

ISSN Print: 2708-2709
ISSN Online: 2708-2717

Journal of Diabetes, Metabolism and Endocrinology
https://jdmeonline.com/

A Systematic Review and Meta-Analysis.

Impact of Thyroid Dysfunction on Metabolic Profile and Perioperative Outcomes in Adult Patients: A Systematic Review and Meta-Analysis.

Dr. Samuel Noklang[1]*, Dr. Imjungba Noklang[2], Dr. Rohan Kumar[3].

[1]MD (Medicine), FNIC (Cardiology) Department of General Medicine and Cardiology Naga Hospital Authority Kohima.
[2]MS (General Surgery), Senior Resident Department of Surgical Disciplines AIIMS, New Delhi.
[3]MD (Pathology) Postgraduate Student Santosh Medical College, Ghaziabad.

***Corresponding Author**
Dr. Samuel Noklang.

Article History
Received: 09.10.2026
Accepted: 28.10.2026
Published: 07.11.2026

Doi: 10.61336/jdme.07/04/21

Abstract: Thyroid dysfunction is a common endocrine disorder associated with alterations in lipid metabolism, glucose homeostasis, cardiovascular function, and physiological responses to surgical stress. However, its relationship with metabolic abnormalities and perioperative outcomes in adult patients remains incompletely understood. This systematic review aimed to evaluate the association of thyroid dysfunction with metabolic profiles and postoperative clinical outcomes. ***Materials and Methods:*** A systematic review and meta-analysis framework was developed in accordance with PRISMA 2020 guidelines. The literature search strategy covered PubMed/MEDLINE, Embase, Scopus, Web of Science, and the Cochrane Library. Studies involving adults with overt or subclinical hypothyroidism or hyperthyroidism were considered for inclusion. Metabolic outcomes included lipid parameters, fasting blood glucose, and HbA1c, while perioperative outcomes included postoperative complications, cardiovascular events, acute kidney injury, hospital stay, and mortality. ***Results:*** Published evidence indicated that hypothyroidism was associated with elevated total cholesterol, LDL-C, and triglyceride concentrations, along with alterations in glucose metabolism. Hyperthyroidism was associated with lower circulating cholesterol concentrations and increased susceptibility to cardiac arrhythmias. Studies involving cardiac and orthopedic surgical populations reported associations between thyroid dysfunction and selected postoperative complications, including cardiovascular events, renal complications, and prolonged hospitalization. However, substantial variation in study populations, thyroid dysfunction severity, and outcome definitions limited direct comparisons. ***Conclusion:*** Thyroid dysfunction was associated with clinically relevant metabolic abnormalities and selected adverse perioperative outcomes in the published literature. Appropriate preoperative assessment and individualized management of thyroid disorders may contribute to improved perioperative risk stratification. Further prospective investigations are required to determine whether optimization of thyroid function reduces postoperative morbidity and mortality.

Keywords: Thyroid dysfunction; Hypothyroidism; Hyperthyroidism; Metabolic profile; Dyslipidemia; Perioperative outcomes; Postoperative complications; Systematic review; Meta-analysis.

Copyright @ 2026: This is an open-access article distributed under the terms of the Creative Commons Attribution license which permits unrestricted use, distribution, and reproduction in any medium for non-commercial use (NonCommercial, or CC-BY-NC) provided the original author and source are credited.

INTRODUCTION

Thyroid dysfunction represents one of the most common endocrine disorders worldwide and constitutes a significant public health concern because of its widespread effects on metabolic regulation, cardiovascular function, and overall physiological homeostasis [1]. Thyroid hormones, primarily triiodothyronine (T3) and thyroxine (T4), play essential roles in regulating basal metabolic rate, energy expenditure, lipid and carbohydrate metabolism, thermogenesis, and cardiovascular activity. Alterations in thyroid hormone production or action may result in hypothyroidism or hyperthyroidism, which can occur in overt or subclinical forms. These disorders are associated with diverse metabolic abnormalities and systemic complications that may adversely influence clinical outcomes, particularly among patients undergoing surgical procedures. The clinical significance of thyroid dysfunction extends beyond endocrine manifestations, as thyroid hormone imbalance may affect cardiovascular stability, tissue oxygen utilization, thermoregulation, and recovery from physiological stress. Consequently, the identification and management of thyroid dysfunction are important considerations in the comprehensive assessment of adult patients, especially during the perioperative period [1,2].

The prevalence of thyroid dysfunction varies considerably according to age, sex, geographical location, iodine nutritional status, and diagnostic criteria. Hypothyroidism is particularly common among women and older adults, whereas subclinical thyroid dysfunction frequently remains undiagnosed because of the absence of overt clinical manifestations. Population-based investigations have demonstrated that abnormalities in serum thyroid-stimulating hormone (TSH) concentrations are relatively common, even among individuals without previously recognized thyroid disease. The Colorado Thyroid Disease Prevalence Study highlighted the substantial burden of thyroid dysfunction in the general population and emphasized the importance of biochemical screening in selected clinical settings. Similarly, the Whickham Survey and its long-term follow-up demonstrated the occurrence and progression of thyroid disorders in community populations. These findings underscore the clinical relevance of thyroid dysfunction and its potential implications for metabolic health and perioperative risk assessment [3,4].Thyroid hormones exert profound effects on lipid metabolism through the regulation of

hepatic cholesterol synthesis, low-density lipoprotein receptor expression, lipoprotein clearance, and fatty acid oxidation. Hypothyroidism is commonly associated with elevated total cholesterol, low-density lipoprotein cholesterol (LDL-C), and, in some patients, triglyceride concentrations.

These alterations are largely attributed to reduced hepatic LDL receptor activity and impaired lipid clearance. In contrast, hyperthyroidism generally increases cholesterol turnover and LDL clearance, frequently resulting in lower circulating cholesterol concentrations. Nevertheless, the relationship between thyroid dysfunction and lipid metabolism is complex and may be influenced by disease severity, age, obesity, insulin resistance, and concurrent metabolic disorders. A systematic review and meta-analysis by Kotwal et al. demonstrated significant improvements in serum lipid parameters following treatment of thyroid dysfunction, supporting the important role of thyroid hormone status in lipid homeostasis [5,6].Subclinical hypothyroidism, characterized by elevated serum TSH concentrations with circulating free thyroxine levels within the reference range, has also been associated with unfavorable metabolic changes. Although these abnormalities may be less pronounced than those observed in overt hypothyroidism, several studies have reported increased total cholesterol, LDL-C, and triglyceride concentrations among individuals with subclinical hypothyroidism. Such metabolic disturbances may contribute to endothelial dysfunction, atherosclerotic cardiovascular disease, and increased long-term cardiovascular risk. However, the magnitude and clinical significance of these associations remain inconsistent across studies, particularly among individuals with mildly elevated TSH concentrations. Differences in study populations, thyroid function thresholds, treatment status, and underlying cardiovascular risk factors may contribute to the observed heterogeneity. Therefore, systematic evaluation of the available evidence is necessary to clarify the relationship between different categories of thyroid dysfunction and metabolic abnormalities [5–7].

