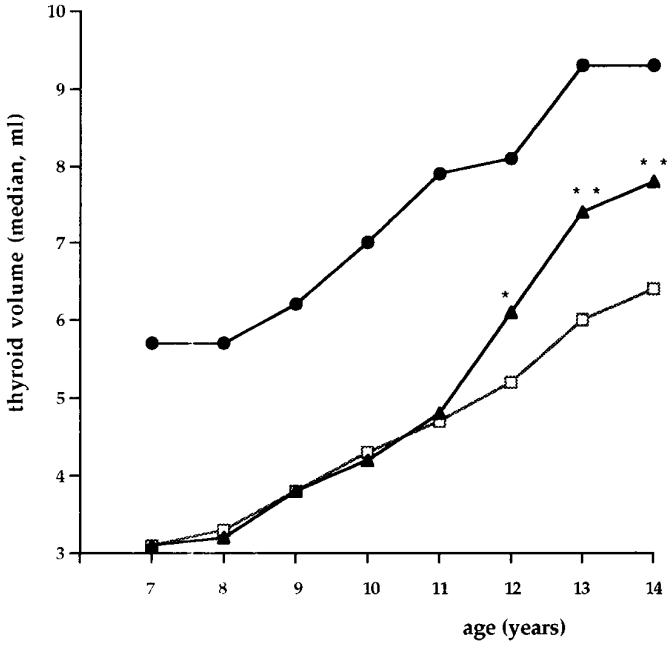

FIG. 2. Median thyroid volume in 7- to 14-yr-old children without goiter at ultrasound from the Tiberina Valley (▲) and control areas (□). The upper limit of thyroid volume in controls is also reported (●).

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