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Selenium supplementation in thyroid disorders: a comprehensive review

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ABSTRACT

Selenium is an essential trace element that plays a key role in thyroid hormone metabolism and antioxidant protection. Among all organs, the thyroid gland has one of the highest selenium concentrations, reflecting the important role of this trace element in thyroid physiology. This review examines recent research on selenium supplements for thyroid diseases, with a focus on autoimmune conditions such as Hashimoto's thyroiditis, Graves' disease, and Graves' ophthalmopathy. The literature review covers studies from the past 10 years found in PubMed, Google Scholar, Web of Science, and ScienceDirect, using keywords such as "selenium supplementation," "thyroid diseases," "Graves' disease," "Hashimoto's," "Graves' ophthalmopathy," and "autoimmune thyroid diseases." Research shows that selenium supplementation can lower thyroid peroxidase antibodies (TPOAb) and thyroid-stimulating hormone (TSH) levels in Hashimoto's thyroiditis, especially after six months. It also benefits people with Graves' disease by boosting quality of life and clinical outcomes. However, there is still uncertainty about the best treatment duration, dosing, and which patients benefit most. Selenomethionine seems to be the most effective form. Selenium supplementation is generally safe, but too much can cause selenosis. This review synthesizes recent findings to provide practical recommendations for selenium use in thyroid diseases and identifies areas requiring further investigation.

Keywords: selenium supplementation, selenium, thyroid diseases, autoimmune thyroiditis, selenoproteins

1. INTRODUCTION

Millions of people worldwide are affected by thyroid disorders. Even in areas where people consume sufficient amounts of iodine, these conditions are very common, particularly autoimmune thyroid diseases such as Hashimoto's thyroiditis and Graves' disease (Winther et al., 2020). The causes of these diseases are complex and include hereditary factors, environmental conditions, and abnormalities in the immune system. Researchers have recently shown increased interest in the role of trace elements, particularly selenium, in thyroid health.

As the amino acid selenocysteine, selenium exists in selenoproteins and is therefore a crucial trace element. The thyroid gland has the most selenium in the body, which highlights how important this element is for its operation (Wang et al.,

2023). Crucial for thyroid hormone generation, control of metabolic processes, and cell defense against oxidative damage are selenium-dependent enzymes including glutathione peroxidases (GPx), thioredoxin reductases, and iodothyronine deiodinases (Linn et al., 2025).

Several factors explain why selenium supplementation helps with thyroid problems. Selenium-containing deiodinase enzymes first convert thyroxine (T4) into the biologically active hormone triiodothyronine (T3), hence helping to control thyroid hormone levels in the body. Second, selenoproteins shield thyroid cells from the oxidative damage that results from the high levels of hydrogen peroxide produced during hormone synthesis. Third, selenium could affect immune system performance and so help lower thyroid gland autoimmune inflammation (Winther et al., 2020; Wang et al., 2023).

Although there are proposed advantages and additional clinical data, the discussion about the effectiveness of selenium supplements in treating thyroid conditions remains ongoing. Results from clinical studies vary, and uncertainties persist regarding the best ways to select patients, appropriate doses, length of treatment, and the effects over an extended period. This review seeks to compile existing information on selenium supplementation in thyroid issues, especially autoimmune thyroid conditions, and to offer healthcare professionals evidence-based insights relevant to their practice.

