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Recent data on iodine intake in Germany and Europe

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ABSTRACT

Iodine is essential for the synthesis of thyroid hormones. These regulate metabolism, promote growth, development and maturation of all organs, especially the brain. Most iodine is found in oceans and most continental soil and ground water is deficient in iodine. Therefore, around 2 billion individuals are estimated to have insufficient iodine intake and are at risk of iodine deficiency disorders. The best carrier for save iodine supplementation is salt, as the daily intake of salt is mainly constant. Due to the collaboration between international and national organisations and the salt industry, many developing and developed countries introduced universal salt iodization (USI) or have mandatory or voluntary fortification programs.

In Germany as in most European countries the use of iodized salt is voluntary not only in household but also in the food industry. Two recent epidemiological surveys in Germany revealed that 33% of children and 32% of adults are still suffering from mild to moderate iodine deficiency. The best surrogate parameter for iodine deficiency is goitre. The goitre prevalence is around 30% in children as well as in adults which is in accordance with the documented iodine deficiency. From other European countries epidemiological derived data on iodine intake are only available from Denmark and Poland. Further efforts are under way to reveal the iodine status with proper methods in all European countries. On this background it might be possible to establish adequate iodine fortification programs in all European countries.

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1. Introduction

Significant amounts of organic-iodine species are found exclusively in the marine flora, which concentrate iodine around 3000-fold. Under sun exposure or mechanical stress, these compounds (mainly CH_3I, CH_2I_2 and I_2) are released from the seaweed. Marine aerosol mainly contains iodate or iodide, which is derived through photolysis or reaction with ozone or nitrate. Around 3–5 × 10^{12} g of these iodine compounds are released per year into the atmosphere and come back to the ocean and continental regions through rain fall [1]. Thus most of the continental areas worldwide are lacking of iodine in the natural food chain, and iodine supplementation is mandatory to prevent iodine deficiency disorders (IDD) [2–5].

Inadequate iodine intake is associated with impaired thyroid function, as iodine is essential for the synthesis of thyroid hormones. Iodine deficiency and therefore low thyroid hormone formation causes the well-known IDD [2]. These include i.e. an

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increased risk of early abortion, low birth weight, preterm delivery, increased risk for behavioural and cognitive impairment, mental retardation as well as goitre development. During infancy, the requirement of thyroid hormones and therefore iodine is highest per kg/BW for normal ongoing neurodevelopment [5–7]. The impact of iodine deficiency and therefore the low availability of thyroid hormones in the brain during early development is comprehensively reviewed in the recently published book of B. Demeneix [8]. She in addition outlined the deleterious interaction with several environmental chemicals, the so called "endocrine disruptors" that interfere with the thyroid hormone action, especially in brain development and maturation.

Several, but not all studies have shown an association between mild to moderate iodine intake during pregnancy and impaired neuro-intellectual outcome in offspring [2,7]. Recent new prospective studies, however, highlight the importance of sufficient iodine intake during pregnancy for the intellectual performance of the progeny. Schoolchildren (mean 8 y) born to mothers having a urinary iodine excretion less than 150 μg/g (iodine-creatinine ratio) during the first trimester were more likely to have scores in the lowest quartile for verbal IQ, reading accuracy, and reading comprehension than were those of mothers with higher iodine excretion [9]. Another recent prospective study was done in northeaster Sicily, which is a known mild to moderate iodine deficient area. IQ tests (Wechsler Intelligence Scale for children) were administered to children (age 6–12y) from mothers using regular iodized salt before and during pregnancy with or without L-Thyroxine supplementation to adjust TSH within the low normal range. The progeny of mothers using iodine supplementation had a better neuro-intellectual outcome and this was independent on TSH or free thyroxine levels of the mother [10]. These prospective studies emphasize that the adequate iodine intake during pregnancy is more important for the brain development and maturation of the foetus than the thyroid status of the mother.

The requirement for sufficient iodine nutrition had already been recognized in 1980, when the WHO (world health organisation) documented that iodine deficiency affects around 20–60% of the whole population. Therefore, national and international programs were initiated with the goal to eliminate IDD worldwide until the end of the 20th century. This ambitious goal, however, could not be achieved [2–4].

