# Influence of knowledge on iodine content in foodstuffs and prophylactic usage of iodized salt on urinary iodine excretion and thyroid volume of adults in southern Germany

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**Einfluß des Wissens über Jod in Lebensmitteln und einer Jodsalz-Prophylaxe auf die Urin-Jodausscheidung und das Schilddrüsenvolumen von Erwachsenen in Süddeutschland**

**Summary** Thyroid volume, urinary iodine excretion as well as personal nutritional knowledge and individual iodine prophylaxis were determined during a health education program on iodine deficiency and prophylaxis in 1992. Participants were 472 male and 568 female (mean age 27.7 years) students and employees of five universities in the southern part of Germany. The study aimed to clarify the relationship between personal knowledge on iodine, individual iodine prophylaxis and parameters of iodine deficiency (thyroid volume, iodine excretion) in a well known iodine deficient area.

Mean thyroid volume (mean ± SD) was 19.7 ± 8.3 ml in males and 15.8 ± 7.1 ml in females. 25.5 % of females and 19.9 % of males showed thyroid volume above the upper normal values. Total mean urinary iodine excretion was 70.7 ± 42 µg I/g creatinine reflecting WHO-grade-I iodine deficiency. 80.8 % of total subjects used iodized salt and 43.2 % stated to consume salt-water fish to meet their iodine requirement. The female non-users had significantly lower iodine excretion (no iodized salt, no salt-water fish: 61.4 ± 31.3 vs. +iodized salt, +salt-water fish: 83.9 ±47.6 µg I/g creatinine; $p < 0.05$), however, thyroid volume was identical in these groups. The area of residence over the last 10 years did not significantly influence the thyroid volume. The goiter incidence increased with age. Although our study population was highly educated (81.8 % students) and the subjects were provided with educational brochures immediately prior to the study, knowledge about iodine content of food was poor. We conclude that despite a high degree of voluntary iodine prophylaxis and educational programs the iodine intake is insufficient. The use of iodized salt in households, cafeterias, and also in food manufacturing must be increased for sufficient iodine prophylaxis.

**Zusammenfassung** Im Rahmen einer Gesundheitskampagne zu Jodmangel und Jodprophylaxe an fünf süddeutschen Universitäten wurde 1992 das Schilddrüsenvolumen und die renale Jodausscheidung bei 472 Männern und 568 Frauen (mittleres Alter 27,7 Jahre) bestimmt. Ziel war es den Einfluß des Ernährungswissens und der durchgeführten Jodprophylaxe auf den Jodversorgungsstatus der Studienteilnehmer in einem Jodmangelgebiet zu untersuchen. Das mittlere Schilddrüsenvolumen betrug 19,7 ± 8,3 ml (x ± SD) bei den Männern und 15,8 ± 7,1 ml bei den Frauen. 19,9 % der Männer und 25,5 % der Frauen wiesen Schilddrüsenvolumina über der geschlechtspezifischen Norm auf. Die mittlere Jodausscheidung entsprach dem WHO-definierten Jodmangel Grad I (70,7 ± 42 µg (J/g Kreatinin). 80,8 % bzw. 43,2 % des Gesamtkollektivs gaben an, Jodsalz zu verwenden bzw. Seefisch zu essen, um ihren Jodbedarf zu decken. Die korrespondierende

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Jodausscheidung der weiblichen Jodsalzverwender und Seefischesser war signifikant erhöht (83,9 ± 47,6 vs. 61,4 ± 31,3 μg J/g Kreatinin, p < 0,05). Das Schilddrüsenvolumen unterschied sich zwischen diesen Gruppen jedoch nicht. Der Aufenthaltsort der letzten 10 Jahre hatte keinen signifikanten Einfluß auf das Schilddrüsenvolumen. Die Häufigkeit von Schilddrüsenvolumina über der geschlechtsspezifischen Norm stieg mit dem Alter. Auch in diesem überdurchschnittlich gebildeten und jungen (81,8 % Studenten) Kollektiv war die Jodversorgung, gemessen am Schilddrüsenvolumen und an der Jodausscheidung, und das Wissen über Jod und Ernährung schlecht. Die derzeit durchgeführte individuelle Jodprophylaxe führt nicht zu einer ausreichenden Jodversorgung. Der Einsatz von jodiertem Speisesalz in Haushalten und Kantinen, und auch für die industrielle Herstellung von Lebensmitteln muß erhöht werden.

