Objective assessment of individual and population iodine status, identification and treatment

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ABSTRACT

Objective: Discussion of iodine deficiency as a worldwide problem, proper identification of iodine status, the role of iodine in humans, and iodine supplementation.

Background: Iodine deficiency is a topic which is occasionally discussed as an epidemic. Iodine status isn't always evaluated by standardized means, and it is challenging to identify an entire country as insufficient with variations in diet and bodily needs. To address iodine deficiencies some countries have a program which universally iodizes all salt in the country. Salt iodization may or may not be the solution.

Methods: Relevant sources found on Logan Chiropractic College databases, Pubmed, EBSCO, published from 1932-2012.

Discussion: Iodine status, particularly deficiency has a number of negative effects some of which are irreversible if left untreated. Some irreversible effects include neurological development, goiter, breast cancer. Currently there are a variety of indirect methods being used to identify iodine status including surveys, topical absorption methods, urinary iodine excretion, urinary iodine concentration, serum blood panels, and thyroid ultrasonography. Iodine needs differ, especially those in pregnant women, lactating women, and children. Some populations meet iodine needs through diet more easily than others. Identifying dietary intake and appropriate supplementation of iodine is challenging due to the narrow optimal range of iodine intake. In iodine deficient countries urinary iodine concentration has been documented as low as 10µg/l, and in sufficient countries documented as high as 1235 µg/l.WHO identifies normal values of UIC ranging from 100-199µg/l and for the whole population minimum sufficient UIC as 100µg/l.

Conclusion: The most accurate assessment of iodine status is by a set of 10 - 24 hr urine samples to calculate Urinary Iodine Excretion (UIE). Calculating overall Iodine status of a country is most frequently tested by Urinary Iodine Concentration (UIC) with spot urine samples. Iodine deficiency disorders (IDD) are usually calculated by thyroid palpation which is practical, but overestimates worldwide IDD. Universal salt iodization in some countries may be effective, but in others may be challenging due to low-salt diets. In pregnant women, lactating women, individuals on a total enteral nutrition diet, and all children's iodine status should be evaluated during these crucial periods of time and monitored if they are susceptible to insufficiency.

Key words:

iodine, iodine/deficiency, iodized salt, iodine/administration & dosage, iodine/urine, skin absorption, humans

INTRODUCTION

The purpose of this article is to discuss iodine status, identification of iodine status, signs and symptoms of deficiency, evaluation and supplementation. Iodine is found in greatest concentration in the thyroid and an iodine deficiency is most often identified by use of thyroid panel and urinalysis (UA). Iodine deficiency in pregnant women may lead to problems in children such as hearing loss, learning deficits, brain damage, and myelination disorders. [1]

Popular sources suggest that iodine can be used to treat a variety of conditions including heart disease, cancer, high cholesterol, obesity, fatigue, the list goes on. Some of the above may be true, and may have some association with iodine levels, but it should not be exaggerated. The extended list covers a variety of symptoms which much of the general population has experienced. These conditions range from mild to severe, some very common such as fatigue and headaches. Other symptoms are ADD, hemorrhoids, fibrocystic breasts, and vaginal infections. Many of these symptoms are identified from a clinician's experience, and should not be used as a list to self-diagnose.[2]

The World Health Organization (WHO) publishes a limited list of signs of iodine deficiency disorders (IDD), which are present in more advanced deficiencies. At all ages IDD may present with goiter, hypothyroidism, impaired mental function, increased susceptibility to nuclear radiation. In pregnant women the complications for the fetus are much greater including causing spontaneous abortion, congenital anomalies, mental deficiencies, deaf mutism.[3]

Countries across the world have begun to widely require thyroid functioning testing, and some countries have decided to increase iodine supplementation. Within most if not all countries the regions vary from iodine deficient to iodine sufficient. Diets vary between rural and urban areas. Urban areas generally are less iodine deificient due to the availability of processed foods which contain iodized salt. Inland China is deficient due to the poor quality of soil leached of minerals such as iodine where many of the foods are grown. Foods such as kelp and saltwater fish are high in iodine content. The population of Japan and coastal areas of China have less iodine deficiency due to their diet containing more kelp and saltwater fish. [4,5] Within the United States there is a region referred to as the "goiter belt" including the great lakes and midwest, it's named this due to its prevalence as an iodine deficient area with a high prevalence of goiters.(Brown) Availability of iodine supplementation also is unequal between areas. Prevalence of iodine deficiency greatly varies by region, therefore requiring an entire population to be tested for thyroid function seems excessive, but a sampling the population periodically may be a useful assessment.[6,7]