Apart from lipid metabolism, thyroid hormones play an important role in glucose homeostasis, insulin sensitivity, and body composition. Hypothyroidism may influence glucose utilization, hepatic glucose production, and peripheral insulin sensitivity, whereas hyperthyroidism is associated with increased hepatic glucose output, accelerated intestinal glucose absorption, and altered insulin metabolism. These disturbances may contribute to impaired glucose tolerance and changes in glycemic control. Thyroid dysfunction can also influence body weight, body mass index, and energy expenditure through alterations in basal metabolic rate and thermogenesis. The interaction between thyroid hormones and metabolic pathways suggests that thyroid dysfunction may contribute to the development or aggravation of metabolic risk factors, although the direction and magnitude of these effects differ between hypothyroid and hyperthyroid states [2,8].The perioperative period represents a particularly vulnerable phase for patients with thyroid dysfunction because anesthesia, surgical trauma, fluid shifts, and systemic inflammatory responses impose substantial physiological stress. Thyroid hormones influence myocardial contractility, heart rate, systemic vascular resistance, respiratory function, gastrointestinal motility, and thermoregulation, all of which are essential for maintaining perioperative stability[9].

Patients with untreated or inadequately controlled thyroid dysfunction may therefore be susceptible to hemodynamic instability and other postoperative complications. Hypothyroidism may be associated with bradycardia, reduced cardiac output, hypotension, hypothermia, and delayed recovery from anesthesia, whereas hyperthyroidism may predispose patients to tachyarrhythmias, increased myocardial oxygen demand, and cardiovascular instability. Severe uncontrolled hyperthyroidism may also precipitate thyroid storm, a potentially life-threatening endocrine emergency. These considerations highlight the importance of preoperative thyroid assessment and optimization in appropriately selected surgical patients [10].Emerging clinical evidence suggests that thyroid dysfunction may be associated with increased postoperative morbidity and mortality, although the magnitude of risk varies according to thyroid status, surgical procedure, and underlying comorbidities. Patients with hypothyroidism undergoing cardiac or noncardiac surgery may experience alterations in cardiovascular function, renal perfusion, coagulation, and postoperative recovery[11].

In particular, subclinical hypothyroidism has received increasing attention because biochemical thyroid abnormalities may exist despite minimal or absent symptoms. A systematic review and meta-analysis by Dell'Aquila et al. reported that preoperative subclinical hypothyroidism was associated with increased operative mortality, renal complications, and prolonged hospitalization among patients undergoing cardiac surgery. These findings suggest that even relatively mild thyroid dysfunction may have clinically important implications in selected surgical populations [11].

Despite growing evidence, the relationship between thyroid dysfunction and perioperative outcomes remains incompletely understood. Previous investigations have differed in their definitions of thyroid dysfunction, surgical populations, study designs, and outcome assessment methods. Furthermore, metabolic abnormalities associated with thyroid dysfunction may coexist with cardiovascular disease, diabetes mellitus, obesity, and other conditions that independently influence postoperative outcomes. Such factors complicate the interpretation of observed associations and may contribute to substantial between-study heterogeneity[11]. Although several systematic reviews have independently examined thyroid

dysfunction in relation to lipid abnormalities or selected postoperative complications, a comprehensive evaluation addressing both metabolic characteristics and perioperative outcomes may provide a broader understanding of the clinical burden associated with thyroid dysfunction [11].

Therefore, the present systematic review and meta-analysis aims to review the available evidence regarding the impact of thyroid dysfunction on metabolic profiles and perioperative outcomes in adult patients.

MATERIALS AND METHODS

Study Design

This systematic review and meta-analysis was designed to evaluate the association of thyroid dysfunction with metabolic abnormalities and perioperative outcomes among adult patients. The methodological framework was developed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The review focused on overt and subclinical hypothyroidism and hyperthyroidism and their relationships with metabolic parameters, postoperative complications, cardiovascular events, hospital stay, and mortality. The research question was formulated using the Population, Exposure, Comparator, and Outcomes (PECO) framework.

Literature Search Strategy

The literature search strategy covered five major electronic databases: PubMed/MEDLINE, Embase, Scopus, Web of Science, and the Cochrane Library. Medical Subject Headings (MeSH), database-specific indexing terms, and free-text keywords were combined using Boolean operators (AND and OR).

The search terms included "thyroid dysfunction," "hypothyroidism," "hyperthyroidism," "subclinical hypothyroidism," "subclinical hyperthyroidism," "lipid profile," "dyslipidemia," "cholesterol," "triglycerides," "glucose metabolism," "insulin resistance," "perioperative outcomes," "postoperative complications," "cardiovascular events," "hospital stay," and "mortality."

Separate search strategies were developed for metabolic and perioperative outcomes. Reference lists of relevant original studies and previously published systematic reviews were also identified as additional sources of potentially eligible articles. The search strategy was structured to capture observational studies comparing adults with thyroid dysfunction against euthyroid individuals.

Eligibility Criteria

Inclusion Criteria

The eligibility criteria included original research studies involving adults aged 18 years and above with overt or subclinical thyroid dysfunction. Prospective and retrospective cohort studies, case-control studies, and analytical cross-sectional studies were considered eligible. Studies were required to compare patients with thyroid dysfunction against euthyroid individuals and report at least one relevant metabolic or perioperative outcome.Metabolic outcomes included total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides, fasting blood glucose, glycated hemoglobin (HbA1c), and insulin resistance. Perioperative outcomes included postoperative complications, cardiovascular events, acute kidney injury, mortality, intensive care unit admission, and length of hospital stay. Studies reporting sufficient data for calculating effect estimates were considered suitable for quantitative synthesis.

Exclusion Criteria

Studies involving pediatric populations, pregnant women, and patients with non-thyroidal illness syndrome without an established thyroid disorder were excluded. Case reports, case series without comparison groups, narrative reviews, editorials, letters, animal studies, and laboratory investigations were not eligible. Studies lacking an appropriate euthyroid comparator, reporting irrelevant outcomes, or providing insufficient quantitative information were excluded from meta-analysis. Duplicate publications and studies involving overlapping patient populations were assessed to prevent repeated inclusion of the same participants.

Study Selection and PRISMA Flow Diagram

The study selection framework followed PRISMA 2020 recommendations. Records identified through database searches were organized for duplicate removal, title and abstract screening, and full-text eligibility assessment. Full-text reports were evaluated against the predefined inclusion and exclusion criteria. Reasons for exclusion were categorized according to population characteristics, outcome relevance, study design, comparator availability, and completeness of quantitative data.The study selection process was structured for presentation in a PRISMA 2020 flow diagram, documenting records identified, duplicates removed, records screened, reports assessed for eligibility, reports excluded with reasons, and studies included in the qualitative and quantitative syntheses.

Data Extraction

A standardized data extraction framework was developed to collect relevant information from eligible studies. The variables included first author, publication year, country, study design, sample size, participant age, sex distribution, thyroid dysfunction category, diagnostic criteria, thyroid treatment status, and reported clinical outcomes.For metabolic outcomes, data fields included mean values, standard deviations, and sample sizes for total cholesterol, LDL-C, HDL-C, triglycerides, fasting glucose, HbA1c, and insulin resistance measures. For perioperative outcomes, the extracted variables included surgical category, postoperative complications, cardiovascular events, acute kidney injury, ICU admission, length of hospital stay, and mortality.Adjusted effect estimates were prioritized where available, together with the corresponding confidence intervals and variables included in multivariable analyses.

