The goiter prevalence and urinary iodine levels among adolescents

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Endemic goiter and iodine deficiency are among the worldwide major public health problems of today. We aimed to research the goiter prevalence and the urinary iodine level of school children.

In this descriptive study, 1,847 school children in Konya aged between 10 and 18 years were included. Urinary iodine level was measured. The mean value of iodine excretion in urine was 198±46.61 µg/L. In 40 students (2.2%), the urinary iodine level was <100 µg/L. Six of these students (0.3%) had moderate iodine deficiency. Thyroid hyperplasia was found with palpation method in 128 students (6.9%). Ultrasonographically, five female students had solid nodule, and one male student had multiple nodules. In our study, no severe iodine deficiency was found. According to the results of our study, the mandatory iodization program in Konya has been conducted successfully.

Key words: goiter, urinary iodine, school children, ultrasonography.

Iodine deficiency disorders (IDDs) are among the worldwide major public health problems of today. Their effects are hidden and profoundly affect quality of life. Globally, 2.2 billion people live in areas with ID and risk its complications[1]. Goiter prevalence and the median urinary iodine concentration in a population usually define endemic ID. ID may be associated with endemic goiter, lowered levels of circulating thyroid hormone and suboptimal brain function[2-4]. Thyroid hormones influence almost all aspects of normal child development and thus play a crucial role as a regulator of nervous system myelination, growth and puberty, dental and skeletal development, metabolism, and organ functions[5]. Early diagnosis and treatments are essential to prevent irreversible and permanent nervous system damage and developmental delay, especially in infants, as they are extremely vulnerable to thyroid dysfunction[6].

The clinical detection of thyroid nodules is increasing among the Turkish population, especially due to greater awareness and to the use of imaging modalities in the neck. Thyroid nodules are found in the vast majority of the population, but only 5 to 10% are malignant, and women are affected more than men by a ratio of 3:1. Ultrasonography of the thyroid, by virtue of being a straightforward, noninvasive method presenting strong correlation with macroscopic aspects of the thyroid gland, is being increasingly used to identify nodules that present a higher risk of malignancy[7-9].

In an attempt to eliminate ID and to comply with the international goal of universal salt iodization, compulsory iodization of all table salt was introduced in Turkey in 1994. To reduce the prevalence of IDDs, the National Iodine Deficiency Disorders Control and Salt Iodization Programs (NIDDCP) were conducted by the Ministry of Health[10,11].

In this study, we aimed to research the goiter prevalence and to determine urinary iodine concentration among school children.

Material and Methods

Subject Selection

This descriptive study was performed among school children selected randomly from 178 primary education and high schools in Konya.

The universe of this study was constituted of 1,847 school children who were educated at the six primary education and high schools in Konya. Konya Province has more than 1,800,000 inhabitants and is a leading industry and trade center in central Turkey. Inhabitants of the province can be argued to be quite similar to the general Turkish population since the province receives incessant migrations not only from the neighboring provinces but also from all over the country, including eastern and southeastern parts of Turkey. Before beginning this research, the study protocol was approved by the Ethical Committee of Selçuk University Meram Faculty of Medicine. For the implementation of this research, two approvals were obtained from the Governorship and National Education Directorate. This research was started with the official permission and cooperation of the directors of the selected schools. In the first step, six primary education and high schools located in central Konya, where the research was performed, were selected randomly from the departmental rosters. In the second step, potential participants aged 10-18 years were selected randomly from these schools. Among these, students with growth retardation such as achondroplasia and pituitary gland dwarfism, students who refused to participate in this study and those who did not attend regularly were excluded from the study. All of the participants were volunteers and did not have health problems. Initially, we intended to include 2,000 children and adolescents in the research; however, we were able to reach only 1,847 participants (92.35%) (1847/2000). A standardized questionnaire was applied to determine the sociodemographic characteristics and to collect information regarding goiter history within the families of the individuals included in this study. The participants' names, surnames, chronological ages, gender, and grade level were recorded on this form. The chronological age was calculated as the decimal age by subtracting the birth date from the observation date. Each year elapsed from their birthday was noted as one age.