China enacted the Universal Salt Iodization (USI) program in 1995, and in 2000 the Chinese Ministry of Health declared elimination of iodine deficiency disorders. WHO/ UNICEF/ ICCIDD recommends dietary allowance of 150µg/d iodized salt, and with the USI program in place 63.5% of iodine intake is from salt. [8] Iodine that is available from salt varies because a variable amount of iodine may be added in processing, there may be an uneven distribution of iodized salt within batches, iodine loss may occur due to salt impurities, packaging, environmental conditions. In the home iodine may be depleted from the salt by food processing, washing, and cooking processes.[3] It is recommended that countries with this program in place may need to continue to monitor the population. Some countries may have a more difficult time having success with this program due to the promotion of low-sodium diets, and cardiovascular concerns. A total diet study in China in 2009 focused on iodine intake. It found that 18-19% of children and 31.5% of adult women were still insufficient. The consequences of the USI haven't been all positive, with transient iodine-induced hyperthyroidism observed in individuals with a genetic predisposition. In other USI studies excess iodine intake leads to overt hypothyroidism.[4]

The World Health Organization identifies about 30% of the world's population to be iodine insufficient, and encourages implementing Universal Salt Iodization (USI) in regions that are insufficient. North America is considered iodine sufficient, although data shows that iodine intake has dropped significantly from 1971-1974 to 1988 to 2002, according to urinary iodine levels.[1] WHO identified the Western Pacific region as having the greatest population of IDD by goiter, and the Eastern Mediterranenean as greatly affected by iodine deficiency with the greatest percentage of people with IDD by goiter (32%).

Signs and symptoms of iodine deficiency and hypothyroidism, may actually be indicative of thyroiditis, and autoimmune thyroiditis, possibly from excess iodine. Individuals will have a high Urinary Iodine Concentration (UIC), using hypoechoic ultrasound and sera positive blood test for anti-thyroperoxidase (andi-TPO) antibodies will confirm chronic autoimmune thyroiditis. For some, excess iodine is tolerable, and others it will take a negative toll on.[9] Knudsen found autoimmune thyroiditis to be the primary cause of hypothyroidism in a borderline iodine deficiency area, with prevalence higher in women.[6]

A long-term prospective study compared children over an almost 10 year period born to healthy women. Children born to healthy mothers of a moderately iodine deficient region were compared to children born to healthy mothers of a marginally sufficient iodine intake area. The children were evaluated first at 18-36 months and again at 8-10 years old. A behavioral and neuropsychological evaluation were performed on each of them by two examiners. ADHD features were present in 9 of 16 children from the iodine deficient region, while none of the children from the iodine sufficient region had features of ADHD.[10]

METHODS

Methods utilized included PubMed and EBSCOhost to search for peer reviewed literature related to iodine deficiency. Articles from 1932-2012 were included. Key words searched for included: deficiency, iodine, skin/absorption, supplement, topical/iodine. The internet was searched with the same keywords in order to identify current public knowledge and public usage.

DISCUSSION

Iodine Status Testing History

A meta-analysis of methods of assessing iodine status in humans found a variety of analyses to be valuable in assessing iodine status. Urinary iodine concentration was identified as an effective biomarker to assess changes in iodine status in some circumstances. Other substances such as serum thyroglobin, serum thyroxine, and TSH are shown to be useful in assessing iodine status in certain population groups. Triiodothyronine was not found to be useful for iodine status. When assessing changes during a supplementation process TSH, thyroxine, UIC all reflect significant changes in iodine status. Thyroglobin has been identified as a promising biomarker that hasn't been traditionally been used or investigated but may be utilized more in the future to assess the thyroid and iodine status.[11]

Iodine status has been tested by topical application to the skin documented as early as the early 20th century and is still being performed today. Instructions vary from being painted on 2x2 square of forearm to the size of a dollar bill where it won't be rubbed by clothing. The skin where the iodine was applied should be checked to see that it's still present after 12 hours, and after 24, if there is no iodine seen on the skin after 24 hours, the person is iodine deficient. It was assumed that the individual was deficient and their skin had thus absorbed it all quickly. The validity of testing for iodine deficiency in this manner has been questioned as early as 1931. Nyiri and Jannitti studied the permeability of skin, permeability of individual substances, iodine evaporation, topical iodine being respired, and the possibility of iodine being rubbed off. Experimentation indicated evaporation of iodine was rapid, with 50% of iodine evaporating within 2 hours post application, and up to 88% of iodine evaporation after 3 days; This experiment was performed with colloidal iodine (iodine suspended in water), tincture of iodine (pure alcoholic solution of iodine), and Lugol's solution (iodine and potassium iodide in water solution), upon glass plates, organic material, paper, gelatin, and skin. Evaporation leaves little iodine available to be absorbed, and is likely to provide false positive results to an examiner who is basing his diagnosis upon the absence of visible iodine, assuming a nutritional need for iodine and so supplementing iodine.[12]