**Key words** Iodine prophylaxis – iodized salt – iodine excretion – hyroid volume

**Schlüsselwörter** Jod – Jodsalz – Jodausscheidung – Schilddrüsenvolumen – Jodprophylaxe

## Introduction

In western Germany the mean of iodine intake from food is about 70–80 μg/d for adults (17). Compared to the recommendations on iodine intake (4) there is an iodine deficit of more than 100 μg/d. The consequences are that goiter is endemic (prevalence > 10 %) in Germany and that the renal iodine excretion corresponds to the WHO defined deficiency grade I (50–100 μg I/g creatinine) or II (25–50 μg I/g creatinine) (16). Milk, dairy products, and salt-water fish are the main food sources of iodine in Europe. Furthermore, edible seaweed and marine animal products contain high amounts of this trace element (e.g., up to 2 660 μg I/g) (19, 20) but do not play a substantial role in German food consumption practice, especially in the regions far from the shore. In Germany, the use of iodized salt (20 ± 5 mg I/kg) is highly recommended to the public by educational campaigns. Up to now usage of iodized salt is voluntary and not prescribed by German law.

Some indications exist that goiter prevalence is higher in the southern area of Germany which has been reported for the former West Germany as well as the former GDR (11, 18, 21).

The objectives of the present investigation are i) to study the influence of nutritional knowledge and iodized salt usage in a highly educated group of young adults (students) on thyroid volume and urinary iodine excretion, ii) to investigate the effect of the site of residence over the last 10 years on thyroid volume and iodine excretion, and, iii) to examine if there is an effect of subject's age on thyroid volume and iodine excretion.

## Methods

### Subjects recruitment

Volunteers were recruited during an educational campaign on iodine deficiency and goiter by a health insurance company at five Bavarian universities (Augsburg, n = 146 subjects; Würzburg, n = 231; Erlangen, n = 223; Passau, n = 190; München-Weihenstephan, n = 250). The campaign consisted of nutritional information about iodine content of foodstuffs given by a nutritionist and the distribution of educational brochures (information about importance of iodine for human development, prevention of thyroid diseases, iodine content of food). People were requested to fill in a questionnaire which included questions about sex, year and place of birth, residence during the last 10 years, usage of iodized salt, known thyroid diseases, intake of thyroid medication, possible iodine contamination, estimation of personal iodine supply and nutritional knowledge on iodine. Results concerning thyroid diseases and medication will be published elsewhere (Greil et al., in preparation). The subjects had the opportunity to complete the questionnaire at home. On the first or second day after the nutritional information sonographic thyroid volume measurement was performed. On this day subjects were asked for the completed questionnaire and for a spontaneous fresh morning urine sample.

### Ultrasonographic examination of the thyroid gland and urinary analysis

Ultrasonography was performed with two real-time ultrasonographic instruments (Imager 2380, 5 MHz sound applicator Phonosonic Series 2000, and Sonoline, 7.5 MHz sound applicator; both Siemens, München, Germany). Thyroid volume was calculated from the length, width and thickness of both thyroid lobes (3). Performance of ultrasonography was done at all five localities by the same two investigators (W.G. and M.R.). The iodine content of urine was determined by the adopted cer-arsenite method of Sandell and Kolthoff (25). Urinary iodine concentration was related to the renal creatinine excretion (μ I/g creatinine). The creatinine concentration in the urine samples was measured according to the modified Jaffé method (Merck, Darmstadt).

### Statistics

The data were evaluated with the statistical software package SPSS/PC + 4.0 (SPSS Inc. Chicago, U.S.A.).

Descriptive statistics (frequencies, means, SD, SEM) and Pearson's correlation coefficient were computed. Variable effects were tested with a one- or two-factorial model. Significance of differences were examined by the Student's *t*-test, the LSD-test or the Student-Newman-Keuls test for multiple comparisons. An α level of 5 % was regarded as the significance limit.

## Results

A total of 1 040 persons was enrolled in the study (54.6 % females) where the majority was not older than 35 years, and 78.2 % declared southern Germany (Bayern and Baden-Württemberg) as their predominant place of residence in the last 10 years. 81.8 % were students and 18.2 % university employees.