Clinical Goiter Survey

The size of the thyroid gland was determined by inspection and palpation using the World Health Organization (WHO) criteria. Nodules are often discovered by the patient as a visible lump, or they are discovered incidentally during a physical examination. Thyroid glands may be normal, smooth or nodular, diffuse or localized, soft or hard, mobile or fixed, and painful or nontender on palpation. While palpation is the clinically relevant method of examining the thyroid gland, it can be insensitive and inaccurate depending on the skills and expertise of the examiner. All students were examined by inspection and palpation method by trained research staff. Goiter grading was done according to the recommended criteria of WHO/UNICEF/ICCIDD9 (Grade 0: no palpable or visible goiter, Grade 1: thyroid palpable but not visible, and Grade 2: thyroid visible with neck in normal position[10].

Iodine in Urine

Iodine nutritional status in humans is assessed by measurements of urinary iodine (UI) concentrations. Daily iodine intake can be estimated by measuring daily excretion, or by random spot urine sampling calculated as UI concentration per liter. Collection of spot UI concentrations is currently the internationally accepted criterion for assessing and monitoring the iodine status of that population[12].

Spot urine specimens were collected in labeled plastic bottles (50 ml capacity with screw cap and thymol crystal as preservative) for quantitative estimation of iodine in urine. Urine specimens were stored at -18°C until required for analysis. The iodine in the urine was measured by a modification of the traditional colorimetric method of Sandell-Kolthoff. Pino et al. [13] developed a simple, convenient and economic method for measuring UI by using 1 mol/L ammonium persulfate, a nonexplosive, nonhazardous chemical, as the oxidizing reagent. ID was regarded as mild with UI concentration of 50-99 μg/L, as moderate in the range 20-49 μg/L and as severe when values were <20 μg/L. Values ≥ 100 μg/L indicate no ID[10].

Thyroid Ultrasonography

Ultrasonography (USG) is the recommended method in epidemiological studies for the diagnosis of goiter. It is reliable particularly for detecting goiters with small volumes and is accepted as a standard method for

measuring thyroid volumes[9]. Thyroid volume measurements were performed in supine position with mobile ultrasound unit (Hitachi EUB-405, 5.0 MHz linear transducer) by a trained radiologist. Normal values for thyroid volume in children aged 6-15 years, according to the recommended criteria of the WHO and the International Council for Control of Iodine Deficiency Disorders (ICCIDD), are shown in Table I[8]. A transverse and sagittal scan was taken of each lobe and lobe volume was calculated according to the following formula: lobe volume = length x depth x width x 0.479[9]. All students were examined by inspection and palpation method and then a USG examination of the thyroid was performed among the students in whom thyroid hyperplasia was found by palpation method.

Ethical Considerations

The study protocol was approved by the Ethics Committee of Selçuk University Meram Faculty of Medicine and an informed written consent was taken from parents of all included subjects.

Statistical Analysis

The SPSS 13.0 statistical software package was used in data entry and analysis. The statistical analysis and evaluations were conducted by the authors. The variables were described as mean, frequency and standard deviation (SD). The relationship between thyroid hyperplasia and the goiter history in the family was analyzed statistically using the *Pearson's* chi-square ($\chi 2$) *test*. The level of significance in statistical tests was set at $p<0.05$.

Results

Of the students taking part in this study, 54.8% (n=1012) were male, 45.2% (n=835) were female, and the mean age was 13.98±2.43 years (min=10, median=14, max=18). Evaluation of the fathers' occupation found that 40.9% (n=755) were tradesmen, 27.6% (n=509) civil servants and 18.9% (n=350) workers. For the mothers, 91.1% (n=1682) were housewives and 6.5% (n=121) were civil servants (Table II). There was a goiter history in the families of 257 school children. Of the participants, 86.1% (n=1590) had no goiter history in their families.

The mean value of urinary iodine excretion (UIE) was 198±46.61 μg/L. According to WHO/UNICEF/ICCIDD recommended criteria, 40 students (2.2%) had UI level <100 μg/L. Six of them (0.3%) had moderate ID (UIE 20-49 μg/L) and 34 (1.8%) of the students had mild ID (UIE 50-99 μg/L). Severe ID was not found (Table III). Thyroid hyperplasia was found by palpation method among 128 students (6.9%) (90 female, 70.3%; 38 male, 29.7%). Nodule was found with palpation method in 3 female students (0.35% of the females). During the USG examination, thyroid volumes were found larger than normal among the students with thyroid hyperplasia as determined by palpation method. The mean value of right thyroid volume was 14.39±3.01 ml and of the left lobule was 13.82±3.26 ml. According to USG, 5 female students (0.27%) had solitary nodule and 1 male student had multiple nodules. Thyroid hyperplasia (by palpation method) was statistically higher in female students than males ($p<0.001$). Statistically, there was no

