Iodine Deficiency

Do we need to rethink?

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Iodine an element named from the Greek for 'violet' is a mineral that is an essential component of the hormones produced by the thyroid gland. Thyroid hormones, and therefore iodine, are essential in humans and are required for the regulation of growth and metabolism as well as playing an important role in foetal brain development. A sub-optimal intake of iodine impairs thyroid function and leads to a range of disorders including goitre, impaired cognitive development and congenital abnormalities.[1] The WHO considers iodine deficiency to be 'the single most important preventable cause of brain damage worldwide'[2] and two billion people worldwide are at risk of iodine deficiency.

Iodine in nature

Iodine naturally occurs in the environment and the majority is found as iodide in the ocean. The iodide in seawater is oxidised to elemental iodine which then enters the atmosphere and the iodine is deposited on land. The amount of iodine deposited decreases with increasing distance from the ocean and hence inland areas have lower soil iodine levels. Furthermore, iodine cycling in many regions is slow and soil levels of iodine remain low. Iodine deplete soils are most common in mountainous regions and areas that are frequently flooded, particularly South and Southeast Asia.

Absorption of iodine

Iodine occurs in many different chemical forms in food, but most ingested iodine is reduced in the gut and absorbed as iodide via the sodium/iodine symporter. This absorption is very efficient, and in healthy adults the absorption of iodide exceeds 90 per cent.[3] The absorbed iodide is then cleared from the circulation by the thyroid and kidney, with the thyroid regulating iodide uptake to meet physiological requirements and thus ensuring adequate thyroid hormone synthesis. During periods of iodine sufficiency, no more than 10 per cent of the absorbed iodine is taken up by the thyroid, whereas during times of chronic deficiency absorption can exceed 80 per cent.[4] During lactation, the mammary gland also up regulates the absorption of iodine and secretes it into breast milk.[5]

The average healthy adult body contains 15-20 mg of iodine, the majority (75%) of which is found in the thyroid. During chronic iodine deficiency, thyroid iodine levels can fall below 20 µg.[6] To remain in homeostasis, in iodine-sufficient areas, the adult thyroid takes up approximately 60 µg of iodine per day. Once within the thyroid, iodine undergoes a series of reactions to produce the iodine containing thyroid hormones thyroxine (T4) and triiodothyronine (T3).

Dietary sources of iodine

In general, the iodine content of most foods and beverages is low, with most foods containing 3-80 µg per serving.[7] Marine plants and animals are rich sources of iodine and population groups consuming large amounts of these foods can have very high iodine intakes. Plant-based foods are generally low in iodine and their iodine content is affected by soil content, irrigation and the use of fertilizers. In the UK, iodine is naturally present in cows' milk although levels can vary depending on the season. Interestingly, endemic goitre once widespread in Britain significantly declined following the introduction of iodine supplementation in dairy herds.[8] In regions affected by iodine deficiency, the addition of iodine to salt is a highly effective strategy for controlling iodine deficiency.

Since 1990, the percentage of household's worldwide using iodised salt has risen from less than two per cent to more than 70 per cent.[1] Other vehicles for iodine fortification include bread, water and milk.

In the UK, milk and dairy foods are the major contributors to iodine intake, providing 33 per cent of the daily mean iodine intake for adults. Dairy products are a good source of iodine as it is added to cattle feed and is also used to clean milking equipment and 'contaminants' milk. However, the use of iodine-based disinfectants is falling in the dairy industry. Dairy products that are derived from cattle that are pasture fed have a lower iodine content than those from cattle that are fed 'cattle cakes'. This explains why organic milk has a lower iodine content, as organic cows' are usually grass fed.

Fish and fish dishes contribute 11 per cent, beer and lager a further 11 per cent, followed by cereal and cereal products that provide 10 per cent[9] of the daily mean iodine intake. See Table One for further information on the iodine content of foods.

Iodine requirements

The Department of Health dietary reference values for iodine and the WHO recommendations are shown in Table Two.

Iodine deficiency in the UK

The 2008/09-2010/11 National Diet and Nutrition Survey indicates that mean daily iodine intakes from food exceed the Reference Nutrient Intake (RNI) for males of all ages (4-65+ years). The mean iodine intake for girls aged 11-18 falls short of the RNI (82%) and the mean intake for females aged 19-64 just meets the RNI (100%). When looking at the Lower Reference Nutrient Intakes (LRNI) 21 per cent of girls aged 11-18 and 10 per cent of women aged 19-64 had daily average iodine intakes below the LRNI. Data from the National Diet and Nutrition Survey (NDNS) also shows that the iodine intake of teenage girls in the UK has dropped since 1997. This may be explained by the reduction in milk intake in this group over recent years.

These findings fit with those of recent studies and show that iodine deficiency is likely to be more of a concern in the UK than previously thought, and it is not a problem just limited to developing countries. One recent cross sectional study in UK schoolgirls, aged 14-15 years, showed that 51 per cent had urinary iodine measurements indicative of mild iodine deficiency, 16 per cent moderate deficiency and one per cent severe deficiency.[13] These findings may well be due to the fact that teenage girls consume low levels of dairy products

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Table One: Iodine Content of Foods

Food	Portion	Average iodine content per portion (µg)
Cows' Milk	200 ml	50-80*
Organic cows' milk	200 ml	30-65*
Yoghurt	150 g	50-100*
Eggs	1 egg (50 g)	20
Cheese	40 g	15
White fish	100 g	115
Oily fish	100 g	50
Shellfish	100 g	90
Meat	100 g	10
Poultry	100 g	10
Nuts	25 g	5
Bread	1 slice (36 g)	5
Fruit and vegetables	1 portion (80 g)	3