Iodine status tested by skin absorption still comes up in conversation in nutrition classes, and is a topic of discussion on natural and alternative health websites, that an iodine deficiency was

found after painting iodine on their skin and then it disappearing. There are a few websites that discuss how practitioners test for iodine status by topical application, but none with references.[13,14] Recent studies of evaluating iodine status by topical application are not present in peer-reviewed literature. Iodine absorption definitely occurs, which can be seen in a case presented with iodine applied to decubitus ulcers although not necessarily associated with iodine status.[15]

Assessment of Iodine Status

Skin absorption of iodine does occur. However, it may have nothing to do with iodine deficiency or excess. A case is reported of a woman whose decubitus ulcers covered with gauze soaked with povidone-iodine solution with dramatically altered serum iodine levels. Over the period of three to five weeks of povidone-iodine solution in addition to a variety of other medications, she had many complications. Her serum iodine level was 2,700µg/dl (normal being 4 to 9) without altered thyroid function. The povidone-iodine soaked gauze was discontinued, and after 10 days her serum iodine level was 21µg/dl, which was still high. Iodine absorption was not the purpose of this treatment. A significant level of absorption was seen in this study. It may be that there was a very large quantity of iodine applied, that povidone iodine is more readily available for skin uptake, or that the decubitus ulcers more readily take up iodine than skin. An updated study of iodine absorption through the skin would be helpful to guide physicians using topical iodine for antiseptic purpose and improve patient safety.[16]

Assessing iodine intake of a population has also been performed by surveying urban and rural regions by questionnaire of total 24-hr recall of food consumption for 3 days. In addition to the survey a sampling a variety of water, salt, condiments, cooking oils, as well as foods from local markets, grocery stores, and rural households were obtained. With iodine calculations made from the foods obtained and the surveys calculations were made to estimate iodine intake for the different regions.[4]

Thyroid palpation plays a large role in determining thyroid size and identifying goiters worldwide as it's easy to perform to identify goiter prevalence. Thyroid palpation is not suitable for neonates, but is appropriate for school-age children an older. A limitation to thyroid palpation is that mild thyroid enlargement isn't as likely to be detected manually as by imaging, palpation is a reasonably quick and affordable way of assessing for thyroid disease.[3,17]

Ultrasonography has been used in some iodine deficiency studies; however is a less direct way of assessing for iodine status with the current available data. Currently there is not an index for standard expected thyroid volumes. WHO suggests using thyroid volume as a function of age, sex, and body surface area. While some other studies used thyroid volume as assessed by ultrasonography as a function of height and weight. Kim compared a study of thyroid

ultrasonography values to similar studies not finding a correlation. Kim suggested local reference values needed for thyroid volumes instead of an international index standard.[3,17]

In Hokkaido, Japan a high iodine area a study was performed to see if iodine intake was correlated with greater goiter size in school-age children. There were two villages tested with average UIC of 1235µg/L and 428µg/L. The results of this study showed a positive correlation in goiter rate and increased thyroid size with high dietary iodine intake. No signs of neurological deficits were present in these children.[5] An epidemiologic study was done in 1991-1994 for prevalence of goiter by ultrasound and to determine iodine levels by UIC in schoolchildren in Slovenia. In 1999 salt iodization was required to be increased from 10 to 25mg potassium iodide per kilogram. A follow-up study in 2002-2003 investigated the prevalence of goiter by palpation, ultrasound, and UIC. The prevalence of goiters was significantly decreased. Grade 2 goiters, both visible and palpable, were in 11% of schoolchildren in the earlier study, the later investigation found only 1% grade 2 goiters. The UIC levels were found to be below 100µg/l in 73% of schoolchildren, and in the post-iodization UIC levels were below 100µg/l in only 22% of children.[18]

Currently urinary iodine concentration (UIC) testing is the most widely used testing method for assessing iodine status and widely available at most standard testing laboratories. A urine sample is obtained and tested by a variety of methods to identify iodine output. WHO states the spot method is a reliable test for iodine status, and identifies iodine status by UIC levels.[3]

