

# Etiological Determinants, Biological Mechanisms, Clinical Spectrum, and Functional Nutritional Therapeutics for Thyroid Disorders in Women - A Narrative Review

A. Radhika<sup>1</sup>, Dr. R. Rekha<sup>2</sup>, Dr. Muthulakshmi<sup>3</sup>

<sup>1</sup>PhD Scholar, Faculty of Yoga Sciences and Therapy, Meenakshi Academy of Higher Education and Research, Chennai-Tamil Nadu, India.

<sup>2</sup>Yoga Practitioner and Academic Counsellor, Member, Executive Council, Andhra University, Visakhapatnam, Andhra Pradesh, India.

Professor and Head, Department of Physiology, Meenakshi Medical College Hospital & Research Institute, Enathur, Kanchipuram, Tamilnadu, India.

**Abstract:** *Thyroid dysfunction is one of the most prevalent endocrine disorders globally and disproportionately affects women due to hormonal variability, autoimmune susceptibility, and increased micronutrient requirements across reproductive life stages. Both hypothyroidism and hyperthyroidism disrupt metabolic homeostasis, reproductive health, cardiovascular function, neurological activity, and skeletal integrity. The aetiology of thyroid disorders involves complex interactions among genetic predisposition, immune dysregulation, environmental exposure, gut microbiota imbalance, and nutritional deficiencies. Emerging evidence highlights the role of functional foods, dietary bioactive compounds, and personalized nutritional interventions in thyroid hormone synthesis, immune modulation, and oxidative stress regulation. This review integrates current evidence on etiological determinants, pathophysiological mechanisms, clinical manifestations, gut–thyroid interactions, and personalized functional nutritional strategies in thyroid disorder management among women.*

**Keywords:** Thyroid dysfunction, personalized nutrition, gut–thyroid axis, functional foods, autoimmune thyroid disease, women’s endocrine health

## 1. Introduction

The thyroid gland plays a central role in regulating metabolic homeostasis through secretion of thyroxine (T4) and triiodothyronine (T3). These hormones influence cellular metabolism, growth, neurological development, cardiovascular activity, and reproductive physiology [3].

Thyroid disorders are among the most common endocrine abnormalities worldwide. Women demonstrate significantly higher disease prevalence due to hormonal transitions, immune sensitivity, and reproductive physiological demands [17]. Thyroid dysfunction during reproductive life stages may impair fertility, pregnancy outcomes, and metabolic stability [12].

Recent advances in nutritional endocrinology emphasize the influence of dietary patterns, micronutrients, gut microbiota composition, and nutrigenomic variability in thyroid disease progression and management [9].

## 2. Literature Search Strategy

A comprehensive literature search was conducted using PubMed, Scopus, and Web of Science databases. Articles published between 2000 and 2025 were included. Keywords used included “thyroid disorders,” “hypothyroidism,” “hyperthyroidism,” “functional foods,” “personalized nutrition,” “gut microbiota,” and “nutrigenomics.” Only peer-reviewed English language studies focusing on nutritional

and microbiome influences on thyroid disorders were considered.

## 3. Physiology of Thyroid Hormone Regulation

Thyroid hormone synthesis is regulated through the hypothalamic–pituitary–thyroid (HPT) axis. The hypothalamus secretes thyrotropin-releasing hormone, stimulating pituitary secretion of thyroid-stimulating hormone (TSH). TSH activates thyroid follicular cells to produce T3 and T4 hormones. These hormones exert negative feedback on hypothalamic and pituitary activity to maintain endocrine balance [3].

## 4. Etiological Determinants of Thyroid Dysfunction in Women

### 4.1 Autoimmune Dysregulation

Autoimmune thyroid diseases represent the leading cause of thyroid dysfunction. Hashimoto’s thyroiditis involves progressive thyroid tissue destruction, whereas Graves’ disease results from thyroid-stimulating antibodies that increase hormone production [1].

### 4.2 Nutritional Imbalance

Micronutrients play essential roles in thyroid hormone metabolism:

- Iodine deficiency reduces hormone synthesis
- Selenium deficiency impairs T4 to T3 conversion

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- Iron deficiency disrupts thyroid peroxidase activity
- Zinc imbalance affects thyroid hormone receptor signalling

These deficiencies are particularly common among reproductive-age women [13, 6].

### 4.3 Genetic Susceptibility

Genetic variations affecting immune regulation and thyroid hormone receptor function increase vulnerability to autoimmune thyroid disorders [1].

### 4.4 Environmental and Lifestyle Factors

Radiation exposure, environmental pollutants, smoking, and chronic psychological stress contribute to oxidative stress and immune dysregulation, increasing thyroid disease risk [5].

### 4.5 Hormonal Life Cycle Transitions

Adolescence, pregnancy, postpartum recovery, and menopause increase thyroid hormone demand and disease susceptibility among women [11].

