Bioavailability of iodine

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Physiology and relevance

The healthy human body contains 15–20 mg of iodine of which about 70–80% is in the thyroid gland most concentrated in the iodinated glycoprotein, thyroglobulin (Hetzel, 1993). The only known role of iodine is for the synthesis of the thyroid hormones, triiodothyronine (T3) and tri-iodothyronine (T3), which help regulate a wide range of physiological processes including metabolic rate, calorigenesis, thermoregulation, growth and development of most organs, and protein synthesis. Iodine occurs in foods mainly as inorganic iodine, which is readily and almost completely absorbed from the gastrointestinal tract (Keating and Albert, 1949). Other food components do not appear to influence inorganic iodine absorption as they do with iron and zinc. Iodide and protein-bound iodine in animal foods are reduced to iodide for absorption. Only about half of the ingested protein-bound iodine is absorbed (Keating and Albert, 1949). Iodide is transported in the body bound to plasma proteins, the necessary amount is removed by the thyroid for hormonal synthesis, and the remainder is excreted by the kidney. Faecal excretion consists mainly of endogenous organic iodine (van Middlesworth, 1960). At normal intakes, urinary iodine is 85–90% of daily intake and is a good indicator of iodine intake and status (Lamberg, 1993). There is no general homeostatic mechanism to conserve iodine by increasing absorption or reducing excretion.

A very active iodide trapping mechanism transports plasma iodide into the thyroid against a high gradient. The iodide is first oxidised to iodine and then incorporated into the tyrosine residues of thyroglobulin. These tyrosine residues then undergo covalent crosslinking to form iodinated tyrosine dimers (Brody, 1994). Both reactions are catalysed by thyreroxidase, a haem protein. Iodinated thyroglobulin then enters the thyroid cells by pinocytosis and the iodinated tyrosine dimers are released by proteolysis mainly as T4 which enters the blood stream by simple diffusion. Most of the T3 in the blood stream results from the deiodination of T4 in the liver and kidney under the action of the selenium dependent enzyme 5-deiodinase. In the plasma, the hormones are mostly bound to albumin and globulin proteins. The thyroid secretion is under the control of the pituitary gland through the thyroid stimulating hormone (TSH). When plasma T4 falls, TSH secretion is increased and thyroid activity including iodide uptake increases.

To ensure an adequate supply of thyroid hormones, the thyroid must trap about 60 μg iodine per day (Underwood, 1977) and to provide a margin of safety, a daily allowance of 150 μg is recommended for adolescents and adults (National Research Council, 1989). Dietary iodine deficiency results in decreased plasma levels of T4 and T3 and a compensatory increase in TSH secretion. In an attempt to increase iodine uptake with limited intake, TSH increases thyroid cell size and cell number and the gland enlarges to form a goitre. When this reaches a prevalence of 10% it is called endemic goitre. Women and adolescent girls seem especially affected. Apart from goitre, there are other effects on growth and development, particularly of the brain, and these are classed together as iodine deficiency disorders (IDD) which can be classified by the different effects on the fetus, neonates and adults (Hetzel et al., 1990). Iodine deficiency of the fetus is the most serious and leads to a greater incidence of stillbirths, spontaneous abortions, congenital abnormalities and cretinism. Endemic cretinism, primarily due to a failure of brain development, occurs when iodine intake falls below 25 μg/d and affects up to 10% of populations in severely iodine deficient areas of India (Kochchupillai and Pandav, 1987), Indonesia (Djokomnoeljanto et al., 1983) and China (Ma et al., 1982).