Table 1 has general recommended daily iodine intakes from WHO for different lifestages. Table 2 has Urinary Iodine Concentration levels and identification of iodine status. Although this table is for schoolchildren, WHO also states as a population 100µg/l is the minimum normal value. China's population gets >60% of their iodine from iodized salt. Iodine can also be found in high concentration in kelp, saltwater fish. Lugol's solution, and supplementation such as Iodoral is also available to support iodine deficiencies.[3,19]

One method of measuring urinary iodine concentration is the Fast B test. The Fast B test requires a heating block, test tubes, vortex, micropipettes, and multipipette, using analytical grade potassium iodate, arsenic trioxide, ammonium persulfate, ammonium cerium (IV) sulfate dihydrate, sodium chloride, ferroine, sulfuric acid. The whole process takes a few hours, and the color change at the end of the process identifies the iodine status.[20] The Rapid Urinary Iodide test is another way of testing a large number of samples such as when performing an epidemiologic study, and it uses no instrumentation or apparatus. High performance liquid chromatography and spectrophotomotor were used to confirm the accuracy of these testing methods.[21] This method accepts that the spot samples overall will account for higher or lower iodine intakes to make an average. If used to assess individual, it assumes that this will be a true reflection of an average daily intake of iodine.[22]

The triple test described by Abraham identifies iodine status by analysis of blood serum, saliva, and urine. The person ingests 50mg elemental iodine in the form of Iodoral (each tablet contains 5mg iodine and 7.5mg iodide) and urine is collected for the following 24 hours, and repeated the following day. About 10-15ml whole blood is collected, and 5-8ml saliva is collected. The saliva/serum iodide ratio and urine iodine excretion assesses the whole body for overall iodine status.[23] This method does not assess the individuals' daily iodine intake, or assess a baseline for iodine concentration or excretion prior to supplementation.

Urine iodine excretion (UIE) is considered by some authors to be a better indicator for individual assessment for iodine status because takes into account urine volume and dilution of samples. UIE was used to assess multiple 24 hour samples of individual found that spot samples aren't an accurate reflection of overall iodine status.[24]

Konig mentions UIE as a better way of assessing iodine status than UIC although without describing it as a separate test. In the literature UIE seems to be used loosely, which becomes confusing. Konig defines UIC as µg/L, and UIE as µg/24h while Pardede expresses UIE as µmol/L. Unless paying particular attention to the language and definitions of separate authors it becomes challenging to know if apples are being compared to apples.[24,25]

In order to describe severity of IDD to different outcome indicators and functional indicators Pardede performed a study comparing many indicators in children. The indicators utilized are goiter inspection and palpation, ultrasonography, urinary iodine excretion, TSH, intellectual performance, height-for-age, weight-for-age, and weight-for-height. Prevalence of goiter was overestimated by inspection and palpation compared to ultrasonography. TSH levels were not found to be associated with any other indicators which may just be true for children. Goiter prevalence, UIE, height-for-age were all found to be significantly related to IQ and socioeconomic status.[25] This study recommends UIE measurement as an indication of IDD but if lab equipment is not available palpation methods should be utilized.

Historically iodine has been used in treating goiters in the form of burnt sponge and seaweed as early as 281-361 AD.[19] Topical iodine more often has a different purpose today. Free iodine itself has microbicidal properties. It likely poisons electron transport, inhibits cellular respiration, destabilizes membranes, inhibits protein synthesis and denatures nucleic acids in microbes. Not surprisingly in higher concentration it causes irritation, burning and stinging when applied topically. In 1952 it was made more stable in the form we use today, povidone-iodine. This version of topical iodine is used for its antiseptic properties before injections, invasive procedures, and surgery. It also promotes tissue healing and is useful for healing chronic non-healing wounds, cases of otitis media and externa, also cases of otomycosis.[26]

Iodine Status Studies

A case of a woman having her decubitus ulcers were covered with gauze soaked with povidone-iodine solution packed into her wounds had altered serum iodine levels. Over the period of three to five weeks of povidone-iodine solution in addition to a variety of other medications, she had many complications. Her serum iodine level was 2,700µg/dl (normal being 4 to 9) without altered thyroid function. The povidone-iodine soaked gauze was discontinued, and after 10 days her serum iodine level was 21µg/dl which is still in excess. Iodine absorption was not the purpose of this treatment. The implication of iodine absorption was not the intentions of this case. Some level of absorption was seen in this study. It may be that there was a very large quantity of iodine applied, that povidone iodine is more readily available for skin uptake, or that the decubitus ulcers more readily take up iodine than skin. It does seem that the povidone-iodine was taken up by the body from this study. An updated study of iodine absorption through the skin would be helpful to guide physicians using topical iodine for antiseptic purposes and improve patient safety.[16]

