

# Thyroid Function Tests

*National Endocrine and Metabolic Diseases Information Service*



U.S. Department  
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## What is the thyroid gland?

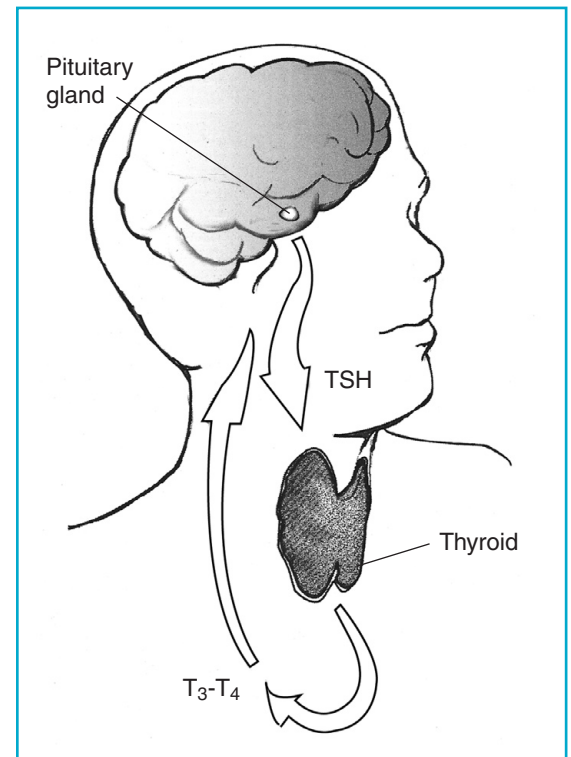
The thyroid is a small, butterfly-shaped gland located in the front of the neck below the larynx, or voice box. The thyroid gland makes two thyroid hormones, triiodothyronine ( $T_3$ ) and thyroxine ( $T_4$ ), which circulate in the bloodstream and act on virtually every tissue and cell in the body. Thyroid hormones affect metabolism, brain development, breathing, heart and nervous system functions, body temperature, muscle strength, skin dryness, menstrual cycles, weight, cholesterol levels, and more.

Thyroid hormone production in the thyroid is regulated by another hormone called thyroid-stimulating hormone (TSH). TSH is made by the pituitary gland, which is located in the brain. From the pituitary gland, TSH travels to the thyroid where it stimulates the production of  $T_3$  and  $T_4$  and their release into the bloodstream.

## Why are thyroid function tests performed?

Thyroid function tests are used to evaluate the thyroid's functioning and to diagnose and help determine the cause of thyroid diseases.

Sometimes the body produces too much or too little thyroid hormone. Too much thyroid hormone in the bloodstream causes hyperthyroidism, which results in increased



The thyroid gland's production of thyroid hormones ( $T_3$  and  $T_4$ ) is regulated by thyroid-stimulating hormone (TSH), which is made by the pituitary gland.

metabolic rate, weight loss, sweating, rapid heart rate, and high blood pressure, among other symptoms. Too little thyroid hormone causes hypothyroidism, which slows down bodily functions and leads to fatigue, weight gain, cold intolerance, and related symptoms.

Hyperthyroidism and hypothyroidism are most often caused by autoimmune diseases. Normally, the immune system produces antibodies that defend the body against foreign substances such as bacteria. In autoimmune diseases, however, the immune system produces “autoantibodies” that attack the body’s own healthy cells and tissues—in this case, the thyroid. Graves’ disease is the most common cause of autoimmune hyperthyroidism. Hashimoto’s disease is the most common cause of autoimmune hypothyroidism. Both Graves’ disease and Hashimoto’s disease are due to an immune attack on the thyroid. In Graves’ disease, the attacking antibodies stimulate thyroid hormone production.

Blood tests assess thyroid function by measuring TSH and thyroid hormone levels and detecting certain autoantibodies present in autoimmune thyroid disease. Radiologic tests either assess thyroid function or detect abnormalities in the thyroid gland.

## What blood tests are used to assess thyroid function?

Usually the first blood test performed is the TSH test. TSH is the key hormone for diagnosing hyperthyroidism and hypothyroidism. If results of the TSH test are abnormal, one or more additional tests are needed to help determine the cause of the problem.

### TSH Test

This blood test is the most sensitive test of thyroid function available. The TSH test can detect TSH blood levels as low as 0.01 milli-international units per liter (mIU/L). The normal range for TSH is between 0.3 and 4 mIU/L, although the range varies from one laboratory to another.

The TSH test is based on the way TSH and thyroid hormones work together. Normally, the pituitary boosts TSH production when

thyroid hormone levels in the blood are low. The thyroid responds by making more hormone. Then, when the body has enough thyroid hormone circulating in the blood, TSH output drops. The cycle repeats continuously to maintain a healthy level of thyroid hormone in the body. The TSH test measures the amount of TSH being secreted by the pituitary.

In people whose thyroid produces too much thyroid hormone, the pituitary shuts down TSH production, leading to low or even undetectable TSH levels in the blood. An abnormally low TSH level suggests hyperthyroidism.