The most common form, neurological cretinism, is characterised by mental deficiency, deaf mutism and spastic diplegia, in contrast to the less common hypothyroid type characterised by thyroid failure and dwarfism. The neurological effects are not reversed by administration of iodine or thyroid hormones. In the neonate, iodine deficiency leads to increased perinatal and infant mortality (Thilly, 1981), whereas in adults and children it is normally associated with goitre, reaching a maximum in adolescence, but it also leads to hypothyroidism with a lower metabolic rate and impaired mental function. Children living in iodine deficient areas also have impaired psychomotor development, school performance and lower IQs (Vermiglio et al., 1990, Bleichrodt et al., 1987). According to recent estimations, 200 million people in the world have goitre and almost six million suffer from the mental and neurological effects of cretinism (World Health Organization, 1990). Endemic goitre affects all parts of the world. In large areas of South America (Ecuador, Peru, Bolivia), Africa (Zaire, Cameroon, Burundi) and Asia (India, Nepal) there is a high prevalence of goitre and cretinism (Lamberg, 1993). IDD was also common in Europe prior to the 20th century, but with more varied diets and salt fortification it has been
The combination of the motor's speed and the positioning of the gear box and the floor's pitch, and the dynamics of the floor, and the dynamics of the motor, results in the floor moving back and forth. The motor's speed is controlled by the controller, which is responsible for adjusting the motor's speed based on the input from the sensors. The floor's pitch is controlled by the floor's mechanism, which adjusts the angle of the floor to provide the desired movement. The dynamics of the motor and the floor are complex and depend on the specific design of the system. The controller must be able to accurately control the motor and floor, and this is achieved through the use of advanced control algorithms. Overall, the system is designed to provide a smooth and comfortable ride, with minimal vibrations and noise. The combination of the motor's speed, the positioning of the gear box and the floor's pitch, and the dynamics of the floor, results in a unique and enjoyable experience for the user.
Critical assessment of methodology

As with other nutrients, balance techniques are imprecise. With iodine, they are further complicated because of analytical difficulties in measuring the trace quantities in the diet and by possible contamination with atmospheric iodine (Dworkin and Simeck, 1965). The relative potency, and the mechanism of action, of various goitrogens have been usefully evaluated using in vitro enzymic assays, by animal tests and in man, often using radioiodine techniques. It is clear that the magnitude of response to a particular goitrogen in the rat may be very different to the response in man (Clements, 1960). The ideal method to measure iodine bioavailability in man would be to use radiiodine and to quantify urinary and faecal excretion as well as thyroid uptake. In this way absorption as well as utilization could be quantified. Iodine has only one stable isotope and stable isotope tracer studies are therefore not possible. Although there is some radioiodine data in man on the effect of extracted plant substances on the utilization of iodine by the thyroid, there have been no systematic studies measuring iodine bioavailability from different plant and animal tissues. Urinary excretion in human subjects consuming a relatively high dose of food iodine was used by Katamine et al. (1987) to measure iodine bioavailability. This method could give a useful indication of iodine absorption if the food were assumed to have no effect on the thyroid utilization of iodine or, if absorption was assumed to be 100%, it would indicate the potential goitrogenic effect.

Conclusions/Recommendations

Iodine bioavailability from foods would appear to be relatively high and deficiency results mainly from low intake. From a public health viewpoint, therefore, the best way to prevent iodine deficiency is to increase iodine intake by fortifying food such as salt with inorganic iodide which is almost completely absorbed. Such strategies have successfully reduced the incidence of IDD. Although much useful data exists on the goitrogenic effect of various substances extracted from plant foods, and their influence on iodine utilization by the thyroid, these studies have usually been made from a pharmaceutical perspective, and their influence in diets is assumed to be important only at marginal iodine intake. Studies on the bioavailability of iodine in man from plant foods and animal tissues do not exist and are now needed together with a quantification of the effect of foods containing known goitrogens (for example cassava, millet and various Brassica vegetables) on iodine utilization. Based on early data, the bioavailability of iodine from protein-bound iodine in animal tissues may be as low as 50%. The radiiodine technique with an extrinsic tag or with intrinsically labelled foods would seem ideal for this purpose. It is also necessary to further investigate the influence of other micronutrients on iodine utilization. The influence of selenium deficiency on thyroid hormone synthesis has been recently reported but vitamin A, and especially iron, are also important for thyroid function and are widely deficient in many of the same developing countries that have low iodine intakes.

References


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