Table I. Upper Limit of Normal Thyroid Volume Measured by Ultrasonography in Children Aged 6-15 Years

	Thyroid volume (ml)	
Age (years)	Boys	Girls
6	5.4	5.0
7	5.7	5.9
8	6.1	6.9
9	6.8	8.0
10	7.8	9.2
11	9.0	10.4
12	10.4	11.7
13	12.0	13.1
14	13.9	14.6
15	16.0	16.1

Table II. Sociodemographic Characteristics of the Students

Characteristics	n	%
Gender		
Female	835	45.2
Male	1012	54.8
Mothers' employment		
Housewife	1682	91.1
Civil servant	121	6.5
Retired	27	1.5
Blue-collar worker	17	0.9
Fathers' employment		
Tradesman	755	40.9
Civil servant	509	27.6
Blue-collar worker	350	18.9
Retired	126	6.8
Farmer	78	4.2
Unemployed	29	1.6
Age (yr)		
10-12	576	31.2
13-15	681	36.9
16-18	590	31.9

relation between thyroid hyperplasia and the UIE ($\chi 2=0.931$, $p=0.335$). Goiter history in the family was higher among female students than males ($p<0.001$). There was a significant relation between gender and history of goiter operation in the family ($p=0.012$). There was no relation between thyroid hyperplasia and the goiter history in the family ($p=0.214$) (Table IV). The thyroid volumes in students with nodule were found statistically larger than in students without nodule ($p<0.01$).

Discussion

Before discussing the results, the limitations of the present study must be considered. For the determination of the iodine nutritional status of an individual, daily UIE is the most reliable measurement of iodine excretion. More than one 24-hour UI sample should be collected for the most reliable assessment. Random spot UI concentration measurements present a problem in UI concentration determinations because of diurnal and day-to-day variations in iodine excretion.

Iodine is an essential micronutrient for normal human growth and development. It is estimated that more than 1.6 billion people live in iodine-deficient environments, yet there are still some countries and areas where the prevalence of IDDs is unknown[14]. In our study, the mean value of UIE was 198±46.61 μg/L. Forty students (2.2%) had a UI level <100 μg/L. Six of them (0.3%) had moderate ID and 34 (1.8%) had mild ID. Severe ID was not found in any student. Thyroid hyperplasia was found with palpation method in 128 students (6.9%) (90 female, 70.3%; 38 male, 29.7%). Assey et al.[15] reported that the mean total goiter prevalence was 21.3% for Unguja and 32.0% for Pemba, and the overall median UI concentration was 127.5 μg/L. Thurlow et al.[16] noted that among 567 children aged 6-13 years in North East Thailand, 83% had UI levels below the 100 μg/L cut-off. In our study, the mean value of UIE was higher than in the studies of Thurlow and Assey et al.[15,16].

Milakovic et al. [17] conducted a cross-sectional population screening study comprising three age groups. The median values for UI concentration in the three age groups were 194 μg/L, 246 μg/L and 190 μg/L, respectively, indicating an adequate iodine intake. In the pediatric group,

Table III. Distribution of the Urinary Iodine Level of the School Children

	Gender				Total	χ2	p
	Female		Male				
	n	%	n	%			
Moderate IDD in the range 20-49 μg/dl	3 0.4		3	0.3	6	2.296	0.130
Mild IDD in the range 50-99 μg/dl	19	2.2	15	1.5	34		
Normal IDD in the range ≥100 μg/dl	813	97.4	994	98.2	1807		
Total	835	100.0	1012	100.0	1847		

the median value of the thyroid volume was 4.7 ml, which coincides with the recently established upper limit of normal for children of that age, of 4.0-4.8 ml (ICCIDD). In our country, similar findings were determined.

Tahirovic et al. [18] assessed the success of implementation of a new rule book on salt iodination in the Federation of Bosnia and Herzegovina. The UIE in school children varied from 50.6 to 303.8 μg/L, with a median of 139.5 μg/L. Values of UI <100.0 μg/L were found in 15.9% of samples of school children; however, no values <50.0 μg/L were found. They concluded that the results of the study indicated that increased iodine supplementation of salt in 2001 was successful and that the Federation of Bosnia and Herzegovina is presently iodine-sufficient. Our study found similar results.