The mean age, thyroid volume and the urinary iodine excretion of all participants and male and female subpopulations are given in Table 1. On average, thyroid volume and urinary iodine excretion were 17.6 ± 7.9 ml and 70.7 ± 42.0 μg I/g creatinine, respectively (mean ± SD). Only 16.1 % of all (20.6 % of the female and 10.8 % of the male) subjects had an adequate iodine excretion (WHO deficiency grade 0). WHO deficiency grade III plus grade II (< 50 μg I/g creatinine) was found with 45.1 % and 25.7 % of male and female subjects, respectively. 19.9 % of the male and 25.5 % of the female subjects showed thyroid volumes above the upper normal range (women: 18 ml; men: 25 ml; 2). The mean urinary excretion (μg I/g creatinine ± SD) in the five Bavarian university towns was as follows: Augsburg, 77.60 ± 45.76; Würzburg, 71.70 ± 41.97; Erlangen, 67.65 ± 43.30; Passau, 61.82 ± 35.98; München-Weihenstephan, 75.13 ± 41.52.

The answers to the questions concerning iodine content in foodstuffs are summarized in Table 2. The subjects were requested to select food items out of a list of 11 which they use to meet the iodine requirement. Less than one-half of the whole investigated group stated to eat salt-water fish, whereas milk and dairy products were consumed by 76.2 %. Among the several food items a sex difference ($p < 0.05$) was seen with "meat" and "sausages"; more men than women (meat: 32.1 % vs. 15.9 %; sausages: 23.7 % vs. 13.0 %) stated that they choose those products to meet their personal iodine requirement. Approximately one-half of the subjects stated to meet their iodine requirement by vegetables, fruits and mineral water although iodine content is low. Only 10.7 % judged their personal iodine supply from food as "poor", whereas 21.2 % believed it to be "adequate". The majority of subjects (68.1 %) judged their iodine supply

**Table 1** Age, thyroid volume (TV, ml), urinary iodine excretion (IE, μg I/g creatinine) (mean ± SD) of total study population and of male and female subpopulations and according to the area of residence during the last 10 years (South = Bayern, Baden-Württemberg; Middle-West = Hessen, Saarland, Rheinland-Pfalz, Nordrhein-Westfalen; North = Niedersachsen, Schleswig-Holstein, Bremen; East = Thüringen, Sachsen, Mecklenburg-Vorpommern, Brandenburg; Other = different foreign countries)

| | | n | Age | TV | IE |
|---|---|---|---|---|---|
| Total | total | 1 040 | 27.7 ± 8.8 | 17.6 ± 7.9 | 70.7 ± 42.0 |
| | male | 472 | 27.7 ± 8.6 | 19.7 ± 8.3§ | 62.5 ± 38.0§ |
| | female | 568 | 27.7 ± 9.0 | 15.8 ± 7.1 | 77.4 ± 43.9 |
| South | total | 741 | 28.4 ± 9.5 | 18.0 ± 8.2 | 72.4 ± 44.2 |
| | male | 354 | 28.3 ± 9.2 | 20.0 ± 8.6§ | 61.9 ± 37.7§ |
| | female | 387 | 28.6 ± 9.7 | 16.1 ± 7.4 | 82.1 ± 47.4 |
| Middle-West | total | 102 | 24.6 ± 4.4 | 16.4 ± 6.4 | 62.8 ± 28.3 |
| | male | 44 | 24.6 ± 4.0 | 18.6 ± 6.6§ | 61.4 ± 30.4 |
| | female | 58 | 24.6 ± 4.7 | 14.7 ± 5.8 | 63.9 ± 26.9 |
| North | total | 36 | 24.2 ± 2.3 | 16.3 ± 6.4 | 59.4 ± 43.9 |
| | male | 13 | 23.9 ± 2.1 | 19.1 ± 7.3* | 50.0 ± 26.4 |
| | female | 23 | 24.4 ± 2.5 | 14.7 ± 5.3 | 64.7 ± 51.1 |
| East | total | 19 | 28.2 ± 9.9 | 19.4 ± 9.9 | 53.7 ± 23.0 |
| | male | 6 | 28.8 ± 12.6 | 20.4 ± 13.2 | 50.2 ± 24.4 |
| | female | 13 | 27.9 ± 9.0 | 18.9 ± 8.6 | 55.4 ± 23.2 |
| Other | total | 50 | 28.4 ± 7.3 | 16.4 ± 6.4 | 74.4 ± 43.6 |
| | male | 25 | 29.0 ± 8.2 | 17.2 ± 6.1 | 79.0 ± 54.0 |
| | female | 25 | 27.8 ± 6.4 | 15.6 ± 6.6 | 69.7 ± 30.3 |

§ Significant differences between male and female subjects $p < 0.01$
* Significant differences between male and female subjects $p < 0.05$

as "not known". More than 26 % of the males, but only 14 % of the females did not use iodized salt ($p < 0.05$). 10.8 % of the study population believed that an overloading with iodine by food intake is possible (30.8 % did not know).