2. Estimation of sufficient iodine intake

Iodide is absorbed from the food in the stomach and upper small intestine by around 90%, and depending on the thyroid iodine content is actively concentrated in the thyroid [11]. Around 70–80% of ingested iodine is concentrated in the thyroid. The normal iodine content in the thyroid is around 0.5–1 mg/g of wet thyroid weight. If the iodine content falls below 0.15 mg/g, thyroid cells start growing exponentially [12]. Therefore, goitre prevalence is the best surrogate marker for iodine deficiency in individuals. Less than 5% of a population should have goitre if iodine supplementation is sufficient [11]. In epidemiologic studies, however, the evaluation of the thyroid volume by ultrasound is rarely done, because this is expensive and difficult to perform in sufficient numbers.

The thyroid function is regulated by TSH, and in severe iodine deficiency TSH is increased along with thyroglobulin, and both can be used to detect iodine deficiency if thyroid diseases like autoimmune thyroiditis or toxic adenomas are excluded. The measurement of TSH in dried blood samples was established for neonatal screening to exclude congenital hypothyroidism [13]. Less than 3% of TSH values should be above 5 mU/L in an iodine sufficient area [11,13].

For practical and economic reasons, the determination of urine iodine concentration (UIC) in spot urine is worldwide established for epidemiological studies, especially for schoolchildren. An UIC of 100–200 μg/L reflects a sufficient iodine intake within a population as defined by the WHO/UNICEF/ICCIDD. This approximates the recommended daily iodine intake of around 150 μg/d [11]. This method however is suitable only for a crude examination as it does not capture the hydration status of individuals and in some surveys therefore the iodine/creatinine ratio had been measured. This is more expensive and therefore not used in most developing countries [4]. The pitfall, however, to ignore the hydration status may underestimate the iodine intake in adults.

3. Recommended iodine intake

The recommended age and gender dependent iodine intake for a given population is under permanent discussion within the national and international expert organisations [14]. This is because the recommendations either are for "optimal health" or "prevention of deficiency". Furthermore, exact data i.e. for the demand of trimester-specific or age-specific iodine intake in infants, childhood and elderly are lacking. The same is true for the upper limit of safe intake [14]. A selection of the different recommended reference values, recommended daily allowance (RDA) and dietary reference intake (DRI) are summarized in Table 1.

The Institute of Medicine (IOM) and newer calculations from iodine sufficient areas revealed a daily requirement for a healthy 70 kg person of 64 μg iodine, corresponding to around 100 μg L-Thyroxine (1.5 μg/kg BW). This, however, is only true, if the iodine storage of the thyroid gland is normal [11]. In infancy, the demand for thyroxine is higher, depending on age. Therefore, in relation to the body weight infants need more iodine compared to adults. The full-term infantís requirement is approximately 7 μg/kg BW iodine, corresponding to 10 μg/kg L-Thyroxine and for preterm infants around twofold [11].

4. Iodine intake in Germany

Since the early 70th of the last century some cross-sectional trials had been done in Germany to evaluate the iodine intake of the population. The first cross-section study in school children (age 13–15) revealed a mean UIC of only 27.5 μg/g creatinine [15]. During the following years the iodine intake gradually increased according to intensive educational advertising to around 80 μg/g creatinine in 1995. In West-Germany it was slightly higher compared to East-Germany (Table 2) [16].

The first epidemiological trial had been done in 1996 [16,17]. The median UIC (μg/g creatinine) was 83 μg/g in adults (n = 566, age 50–70 y), 57 μg/g in conscripts (n = 769) and 156 μg/g in breast-feeding mothers (n = 751) taking iodine supplements [17]. Around 30% of all individuals had an iodine intake below the WHO the recommendations. This corresponds to a goitre and thyroid nodule prevalence of around 30% within the adult German population [18]. The main sources of iodine intake were milk and milk products (20–30 μg), bakeries (20–30 μg) and to less amount seafood (10 μg) as identified by specially designed food questionnaire [17]. The contribution of iodized salt, used exclusively in the household was as less than around 6 μg of iodine per day [19].

In 2003–2006 a follow-up epidemiologic survey, including 18 000 infants and school children age 0–17 was operated by the national Robert-Koch-Institute, Berlin, Germany (Studie zur Gesundheit von Kindern und Jugendlichen in Deutschland = KiGGS) [20]. The mean UIC was 117 μg/d, and around 33% had an UIC less than 100 μg/d. This again is consistent with a goitre prevalence of around 30% in these children, evaluated by concomitant ultrasound