Source: Adapted from[10]
* Value depends on the season, higher iodine content in winter

Table Two: Recommendations for Iodine Intake (µg/day)[2, 11]

Age or population group	Reference Nutrient Intake (µg/day)	Age or population group	WHO recommended nutrient intake (µg/day)
1-3 years	70	Children 0-5 years	90
4-6 years	100		
7-10 years	110	Children 6-12 years	120
11-14 years	130		
15-18 years	140		
19-50 years	140	Adults ≥ 12 years	150
50+ years	140		
Pregnant women	No increment	Pregnant women	250
Lactating women	No increment	Lactating women	250

and data from the NDNS suggests that this group generally have a poor diet, with a low intake of fruit, vegetables and oily fish as well as having a poor intake of other nutrients such as iron and calcium. To put this estimate of iodine deficiency into perspective, the UK lies between Angola and Mozambique in the list of top ten countries with the greatest number of school aged children with insufficient iodine intake.

The effect of severe iodine deficiency in pregnancy on childhood outcomes is well documented. Thyroid hormone is essential for normal neuronal migration and myelination of the brain during foetal and early postnatal life[14] and deficiency leads to mental retardation and cretinism.[14] However, less is known about the effects of mild and moderate iodine deficiency on childhood outcomes. This is of relevance in the UK as there is evidence that not only does iodine deficiency exist, but it occurs in women of childbearing age and pregnant women.[12, 15-17] A study[18] published earlier this year looked at mother-child pairs from the Avon Longitudinal Study of Parents and Children (ALSPAC) and the association between maternal iodine status and child IQ at age eight years and reading ability at age nine years was assessed. The results were adjusted for 21 potential confounders that affect cognitive development, including maternal iron, omega-3 fatty acid, alcohol intakes, breastfeeding status and markers of socioeconomic status. Iodine status was adjudged based on WHO criteria using urinary iodine-to-creatinine ratios, and mothers were split into two groups; those with a urinary iodine-to-creatinine ratio less than 150 μg/g (i.e. iodine deficient) or those with a ratio greater than 150 μg/g (i.e. iodine sufficient). After adjustment for confounding factors, children of women with a ratio below 150 μg/g were more likely to have scores in the lowest quartile for verbal IQ, reading accuracy and reading comprehension than those of mothers with ratios greater than 150 μg/g.[18] The study indicates that there is an association between mild to moderate iodine deficiency in pregnancy and impaired cognitive outcomes in their children at ages eight to nine years.

Meeting iodine requirements in at risk groups

Although observational in nature, the findings from this study highlight the potential need for UK intake guidelines to be revised for pregnant and lactating women as the current RNI may be too low for this group, and should probably be more in line with WHO recommendations. Women of childbearing age are advised to ensure a sufficient iodine intake, most preferably preconception, to ensure that thyroid iodine requirements are met during pregnancy and lactation (maternal iodine is expressed in breast milk and is important for early brain development).[14] Meeting iodine requirements during lactation is essential as babies fed by mothers with inadequate iodine intakes may not get sufficient iodine. The Scientific Advisory Committee on Nutrition (SACN) are currently reviewing iodine deficiency in the UK in order to consider whether there is sufficient evidence to judge if iodine intakes are inadequate in the UK and potentially to set new RNIs for pregnant and lactating women.

Meeting iodine requirements during pregnancy and lactation may be difficult from diet alone and a supplement may be useful to ensure that iodine requirements are met. However, a large proportion of pregnancies are unplanned so iodine intake may remain suboptimal pre-pregnancy. Most multivitamin and mineral pregnancy supplements contain iodine and should provide 140 μg or 150 μg of iodine.[10] The remainder of the 250 μg/d WHO requirement can be met from suitable dietary sources of iodine.

Vegetarians and vegans may also be at greater risk of iodine deficiency as they may not eat many of the iodine rich food sources, such as meat, fish and dairy. It is also important to be aware that non-dairy milk alternatives such as soya milk are often not fortified with iodine.

Iodised salt is used in industrially processed foods in Germany and some European countries, including Austria and Turkey, who have compulsory iodine fortification (although not always rigorously enforced) of products such as bread. In light of the prevalence of iodine deficiency in the UK, should we consider fortification strategies in order to improve iodine intakes, particularly for those in at risk groups who typically have poor intakes of iodine rich dairy foods? A range of foods, including bread, water and salt can be fortified with iodine and a strategy to improve iodine intake should seriously be considered as a way of bridging the shortfall in iodine intake. Although iodised salt is a simple, cheap, far-reaching and highly effective way of improving iodine intake, the government and food industry are working together to reduce the nation's salt intake and average salt intakes have fallen and are likely to continue falling over coming years. One solution to this would be to increase the proportion of iodine in salt to compensate for the reduced intake. Whatever the approach, a rethink is required to tackle this growing health concern.

Summary

Iodine has received little attention in the UK since the 1960s when deficiency was last a common problem. However, recent research has highlighted that mild to moderate iodine deficiency is still a concern, particularly in teenage girls and pregnant mothers, and has measurable effects on cognitive outcomes in children born to iodine deficient mothers. Increasing awareness of the dietary sources of iodine, how iodine requirements change during pregnancy and lactation, the importance of meeting iodine requirements and the at risk groups for suboptimal iodine intake is required. Finally, as a nation do we need to develop an iodine fortification strategy in response to the mounting evidence of iodine insufficiency in the UK and the effects this may have on public health.

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