## 5. Pathophysiology and Clinical Manifestations of Hypothyroidism

Hypothyroidism is characterized by insufficient thyroid hormone production, leading to decreased metabolic activity and impaired cellular energy production [4].

Clinical Manifestations

- Fatigue, weight gain, cold intolerance
- Depression and cognitive impairment
- Bradycardia and dyslipidaemia
- Menstrual irregularities and infertility
- Dermatological manifestations including dry skin and hair thinning

Untreated hypothyroidism may progress to cardiovascular disease and myxoedema coma [4].

## 6. Pathophysiology and Clinical Manifestations of Hyperthyroidism

Hyperthyroidism results from excessive thyroid hormone secretion, leading to metabolic acceleration and increased sympathetic activity. Severe untreated hyperthyroidism may cause osteoporosis and thyroid storm [15].

Clinical Manifestations

- Weight loss and heat intolerance
- Anxiety, tremors, and insomnia
- Tachycardia and atrial fibrillation
- Ophthalmopathy associated with autoimmune disease
- Reproductive dysfunction

## 7. Functional Nutritional Therapeutic Strategies

Functional foods provide bioactive compounds that support thyroid function through micronutrient supplementation, antioxidant protection, and immune modulation [9].

**Table 1: Functional Foods Beneficial in Hypothyroidism**

Nutrient	Functional Food Sources	Physiological Role	References
Iodine	Iodized salt, marine fish, dairy products, seaweed	Thyroid hormone synthesis	[22]
Selenium	Brazil nuts, sunflower seeds, eggs, seafood	T4 to T3 conversion, antioxidant protection	[13]
Iron	Spinach, legumes, red meat	Thyroid enzyme activity	[6]
Zinc	Pumpkin seeds, whole grains, nuts	Hormone receptor function	[6]
Probiotics	Yogurt, kefir, fermented vegetables	Gut microbiota modulation	[16]
Antioxidants	Berries, turmeric, green tea, nuts	Reduce thyroid inflammation	[9]

**Table 2: Functional Foods Beneficial in Hyperthyroidism**

Nutrient	Functional Food Sources	Physiological Role	References
Calcium	Milk, sesame seeds, leafy vegetables	Bone density maintenance	[21]
Vitamin D	Fortified dairy, sunlight exposure	Bone metabolism and immune regulation	[21]
Omega-3 Fatty Acids	Flaxseeds, walnuts, fatty fish	Anti-inflammatory and cardiovascular protection	[14]
Cruciferous Vegetables	Broccoli, cabbage, cauliflower, kale	Moderate thyroid hormone production	[9]

**Table 3: Foods to Limit or Avoid in Thyroid Disorders**

Condition	Foods to Avoid	Reason	References
Hypothyroidism	Excess soy, raw cruciferous vegetables, high fiber during medication	Reduces hormone absorption	[22]
Hyperthyroidism	Excess iodine intake, caffeine, stimulants, refined sugar	Worsens metabolic symptoms	[22]

## 8. Gut–Thyroid Axis and Microbiome Interactions

The gut–thyroid axis represents bidirectional communication between intestinal microbiota and thyroid gland function [20].

### 8.1 Immune Regulation

Gut microbiota influence T-regulatory cell development and cytokine production. Dysbiosis may trigger autoimmune thyroid disorders through inflammatory signaling and molecular mimicry [10].

### 8.2 Micronutrient Bioavailability

Gut bacteria regulate absorption of iodine, selenium, iron, and zinc, which are essential for thyroid hormone synthesis and metabolism [20].

### 8.3 Microbial Enzymatic Activity

Microbial enzymes such as  $\beta$ -glucuronidase influence enterohepatic recycling of thyroid hormones and may affect circulating hormone levels [20].

### 8.4 Gastrointestinal Motility and Thyroid Function

Thyroid hormones regulate intestinal motility. Hypothyroidism delays gastrointestinal transit, while hyperthyroidism accelerates motility, influencing microbial composition.

## 9. Gut Dysbiosis in Autoimmune Thyroid Disorders

Studies demonstrate altered microbial diversity in autoimmune thyroid disease, including reduced beneficial bacterial species and increased inflammatory strains [10, 23]. These changes may exacerbate immune dysregulation.

## 10. Dietary Bioactive Compounds and Thyroid Health

### 10.1 Polyphenols

Polyphenols reduce oxidative stress and inflammatory cytokine activity while promoting beneficial microbial growth [18].

### 10.2 Omega-3 Fatty Acids

Omega-3 fatty acids reduce systemic inflammation and provide cardiovascular protection in thyroid disorders [14].

### 10.3 Probiotics

Probiotics restore microbial diversity, improve intestinal barrier integrity, and enhance micronutrient absorption [2].

### 10.4 Selenium

Selenium supports antioxidant enzyme activity and reduces thyroid autoantibody levels [19].

