Thyroid gland volume and echo structure in 13-year-old children in northern Finland

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Abstract. The purpose of this work was to determine by ultrasound the volume and echo structure of the thyroid gland in 13-year-old schoolchildren in northern Finland. 76 healthy schoolchildren underwent cervical ultrasound examinations during the period of Jan-Feb 1990, performed with a real-time scanner using a 7.5 MHz linear transducer and direct contact method. The volume of each lobe was calculated according to the formula for a volume of rotation ellipsoid by multiplication of maximal thickness, width and height of the lobe by the correction factor 0.479. Any focal lesion that could be distinguished in the homogenous thyroid parenchyma was assessed for echogenicity as compared with the normal thyroid gland and was measured with electronic calipers. The mean thyroid volume was 6.5±1.6 ml (mean ±sd), being 6.3±1.8 ml in the boys and 6.7±1.4 ml in the girls. The sex difference was not significant. The right lobe was significantly larger than the left one (mean 3.7 and 2.8 ml, respectively). Thyroid volume was correlated with body weight and body surface area in both sexes. Abnormal lesions in terms of echo structure were noted in one subject (1.3%). Comparing the results with the findings reported from other countries, it can be concluded that the thyroid volume in these 13-year-old Finnish schoolchildren was about 30% less than that reported for the same age group in the FRG (with insufficient iodine intake) and about 35% more than in 13-year-old schoolchildren in Sweden (with sufficient iodine intake).

Accurate estimation of the size of the thyroid gland is very important for the evaluation and management of thyroid disorders (1).

Previous studies for determining the volume of the thyroid in adults have been performed by evaluating chest X-rays, and by palpation and radio-
uclide imaging (2-5), whereas assessments of goitre prevalence in children have been based solely on palpation or measuring urinary iodine excretion (6,7).

Ultrasound (US) is now considered the most reliable method for determining the volume and echo structure of the thyroid (8-15).

US demonstrates thyroid enlargement in adults with a sensitivity of 93%, palpation with a sensitivity of 91%, and radiography with a sensitivity of 45% (5). Although the sensitivity of palpation in adults is acceptable (91%), its specificity is only 64% (13), and it is even less reliable in younger subjects and almost useless in children below 10 years of age (12,13). The probability of error in demonstrating thyroid weight by palpation is almost 50% (16). US has the disadvantage of poor quantitative demonstration of retrosternal goitre (5).

A few epidemiological determinations of the normal volume of the thyroid gland in children have been carried out (Table 2).

The purpose of this work was to determine the volume and echo structure of the thyroid gland by US in schoolchildren aged 13 years in northern Finland and to compare the results with those reported in other countries.

Subjects and Methods

The series consisted of 76 child volunteers (35 boys and 41 girls) aged 13 years (born in 1976) with no known thyroid or other disease. US examinations were performed during the period Jan-Feb 1990, by which time 8
of the children had already reached the age of 14 years. A school nurse had measured the height and body weight of the children 1 to 2 months before the US examination.

The mean age of the group was 13.6±0.3 years, mean height 158.9±5.9 cm (range 145.0-170.7), boys 159.2±6.6 cm (range 145.0-169.5) and girls 158.6±5.4 cm (range 148.5-170.7), and mean weight 48.6±7.8 kg (range 34.6-67.7), boys 48.3±7.2 kg (range 36.6-64.0) and girls 48.9±8.4 kg (range 34.6-67.7). The mean body surface area was 1.5±0.1 m² (range 1.2-1.7 for boys and 1.2-1.8 for girls).

Information on possible thyroid disorders in the family was obtained from the parents by a questionnaire, and the parent’s and children’s consent was obtained before the US examinations.

All the examinations were performed by the same person (RT) using an Aloka SSD-650 real-time scanner with a 7.5 MHz linear transducer and using direct contact method. The length of the contact surface of the transducer was 4 cm, the lateral resolution 3 mm, and the axial resolution 2 mm to an axial depth of 0-4 cm. The thyroid gland was palpated by the examiner before US was performed. The children were examined in the supine position with the neck hyperextended, a pillow beneath the shoulders, and the skin covered by acoustic gel.

The height, width and thickness of both thyroid lobes were measured on the viewing monitor of the scanner using electronic calipers and the figures stored on video tape. The volume of an individual lobe was calculated using the method modified according to Brunn et al. (8) (height × width × thickness of the lobe × correction factor 0.479). The width and thickness of each lobe were measured at their maximal values in the same transverse plane, at right angles to each other. The width of each lobe was measured from the tracheal border. When measuring the width and thickness, the transducer was held upright and at right angles to the trachea. The height was measured at its maximal value from the cranial to the caudal border in the long axis plane of the lobe, the transducer being held in the same direction as the trachea. The long axis plane of the lobe was composed of two figures if the height of the lobe was more than 4 cm (Fig. 1). The isthmus was not measured separately.