In people whose thyroid is not functioning normally and produces too little thyroid hormone, the thyroid cannot respond normally to TSH by producing thyroid hormone. As a result, the pituitary keeps making TSH, trying to get the thyroid to respond. An abnormally high TSH level suggests hypothyroidism.

Occasionally, however, a low TSH level can indicate a type of hypothyroidism called secondary hypothyroidism. Instead of a problem with the thyroid gland, this type of hypothyroidism is caused by an abnormality in the pituitary that prevents it from making enough TSH to stimulate thyroid hormone production.

Very rarely, hyperthyroidism can result from a problem with the pituitary rather than the thyroid. Noncancerous, or benign, pituitary tumors may overproduce TSH and cause thyroid hormone levels to rise. However, such tumors are extremely rare. The usual cause of a high TSH level is an underfunctioning thyroid gland or inadequate dosage of thyroid hormone medication in patients taking replacement hormone.

## T<sub>4</sub> Tests

T<sub>4</sub> is the principal thyroid hormone and exists in two forms—T<sub>4</sub> that is bound to proteins in the blood and kept in reserve until the body needs it, and a small amount of unbound or “free” T<sub>4</sub> (FT<sub>4</sub>), which is the active form of the hormone and is available to body tissues. The normal range for total T<sub>4</sub>—bound and free together—is usually about 4.5 to 12.6 micrograms per deciliter (μg/dL), although the range varies from one laboratory to another. The normal FT<sub>4</sub> range is about 0.7 to 1.8 nanograms per deciliter (ng/dL).

Elevated total T<sub>4</sub> or FT<sub>4</sub> suggests hyperthyroidism, and low total T<sub>4</sub> or FT<sub>4</sub> suggests hypothyroidism. Sometimes total T<sub>4</sub> levels are abnormal because the protein-bound T<sub>4</sub> is abnormally high or low due to elevated or low concentrations of the protein that binds T<sub>4</sub>. Therefore, FT<sub>4</sub> must be calculated separately.

Measuring FT<sub>4</sub> directly requires complicated laboratory procedures, so FT<sub>4</sub> is usually estimated based on the ratio of binding protein to total T<sub>4</sub>. Normal FT<sub>4</sub> levels, when the total T<sub>4</sub> is high or low, indicate the issue is the binding protein, not the thyroid. For example, pregnancy or the use of oral contraceptives increases levels of binding protein in the blood. In this case, the total T<sub>4</sub> will be high due to the binding protein but the person does not have hyperthyroidism. Severe illness or the use of corticosteroids—a class of medications that treat asthma, arthritis, and skin conditions, among other health problems—can decrease binding protein levels. The total T<sub>4</sub> measurement will be low as a consequence, but the person does not have hypothyroidism. In either case—having high binding protein or having low binding protein—the FT<sub>4</sub> will be normal and the person has normal thyroid function—also called euthyroid.

## T<sub>3</sub> Test

Only about 20 percent of the T<sub>3</sub> circulating in the blood comes from the thyroid gland, while all of the circulating T<sub>4</sub> comes from the thyroid. The remaining 80 percent of circulating T<sub>3</sub> comes from various cells all over the body where T<sub>4</sub> is converted to T<sub>3</sub>. T<sub>3</sub> is far more active than T<sub>4</sub> and, like T<sub>4</sub>, exists in both bound and free states. In some cases of hyperthyroidism, FT<sub>4</sub> is normal but free T<sub>3</sub> (FT<sub>3</sub>) is elevated, so measuring both forms is useful if hyperthyroidism is suspected. The normal FT<sub>3</sub> range is about 0.2 to 0.5 ng/dL. The T<sub>3</sub> test is not useful in diagnosing hypothyroidism because levels are not reduced until the hypothyroidism is severe.

## Thyroid-stimulating Immunoglobulin (TSI) Test

TSI is an autoantibody present in Graves’ disease, the most common cause of hyperthyroidism. TSI mimics TSH by stimulating the thyroid cells, causing the thyroid gland to secrete excess hormone. The TSI test detects TSI circulating in the blood and is usually measured in specific instances in people with Graves’ disease—when the diagnosis is obscure, during pregnancy, and to determine if remission has occurred.

## Antithyroid Antibody Test

Antithyroid antibodies are present in Hashimoto’s disease, the most common cause of hypothyroidism. Antithyroid antibodies are markers in the blood, and their presence is extremely helpful in diagnosing Hashimoto’s disease. Two principal types of antithyroid antibodies are

- anti-TG antibodies, which attack a protein in the thyroid called thyroglobulin
- anti-thyroperoxidase, or anti-TPO, antibodies, which attack an enzyme in thyroid cells called thyroperoxidase

## What radiologic tests are used to assess thyroid function?

Two radiologic tests—the radioactive iodine uptake (RAIU) test and a thyroid scan—may be used to aid diagnosis and treatment.

### RAIU Test

The thyroid uses iodine from food to make thyroid hormone. The RAIU test measures the amount of iodine the thyroid collects from the bloodstream. The test helps doctors evaluate how the thyroid is functioning and determine the cause of hyperthyroidism. The RAIU is not used to assess hypothyroidism.