### 10.5 Vitamin D

Vitamin D modulates immune responses and improves T-regulatory cell activity [7].

## 11. Personalized Nutritional Strategies in Thyroid Disorders

**Table 4:** Personalized Nutritional Strategies in Hypothyroidism

Component	Individual Considerations	Therapeutic Role	References
Iodine Intake	Regional iodine status	Hormone synthesis	[22]
Selenium Supplementation	Serum selenium levels	Improve hormone conversion	[19]

Iron Intake	Presence of anemia	Enhance thyroid enzyme activity	[6]
Probiotics	Gut dysbiosis	Immune regulation	[16]
Anti-Inflammatory Diet	Autoimmune activity	Reduce inflammation	[9]

**Table 5:** Personalized Nutritional Strategies in Hyperthyroidism

Component	Individual Considerations	Therapeutic Role	References
Calcium and Vitamin D	Bone mineral density	Prevent osteoporosis	[21]
Omega-3 Fatty Acids	Cardiovascular risk	Anti-inflammatory protection	[14]
Controlled Iodine Intake	Autoimmune hyperthyroidism	Prevent hormone excess	[22]
Goitrogenic Vegetables	Hormone levels	Moderate thyroid activity	[9]

## 12. Clinical Implications of Integrated Nutritional and Microbiome Therapy

Long-term dietary interventions targeting immune regulation, microbiome modulation, and micronutrient balance may complement pharmacological therapy. However, excessive supplementation of iodine or bioactive compounds may produce adverse endocrine effects.

## 13. Importance of Early Diagnosis and Integrated Management

Serum TSH, T3, and T4 remain primary diagnostic tools. Early detection improves treatment outcomes and prevents complications [8]. Multidisciplinary management including nutritional therapy and lifestyle modification improves long-term outcomes.

## 14. Research Gaps

Despite growing evidence, several limitations remain:

- Lack of large randomized controlled trials
- Variability in micronutrient supplementation doses
- Limited nutrigenomic data
- Insufficient long-term microbiome studies

## 15. Limitations of the Review

This review included only English language publications and relied primarily on observational and small clinical trials, which may introduce selection bias.

## 16. Conclusion

Thyroid dysfunction in women represents a complex, systemic endocrine disorder arising from the convergence of genetic predisposition, immune dysregulation, hormonal transitions, environmental exposures, micronutrient imbalances, and gut microbiome alterations. The disproportionate burden of thyroid disease among women underscores the necessity of adopting a gender-sensitive and

life-stage-specific approach to endocrine health. Physiological transitions such as pregnancy, postpartum recovery, and menopause significantly modulate immune tolerance, micronutrient metabolism, and hormonal equilibrium, thereby amplifying disease susceptibility.

This review highlights compelling evidence that thyroid health extends beyond isolated glandular pathology and must be understood within a broader metabolic and immunological framework. Micronutrients including iodine, selenium, iron, zinc, and vitamin D are not merely supportive elements but integral regulators of thyroid hormone synthesis, enzymatic conversion, antioxidant defense, and immune modulation. Concurrently, emerging research on the gut–thyroid axis indicates that intestinal microbiota composition influences thyroid hormone recycling, micronutrient bioavailability, and autoimmune activation pathways. These findings reinforce the concept that thyroid dysfunction is a systemic condition requiring integrative therapeutic strategies.

Functional nutritional therapeutics- encompassing bioactive dietary compounds, probiotic supplementation, anti-inflammatory dietary patterns, and individualized micronutrient optimization- offer promising adjunctive roles in thyroid disorder management. Personalized nutritional interventions tailored to biochemical status, autoimmune activity, and microbiome diversity may enhance treatment responsiveness, reduce inflammatory burden, and improve long-term quality of life in affected women. Importantly, such approaches align with the growing global shift toward precision medicine and preventive healthcare.

From a public health perspective, early screening, nutritional awareness programs, and targeted micronutrient interventions may substantially reduce disease progression, reproductive complications, cardiovascular risks, and metabolic comorbidities associated with thyroid disorders. Integrating nutritional endocrinology into routine clinical practice- particularly in primary care and women’s health settings- has the potential to improve therapeutic outcomes while reducing long-term healthcare burden.

However, despite promising evidence, the field requires rigorously designed multicentre randomized controlled trials, standardized supplementation protocols, and longitudinal microbiome studies to establish definitive clinical guidelines. Advances in nutrigenomics and systems biology may further enable individualized therapeutic precision.

In conclusion, thyroid disorders in women should no longer be approached solely as isolated endocrine abnormalities but rather as multifactorial systemic conditions influenced by nutrition, immunity, microbiota, and hormonal transitions. Integrative and personalized nutritional strategies represent a transformative adjunct to conventional therapy and hold substantial potential to reshape future thyroid disorder management paradigms. Strengthening interdisciplinary research and clinical integration in this domain may significantly advance women’s endocrine health and overall metabolic well-being.

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