Thyroid echogenicity was assessed with respect to its homogeneity and level by comparison with the echogenicity of the adjacent muscles. Normal thyroid tissue is homogenously more echogenic than the surrounding muscles. Any focal irregularities that could be distinguished from the homogenous thyroid parenchyma were assessed for echogenicity compared with that of the normal thyroid gland and were measured with electronic calipers.

Statistical evaluation was performed using Student’s t-test when the variables were on a continuous scale and Wilcoxon’s signed rank test and Mann-Whitney’s U-test when the data were not normal in distribution. Linear regression analysis was used to test the correlation between thyroid volume and body height, weight and body surface area. Results are expressed as mean ±sd. Level of significance, p<0.05.

Fig. 1.
Normal thyroid gland. Transverse (a) and longitudinal (b) ultrasound scans and their schemes. Common carotid artery (A), internal jugular vein (V), small cervical muscles (M), longus colli muscle (L), trachea (Tr), cervical spine (S). The arrows indicate the three dimensions used for the calculation: thickness (1), width (2), height (3).
Results

The mean volume of the thyroid gland in these 13-year-old Finnish schoolchildren was 6.5±1.6 ml (median 6.3, range 2.9-9.5) (Fig. 2). The boys had a mean volume of 6.3±1.8 ml (median 5.9, range 3.3-9.5) and the girls 6.7±1.4 ml (median 6.7, range 2.9-9.4).

No significant difference in mean thyroid volume was observed between the boys and girls (p=0.106), nor was any significant difference in body weight found between them (p=0.356).

The right lobe was significantly larger than the left one in the total group and in the boys and girls separately (p<0.001). The average ratio of right lobe volume to left lobe volume was 1.4 (SEM in the total group 0.04, in the boys 0.07 and in the girls 0.06).

The total group and the boys and the girls separately had positive correlations between the thyroid volume and body height, weight, and surface area. In the total group and in girls the best correlation was found between the thyroid volume and body weight. In the boys the best correlation was found between the thyroid volume and body surface area (Table 1, Fig. 3).

Seven mothers (9.2%) of the children had had a thyroid disease: hypothyreosis in 3, hyperthyreosis in one, thyroiditis in one, and thyroid cyst in 2, of which one had been operated on.

Table 1. Correlations between thyroid volume and body height, weight, and surface area in 13-year-old schoolchildren in northern Finland.

<table>
<thead>
<tr>
<th></th>
<th>Total group (N=76)</th>
<th>Boys (N=35)</th>
<th>Girls (N=41)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>(95% CL)</td>
<td>r</td>
</tr>
<tr>
<td>Height</td>
<td>0.30</td>
<td>(0.08-0.49)</td>
<td>0.40</td>
</tr>
<tr>
<td>Weight</td>
<td>0.46</td>
<td>(0.26-0.62)</td>
<td>0.41</td>
</tr>
<tr>
<td>Body surface</td>
<td>0.45</td>
<td>(0.25-0.61)</td>
<td>0.45</td>
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</tbody>
</table>