For this test, the patient swallows a small amount of radioactive iodine in liquid or capsule form. After 4 to 6 hours and again at 24 hours, the patient returns to the testing center, where the doctor measures the amount of radioactive iodine taken up by the thyroid. The measurement is taken with a small device called a gamma probe, which resembles a microphone. The gamma probe is positioned near the patient's neck over the thyroid gland. Measurement takes only a few minutes and is painless.

In the diagnosis of hyperthyroidism, a high RAIU reading usually indicates an overactive thyroid that produces too much thyroid hormone, as seen in Graves' disease or toxic nodular goiter, an enlargement of the thyroid gland. A low RAIU reading suggests the thyroid is not overactive.

Thyroiditis may cause leakage of thyroid hormone and iodine out of the thyroid gland into the bloodstream, which can lead to high

T<sub>4</sub> levels. Because the thyroid is inflamed, it does not take up the radioactive iodine given as part of the RAIU test. Hyperthyroidism seen in Graves' disease would be marked by high blood T<sub>4</sub> and a high RAIU. In thyroiditis, temporary hyperthyroidism may exist because of the release of T<sub>4</sub> into the blood, but the RAIU is low because of the inflammation. Temporary hyperthyroidism in thyroiditis is often followed by a period of hypothyroidism before the thyroid heals.

The radioactive compound used in the RAIU test is safe to ingest in the small amount given. Pregnant and nursing women should not undergo this test, however, because the radioactive material can travel across the placenta to the baby's bloodstream or be transmitted to the baby via breast milk.

### Thyroid Scan

A thyroid scan does not test thyroid function *per se*, but instead uses radioactive material to create a picture of the thyroid. The scan shows the size and shape of the thyroid and provides images of irregularities such as nodules. Nodules are tumors in the thyroid that can either be benign or cancerous and can sometimes produce excess thyroid hormone. The scan does not identify whether the nodules are benign or cancerous.

For the scan, radioactive iodine or radioactive technetium is either injected into the patient's vein or swallowed in liquid or capsule form. The scan takes place 30 minutes after an injection or 6 to 24 hours after the radioactive substance is swallowed. The patient lies on an examining table for the scan, which takes about 30 minutes. A

device called a gamma camera is suspended over the table or may be located within a large, doughnut-shaped machine that resembles a computerized tomography (CT) scanner.

The gamma camera detects the radioactive material and sends images to a computer that show how and where the radioactive substance has been distributed in the thyroid. Nodules that produce excess thyroid hormone—so-called “hot,” or toxic, nodules—show up clearly because they absorb more radioactive material than normal thyroid tissue. Graves’ disease shows up as a diffuse, overall increase in radioactivity rather than a localized spot.

## What do thyroid function test results tell doctors?

The pattern of test results in people with hyperthyroidism or hypothyroidism can help doctors determine the underlying cause of the condition. The following tables give the usual pattern of thyroid function test results.

Because many complex factors affect thyroid function and hormone levels, doctors must take the patient’s full medical history into account when interpreting thyroid function tests.

**Table 1. Typical thyroid function test results: Hyperthyroidism**

Cause	Test			
	TSH	T <sub>3</sub> /T <sub>4</sub>	TSI	RAIU
Graves’ disease	↓	↑	+	↑
Thyroiditis (early stage)	↓	↑	–	↓
Thyroid nodules (hot, or toxic)	↓	↑	–	↑ or N

**Table 2. Typical thyroid function test results: Hypothyroidism**

Cause	Test		
	TSH	T <sub>3</sub> /T <sub>4</sub>	Antithyroid Antibody
Hashimoto’s (thyroiditis) disease	↑	↓ or N	+
Hashimoto’s (thyroiditis) disease (later stage)	↑	↓	+
Pituitary abnormality	↓	↓	–

**Key:** N = Normal    ↑ = Above normal    ↓ = Below normal    + = Positive    – = Negative

## Points to Remember

- Hyperthyroidism occurs when the thyroid gland produces too much thyroid hormone or hormone leaks out of the inflamed gland. Hypothyroidism occurs when the thyroid gland does not produce enough thyroid hormone.
- Blood tests are used to diagnose hyperthyroidism and hypothyroidism and help determine the cause of these disorders.
- Thyroid-stimulating hormone (TSH) is the key hormone for diagnosing hyperthyroidism and hypothyroidism.
- Radiologic tests that use radioactive materials evaluate how the thyroid is functioning and create pictures of the gland to further pinpoint the cause of thyroid disorders.

## Hope through Research

Researchers are investigating the development, signs and symptoms, and genetics of thyroid function disorders to better understand thyroid diseases. Scientists continue to study treatment options for hyperthyroidism, hypothyroidism, and other thyroid disorders.

Participants in clinical trials can play a more active role in their own health care, gain access to new research treatments before they are widely available, and help others by contributing to medical research. For information about current studies, visit [www.ClinicalTrials.gov](http://www.ClinicalTrials.gov).

## For More Information

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