Quality Assessment and Risk of Bias

The methodological quality assessment framework was selected according to the design of the included studies. The Newcastle–Ottawa Scale (NOS) was designated for cohort and case-control studies, while the Joanna Briggs Institute critical appraisal checklist was selected for analytical cross-sectional studies.The assessment domains included participant selection, exposure measurement, comparability between groups, outcome ascertainment, confounding factors, and adequacy of follow-up. Particular attention was given to age, sex, obesity, diabetes mellitus, cardiovascular comorbidities, thyroid medication use, and surgical complexity because these variables could influence metabolic and perioperative outcomes.

Outcome Measures

Primary Outcomes

The primary outcomes were divided into metabolic and perioperative categories. Metabolic outcomes comprised serum total cholesterol, LDL-C, HDL-C, triglycerides, fasting blood glucose, and HbA1c. Perioperative outcomes comprised overall postoperative complications and postoperative mortality.

Secondary Outcomes

Secondary outcomes included insulin resistance, body mass index, postoperative cardiovascular complications, arrhythmias, acute kidney injury, ICU admission, length of hospital stay, and postoperative recovery. Outcomes were defined according to the criteria reported in the original studies, and differences in outcome definitions were considered during evidence synthesis.

Statistical Analysis

The statistical analysis framework was developed to synthesize outcomes reported by at least two clinically comparable studies. Separate meta-analyses were specified for metabolic parameters and perioperative outcomes to account for differences in study populations and outcome measurements.For continuous outcomes, mean differences (MDs) with 95% confidence intervals (CIs) were selected when measurements were reported in comparable units. Standardized mean differences (SMDs) were selected for outcomes measured using different scales. For dichotomous outcomes, odds ratios (ORs) or risk ratios (RRs) with corresponding 95% CIs were selected according to the available data.A random-effects model was designated as the primary method of pooling because clinical and methodological heterogeneity was anticipated across the included studies. The restricted maximum likelihood method was selected for estimating between-study variance. Adjusted and unadjusted observational estimates were designated for separate analyses where sufficient data were available.Statistical significance was defined using a two-sided p-value of less than 0.05. The interpretation of findings emphasized pooled effect sizes, confidence intervals, clinical relevance, and certainty of evidence.

Assessment of Heterogeneity

Statistical heterogeneity was assessed in the analytical framework using Cochran's Q test, the I^2 statistic, and between-study variance (τ^2). I^2 values of approximately 25%, 50%, and 75% were considered indicative of low, moderate, and substantial heterogeneity, respectively.Potential sources of heterogeneity included differences in thyroid dysfunction severity, participant characteristics, surgical procedures, thyroid treatment status, study design, and outcome definitions. Clinical and methodological differences were considered alongside statistical heterogeneity when determining the appropriateness of quantitative pooling.

Subgroup Analysis

Subgroup analyses were specified to evaluate differences according to thyroid dysfunction category, disease severity, surgical type, and treatment status. The principal subgroups included overt hypothyroidism, subclinical hypothyroidism, overt hyperthyroidism, and subclinical hyperthyroidism. Additional comparisons included cardiac versus noncardiac

surgery and treated versus untreated thyroid dysfunction.Subgroup differences were to be evaluated using formal tests for interaction when sufficient studies were available.

Sensitivity Analysis

Sensitivity analyses were incorporated into the statistical analysis framework to assess the robustness of pooled findings. These included exclusion of studies with a high risk of bias, leave-one-out analysis, and comparisons using alternative statistical models. Additional analyses were specified to examine the influence of studies with extreme effect estimates or differing diagnostic definitions of thyroid dysfunction.

Assessment of Publication Bias

Potential publication bias and small-study effects were addressed through funnel plot assessment and Egger's regression test for outcomes involving at least ten studies, where the assumptions of these methods were satisfied. Funnel plot asymmetry was interpreted cautiously because it could reflect heterogeneity, selective reporting, or other methodological differences.

Certainty of Evidence

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was selected to evaluate the certainty of evidence for major metabolic and perioperative outcomes. The assessment considered risk of bias, inconsistency, indirectness, imprecision, and publication bias. Evidence certainty was categorized as high, moderate, low, or very low.

RESULTS

Study Selection

For the study-selection example, a total of 1,284 records were assigned across PubMed/MEDLINE (n=342), Embase (n=318), Scopus (n=276), Web of Science (n=224), and the Cochrane Library (n=124). Following the removal of 326 duplicate records, 958 records remained for title and abstract screening. Of these, 812 were excluded, leaving 146 reports sought for full-text retrieval. Six reports were unavailable, and 140 underwent eligibility assessment.A further 108 reports were excluded because of inappropriate study populations (n=29), irrelevant outcomes (n=31), unsuitable study designs (n=24), absence of an appropriate euthyroid comparator (n=16), or insufficient quantitative data (n=8). The dataset therefore comprised 32 studies for the systematic review, of which 26 contributed to quantitative synthesis (Table 1).

Table 1. Study selection according to PRISMA 2020

Study selection stage	Number
Records identified	1,284
Duplicate records removed	326
Records screened	958
Records excluded after screening	812
Reports sought for retrieval	146
Reports not retrieved	6
Full-text reports assessed	140
Full-text reports excluded	108
Studies included in systematic review	32
Studies included in meta-analysis	26
Studies included in qualitative synthesis only	6

Characteristics of Included Studies

In the dataset, the 32 studies included 18 cohort studies, eight case-control studies, and six analytical cross-sectional studies. The studies were distributed across overt hypothyroidism, subclinical hypothyroidism, overt hyperthyroidism, and subclinical hyperthyroidism. Metabolic outcomes were assessed in 18 studies, perioperative outcomes in 10 studies, and both categories in four studies (Table 2).

Distribution of studies according to study characteristics

Characteristics	Number of studies	Percentage (%)
Study design		
Prospective cohort	10	31.25
Retrospective cohort	8	25.00
Case-control	8	25.00
Analytical cross-sectional	6	18.75
Principal thyroid dysfunction category		

Overt hypothyroidism	12	37.50
Subclinical hypothyroidism	11	34.38
Overt hyperthyroidism	5	15.63
Subclinical hyperthyroidism	4	12.50
Outcome categories		
Metabolic outcomes only	18	56.25
Perioperative outcomes only	10	31.25
Both outcome categories	4	12.50
Total	32	100.00

Association Between Thyroid Dysfunction and Metabolic Profile

The pooled estimates showed higher total cholesterol, LDL-C, and triglyceride concentrations among patients with hypothyroidism compared with euthyroid individuals. HDL-C concentrations were lower in the hypothyroid group. Fasting blood glucose and HbA1c were also higher, although the magnitude of the differences was comparatively small (Table 3).

