The Nutrition Academy

APPLIED FUNCTIONAL NUTRITION COURSE

FOOD AND YOUR HORMONES

Module

3

The thyroid and iodine: diet and diagnosis

The thyroid is one of the most important glands in the body. It is responsible for maintaining our weight, energy levels, mood, heart rate, temperature control, and many other critical functions of our physiology [1].

The thyroid is a large butterfly-shaped endocrine gland that straddles the trachea in front of the neck (Figure 1). The gland has two primary functions:

1. To secrete thyroid hormones, and
2. To secrete calcitonin hormone

Thyroid hormone helps regulate lipid and carbohydrate metabolism and stimulates oxygen consumption by most cells in the body.

Calcitonin hormone regulates circulating levels of calcium.

Formation and secretion of thyroid hormones

The primary hormone secreted by the thyroid is thyroxine (T_4), and lesser amounts of triiodothyronine (T_3) [2]. Several aspects of the production of thyroid hormones are unusual:

1. Thyroid hormones contain large amounts of iodine. The biosynthesis of the active form of thyroid hormone requires adequate amounts of this scarce element.
2. The thyroid is the principal site of storage of concentrated iodide.
3. T_4, the major secreted product, is not the potent biologically active form of the hormone, but must be converted to T_3.

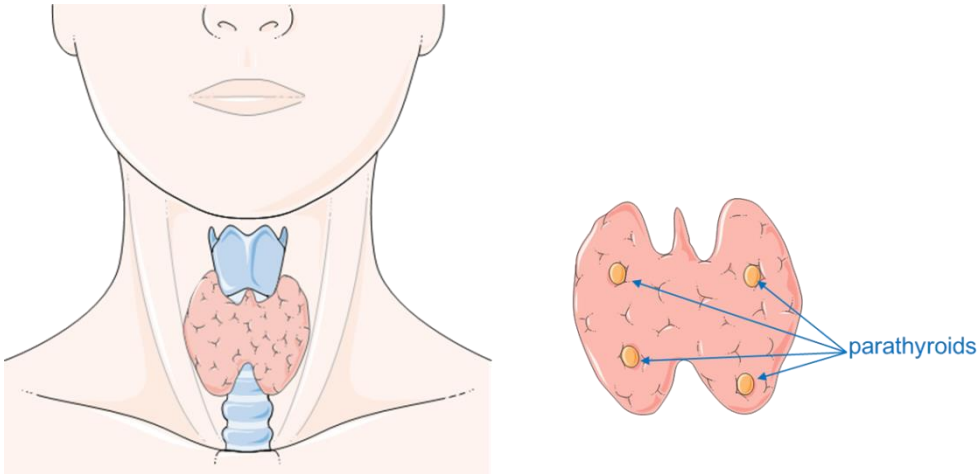

Figure 1: The thyroid gland and parathyroids. Diagram produced from Servier Medical Art, www.servier.com.

Thyroid disorders are one of the most common endocrine disorders.

Signs and symptoms of thyroid malfunction include:

- Fatigue.
- Unexplained weight loss or weight gain.
- Libido swings.
- Mood changes.
- Insomnia.
- Hair loss.
- Depression.
- Enlarged thyroid or goiter.
- Constipation or diarrhoea.
- Muscle weakness.
- Increased sensitivity to heat or cold.
- Anxiety and panic attacks.
- Menstrual irregularities.
- Changes in appetite.
- Blood sugar problems.
- Heart problems.
- Difficulty in expressing one self, verbally and non-verbally.

Key thyroid disruptors

Most thyroid malfunctions are due to three commonly overlooked, yet profoundly important factors [1].