r=correlation coefficient; CL=confidence limits at 95% of probability.
Table 2.
Materials, methods and results of published epidemiological surveys of the thyroid by ultrasound in children and adolescents in the literature.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Material</th>
<th>Method</th>
<th>Results</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean Volume</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US, 4-5 MHz</td>
<td>9.3 ml, FRG</td>
</tr>
<tr>
<td>Gutekunst et al.</td>
<td>N=2244, FRG</td>
<td>Brunn et al. method (8)</td>
<td>4.2 ml, Sweden</td>
</tr>
<tr>
<td>1985 (12)</td>
<td>N=224, Sweden age range: 13 years</td>
<td></td>
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</tr>
<tr>
<td>Leisner et al.</td>
<td>N=181, FRG age range: 3-18 years</td>
<td>US, 5 MHz</td>
<td>not mentioned</td>
</tr>
<tr>
<td>1985 (19)</td>
<td></td>
<td>Igl et al. method (3)</td>
<td></td>
</tr>
<tr>
<td>Gutekunst et al.</td>
<td>N=619, FRG age range: 6-16 years</td>
<td>US, 4 MHz</td>
<td>1.8 ml, 6 years</td>
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<tr>
<td>1986 (13)</td>
<td></td>
<td>Brunn et al. method (8)</td>
<td>10.8 ml, 16 years</td>
</tr>
<tr>
<td>Klima et al.</td>
<td>N=183, Austria age range: 7-11 years</td>
<td>US, 5 MHz</td>
<td>4.2 ml, 7 years</td>
</tr>
<tr>
<td>1986 (20)</td>
<td></td>
<td>Brunn et al. method (8)</td>
<td>4.4 ml, 9 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.1 ml, 11 years</td>
</tr>
<tr>
<td>Klingmüller et al.</td>
<td>N=450, FRG age range: 0-16 years</td>
<td>US, 3.5-5 MHz</td>
<td>1.1 ml, newborn</td>
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<td>1989 (21)</td>
<td></td>
<td>Brunn et al. method (8)</td>
<td>3.3 ml, 5-8 years</td>
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<td></td>
<td></td>
<td></td>
<td>7.5 ml, 13-16 years</td>
</tr>
<tr>
<td>Müller-Leisse et al.</td>
<td>N=1080, FRG age range: 7-20 years</td>
<td>US, 5 MHz</td>
<td>5.5 ml, 7-10 years</td>
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<td>1988 (22)</td>
<td></td>
<td>Brunn et al. method (8)</td>
<td>11.7 ml, 10-20 years</td>
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<td>Einekel et al.</td>
<td>N=50, GDR newborn</td>
<td>US, 3.5-5 MHz</td>
<td>2.1 ml, newborn</td>
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<td>1989 (17)</td>
<td></td>
<td>Gutjahr et al. method (10) (correction factor 0.5)</td>
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<tr>
<td>Ivarsson et al.</td>
<td>N=66, Sweden age range: 5-16 years</td>
<td>US, 10 MHz</td>
<td>1.3 ml, 5-6 years</td>
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<td>1989 (1)</td>
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<td>Brunn et al. method (8)</td>
<td>4.1 ml, 13 years</td>
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<td></td>
<td></td>
<td></td>
<td>7.0 ml, 15-16 years</td>
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<tr>
<td>Tajiakova et al.</td>
<td>N=852, Czechoslovakia age range: 7-16 years</td>
<td>US, 5 MHz</td>
<td>2.5 ml, 7-8 years</td>
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<td>1989 (23)</td>
<td></td>
<td>Brunn et al. method (8)</td>
<td>5.5 ml, 13-14 years</td>
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<td>(correlation factor 0.524)</td>
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US = ultrasound

No palpable nodules were found. The echogenicity of the thyroid was distinctly greater than that of the adjacent muscles throughout. Focal irregularities in echo structure were noted in 5 children (6.6%), 3 girls and 2 boys. In 4 children one or more anechoic, rounded structures 2-3 mm in diameter, were found in one or both lobes. These were considered to be either cysts or more probably dilated follicles. Three anechoic, small, rounded lesions, 5 mm in diameter, were noted in the left lobe in one girl. These lesions were considered to be cysts.

The lesions found in the US scans were so small that fine-needle biopsy was not performed. A fol-
low-up examination will be performed after one year.

Discussion

Accurate estimation of the normal volume and echo structure of the thyroid gland is important for evaluating the possible influences of different diseases on the thyroid gland. The method to determine the thyroid volume should be easy to use and reliable.

Isotope examinations for the determination of the size, location and functioning of the thyroid gland are not recommended in children because of the radiation risk (1), and palpation is especially unreliable in children (12,13). Thyroid US, a non-invasive and radiation-free examination, is recommended especially for pediatric use (17).

The early method for determining thyroid volume by static US was developed by Rasmussen & Hjort (18), who used cross-sections through the gland at 0.5-2.0 cm intervals and a computer programme to calculate the areas of the sections and, finally, the thyroid volume. Later Brunn et al. (8) described a more simple, and more convenient and less time-consuming method using realtime US for field surveys, which involves estimation of three dimensions of each lobe and calculation of its volume as a rotation ellipsoid. The average error of this method has been estimated to be 16% when compared with direct measurements obtained by submersion. The isthmus is not measured separately, but it is less than 5% of the total thyroid volume (8).

The materials, methods and results of existing epidemiological surveys of the thyroid by ultrasonic in children and adolescents are presented in Table 2. The materials ranged from 50 to 2244 cases and the age of the subjects from 0 to 20 years. Differences in daily iodine intake, genetic background, and environmental factors could contribute to the differences in mean thyroid volume (24). The volume certainly varies from one report to another, and iodine deficiency appears to be the decisive factor in endemic goitre areas (25).

Gutekunst et al. (12) found the mean thyroid volume in 13-year-old schoolchildren in the northern part of West Germany to be 6 ml in boys and 8 ml in girls, that in southern West Germany to be 12 ml in boys and 14 ml in girls, and that in Sweden to be 4.1 ml in boys and 4.3 ml in girls. Müller-Leisse et al. (22) found the mean thyroid volume of 13-year-old German schoolchildren to be 9.7±3.3 ml. Ivarsson et al. (1), studying a small series of 13-year-old Swedish children, found a mean thyroid volume of 4.1 ml. The mean thyroid volume in these 13-year-old Finnish schoolchildren was 6.5±1.6 ml, in the boys 6.3±1.8 ml against 6.7±1.4 ml in the girls, which lies between the figures found in West Germany (with insufficient iodine intake) and Sweden (presumably with sufficient iodine intake) (Fig. 4).

