Iodine and goitre status of primary schoolchildren near Worcester in the Western Cape

SAJCN Feb./Mar. 2004, Vol. 17, No. 1

Nutritional Intervention Research Unit, Medical Research Council, Tygerberg, W Cape
P L Jooste, BSc Hons (Epidemiol), PhD
Department of Health, Boland/Overberg Region, Worcester, W Cape
E Joubert, BSc (Diet)

Objective. To investigate whether or not iodine deficiency and endemic goitre currently prevail among the children attending a primary school near Worcester in the Western Cape, as was suggested by the results of the national iodine deficiency survey carried out 2 years previously.

Design. A cross-sectional study of all Grade 5 and 6 children attending the school.

Methods. The iodine status of the 66 participants (42 boys and 24 girls) in the study was assessed by means of the urinary iodine concentration, and the size of their thyroid glands was determined by palpation and by ultrasonography. Anthropometric measurements of their body height and weight were made. In addition, household salt samples were obtained from these children, retail salt samples were purchased at the nearest small food shops in the area of the school, and water samples were taken at the school for iodine analysis.

Results. The goitre prevalence (by palpation) in the whole group was 7.6%, accompanied by a median urinary iodine concentration of 177.5 µg/l, which reflected an adequate dietary iodine intake. The median thyroid volume of 2.8 ml was also low, and only 2 children (3%) with enlarged thyroid volumes were detected ultrasonographically. Although the iodine concentration in retailer and household salt samples varied somewhat, it provided sufficient iodine to these children.

Conclusion. The mild iodine deficiency that existed 2 years previously in these schoolchildren has been eradicated, most likely by the adequate amount of iodine in the salt.

Mandatory iodisation of table salt at an elevated iodine concentration was introduced in South Africa in 1995 as a public health measure to avoid the grave consequences of iodine deficiency, particularly the effect on brain functioning.[1,2] Because mild iodine deficiency was found in children attending a primary school near Worcester in the Western Cape in 1998,[3] this study assessed the iodine, goitre, and anthropometric indices of nutritional status of Grade 5 and 6 children at the same school 2 years later.

Subjects and methods

All the Grade 5 and 6 children, from labourer families, attending the primary school near Worcester in the Western Cape, were included in this study. Written consent was obtained from the parents of the children, the headmaster of the school and the Director of the Boland/Overberg Regional Office of the Department of Health. The Ethics Committee of the Medical Research Council (MRC) approved all the measurements applied in this assessment.

Demographic information regarding birth date and gender was provided by the teaching staff.

Anthropometric measurements of body height and weight were collected for calculation of the indices of nutritional status. Body height was determined to the nearest millimetre using a metal tape fixed to a wall, with a moveable headpiece that was rested horizontally on the head of each child. Body weight was determined without shoes and with the children dressed in light summer clothing, on an electronic scale accurate to 50 g. The *z*-scores of height-for-age and weight-for-age indices were calculated using the Epi 2000 software programme and the reference values of the National Center for Health Statistics (NCHS).[4]

The size of the thyroid was determined by palpation as well as by ultrasonography. The thyroid was visually inspected and then palpated and the size categorised according to the joint criteria of the World Health Organisation (WHO), United Nations Children's Fund (UNICEF) and International Council for the Control of Iodine Deficiency Disorders (ICCIDD) as no palpable goitre (grade 0), palpable but not visible (grade 1) and palpable and visible (grade 2).[5] The observer who performed the thyroid palpation (PLJ) was trained by medical colleagues during previous field studies and has gained extensive experience during several studies.

For the ultrasonographic determination of thyroid size, a Toshiba Just Vision 200 ultrasonograph was used with a 7.5 MHz transducer. Transverse and longitudinal scans were performed of each lobe of the thyroid gland, and the volume of each lobe was calculated using the formula: volume = $0.479 \times w \times d \times l$, where w represents the width, d represents the depth, and l represents the long axis of each lobe.[6] The thyroid volume was the sum of the volumes of the two lobes. Because undernutrition and retarded growth appeared prevalent among these children, the thyroid size was also assessed in relation to the body surface area (BSA) of the children. The BSA of each child was calculated using the formula: BSA = $W^{0.425} \times H^{0.725} \times 71.84 \times 10^{-4}$, where W is the weight in kg and H is the height in cm. One observer (PLJ) performed both the palpation and the ultrasound measurements on all the children.

The thyroid size of each child, measured by ultrasonography, was then evaluated against the 97th percentile revised cut-off values of the WHO, UNICEF and the ICCIDD for age as well as for body surface area.[7] Children with thyroid sizes exceeding these cut-off levels were considered goitrous. When the prevalence of goitres, determined either by palpation or by ultrasonography, exceeds 5%, it is said that a public health problem of endemic goitre exists in such a population.