1. Overactive immune system.
2. Low iodine levels.
3. Unbalanced hormones.

An overactive immune system

Hashimoto's and Graves' disease

Low thyroid function or hypothyroidism, also referred to as Hashimoto's disease, and high thyroid function or hyperthyroidism, also referred to as Graves' disease, are autoimmune disorders [1]. You might remember that an autoimmune disease is one where the body actually attacks itself. Normally, when a foreign particle (e.g. virus) enters your body, the immune system will mobilise antibodies and other molecules to dispose of the invader. However, in an autoimmune disorder, the immune system raises an immune response against its own host. In this case, the persistent immune response over time can have a profound effect on the body's internal organs, causing the tissue to become inflamed, and in the case of glands, can lead to them "burning" out [1,3]. In the case of Hashimoto's and Graves' disease, an overactive immune system will attack and destroy certain cells of the thyroid gland which results in thyroid malfunction [1].

Signs and symptoms of Hashimoto's disease

- Weight gain.
- Depression.
- Mania.
- Sensitivity to heat and cold temperatures.
- Tingling of the extremities.
- Panic attacks.
- Heart racing.
- Hypoglycaemia.

- Constipation.
- Migraines.
- Muscle weakness or cramps.
- Memory loss.
- Infertility.
- Hair loss.

Signs and symptoms of Graves' disease

- Anxiety.
- Protruding eyeballs.
- Fatigue.
- Frequent bowel movements.
- Goiter.
- Heat intolerance.
- Increased appetite.
- Insomnia.
- Menstrual irregularities.
- Increased sweating.
- Nervousness.
- Rapid or irregular heartbeat.
- Tremor.
- Weight loss.

Iodine homeostasis

Iodine is an essential raw material for thyroid hormone synthesis. Dietary iodine (e.g. dairy products, seafood, seaweed, eggs, some vegetables and iodised salt) is absorbed by the intestine and enters the blood circulation. The principle organs that take up circulating iodide is the thyroid which uses it to make thyroid hormones T_3 and T_4, and the kidneys, which excrete it in urine [2]. The minimum daily iodine intake that will maintain normal thyroid function is 150 µg in adults [2].

When you become deficient in iodine, T_3 and T_4 cannot be produced in optimal amounts and thus, the thyroid cannot work to its full potential. This may result in in a hypothyroid state as in Hashimoto's disease, or a hyperthyroid state as

in Graves' disease [2]. Low iodine levels are often the missing link in correcting thyroid disorders [1]. Iodine is necessary for many biological functions and for maintaining our vitality including proper hormone balance, mental sharpness, mood stability, immune health and thyroid function [1].

Why is my iodine level low?

There are many reasons why your iodine levels may be low, however the most common reason is lack of dietary iodine intake. Iodine deficiency is considered to be one of the most common endocrine disorders and the most preventable cause of mental retardation globally [4,5].

Common causes of iodine deficiency [1]

- Malabsorption syndrome (the intestines ability to absorb nutrient is compromised).
- Mercury fillings.
- Fluoride supplementation.
- Food ingredients.
- Post-traumatic stress disorder.
- Genetics.
- Lifestyle.
- Environmental toxins, pesticides, heavy metals, chemicals.
- Microbial infections.
- Poor dietary habits.

Testing iodine

More than 90% of dietary iodine is excreted in the urine. There are basically 5 methods to determine iodine status. Each test has its advantages and disadvantages (Table 1) [4].

Table 1: Methods to assess iodine status and their strengths and weaknesses

Test	Advantages	Disadvantages	Notes
Spot urine	Sensitive indicator of recent iodine uptake	Highly variable from day to day	Not valid to assess iodine intake in individuals

24-hour urine test	Sensitive indicator of recent iodine intake	Does not measure thyroid function	Considered the gold standard [5]
Thyroglobulin	Iodine intake over weeks to months. Measures thyroid function.	Also elevated in thyroid damage and thyroid cancer	Appears to be a functional measure of actual rather than just iodine intake
Thyroid-stimulating hormone	Useful indicator of iodine in the new-born	Limited usefulness in other age groups	The standard for thyroid activity
Thyroid enlargement (e.g. goiter)	Measures long-term deficiency (months to years). Measure of thyroid function	Changes very slowly with iodine status. Palpation (using one's hands) has poor sensitivity	Ultrasound detects enlargement far sooner and more accurately than palpation

Source: Pizzorno (2012) [4].