According to the research conducted by Chandra et al.[19], the median UI level was 200 μg/L among school children (6-12 years) of Sundarban Delta in North 24-Parganas district of West Bengal in Eastern India. Results indicated that the studied region is clinically severely goiter- endemic, having a goiter prevalence of 33.1% (grade 1: 30.4%; grade 2: 2.7%). In our study, the median UI level was similar.

In a study of Kapil et al.[20], the median UIE level amongst school children in 24 districts in Southern India was found to be <100 μg/L, indicating ID. This rate was significantly lower than in our study.

In a school-based study of Jayatissa et al.[21], 6,574 randomly selected children in the age group 8-10 years from 263 schools were assessed for goiter by palpation. UI levels were measured in 2,630 of these children. The median UI levels in Sri Lanka were above the cut-off point of 100 μg/L. The highest median UI level was reported in North Central Province (231.3 μg/L). Overall, 35.4% of the children

Table IV. Distribution of the Urinary Iodine and Goiter According to Gender

	Gender						χ2	p
	Male		Female		Total			
	n	%	n	%	n	%		
Goiter in family								
Absent	902	56.7	688	43.3	1590	100	17.326	0.000
Present	110	42.8	147	57.2	257	100		
Thyroid palpation								
Normal	974	56.7	745	43.3	1719	100	34.991	0.000
Palpable	38	29.7	90	70.3	128	100		
Goiter surgery in family								
Present	61	44.5	76	55.5	137	100	6.296	0.012
Absent	951	55.6	759	44.4	1710	100		
Urinary iodine level								
<100 μg/dl	22	55.0	18	45.0	40	100	2.225	0.136
≥100 μg/dl	1052	58.2	755	41.8	1807	100		

had UI levels in the 'ideal' range (100-199.9 μg/L); 30.6% had lower values (<100 μg/L) indicating ID; and 16.3% had higher values (<300 μg/L) indicating excessive iodine intake. The prevalence of goiter varied from 16.3% to 26.2%.

According to the research conducted by Erdoğan et al.[22], median UI concentration was 107 μg/L (147 in urban, 42 in suburban and rural areas, p<0.001). Severe ID was present in 7.2%, and moderate and mild ID in 20.6% and 19.3%, respectively, of the school-age children. UI concentration was sufficient (>100 μg/L) in 50% of the study population, whereas it was excessive (>300 μg/L) in 10.5%. ID was still an important problem in rural areas. In our study, the median UI concentration was 198±46.61 μg/L, and no case was determined to have severe ID.

Budak et al.[23] emphasized that the median UIE of all school children was 25.5±17.2 μg/L. Iodine status of the population was gauged based on median UI values categorized as normal (≥100 μg/L), mild (50-99 μg/L), moderate (20-49 μg/L), and severe (<20 μg/L) ID and classified according to age, gender and body mass index (BMI). While UIE of 289 school children (16.2%) was in normal range (≥100 μg/L), 747 of the school children (41.9%) had UIE <20 μg/L. This rate was significantly lower than in our study.

Bastemir et al.[24] in their study evaluated the effects of iodine intake on the prevalence of thyroid dysfunction, autoimmunity and goiter in two regions with different iodine status after two years of iodization in Turkey. In total, 1,733 adolescent subjects were enrolled into the study (993 from an iodine-sufficient area--the Eastern Black Sea region (Group 1) and 740 from an iodine-deficient area--Central Anatolia (Group 2). They measured UI, and examined the thyroid gland by ultrasound. Median UIE was found to be significantly different in Group 1 and Group 2 (139 μg/L vs 61μg/L, p<0.001). Hyperthyroidism was more frequent in Group 1 (3.6% vs 0.7%; p<0.001), but the hypothyroidism rate was similar between the groups (1.8% vs 1.4%; p>0.05). Thyroid volumes of the hyperthyroid subjects in both groups were significantly higher than in hypo- and euthyroid subjects. In our study, the thyroid volumes in students with nodule were found statistically larger than in students without nodule (p<0.01).