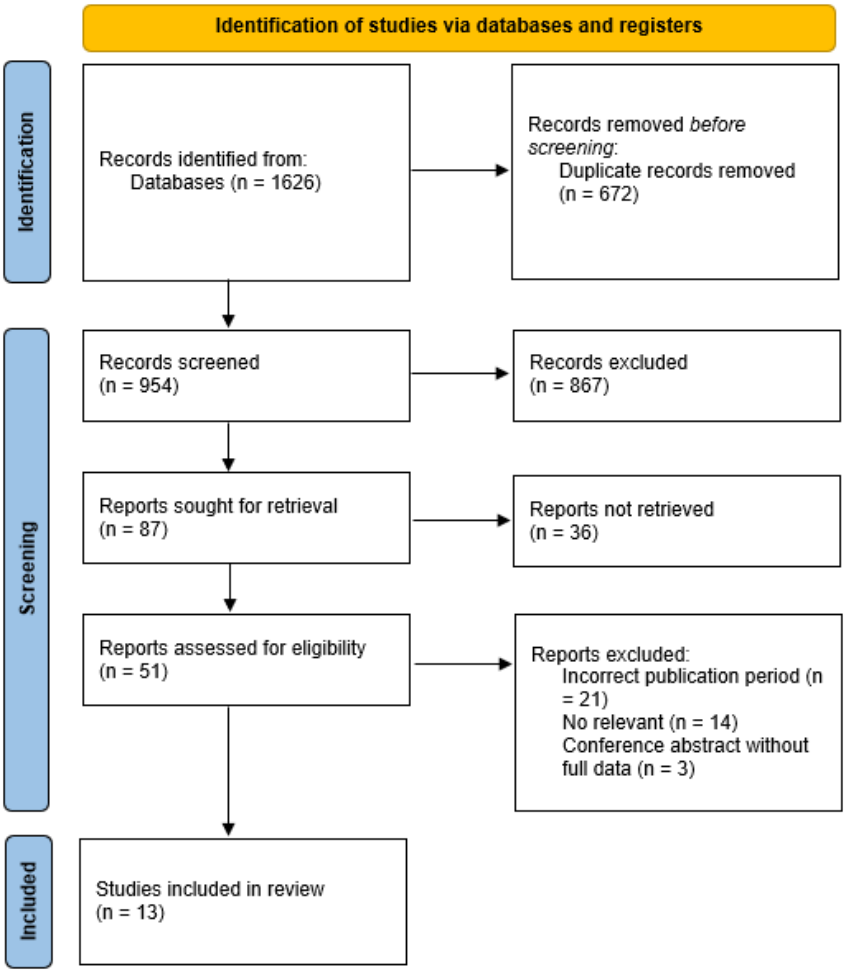

Figure 1. PRISMA flow diagram

2. REVIEW METHODS

We began by searching PubMed, Google Scholar, Web of Science, and ScienceDirect for studies examining selenium supplementation and thyroid disease. To keep the review focused on recent evidence, only papers published from 2016 onward were considered. The final selection consisted of studies that directly addressed the topic of interest.

The following keywords and their combinations were helpful in the search: “selenium supplementation”, “selenium”, “thyroid diseases”, “thyroid disorders”, “Hashimoto’s thyroiditis”, “autoimmune thyroiditis”, “Graves’ disease”, “Graves’ ophthalmopathy”,

"thyroid-associated eye disease", "antithyroid peroxidase antibodies", "anti-thyroglobulin antibodies" ,"selenoproteins", and "selenomethionine."

The study used the following inclusion criteria: (1) systematic reviews, meta-analyses, randomized controlled trials (RCTs), and narrative reviews; (2) studies on selenium supplementation in patients with thyroid diseases; (3) articles published in English; (4) publications from 2016 onwards. Exclusion criteria comprised: (1) case reports and case series; (2) studies focusing exclusively on selenium deficiency without intervention; (3) animal studies; and (4) articles not available in English.

Titles and abstracts of the identified publications were evaluated first. When a study appeared relevant to the topic, its full text was reviewed. Additional papers were located through the reference sections of the included articles. Following this process, the studies most closely related to selenium supplementation and thyroid disorders were selected for discussion in this review. The article screening process followed the PRISMA guidelines (Figure 1).

3. RESULTS AND DISCUSSION

Selenium and Thyroid Physiology

Selenoproteins and Thyroid Function

Many biological processes are regulated by selenium. This is possible due to selenium's role as a component of selenoproteins, which include selenocysteine in their structure. The human genome encodes approximately 25 of these proteins, most of which occur in the thyroid gland. In this gland, they play an important function in preserving cell homeostasis and in the metabolism of thyroid hormones (Wang et al., 2023). Thyroid hormone activity is influenced to a large extent by deiodinases, a group of selenium-containing enzymes. The three known members of this family—DIO1, DIO2, and DIO3—are involved in hormone metabolism but perform different functions. Whereas DIO1 and DIO2 contribute to the production of active T3 from T4, DIO3 participates in pathways that reduce hormone activity. Together, these enzymes fine-tune thyroid hormone availability according to the needs of the body and individual tissues (Linn et al., 2025).