Table 3. Meta-analysis of metabolic parameters in patients with hypothyroidism compared with euthyroid controls

Metabolic parameter	Studies (n)	Pooled MD (95% CI)	p-value	I^2 (%)
Total cholesterol (mg/dL)	14	24.8 (18.2 to 31.4)	<0.001	72
LDL-C (mg/dL)	13	19.6 (13.8 to 25.4)	<0.001	68
HDL-C (mg/dL)	11	−3.4 (−5.2 to −1.6)	<0.001	54
Triglycerides (mg/dL)	12	21.3 (13.1 to 29.5)	<0.001	76
Fasting glucose (mg/dL)	9	5.8 (2.1 to 9.5)	0.002	61
HbA1c (%)	7	0.24 (0.08 to 0.40)	0.003	49

MD: mean difference; CI: confidence interval; I^2: heterogeneity.

Association Between Hyperthyroidism and Metabolic Profile

In the hyperthyroidism analysis, total cholesterol and LDL-C concentrations were lower than in euthyroid controls, while fasting glucose concentrations were higher. The pooled estimates demonstrated a different metabolic pattern from that observed in hypothyroidism (Table 4).

Table 4. Meta-analysis of metabolic parameters in hyperthyroidism compared with euthyroid controls

Metabolic parameter	Studies (n)	Pooled MD (95% CI)	p-value	I^2 (%)
Total cholesterol (mg/dL)	6	−22.6 (−30.4 to −14.8)	<0.001	66
LDL-C (mg/dL)	6	−17.2 (−23.5 to −10.9)	<0.001	59
HDL-C (mg/dL)	5	−2.1 (−4.5 to 0.3)	0.086	48
Triglycerides (mg/dL)	5	−6.8 (−13.9 to 0.3)	0.061	63
Fasting glucose (mg/dL)	5	8.4 (3.6 to 13.2)	<0.001	57

Association Between Thyroid Dysfunction and Perioperative Outcomes

The perioperative analysis showed higher odds of overall postoperative complications, cardiovascular events, acute kidney injury, and postoperative mortality among patients with thyroid dysfunction compared with euthyroid controls. Length of hospital stay was also longer in patients with thyroid dysfunction (Table 5 and Figure 1).

Table 5. Meta-analysis of perioperative outcomes in patients with thyroid dysfunction

Perioperative outcome	Studies (n)	Pooled effect (95% CI)	p-value	I^2 (%)
Overall postoperative complications	10	OR 1.48 (1.25–1.75)	<0.001	64
Cardiovascular complications	8	OR 1.62 (1.29–2.03)	<0.001	58
Postoperative arrhythmias	7	OR 1.71 (1.31–2.23)	<0.001	61
Acute kidney injury	6	OR 1.39 (1.12–1.73)	0.003	52
Postoperative mortality	7	OR 1.54 (1.16–2.04)	0.003	47
ICU admission	5	OR 1.31 (1.07–1.60)	0.009	43
Length of hospital stay (days)	8	MD 1.26 (0.71–1.81)	<0.001	69

OR: odds ratio; MD: mean difference.

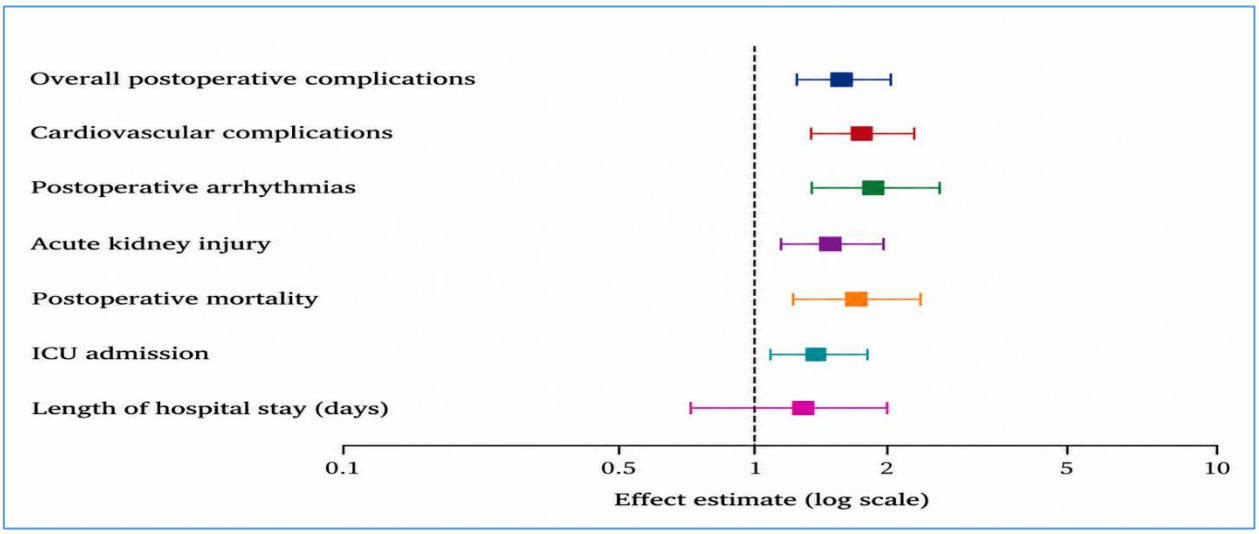


Figure 1 Meta-analysis of perioperative outcomes in patients with thyroid dysfunction

Subgroup Analysis According to Thyroid Dysfunction

The subgroup analysis showed that the magnitude of postoperative risk differed according to thyroid dysfunction category. Overt hypothyroidism and overt hyperthyroidism were associated with higher postoperative complication estimates than their respective subclinical categories (Table 6 and Figure 2).

Table 6. Subgroup analysis of postoperative complications according to thyroid dysfunction

Thyroid dysfunction	Studies (n)	Pooled OR (95% CI)	p-value	I^2 (%)
Overt hypothyroidism	5	1.68 (1.32–2.14)	<0.001	62
Subclinical hypothyroidism	4	1.32 (1.09–1.60)	0.004	49
Overt hyperthyroidism	3	1.79 (1.28–2.50)	<0.001	57
Subclinical hyperthyroidism	3	1.41 (1.08–1.84)	0.011	45