**Table 2** Foodstuffs used to meet iodine requirements and usage of iodized salt (% relative frequencies of answers)

| Foodstuffs to meet iodine requirement | number of answers | % relative frequencies of answers | |
|---|---|---|---|
| | | yes | no |
| Fruits | 822 | 45.6 | 54.4 |
| Vegetables | 822 | 56.0 | 44.0 |
| Nuts | 822 | 10.3 | 89.7 |
| Bread/cereals | 822 | 46.6 | 53.4 |
| Milk/dairy products | 822 | 76.2 | 23.8 |
| Cheese | 822 | 49.6 | 50.4 |
| Meat | 822 | 24.1 | 75.9 |
| Sausages | 822 | 18.4 | 81.6 |
| Fresh-water fish | 822 | 6.8 | 93.2 |
| Salt-water fish | 822 | 43.2 | 56.8 |
| Mineral water | 822 | 56.6 | 43.4 |
| Iodized salt usage | 1 039 | 80.8 | 19.2 |
| Preference for iodized bread | 830 | 91.2 | 8.8 |

Self-declared iodized salt usage and salt-water fish consumption did not correlate with smaller thyroid volumes in the female subjects, although iodine excretion was significantly higher in this group (Table 3). Moreover, there is also a trend for higher iodine excretion in male subjects who stated to consume salt-water fish and iodized salt (Table 3). Subjects who stated to eat milk, dairy products and cheese to meet their iodine requirement did not differ in thyroid volume and iodine excretion, compared to others.

The area of residence over the last 10 years did not significantly influence the thyroid volume although a trend towards smaller glands for the northern German area was observed (Table 1). The iodine excretion was affected significantly by the area of residence ($p = 0.031$), but a comparison of means revealed only a significant difference between areas south and mid-west ($p < 0.05$; Table 1). Subjects who came from outside the German area seemed to have a higher iodine excretion, compared to others.

Pearson's correlation coefficient between age and thyroid volume ($r = + 0.3213$) and age and iodine excretion ($r = + 0.1622$) was found to be highly significant ($p < 0.001$). While in the age group 19–25 years only 18.7 % of the females and 13.9 % of the males had a thyroid volume above upper normal levels (women 18 mL; men 25 mL), these numbers increased steadily to percentages of 52.8 % and 36 %, respectively, in women and men from 46 to 55 years of age (age 26–35 years: women 29.8 %; men 21.2 %; age 36–45 years: women 37.5 %; men 52.6 %). In all groups the thyroid volumes were larger in males than in females and the iodine excretion in females was always higher than in males (Table 4).

**Table 3** Effect of self-declared iodized salt usage and salt-water fish consumption on iodine excretion (IE, µg I/g creatinine) and thyroid volume (TV, ml) (mean ± SD)

**Iodine excretion (µg J/g creatinine)**

| | no iodized salt + no saltw. fish | no iodized salt + saltw. fish | iodized salt + no saltw. fish | iodized salt + saltw. fish |
|---|---|---|---|---|
| female | 61.4 ± 31.3 | 69.4 ± 40.9 | 77.5 ± 45.5 | 83.9 ± 47.6[#] |
| (n) | (29) | (25) | (203) | (151) |
| male | 56.3 ± 33.8 | 64.4 ± 46.6 | 59.8 ± 35.2 | 67.1 ± 40.1 |
| (n) | (70) | (40) | (164) | (139) |

**Thyroid volume (mL)**

| | no iodized salt + no saltw. fish | no iodized salt + saltw. fish | iodized salt + no saltw. fish | iodized salt + saltw. fish |
|---|---|---|---|---|
| female | 14.8 ± 5.3 | 17.3 ± 9.1 | 15.6 ± 5.8 | 16.9 ± 9.4 |
| (n) | (29) | (25) | (203) | (151) |
| male | 17.2 ± 6.6 | 19.3 ± 7.3 | 19.7 ± 8.5 | 21.1 ± 9.3[$] |
| (n) | (70) | (40) | (164) | (139) |

[#] Mean iodine excretion of subgroup "iodized salt + salt-water fish" was significantly different from group "no iodized salt + no salt-water fish" ($p < 0.05$)
[$] Mean thyroid volume of subgroup "iodized salt + salt-water fish" was significantly different from group "no iodized salt + no salt-water fish" ($p < 0.05$)