In a longitudinal study of women living in a borderline iodine deficient region found that 10 repeated spot samples of an individual compared to a 24 hour urine sample has a precision of 20%. Due to variation in sodium intake in a country that gets the majority of iodine from their salt intake, shows a need for five 24 hour urinary collections to determine overall iodine status.[24]

Sang performed a study on euthyroid Chinese adults in order to identify upper limits of iodine intake. Daily supplements for four weeks ranged from 0µg-2000µg. At levels of 300µg/d, 400µg/d, and 500µg/d there were 5%, 5%, and 15% of participants that had subclinical hypothyroidism at week four. The participants with subclinical hypothyroidism were checked again a month later and 14 of 35 still had subclinical hypothyroidism. Thyroid volume remained the same in groups ≤400µg/d. At upper levels of iodine supplementation 1500-, 1750-, and 2000µg/d thyroid volume had decreased. Literature had previously suggested safe upper limits for China to be 2000µg/d, while this study suggests daily iodine intake should not exceed 800µg.[7]

A large scale study was performed in Switzerland on adults and children to see if there was a relationship between circadian rhythm and urinary iodine excretion. The hour of sampling was found to be significant, age was not found to be a significant in urinary iodine concentration. The peak hours of urinary iodine concentration are 13-14 hours, 16-17 hours, and 22-23 hours.[27]

Men in a mild to moderately deficient area of Denmark were studied for iodine status. Blood and urine samples were analyzed monthly. Individual UIC samples varied from 10-260µg/L. Individual 24h UIC varied from 18-142µg/24h. From this study UIC was found to be greater in the spring and summer than the fall and winter. From the individual urine samples 7% were severely deficient with <25µg/L, however over the year of sampling none of the participants

had such low overall iodine excretion rates. Depending on location, changes of diet throughout the year, for some individuals it may be advantageous to assess at different times of the year.[28]

Treatment

Abraham researched Lugol's solution which 0.1-0.3ml contains 12.5-37.5mg iodine/iodide which has been used as a form of iodine supplementation to support the thyroid. Lugol's solution cannot be very accurately distributed, can stain clothing, has a negative taste, and may cause gastric irritation. Abraham wanted to mimic Lugol's solution which was administered to treat many iodine deficiency related conditions but without the negative effects. He helped in the discovery of Iodoral a tablet containing 5mg iodine and 7.5mg iodide to address the side effects and make a precise supply of iodine available. He suggests the triple iodine loading test described above with these supplements to assess iodine status. It is not described how it is decided how many tablets to prescribe per iodine status.[19]

Multiple comparison studies were done of children from moderately and severely iodine deficient regions, utilizing the intelligence quotient (IQ) test there was a 10 point decrease seen in children from the more severely more deficient region.[29] A study done with mildly iodine deficient children in New Zealand supplemented 150µg/D potassium iodate for 28 weeks showed an significant overall improved cognition by increased scores on 2 of 4 cognitive tests. The iodine supplementation was found to have little effect on memory in these children.[29] A similar double-blind randomized controlled trial study was performed on children in iodine deficient areas of Bangladesh. This study supplemented participants with 400mg of oral iodized poppy seed oil (lipiodol). The study analyzed the effects on cognition, motor function, T4, TSH, UIC, and weight. The study showed improved levels of UIC, but no other changes after a four month intervention. Other studies were discussed showing greater and longer lasting effects increasing iodine levels utilizing rapeseed oil, peanut oil, and Oriodol.[30]

A study in Japan checked patients on long-term total enteral nutrition such as Ensure for iodine deficiencies, participants in this study received their nutrition from these formulae due to swallowing disorders. The content of iodine in the total enteral formulas calculated to be 19.8 ± 15.1 µg, putting these individuals at a higher risk for iodine deficiency disorders. The study supplemented powdered kelp to 35 participants all with UIC <100µg/L. Of the 1-2g powdered kelp given, 200-400µg of iodine was made available. The supplementation of powdered kelp was shown to effectively return the UIC levels within a normal range.[31]