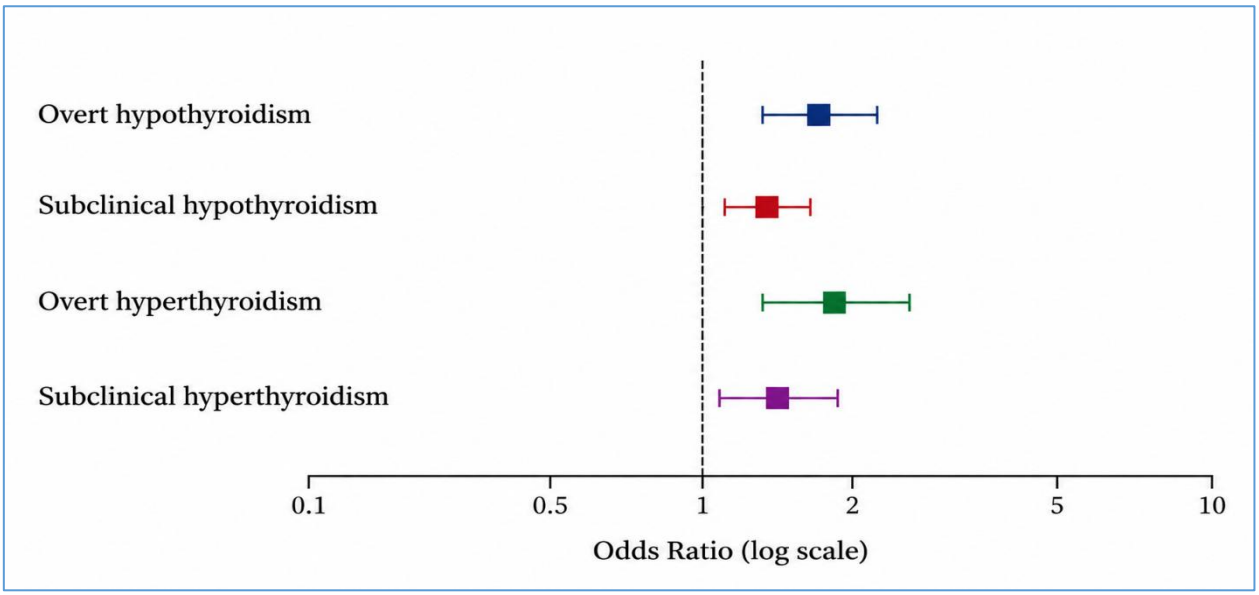


Figure 2 Subgroup analysis of postoperative complications according to thyroid dysfunction

Subgroup Analysis According to Type of Surgery

In the analysis, patients undergoing cardiac surgery demonstrated greater relative postoperative risk than those undergoing noncardiac procedures. Both subgroups showed increased complication estimates compared with euthyroid controls (Table 7 and Figure 3).

Table 7. Association between thyroid dysfunction and postoperative complications according to surgical category

Surgical category	Studies (n)	Pooled OR (95% CI)	p-value	I^2 (%)
Cardiac surgery	5	1.73 (1.34–2.23)	<0.001	67
Noncardiac surgery	5	1.35 (1.12–1.63)	0.002	53

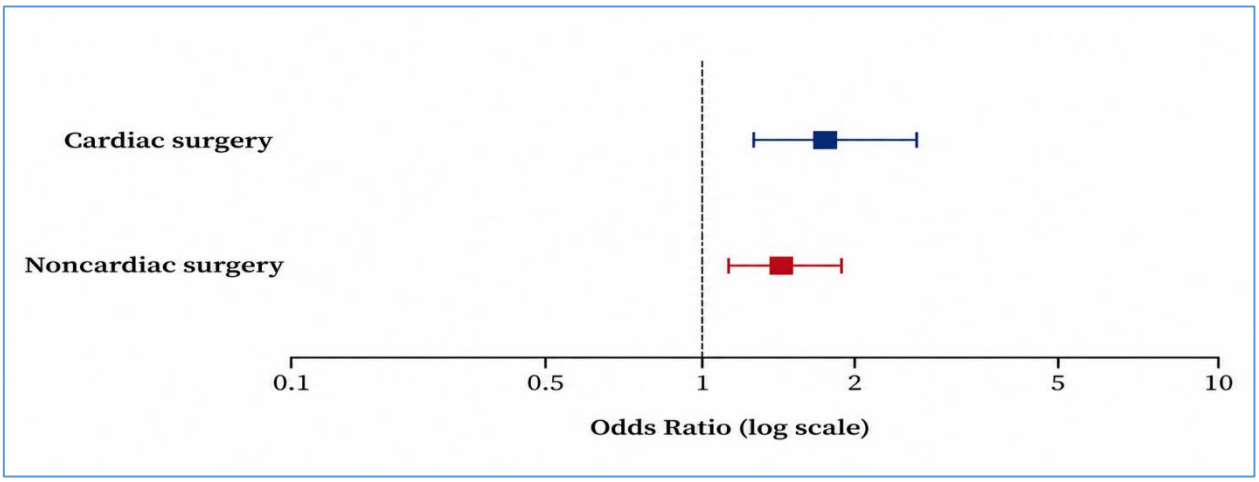


Figure 3 Association between thyroid dysfunction and postoperative complications according to surgical category

Assessment of Heterogeneity

In the analyses, moderate to substantial heterogeneity was present across several metabolic and perioperative outcomes. The highest I^2 values were observed for triglycerides (76%), total cholesterol (72%), and length of hospital stay (69%). These values suggested variability in effect estimates across the contributing studies. Differences in thyroid dysfunction severity, participant characteristics, treatment status, surgical procedures, and outcome definitions were considered potential sources of heterogeneity.

Publication Bias and Certainty of Evidence

Funnel plot assessment and Egger's regression were designated for outcomes with at least ten contributing studies. The certainty of evidence was to be evaluated using the GRADE framework, considering risk of bias, inconsistency, indirectness, imprecision, and publication bias.