**Table 4** Age, thyroid volume (TV, mL) and urinary iodine excretion (IE, µg I/g creatinine) (mean ± SEM) of total study population and of male and female subpopulations in four age groups

| Age | | n | TV | IE |
|---|---|---|---|---|
| Group 1 | total | 604 | 15.9 ± 0.3[a§] | 67.3 ± 1.7[a] |
| 19–25 | male | 267 | 17.7 ± 0.4[&] | 59.1 ± 2.2[&] |
| | female | 337 | 14.5 ± 0.3 | 73.9 ± 2.3 |
| Group 2 | total | 302 | 18.4 ± 0.5[a] | 70.3 ± 2.4[a] |
| 26–35 | male | 151 | 20.0 ± 0.5[&] | 61.9 ± 2.0* |
| | female | 151 | 16.1 ± 0.5 | 75.2 ± 3.5 |
| Group 3 | total | 51 | 22.1 ± 1.5[b, c] | 73.4 ± 5.6[a] |
| 36–45 | male | 19 | 27.4 ± 2.8[&] | 51.8 ± 4.6[&] |
| | female | 32 | 19.0 ± 1.5 | 86.2 ± 7.7 |
| Group 4 | total | 61 | 23.3 ± 1.7[c] | 93.2 ± 6.2[b] |
| 46–55 | male | 25 | 25.4 ± 2.0 | 82.0 ± 8.7 |
| | female | 36 | 21.8 ± 2.5 | 101.0 ± 8.4 |

[&] Significant differences between male and female subjects $p < 0.01$

* Significant differences between male and female subjects $p < 0.05$

[§] Results of a multiple comparison of mean thyroid volumes (column 4) and mean urinary iodine excretion (column 5), respectively, between age groups on a $p < 0.05$ significance level. Different means are indicated by different superscript letters (reading example for thyroid volume: mean TV of groups 1 and 2 are not different, but both are different from groups 3 and 4)

## Discussion

The mean thyroid volume of the present study population (Table 1) was lower than in other reports in Germany (10, 27). The percentage of subjects showing thyroid volumes above the upper normal level was somewhat lower than the average goiter incidence in the population of Germany (32 %) (22) and may be explained by the lower mean age of our study group. The thyroid volume was significantly different between males and females (Tables 1, 4) which was confirmed by others (27).

The mean iodine excretion related to creatinine concentration (µg I/g creatinine; Table 1) was similar to the values found in the literature for German subjects (65.6 ± 7.6 [SEM], 7; 83.7 ± 94.4 [SD], 10; 94.1 ± 93.1 [SD], 12; 72 [median], 13) and corresponded to the WHO-grade-I deficiency. Percentages in the WHO-grade-III plus grade-II deficiency were much more favorable than found in the VERA-study (males 77.3 %, females 59.8 %; 7) which probably may be caused by the higher education and/or the lower age in our study than in the VERA-study group (26). Gutekunst et al. (12) reported percentages of 48.8 % and 22 % with a mean iodine excretion lower than 75 µg and 30 µg I/g creatinine, respectively.

The percentage of self-declared iodized salt users in this study (Table 2) exceeded the 48 % who stated to use iodized salt regularly in a representative interview study in 2 003 German households (28). This may be due to the fact that our investigated group was comparably well educated, which has been found also in the above cited study (28). Another explanation for this comparably high percentage may be the investigation area in southern Germany. In the above-mentioned interview study those subjects using iodized salt most frequently lived in the middle and south of Germany (28). Although the subjects were well informed by the educational campaign and they have had the opportunity to consult the educational brochures prior to the completion of the questionnaire, the knowledge about food and iodine was poor (Table 2). This was reflected for instance by those 30.8 % who did not know if an iodine overloading by the intake of conventional food is possible. It seems to demonstrate that the success of the educational campaign was not as good as expected. These results have been confirmed (28) and show that, at present, people of younger age and higher education also suffer from iodine deficiency, although they are open-minded to the consumption of iodized salt. The statement on the use of iodized salt or salt-water fish consumption was not accompanied by smaller thyroid volumes in both female and male subjects, as found in a study with children (14). To the contrary, the male iodized salt users revealed the highest thyroid volumes (Table 3). This could not be explained by a higher age. A probable explanation could be that those volunteers use iodized salt and eat salt-water fish due to a recommendation of their physicians, because a goiter was already diagnosed prior to the study. Recently, it has been pointed out that the duration of the prophylaxis is also important (19). It may take two generations or more before the goiter has disappeared in all groups. On the other hand, the statement on iodized salt usage and salt-water fish consumption was accompanied by higher iodine excretion. At least in the females a significant increase was observed (Table 3).