Urine samples were obtained from all the children during school hours, and four drinking water samples were taken from the water tap at the school. The iodine concentration in the urine and water samples was analysed by means of a mild perchloric acid digestion, followed by the spectrophotometric analysis for iodine concentration using the Sandell-Kalthoff method.[8] The median urinary iodine concentration is used to assess the iodine status. A median urinary iodine concentration below 20 µg/l indicates severe iodine deficiency, 20 - 49 µg/l indicates moderate iodine deficiency, 50 - 99 µg/l mild iodine deficiency, 100 - 199 µg/l an adequate iodine intake, 200 - 299 µg/l more than adequate iodine intake, and more than 300 µg/l an excessive iodine intake.[5]

Each child was asked to bring three teaspoons (approximately 15 g) of salt used in the preparation of food at home, to school in a plastic zip-seal bag provided. In addition, three packets of retailer salt were purchased at each of the five small shops selling groceries in this area. These 15 retail salt samples, as well as the salt brought from home, were analysed for iodine concentration using the standard titration method.[9]

Results

All 66 children in Grades 5 and 6, 42 boys and 24 girls, participated in the study. Their demographic and anthropometric characteristics are summarised, by sex and for the total group, in Table I. This table shows that a substantial percentage of the children were growth retarded as is evident from the high percentage of stunted children (33.3%). Approximately 20% of the children were also underweight. The boys, whose mean age of 13.2 years was higher than the 11.8 years of the girls, had higher stunting and underweight rates than the girls.

The results of the median urinary iodine, prevalence of goitre by palpation, thyroid volume and the iodine concentration in the salt samples brought from home are summarised in Table II. The goitre prevalence (by palpation) in the whole group was 7.6%, accompanied by a median urinary iodine concentration of 177.5 µg/l. The median thyroid volume of 2.8 ml was also low, but 2 children were goitrous, representing a goitre rate of 3% based on the ultrasonographic measurement.

The concentration of iodine in 15 retailer salt samples purchased from five small grocer shops in the area, where people from the study area usually buy their food, ranged from 5 to 116 parts per million (ppm), with a mean value of 42 ppm. However, 5 of the 15 samples had iodine concentrations of less than 15 ppm. The mean iodine concentration of household salt samples was also 42 ppm (Table II), ranging from 0 to 184 ppm. However, only 67% of these salt samples were adequately iodised, containing more than 15 ppm of iodine. Four water samples obtained from the water source at the school generally contained little iodine, ranging from 0 to 16 µg/l.

Discussion

Based on the mean iodine concentration of 42 ppm in both the retail and household salt samples, which was higher than in other South African studies,[10,11] it was reasonable to expect an adequate iodine status in the schoolchildren who participated in this study. Their median urinary iodine value of 177 µg/l indeed indicated a sufficient iodine intake, and was markedly higher than the median value of 97 µg/l obtained in the same school during the national survey more than 2 years earlier.[3] Although we were concerned about the variability of the iodine concentration in the retail and household salt, and in particular about the third of these salt samples that

Table I. Demographic and anthropometric characteristics (mean ± SD) of the children

Study subjects	Mean age (years)	Height (m)	Height-for-age (z-score)	Stunting % < –2 SD	Weight (kg)	Weight--for-age (z-score)	Under-weight % < –2 SD
Boys	13.2	146.8	–1.44	35.7	37.2	–1.36	21.4
(N = 42)	± 1.2	± 8.8	± 1.02		± 7.8	± 0.99	
Girls	11.8	138.9	–1.48	29.2	31.8	–1.48	16.7
(N = 24)	± 0.9	± 8.3	± 0.95		± 7.1	± 0.95	
Total	12.7	143.9	–1.45	33.3	35.2	–1.33	19.7
(N = 66)	± 1.3	± 9.4	± 0.98		± 7.9	± 0.92	

SD = standard deviation.

Table II.	The iodine concentration in urine and salt, and the goitre prevalence and thyroid volume of the study participants				
			Thyroid volume (by ultrasonography)		
Study subjects	Median urinary iodine (µg/l)	Goitre prevalence by palpation (%)	Median (ml)	% > P97*	Mean iodine content in household salt (ppm) (SD)
Boys (*N* = 42)	147.3	9.5	2.8	0	43 (37)
Girls (*N* = 24)	239.6	4.2	2.7	0	41 (44)
Total (*N* = 66)	177.5	7.6	2.8	0	42 (40)

*Percentage of children exceeding the 97th percentile cut-off levels of the WHO/UNICEF/ICCIDD.[6]
SD = standard deviation.

were under-iodised, the median of the urinary iodine concentration nevertheless indicated a sufficient iodine status in this study population.