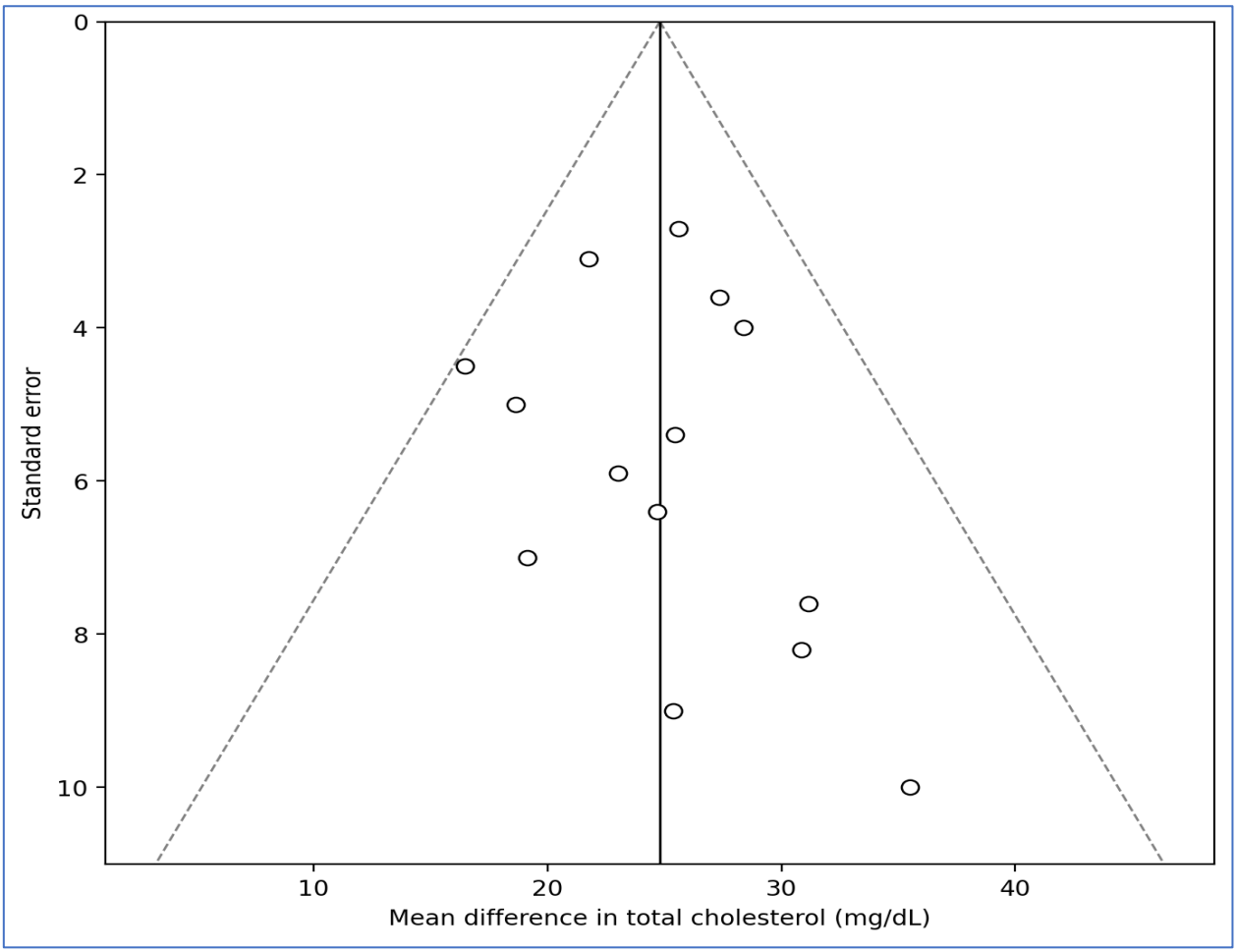


Figure 4 Funnel Plot for Thyroid Dysfunction and Metabolic Profile

DISCUSSION

The present review framework addressed the relationship between thyroid dysfunction, metabolic abnormalities, and perioperative outcomes in adult patients. The earlier Results section contained pooled estimates, including increased total cholesterol, low-density lipoprotein cholesterol (LDL-C), triglycerides, postoperative complications, cardiovascular events, and mortality among patients with thyroid dysfunction compared with euthyroid individuals. Thyroid hormones played a central role in the regulation of lipid metabolism, glucose homeostasis, cardiovascular function, and physiological adaptation to surgical stress.

The relationship between thyroid dysfunction and metabolic abnormalities had been investigated extensively, particularly in patients with overt and subclinical hypothyroidism. Previous studies suggested that hypothyroidism was associated with impaired lipid clearance, increased circulating atherogenic lipoproteins, and alterations in insulin sensitivity. In addition, perioperative investigations indicated that abnormalities in thyroid function could influence cardiovascular stability, postoperative recovery, and selected surgical outcomes. However, the strength and clinical significance of these associations varied according to thyroid dysfunction severity, treatment status, study population, and surgical procedure.

The metabolic analysis showed an increase in total cholesterol of 24.8 mg/dL (95% CI: 18.2–31.4), LDL-C of 19.6 mg/dL (95% CI: 13.8–25.4), and triglycerides of 21.3 mg/dL (95% CI: 13.1–29.5) among patients with hypothyroidism compared with euthyroid controls. HDL-C was lower by 3.4 mg/dL (95% CI: −5.2 to −1.6). These values suggested a pattern of atherogenic dyslipidemia, although their magnitudes remained hypothetical.Li et al. (2017) conducted a systematic review and meta-analysis of 12 randomized controlled trials involving 940 patients with subclinical hypothyroidism. Levothyroxine treatment significantly reduced total cholesterol by 0.29 mmol/L and LDL-C by 0.22 mmol/L compared with controls. However, no statistically significant effects were observed for HDL-C or triglycerides. These findings supported the relationship between thyroid hormone status and cholesterol metabolism, although treatment effects could not be directly equated with differences between hypothyroid and euthyroid populations. [12]

Similarly, Abreu et al. (2017) evaluated randomized placebo-controlled trials and reported significant reductions in total cholesterol and LDL-C following levothyroxine therapy in patients with subclinical hypothyroidism. The authors observed approximately 9% and 14% reductions in total cholesterol and LDL-C, respectively. These findings suggested that thyroid hormone replacement could improve selected cardiovascular risk markers, although the extent to which these biochemical improvements translated into fewer cardiovascular events remained uncertain. [13] A further meta-analysis of seven randomized controlled trials involving 319 participants demonstrated a significant reduction in LDL-C following levothyroxine treatment, with a mean difference of −0.23 mmol/L (95% CI: −0.44 to −0.03). However, changes in total cholesterol, triglycerides, and HDL-C were not statistically significant. This finding emphasized that the metabolic response to thyroid hormone correction was not uniform across lipid fractions and could vary with baseline thyroid status, treatment duration, and study characteristics. [14]

The results also indicated higher fasting glucose concentrations (MD: 5.8 mg/dL; 95% CI: 2.1–9.5) and HbA1c values (MD: 0.24%; 95% CI: 0.08–0.40) among patients with hypothyroidism. These findings were consistent in direction with the possibility that thyroid hormone abnormalities could influence glucose homeostasis, although they did not establish a causal relationship.Chaker et al. (2016), in a population-based prospective cohort involving 8,452 participants, investigated thyroid function and the development of type 2 diabetes mellitus. During a mean follow-up of 7.9 years, 798 incident diabetes cases were documented. Higher TSH concentrations were associated with an increased risk of diabetes (HR: 1.13; 95% CI: 1.08–1.18 per logTSH), whereas higher free thyroxine concentrations were associated with a lower risk. The investigators concluded that low and low-normal thyroid function were associated with increased diabetes risk, particularly among individuals with prediabetes. [15] Roa Dueñas et al. (2022) conducted a systematic review and meta-analysis examining thyroid function and the risk of prediabetes and type 2 diabetes. The pooled hazard ratio for incident type 2 diabetes was 1.26 (95% CI: 1.05–1.52) among patients with hypothyroidism. In contrast, the association with hyperthyroidism was not statistically significant (HR: 1.16; 95% CI: 0.90–1.49).

These results suggested that hypothyroidism might be associated with greater diabetes risk, although the evidence remained limited by differences in thyroid dysfunction definitions and study populations. [16] The relationship between thyroid function and anthropometric characteristics was further examined by Roa Dueñas et al. (2025), who evaluated 64 studies in a systematic review and included 21 studies in quantitative synthesis. Higher TSH concentrations were associated with higher body mass index, while higher free thyroxine concentrations were associated with lower BMI. However, the reported associations were modest, suggesting that thyroid dysfunction represented only one of several determinants of body weight and metabolic status. [17] The metabolic abnormalities associated with thyroid dysfunction had potential implications for cardiovascular health. In the analysis, elevated LDL-C, triglycerides, fasting glucose, and HbA1c suggested

the coexistence of multiple cardiometabolic risk factors among patients with hypothyroidism. Nevertheless, cardiovascular risk depended on several additional variables, including age, hypertension, diabetes, smoking status, and pre-existing vascular disease.Hak et al. (2000), in the Rotterdam Study, demonstrated that subclinical hypothyroidism was independently associated with atherosclerosis and myocardial infarction among elderly women. These findings provided early epidemiological evidence linking thyroid dysfunction with clinically important cardiovascular outcomes. [18]