In a study of a Chinese population, a correlation was made between thyroid nodules and UIC; Those with a single thyroid nodule had an average UIC 139.46µg/L, and individuals with multiple thyroid nodules had an average UIC of 129.28µg/L, which both are iodine sufficient levels. This does not take into account a history of thyroid disease, age, sex, or if their iodine

status had been insufficient for a period of time in their life. This is an area which should be further researched.[8]

It's not surprising that iodine deficiency has a correlation with breast tissue structure and function since one of the signs of iodine deficiency is fibrocystic breast disease. The changes in breast tissue can be pathologic including altered RNA/DNA ratios, changes in receptor proteins and cytosol iodine levels. Some of these changes lead to neoplasia. A study in rats with chemically induced mammary cancer, molecular iodine was found to be more effective at inhibiting cancer than iodide or thyroxine. A study on women with fibrocystic breast disease were supplemented with either sodium iodide or protein-bound iodide by weight based dosage for 2-5 years. Sodium iodide resulted in improvements of fibrocystic breast disease in 70% of the participants, while protein-bound iodide had 40% improvements in breast tissue. All participants had some side effects including: acne, coryza, weakness, and foul breath. (Iodine Monograph) Human breast milk has iodine in concentration four times greater than in thyroid tissue. This is essential for proper neonatal thyroid function and neural development.[1] Pregnant women need a greater amount of iodine to support the growing fetus, this is a problem in China as they don't have supplementation readily available. Only a minority of pregnant women take these imported supplements.[4]

Iodine insufficiency is not something to be taken lightly, but it is also not something that can be assessed by a few symptoms. An article published by New England Journal of Medicine published stated that when it comes to iodine, more is better, as they recommend 300-400µg/D iodine. Alternately, Camargo points out that this is double recommendations put out by the World Health Organization. Studies have been done on individuals with excessive intake which show an increased incidence of chronic autoimmune thyroiditis with UIC >301µg/L iodine.[9] Some countries have now been identified with a higher median urinary iodine concentration without complications. Countries identified with median UIC >300µg/L include Brazil, Algeria, Cote d'Ivoire, Zimbabwe, and Uganda. Chile and Congo have concentrations >500µg/L.[5] Early in the 20th century recommendations of iodine for prevention of goiter in adolescent females was 9mg iodide. Even in 1995 daily recommendations of Lugol's solution for treatment of goiter equated to 12.5-37.5mg iodine/iodide supplementation.[19]

CONCLUSION

Checking iodine status using topical iodine was shown not to be an effective way of testing for iodine status in 1932, and there are no recent studies that show it to be accurate. The only more recently written article found on using topical iodine status is not a study but a summary of the Nyiri study in 1932.

Iodine status is a worldwide concern, as there is a large population which is negatively affected by a lack of availability of iodine in their diet. However, there are great differences regionally

that should be taken into account when making recommendations, and implementing government programs to alleviate the problem if it is only a few regions, may actually cause more problems.

The salt iodization approach seems to have made a difference overall in many populations of iodine status. Although this doesn't reach the whole population, and these epidemiological studies don't help narrow down why the other percentage of the population remains deficient. There is still a need for a more precise approach for treating diagnosed or borderline iodine deficiencies, especially for populations that have concerns about their salt intake, but have little other access to iodine.

Thyroid palpation and ultrasonography of the goiter are not specific for iodine deficiency and requires further investigation. Blood serum can also be checked for overall iodine status, but is less frequently utilized, and there is less information in the literature on its accuracy.

From the variety of approaches to analyzing iodine status for larger studies, UIC is the most commonly used, reliable, and economical. For individual iodine status, UIC is the most commonly used, however individual spot UIC will not give an accurate assessment for iodine status. Ten spot samples, or ten- 24 hour collections is suggested as the most accurate assessment of iodine status.

TABLES

Table 1: Recommended daily iodine intake, WHO

Age	**Recommended iodine intake (µg/L)**
Preschool children (0-59 months)	90
Schoolchildren (6-12 years)	120
Adults (12+ years)	150
Pregnant and lactating women	200

Table 2: Iodine status by UIC, WHO

Median Urinary Iodine (µg/L)	Iodine intake	Iodine nutrition
<20	Insufficient	Severe iodine deficiency
20-49	Insufficient	Moderate iodine deficiency
50-99	Insufficient	Mild iodine deficiency
100-199	Adequate	Optimal
200-299	More than adequate	Risk of iodine-induced hyperthyroidism within 5-10 years following introduction of iodized salt in susceptible groups
>300	Excessive	Risk of adverse health consequences (iodine-induced hyperthyroidism, autoimmune thyroid diseases)

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