An improvement of this magnitude is almost certainly due to a higher iodine intake, and the most likely source of the additional iodine is iodised salt. During the National IDD Survey in 1998, the two salt samples obtained from children of this primary school contained 12 and 17 ppm of iodine, indicating a low iodine content in the salt. Although the sample size was very small, it nevertheless appears likely that the iodine content of table salt increased substantially from the time of the national survey to the time of the MRC assessment 2 years later, providing the additional dietary iodine. The improved iodine status of the children could also be ascribed partly to input from the Department of Health, which ensured that after the 1998 study, children, teachers, parents and shopkeepers in the community in which the school was situated were educated about the importance of using iodised salt; the importance of including foods high in iodine content in the daily diet was also emphasised. Therefore, the information on the iodine status of the children, substantiated by the data on the iodine content of retailer and household salt, indicates an adequate iodine intake in these children and consequently no need for an iodine intervention programme.

Effective salt iodisation results in a rapid eradication of iodine deficiency within 1 year, but the goitres take longer to regress in children with endemic goitre and iodine deficiency.[12] The goitre prevalence of 7.6% in the children should therefore not be of concern because the goitre rate appears to decline gradually over a number of years, as seen elsewhere in the country after the correction of iodine deficiency through salt iodisation (P Jooste — unpublished data). It is likely that the goitre rate among the children of this primary school was higher at the time of the national survey than the current rate, and that it is on the decline. Furthermore, the thyroid volume measured by ultrasound was normal, and this method indicated an acceptably low goitre prevalence rate of 3%.

Despite the relatively small sample size, the anthropometric indices of malnutrition in these children indicated a high prevalence of undernutrition. Because undernourished children are usually vulnerable to micronutrient deficiencies, it is gratifying to report that their current iodine status is normal. Interestingly, the nutritional status of the boys in this group of children was worse than that of the girls. The prevalence of stunting (35.7%) and underweight (21.4%) was higher among the boys than the girls, their median urinary iodine concentration was lower (but within the normal range), and their goitre rate appeared higher.

In conclusion, this investigation showed that the iodine status of the children is currently normal. Although their goitre rate, established by palpation, is marginally above the cut-off level of 5%, the ultrasonographic measurement of thyroid size indicated an acceptably low prevalence of goitre. The improved iodine status of these children can be ascribed to the national salt iodisation programme providing sufficient iodine to the children, as well as to the nutrition education given to the community.

We would like to thank the headmaster, staff and children of the primary school for their wholehearted collaboration in this study.

1. Bleichrodt N, Born MP. A metaanalysis of research on iodine and its relationship to cognitive development. In: Stanbury JB, ed. *The Damaged Brain of Iodine Deficency: Cognitive, Behavioral Neuromotor, and Educative Aspects.* New York: Cognizant Communication Corporation, 1994.
2. Benadé JG, Oelofse A, Van Stuijvenberg ME, Jooste PL, Weight MJ, Benadé AJS. Endemic goitre in a rural community of KwaZulu-Natal. *S Afr Med J* 1997; **87:** 310-313.
3. Immelman R, Towindo T, Kalk WJ, *et al. Report of the South African Institute for Medical Research on the Iodine Deficiency Disorder Survey of Primary School Learners for the Department of Health, South Africa*. South African Institute for Medical Research, 2000.
4. Hamill PVV, Drizd TA, Johnson CL, Reed RB, Roche AF, Moore WM. Physical growth: National Center for Health Statistics percentiles. *Am J Clin Nutr* 1979; **32:** 607-629.
5. WHO/UNICEF/ICCIDD. *Assessment of Iodine Deficiency Disorders and Monitoring their Elimination. A Guide for Programme Managers*. Geneva: World Health Organisation, WHO/NHD/01.1, 2001.
6. Delange F, Benker G, Caron PH, *et al.* Thyroid volume and urinary iodine in European schoolchildren: standardization of values for assessment of iodine deficiency. *Eur J Endocrinol* 1997; **136:** 180-187.
7. Zimmerman MB, Molinari L, Spehl M, Weidinger-Toth J, Podoba J, Delange F. Updated provisional WHO/ICCIDD reference values for sonographic thyroid volume in iodine-replete school-age children. *ICCIDD Newsletter* 2001; **17:** 12.
8. Sandell EB, Kotlhoff IM. Micro determination of iodine by a catalytic method. *Mikrochemica Acta* 1937; **1:** 9-25.
9. Mannar MGV, Dunn JT. *Salt Iodization for the Elimination of Iodine Deficiency*. International Council for the Control of Iodine Deficiency Disorders, 1995: 107-112.
10. Jooste PL, Weight PL, Locatelli-Rossi L, Lombard CJ. Impact after 1 year of compulsory iodisation on the iodine content of table salt at the retailer level in South Africa. *Int J Food Sci Nutr* 1999; **50:** 7-12.
11. Jooste PL, Weight MJ, Lombard CJ. A national survey of the iodine content of household salt in South Africa. *Bull World Health Organ* 2001; **79:** 534-540.
12. Jooste PL, Weight MJ, Lombard CJ. Short-term effectiveness of mandatory iodization of table salt, at an elevated iodine concentration, on the iodine and goitre status of schoolchildren with endemic goitre. *Am J Clin Nutr* 2000; **71:** 75-80.