Egri et al.[25] reported that the median UI concentration was 66 μg/L in 568 school children (317 boys, 251 girls), aged 7-11 years, living in Malatya province, a well-known endemic goiter area in Turkey. In our study, the median UI level was significantly higher than in their study.

Darcan et al.[26] reported that the prevalence of goiter determined by palpation was 12.1% and median UI was 53 (2-142) μg/L among children 6-12 years in the west coast (Aegean region) of Turkey. Mild to severe ID was detected in the region as well. In our study, the median UI level was significantly higher than in that study and no severe ID was determined.

According to the research conducted by Simsek et al.[3], the degree of ID related to concentration of UI was severe in 276 children (38%), moderate in 151 (20.8%), mild in 114 (15.7%), and within normal levels in 186 (25.4%). Whereas urban areas showed normal or mild UIE, four rural areas showed from mild to severe ID (p<0.001). Thyroid volumes of the severe ID group were significantly higher than those of the moderate and mild ID groups (p<0.001). In our study, the thyroid volumes in students with nodule were found statistically larger than in students without nodule (p<0.01).

In a study of Ozkan et al.[27], overall goiter was found in 47.6% of children, in 22.8% of girls and in 24.8% of boys. Mean thyroid volumes did not differ significantly according to gender. Median UI concentrations in subjects with and without goiter were 20 μg/L and 5.2 μg/L, respectively. Despite the implementation of a salt iodization program in Turkey, Ozkan's study indicates that severe ID is still present in some regions. Compared with Ozkan's study, the extent of ID determined in our study was less.

Welker et al.[28] stated that palpable thyroid nodules occurred in 4 to 7% of the population, but nodules found incidentally on USG suggest a prevalence of 19 to 67%. The majority of thyroid nodules are asymptomatic. Because about 5% of all palpable nodules are found to be malignant, the main objective of evaluating thyroid nodules is to exclude malignancy. In

our study, thyroid hyperplasia was found with palpation method in 128 students (6.9%) (90 female, 38 male). Nodule was found with palpation method in 3 female students (0.35% of the females).

In a study of Akpınar et al.[29], goiter frequency and UIE were investigated among the students aged 13-18 years. Of the 452 students, 39% had visible goiter (grade 1b and 2) by palpation. Goiter prevalence was significantly higher ($p<0.02$) in girls (46.8%) than in boys (35.4%). Nodular goiter was observed in 2.9% of the students (solitary nodule 2.2%; multinodular goiter 0.7%), and in two, these nodules were diagnosed as thyroid carcinoma (4.4/100,000). UI was found sufficient (>100 μg/L) in 80% and deficient in 20% of the students. As a result, although Istanbul is an iodine-sufficient area, goiter prevalence shows that it is a goiter-endemic region.

Akarsu et al.[30] concluded that goiter resulting from ID has been an important health problem in Erzurum. According to our findings, there was minimal ID and it was generally mild.

Puberty is a crucial period of hormonal interactions in the human life cycle. Marked changes in thyroid function occur during puberty as an adaptation of body and sexual development. Minimal diffuse enlargement of the thyroid gland is found in many teenage boys and girls and is usually a physiological response to the complex structural and hormonal changes occurring at that time[31]. All forms of thyroid disorders like nontoxic goiter, Grave's disease, Hashimoto's thyroiditis, and thyroid neoplasm are more common in females than males[30]. We were unable to find a plausible explanation for thyroid hyperplasia, which was higher in females than in males. Further studies on the explanation of gender differences must be performed. In our study, thyroid hyperplasia determined with palpation method was also statistically higher in female students than males ($p<0.001$).

In conclusion, endemic goiter and ID are serious public health problems in Turkey[32]. Although a salt iodization program has been started in Turkey, severe ID is still present in some regions. In our study, the mean value of iodine excretion in urine was 198±46.61 μg/L. There were 40 students (2.2%) with a UI level <100 μg/L. No severe ID was determined in any student. Although mandatory iodization of household salt seems to be the essential measure taken for the time being, additional measures may be needed in the near future. The objective of the control program to reduce and prevent iodine disorders was to decrease overall IDD prevalence (goiter) to <5% in school children aged 6-12 years.

In this study, we concluded that the iodization program by the Ministry of Health has been effective in reducing the severity of ID in Konya, at least among school children. However, this program should be implemented with stronger enthusiasm to eliminate even mild ID country wide.

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