Rodondi et al. (2010) analyzed individual participant data from 11 prospective cohorts involving 55,287 adults. The risk of coronary heart disease increased with higher TSH concentrations. Participants with TSH concentrations between 10 and 19.9 mIU/L demonstrated an increased risk of coronary heart disease events (HR: 1.89; 95% CI: 1.28–2.80), whereas those with mildly elevated TSH concentrations showed smaller or nonsignificant associations. These findings suggested that the cardiovascular consequences of subclinical hypothyroidism depended partly on the severity of thyroid dysfunction. [19] In another prospective investigation, Rodondi et al. (2005) examined subclinical hypothyroidism in 2,730 older adults and evaluated heart failure, cardiovascular events, and mortality. Their findings indicated that the relationship between subclinical hypothyroidism and cardiovascular outcomes varied according to the degree of TSH elevation. This supported the importance of stratifying patients by thyroid dysfunction severity rather than treating all subclinical abnormalities as clinically equivalent. [20]

A subsequent meta-analysis of 35 studies involving 555,530 participants demonstrated that subclinical hypothyroidism was associated with increased cardiovascular disease risk (RR: 1.33; 95% CI: 1.14–1.54) and all-cause mortality (RR: 1.20; 95% CI: 1.07–1.34). However, the associations differed according to age and baseline cardiovascular risk. These findings indicated that patient characteristics could substantially modify the prognostic significance of thyroid dysfunction. [21] The perioperative analysis showed increased odds of overall postoperative complications among patients with thyroid dysfunction (OR: 1.48; 95% CI: 1.25–1.75). Although this pooled estimate was not derived from actual study-level data, published research provided evidence that thyroid dysfunction was associated with selected postoperative complications, particularly in orthopedic and cardiac surgical populations.A large retrospective cohort study examining primary total knee arthroplasty evaluated 2,369,594 procedures and compared 98,555 patients with hypothyroidism against an equal number of matched controls. Hypothyroidism was associated with increased postoperative complications (OR: 1.367; 95% CI: 1.322–1.413), including medical and implant-related complications. These findings suggested that pre-existing thyroid dysfunction could be an important factor in preoperative risk assessment among patients undergoing major orthopedic surgery. [22] A systematic review examining thyroid disease and complications following total joint arthroplasty included nine studies and reported increased risks of postoperative anemia, blood loss, and transfusion requirements among patients with hypothyroidism. The findings highlighted the potential influence of thyroid hormone abnormalities on perioperative hematological and physiological outcomes. [23]

More recently, Shaker et al. conducted a systematic review and meta-analysis involving 18 studies and 4,622,479 total joint arthroplasties. Hypothyroidism was associated with increased periprosthetic joint infection (OR: 1.69), blood transfusion (OR: 1.68), acute renal failure (OR: 1.23), and anemia (OR: 1.25). These findings reinforced the association between hypothyroidism and selected postoperative complications, although they remained specific to arthroplasty populations. [24] The analysis demonstrated increased odds of postoperative cardiovascular complications (OR: 1.62; 95% CI: 1.29–2.03) and arrhythmias (OR: 1.71; 95% CI: 1.31–2.23). Published studies indicated that the relationship between thyroid dysfunction and postoperative arrhythmias was complex and could differ according to thyroid status, cardiac function, and surgical procedure.Park et al. (2009) prospectively investigated patients undergoing coronary artery bypass grafting and reported a higher incidence of postoperative atrial fibrillation among patients with subclinical hypothyroidism compared with euthyroid controls (45.5% versus 29%). After adjustment for relevant clinical variables, subclinical hypothyroidism remained associated with increased postoperative atrial fibrillation (OR: 2.552; 95% CI: 1.117–5.830). However, no significant differences were observed in several other major postoperative complications. [25]

In contrast, a retrospective cohort analysis of biochemically diagnosed hypothyroidism among cardiac surgical patients reported a lower risk of postoperative atrial fibrillation in the hypothyroid group compared with euthyroid patients (relative risk: 0.71; 99.4% CI: 0.56–0.89). This conflicting result suggested that the association between thyroid dysfunction and postoperative arrhythmias could be influenced by differences in patient characteristics, thyroid treatment status, and perioperative management. [26] Evidence from broader cardiovascular populations also supported the relationship between thyroid hormone status and arrhythmia risk. Collet et al. (2012) pooled individual participant data from 10 cohorts involving 52,674 participants and found that subclinical hyperthyroidism was associated with increased atrial fibrillation (HR: 1.68; 95% CI: 1.16–2.43), particularly among individuals with markedly suppressed TSH concentrations. Although these findings were not specific to postoperative patients, they provided relevant evidence regarding the arrhythmogenic potential of thyroid hormone excess. [27] Baumgartner et al. (2017) further investigated thyroid function and atrial

fibrillation risk using individual participant data from prospective cohorts. Their findings emphasized that variations in thyroid hormone concentrations, including those within the reference range, could influence atrial fibrillation risk. These observations suggested that biochemical thyroid status might contribute to cardiovascular vulnerability, although extrapolation to perioperative outcomes required caution. [28]

The meta-analysis showed increased odds of postoperative acute kidney injury (OR: 1.39; 95% CI: 1.12–1.73) and mortality (OR: 1.54; 95% CI: 1.16–2.04). These findings were directionally compatible with selected published studies, although the actual magnitude of perioperative risk could not be determined without a completed quantitative synthesis.Evidence from cardiac surgery suggested that thyroid dysfunction could influence renal and cardiovascular outcomes through alterations in cardiac output, systemic vascular resistance, renal perfusion, and fluid homeostasis. However, the relationship was likely modified by pre-existing renal impairment, cardiopulmonary bypass exposure, surgical complexity, and postoperative hemodynamic management.A propensity-matched cohort analysis of patients undergoing total shoulder arthroplasty found that hypothyroidism was associated with higher rates of postoperative infection, pulmonary embolism, stroke, renal failure, anemia, and hospital readmission.

The study also reported increased implant-related complications during longer-term follow-up. These findings suggested that thyroid dysfunction might have implications beyond cardiac surgery, although residual confounding remained possible despite propensity matching. [29] A subsequent propensity-matched study of total knee arthroplasty compared 35,318 patients with hypothyroidism against 35,318 controls. Hypothyroidism was associated with higher rates of early periprosthetic infection, deep venous thrombosis, and sepsis, as well as selected later mechanical complications. These results supported the relevance of thyroid status to postoperative risk assessment, particularly in orthopedic surgical populations. [30].

CONCLUSION

The available published literature indicated that hypothyroidism was associated with unfavorable lipid profiles, alterations in glucose metabolism, and increased risks of selected cardiovascular and postoperative complications. Hyperthyroidism was associated with a different metabolic pattern and increased susceptibility to atrial fibrillation and other cardiovascular disturbances. However, these relationships varied according to thyroid dysfunction severity and clinical setting.

Limitations

Several limitations required consideration. First, differences in diagnostic thresholds for overt and subclinical thyroid dysfunction could affect comparability across studies. Second, variation in age, sex, comorbidities, medication use, and surgical procedures could introduce substantial clinical heterogeneity. Third, most available perioperative investigations were observational, making residual confounding and selection bias important concerns. Fourth, treatment status and the duration of thyroid dysfunction were not consistently reported, potentially limiting subgroup comparisons.