What is the maximum safe dosage of iodine?

While some clinicians recommend daily doses of iodine in excess of 10 mg, others assert anything more than 300 µg risks toxicity [4]. The key to determining the optimal dosage is to first determine the actual safe dosage. The World Health Organization has proposed a safe limit of 500 µg iodine, and the US Institute of Medicine suggests a maximum intake of 1100 µg poses no excessive risk [4]. The majority of toxicity data is from monitoring the effects of iodine in iodine-deficient populations. An increase in iodine intake in such populations is almost always associated with a significant rise in the incidence of hyperthyroidism [4].

Several mechanisms exist that are involved in the normal homeostasis of thyroid hormone secretion, even when iodine intake exceeds physiological requirements by as much as a factor of 100 [4]. Iodide transporters are responsible for the transport of iodide. In the case of excess iodide, the transporter decreases the transport of iodide into the thyroid and therefore limits thyroid dysfunction [6].

In some susceptible individuals such as those with Graves' disease or autoimmune thyroiditis, the iodide transport system fails to shut down and

these patients accumulate high concentrations of iodide and thus, chronic hypothyroidism results [4].

There are a large number of studies that have reported on the safe dosage of dietary iodine. For example, one outbreak of hyperthyroidism that was carefully investigated occurred in Tasmania in the late 1960s. It was found that supplementation of iodine tablets and iodised bread and the use of iodophors (preparation containing iodine complexed with a solubilising agent) by the milk industry led to an increase in hyperthyroidism from 24 per 100,000 in 1963 to 125 in 1967 [7]. The disease occurred most frequently in patients over the age of 40 years and with multi-nodular goitres and pre-existing heart disease [7]. There was no evidence of any pathological mechanism for the Tasmania epidemic (lasted 10-12 years) other than iodine deficiency. The reason for the development of iodine-induced hyperthyroidism after iodine supplementation has now been elucidated: iodine deficiency increases thyroid cell growth and proliferation and mutation rates [7]. Accordingly, iodine-induced hyperthyroidism is an iodine deficiency disorder [7].

Other studies on iodine supplementation and the facilitation of autoimmune thyroiditis was reported by McConahey et al. (1962) [8]. In these studies it was identified that there was a rise from 0.1% in 1930 to 13% in 1959 in the frequency of Hashimoto's thyroiditis in patients that had their goitres removed in the Mayo Clinic, USA [8].

In an international study of 6-12 year old children (3319 participants) from 5 continents it was found that chronic intake of iodine approximately twice that recommended (300-500 µg/L) did not increase thyroid volume [9]. However, an iodine concentration greater than 500 µg/L was associated with an increase in thyroid volume and it was suggested that this reflects the adverse effects of chronic iodine excess. Similarly, in 256 euthyroid (having normal thyroid function) Chinese adults given iodine supplementation ranging from 0 – 2000 µg, it was found that subclinical hypothyroidism appeared in patients who had iodine supplementation of 800 µg [10].

Japanese populations have historically consumed significant amounts of dietary iodine from seaweed, averaging 5,280 µg (5.280 mg) to 13,800 µg (13.800 mg)in comparison to the U.S daily consumption of 167 µg [5].

Accordingly, the Japanese therefore consume dietary iodine approximately 4-14 times higher above the upper safety limit of 1 mg by U.S standards [5]. These higher levels appear to have no adverse effects on thyroid function.

A study comparing 654 Japanese children found 16% of those tested excreted over 1000 µg/L of iodine [11]. Moreover, the elevated levels of iodine in the urine of these children did not predict increased thyroid gland volume, as expected from a Chinese study that found excess levels of iodine was associated with autoimmune thyroiditis and hypothyroidism [12]. Of the 3018 participants, it was identified that those with more than adequate iodine intake (243 µg/L) and excessive intake (651 µg/L) were at a greater risk of developing autoimmune thyroiditis and hypothyroidism than those with a mildly deficient iodine intake (84 µg/L) [12].