A similarly difference in thyroid volume has also been found between German and Swedish adults, the mean thyroid volume being 21.4 ml in German adults and 10.1 ml in Swedish adults (13). Brander & Kivisaari (26) found a thyroid volume of 11.5-14.2 ml in pregnant women and 12.2 ml in controls in small series of Finnish adults (N=43). According to Müller-Leisse et al. (22) the difference in thyroid gland volume between Germans and Swedes can be explained by adequate iodine salt prophylaxis in Sweden. The iodized salt in Finland contains 25 mg

Fig. 4.
The 95% confidence limits for mean thyroid volume (shaded and white boxes) and ranges (filled circles) for thyroid volume in 13-year-old children in Finland, Sweden and West Germany.

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iodine (potassium iodate) per kg, where the optimum iodine intake recommended by WHO is 150-300 μg iodine daily (27). Gutekunst et al. (13) found little difference in iodine excretion between subjects (children and/or adults) using iodized salt and those not doing so (p<0.05), since all show the same kind of iodine deficiency. Thyroid volume similarly did not differ.

There is disagreement in the literature regarding sex-related differences in thyroid volume (1,9,12,17,19,20,22,28,29). No significant difference in thyroid volume was observed in this study between the boys and the girls (p=0.106), presumably because there was no significant difference in mean body weight or mean body surface area between them. No difference was presented either by Gutekunst et al. (12), Klima et al. (20), Einenkel (17) or by Ivarsson et al. (1) (Table 2). Müller-Leisse et al. (22) found no sex-related differences in thyroid volume before the age of 10 years, but the thyroid volume of the girls was found to be significantly larger than that of the boys at the time of puberty. Leisner et al. (19) reported uniformly greater thyroid volume in girls than in boys. The thyroid volume was larger in the girls than in the boys among the 13-year-old German schoolchildren (12). This could partly be explained by a difference in body weight, but no such reason was mentioned. The difference in the thyroid gland volume between adult males and females was explained by Hegedüs et al. (9) and Berghout et al. (29) solely by a difference in body weight, as there was no significant difference in the ratio of thyroid volume to body weight. Olbricht et al. (28) found a significant difference in thyroid volume between males and females (p<0.05), but thyroid volume was not related to body weight or height in regression analysis.

The present figures show the right lobe to be significantly larger than the left one (p<0.001) in both boys and girls. This is in accordance with the findings of Müller-Leisse et al. (22) and Einenkel (17). On the other hand, Tajakova et al. (23) found no difference between the volumes of the right and left thyroid lobe in children aged 7 to 14 years, although the right lobe was found to be significantly larger than the left one at 15-16 years of age. In the adults studied by Olbricht et al. (28), Oberhofer et al. (15) and Struve & Hinrichs. (30) the right lobe was significantly larger than the left one.

Positive correlations were found in our material between thyroid volume and body height, weight, and surface area in the total group. The girls had the best correlation between thyroid volume and weight. The boys had the best correlation between thyroid volume and body surface area. Our findings are in agreement with those of Leisner et al. (19) and Ivarsson et al. (1) (Table 1). They found even better correction factors between thyroid volume and body weight, height and surface area; the correction factors varied from 0.71 to 0.79. In the adults Hegedüs et al. (9) and Oberhofer et al. (15) found thyroid volume significantly correlated with both body weight and age. In the study of Berghout et al. (29) thyroid volume was positive related to body weight, but not to age. Olbricht et al. (28) found only a weakly positive correlation between thyroid volume and age or body surface area.

Focal irregularities in echo structure were found in 5 of the present subjects (6.6%). Small, rounded, anechoic structures are considered to be dilated follicles and found in normal thyroid glands (11). The echo structure was considered pathological in one (1.3%) of our subjects. In the literature, focal changes have been found in 0.0-0.9% of cases (Table 2). Apart from Ivarsson et al. (1) (10 MHz), all the other groups employed a 3.5-5 MHz transducer, giving a poorer resolution than with the 7.5 MHz transducer used here. In symptomless adults, focal irregularities in echo structure have been found in 3.6-35.6% (13,31).

In summary, US is by far the most reliable non-invasive method to determine the thyroid volume. The measurement methods and US apparatus used and the intra- and inter-observer errors can influence the results. These factors should be examined in future. The differences in thyroid volume between different areas and countries are so high that the decisive factor for thyroid gland volume must be considered to be alimentary iodine intake. More research is nevertheless needed, focusing on different age groups, on different stage of puberty, and on the consistency and validity of the measuring method.

References


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