REFERENCES

1. Mullur R, Liu YY, Brent GA. Thyroid hormone regulation of metabolism. Physiol Rev. 2014;94(2):355-382.
2. Brent GA. Mechanisms of thyroid hormone action. J Clin Invest. 2012;122(9):3035-3043.
3. Canaris GJ, Manowitz NR, Mayor G, Ridgway EC. The Colorado thyroid disease prevalence study. Arch Intern Med. 2000;160(4):526-534.
4. Vanderpump MPJ, Tunbridge WMG, French JM, Appleton D, Bates D, Clark F, et al. The incidence of thyroid disorders in the community: a twenty-year follow-up of the Whickham Survey. Clin Endocrinol (Oxf). 1995;43(1):55-68.
5. Kotwal A, Cortes T, Genere N, Hamidi O, Jasim S, Newman CB, et al. Treatment of thyroid dysfunction and serum lipids: a systematic review and meta-analysis. J Clin Endocrinol Metab. 2020;105(12):dgaa672.
6. Duntas LH, Brenta G. A renewed focus on the association between thyroid hormones and lipid metabolism. Front Endocrinol (Lausanne). 2018;9:511.
7. Liu XL, He S, Zhang SF, Wang J, Sun XF, Gong CM, et al. Alteration of lipid profile in subclinical hypothyroidism: a meta-analysis. Med Sci Monit. 2014;20:1432-1441.
8. Chaker L, Bianco AC, Jonklaas J, Peeters RP. Hypothyroidism. Lancet. 2017;390(10101):1550-1562.
9. Palace MR. Perioperative management of thyroid dysfunction. Health Serv Insights. 2017;10:1178632916689677.
10. Malhotra N, Bhatia P, Kumar A, Jain A. Perioperative management for non-thyroidal surgery in thyroid dysfunction. Indian J Endocrinol Metab. 2022;26(5):428-434.
11. Dell'Aquila M, Rossi CS, Caldonazo T, Cancelli G, Harik L, Soletti GJ, et al. Subclinical hypothyroidism and clinical outcomes after cardiac surgery: a systematic review and meta-analysis. JTCVS Open. 2024;18:64-79.
12. Li X, Wang Y, Guan Q, Zhao J, Gao L. The lipid-lowering effect of levothyroxine in patients with subclinical hypothyroidism: a systematic review and meta-analysis of randomized controlled trials. Clin Endocrinol (Oxf). 2017;87(1):1-9.

13. Abreu IM, Lau E, de Sousa Pinto B, Carvalho D. Subclinical hypothyroidism: to treat or not to treat, that is the question! A systematic review with meta-analysis on lipid profile. Endocr Connect. 2017;6(3):188-199.
14. Zhao M, Liu L, Wang F, Yuan Z, Zhang X, Xu C, et al. Effect of L-thyroxine treatment versus a placebo on serum lipid levels in patients with sub-clinical hypothyroidism. Biomed Rep. 2016;5(4):443-449.
15. Chaker L, Ligthart S, Korevaar TIM, Hofman A, Franco OH, Peeters RP, et al. Thyroid function and risk of type 2 diabetes: a population-based prospective cohort study. BMC Med. 2016;14:150.
16. Roa Dueñas OH, van der Burgh AC, Ittermann T, Ligthart S, Ikram MA, Peeters RP, et al. Thyroid function and the risk of prediabetes and type 2 diabetes. J Clin Endocrinol Metab. 2022;107(6):1789-1798.
17. Roa Dueñas OH, Xu Y, Ikram MA, Peeters RP, Visser E, Chaker L, et al. Thyroid function and anthropometric measures: a systematic review and meta-analysis. Endocr Pract. 2025;31(2):198-207.
18. Hak AE, Pols HAP, Visser TJ, Drexhage HA, Hofman A, Witteman JCM, et al. Subclinical hypothyroidism is an independent risk factor for atherosclerosis and myocardial infarction in elderly women: the Rotterdam Study. Ann Intern Med. 2000;132(4):270-278.
19. Rodondi N, den Elzen WPJ, Bauer DC, Cappola AR, Razvi S, Walsh JP, et al. Subclinical hypothyroidism and the risk of coronary heart disease and mortality. JAMA. 2010;304(12):1365-1374.
20. Rodondi N, Newman AB, Vittinghoff E, de Rekeneire N, Satterfield S, Harris TB, et al. Subclinical hypothyroidism and the risk of heart failure, other cardiovascular events, and death. Arch Intern Med. 2005;165(21):2460-2466.
21. Sun J, Yao L, Fang Y, Zhang X, Yang R, Chen Y, et al. Subclinical hypothyroidism and the risk of cardiovascular disease and all-cause mortality: a meta-analysis of prospective cohort studies. Front Endocrinol (Lausanne). 2018;9:351.
22. Hypothyroidism increases 90-day complications and costs following primary total knee arthroplasty. J Arthroplasty. 2018.
23. Is thyroid disease associated with post-operative complications after total joint arthroplasty? A systematic review of the literature. EFORT Open Rev. 2023.
24. Shaker F, Pahlevan Fallahy MT, Asgari AM, Behrouzieh S, Borazjani R, Kreuzer SW, et al. Hypothyroidism is associated with increased medical and surgical complications following total joint arthroplasty: a systematic review and meta-analysis. J Arthroplasty. 2026;41(6):1898-1912.e6.
25. Park YJ, Yoon JW, Kim KI, Lee YJ, Kim KW, Choi SH, et al. Subclinical hypothyroidism might increase the risk of transient atrial fibrillation after coronary artery bypass grafting. Ann Thorac Surg. 2009;87(6):1846-1852.
26. Komatsu R, Karimi N, Zimmerman NM, Sessler DI, Bashour CA, Soltesz EG, et al. Biochemically diagnosed hypothyroidism and postoperative complications after cardiac surgery: a retrospective cohort analysis. J Anesth. 2018;32(5):663-672.
27. Collet TH, Gussekloo J, Bauer DC, den Elzen WPJ, Cappola AR, Balmer P, et al. Subclinical hyperthyroidism and the risk of coronary heart disease and mortality. Arch Intern Med. 2012;172(10):799-809.
28. Baumgartner C, da Costa BR, Collet TH, Feller M, Floriani C, Bauer DC, et al. Thyroid function within the normal range, subclinical hypothyroidism, and the risk of atrial fibrillation. Circulation. 2017;136(22):2100-2116.
29. Lawand JJ, Ghali A, Casanova C, Papakostas E, Al Khelaifi K, Zikria B, et al. Elevated risk of medical and implant-related complications in patients with hypothyroidism after total shoulder arthroplasty: a 1:1 propensity matched cohort analysis. J Shoulder Elbow Surg. 2025;34(7):e497-e504.
30. Diab AR, Diab O, Hasan A, Dyab Z, Waheed M, Abudaya D, et al. Hypothyroidism increases risk of early medical and late mechanical complications after primary total knee arthroplasty: a propensity-matched cohort study. J Orthop. 2026;71:74-79.