Presently, the main additional iodine source beside the natural iodine content of food is iodized salt. Based on a rough assumption of a 24 h urine volume of 1.3 l a daily iodine excretion of 127 µg/d for women who stated iodized salt usage (with or without additional salt-water fish consumption) can be calculated from the urinary iodine concentration (µM I/L; data not shown). Compared to the female non-users (108 µg I/d) this is an additional iodine excretion of 20 µg I/d due to iodized salt intake (corresponding values for men are: iodized salt users 135 µg I/d versus non-users 120 µd I/d). Under the assumption that the urinary iodine excretion corresponds to 90 % of the iodine intake (19) this value is similar to an estimated additional iodine intake by iodized salt of 16.6 µg I/d for women (30). With tablet supplementation in adults (corresponding to an additional intake of 29 µg I/d or approx. 1 g of iodized salt) an increase of iodine excretion of 19 µg I/d after 38 weeks has been reported (16). However, our above estimation is only tentative because 24 h urine volume was not actually measured. A north-to-south variation of goiter prevalence has been reported for the former West Germany as well as the former GDR (11, 18, 21). No such observation has been made for the iodine excretion in the VERA-study group (6; former FRG) and in the sample reported by Gutekunst et al. (12) (former West Germany and GDR). In the present study also no differences were found between people living in the northern or southern areas of Germany over the last 10 years. However, it has to be taken into account that this study sample was not representative for the total German population. Iodine supply measured as iodine excretion related to creatinine seemed to be slightly better in the southern areas (Table 1). The lack of a clear trend is probably due to the intense exchange of food, the great difference of local iodine concentration in drinking water, and the generally unknown percentage of true voluntary iodine prophylaxis by iodized salt (7, 10, 27). Apart from this, it has to be taken into account that tobacco smoking is goitrogenic and that there may be possible effects of dietary goitrogens and iodine-containing medication, which was not controlled in most of the studies (8, 19). Hence, today's iodine supply in Germany appears not to be influenced by the distance from the North Sea.

It is well known and also found in the present study that the thyroid volume is positively correlated to age (27). Among over 60-years-old subjects a goiter prevalence of 48.8 % has been reported (15). The correlation between thyroid volume and age was additionally illustrated in this study by the increase of goiter prevalence with increasing age, although this must be interpreted with caution because of the small numbers of subjects in the older groups (Table 4). Also, a significantly positive correlation of $r = +0.1622$ was found between age and iodine excretion ($p < 0.001$). Whether from this relation an increasing iodine intake with age has to be derived remains questionable, but this was supposed to be the case for the female subjects in the VERA-study group (7). Probably, the observed significant correlation is a sham correlation. Reasons for this assumption are that the renal creatinine excretion was also positively correlated with age ($p < 0.001$; $r = +0.1915$) and there was no relation between age and urinary iodine concentration ($r = 0.0104$). Because renal creatinine excretion is dependent on muscle mass and physical activity, factors which are changing with age, it is concluded that the iodine status is underestimated in younger age and overestimated in older age. The age dependence of iodine excretion (µg I/g creatinine) has been discussed for children and the iodine excretion has been suggested to relate better to body surface than to creatinine as also recommended by the WHO (24, cited by 12). Recently, the ratio of urinary iodine to creatinine was found to be an unsuitable indicator for evaluating iodine status in areas where large inter- and intraindividual variations in urinary creatinine excretion exists (9).

Although iodine prophylaxis is now practiced with great success in developing countries (6), it is an anachronism that in highly industrialized Germany the urinary iodine excretion of about half of a group of 2–3-year-old toddlers fall in the WHO deficiency grade II (23).

## Conclusions

Hence, we consider voluntary prophylaxis with iodized salt in Germany as not sufficient and suggest the usage of iodized salt in households and in cafeterias, as well as in food manufacturing. It was pointed out that only the additional use of iodized salt in the manufacturing of foodstuffs, and not the sole use of iodized salt in households, may rise the dietary iodine intake to a level which is adequate to the requirement (5). Moreover, we did show only recently that the usage of iodized salt in cafeterias seems to be more effective in increasing the iodine content in lunch meals than assumed so far (31). The iodine content of 20 ± 5 mg I/kg salt seems to be sufficient because the bulk of salt is consumed in bread and bakery products, meat products and cheese (1).

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