Interestingly, Japanese women who consume a traditional diet high in seaweed also have a low incidence of malignant breast cancer [12]. In contrast, Japanese woman who consume a western diet low in seaweed or who emigrated to the United States lose this protective advantage and have the same risk for breast cancer as their western counterparts [12].

Unequivocally, iodine deficiency is a common, global issue. The recommended daily intake of iodine for normal thyroid is approximately 200 µg - 300 µg. However, this is not necessarily the optimal range for other health benefits. There are benefits to using a higher dose of iodine especially for women with disorders such as fibrocystic disease and breast cancer [4]. However, it is important that when prescribing high dosage of iodine, that regular monitoring of TSH, thyroid hormone and thyroid antibodies should be performed [4]. Thus, high dosage of iodine will likely cause toxicity in a significant portion (25%) of the population, but will be safe for most, but not all patients [4].

Summary

The thyroid gland is critically important for maintaining essential biological functions. Its primary two functions are to secrete thyroid and calcitonin hormones. Thyroid malfunctions are contributed to an overactive immune system, low iodine levels, and hormone imbalance. Two major diseases associated with an overactive immune system are Hashimoto's disease and

Graves' disease. Iodine is essential for the formation of thyroid hormones. A deficiency in iodine can result in hypothyroidism or hyperthyroidism. Several tests are available to assess biological iodine status all of which have their advantages and disadvantages. While the maximum safe dosage of iodine is recommended to be approximately 150 µg, larger dosages have been reported without any adverse effects on human health.

References

1 Faithe, E. Hormone lies and thyroid misunderstandings. BookLocker.com, Inc, Florida U.S. ISBN: 9781626463691. (2013).

2 Barrett, K. E., Boitano, S., Barman, S. M. & Brooks, H. L. Ganong's Review of Medical Physiology. McGraw and Hill Companies, Ltd. ISBN: 978-0-07-160568-7. (2010).

3 Kirshner, H. Hashimoto's Encephalopathy: A Brief Review. *Curr Neurol Neurosci Rep* 14, 1-4, doi:10.1007/s11910-014-0476-2 (2014).

4 Pizzorno, J. How much iodine should we prescribe? *Integrative Medicine: A Clinician's Journal* 11, 8-13 (2012).

5 Patrick, L. Iodine: deficiency and therapeutic considerations. *Alternative Medicine Review* 13, 116-127 (2008).

6 Spitzweg, C. & Morris, J. C. Sodium Iodide Symporter (NIS) and Thyroid. *Hormones. DOI: 10.14310/horm.2002.1150* (2002).

7 delange, F. & Lecomte, P. Iodine Supplementation: Benefits Outweigh Risks. *Drug Safety* 22, 89-95 (2000).

8 McConahey, W. M., Keating, F. R., Beahrs, O. H. & Woolner, L. B. On the Increasing Occurrence of Hashimoto's Thyroiditis. *The Journal of Clinical Endocrinology & Metabolism* 22, 542-544, doi:10.1210/jcem-22-5-542 (1962).

9 Zimmermann, M. B., Ito, Y., Hess, S. Y., Fujieda, K. & Molinari, L. High thyroid volume in children with excess dietary iodine intakes. *The American Journal of Clinical Nutrition* 81, 840-844 (2005).

10 Sang, Z. *et al.* Exploration of the safe upper level of iodine intake in euthyroid Chinese adults: a randomized double-blind trial. *The American Journal of Clinical Nutrition*, doi:10.3945/ajcn.111.028001 (2012).

11 Fuse, Y., Saito, N., Tsuchiya, T., Shishiba, Y. & Irie, M. Smaller thyroid gland volume with high urinary iodine excretion in Japanese schoolchildren: normative reference values in an iodine-sufficient area and comparison with the WHO/ICCIDD reference. *Thyroid : official journal of the American Thyroid Association* 17, 145-155, doi:10.1089/thy.2006.0209 (2007).

12 Teng, W. *et al.* Effect of Iodine Intake on Thyroid Diseases in China. *New England Journal of Medicine* 354, 2783-2793, doi:doi:10.1056/NEJMoa054022 (2006).