Another important group of selenoproteins in the thyroid is glutathione peroxidases. Thyroid cells are susceptible to damage caused by oxidants, and GPx1 and GPx3 protect them by reducing levels of hydrogen peroxide, which is produced in large quantities during the synthesis of thyroid hormones. This antioxidant function is very important because thyroid peroxidase uses hydrogen peroxide to facilitate the iodination of thyroglobulin (Wang et al., 2023).

Thioredoxin reductases are selenoproteins that help maintain redox balance in cells and regulate various cellular processes, such as cell proliferation, apoptosis, and immune functions. These enzymes may play a role in modulating the autoimmune response in thyroid diseases (Winther et al., 2020). The table 1 compares selenoproteins and their functions.

Table 1. Selenoproteins Involved in Thyroid Physiology and Their Functions

Selenoprotein	Location	Primary Function	Role in Thyroid Physiology
Iodothyronine Deiodinase Type 1 (DIO1)	Liver, kidney, thyroid	Converts T4 to T3; degrades rT3	Regulates peripheral thyroid hormone activation and inactivation
Iodothyronine Deiodinase Type 2 (DIO2)	Brain, pituitary, thyroid, skeletal muscle	Converts T4 to T3 locally	Maintains intracellular T3 concentrations; critical for TSH feedback regulation
Iodothyronine Deiodinase Type 3 (DIO3)	Placenta, brain, skin	Inactivates T4 and T3 to rT3 and T2	Protects tissues from excess thyroid hormone; essential during fetal development
Glutathione Peroxidase 1 (GPX1)	Cytoplasm (ubiquitous)	Reduces hydrogen peroxide and organic hydroperoxides	Protects thyrocytes from oxidative damage during thyroid hormone synthesis
Glutathione Peroxidase 3 (GPX3)	Plasma, thyroid	Extracellular antioxidant; reduces hydroperoxides	Protects thyroid gland from extracellular oxidative stress
Glutathione Peroxidase 4 (GPX4)	Cell membranes (ubiquitous)	Reduces lipid hydroperoxides in	Prevents lipid peroxidation in thyroid cell membranes

		membranes	
Thioredoxin Reductase 1 (TXNRD1)	Cytoplasm (ubiquitous)	Reduces thioredoxin; maintains cellular redox balance	Supports antioxidant defense and redox signaling in thyrocytes
Thioredoxin Reductase 2 (TXNRD2)	Mitochondria (ubiquitous)	Reduces mitochondrial thioredoxin	Protects mitochondria from oxidative damage in thyroid cells
Selenoprotein P (SELENOP)	Plasma, liver	Selenium transport and storage; antioxidant	Delivers selenium to thyroid gland; maintains selenium homeostasis
Selenoprotein S (SELENOS)	Endoplasmic reticulum	Involved in ER stress response and inflammation	Modulates inflammatory responses in autoimmune thyroid disease

Selenium Concentrations and the Risk of Thyroid Disease

Epidemiological studies have revealed a relationship between selenium concentrations and the prevalence of thyroid disorders. In various populations, the risk of goiter, thyroid nodules, or autoimmune thyroid diseases has been associated with reduced selenium concentrations (Winther et al., 2020). The correlation between selenium concentration and thyroid disorders is multifactorial and may be influenced by, among other things, iodine intake, genetics, or place of residence.

Selenium in smaller amounts consumed comes from its access in. It has been shown that if you maintain the thyroid gland gradually, the old concentration of selenium despite changes in its concentration in food. This may be an adaptive mechanism that has a beneficial effect on selenoproteins in the gland (Linn et al., 2025).

Selenium Supplementation in Hashimoto's Thyroiditis

Effect on thyroid antibodies

Lymphocytic infiltration in the thyroid gland and the presence of autoantibodies are characteristic of Hashimoto's thyroiditis. These include antibodies against thyroid peroxidase (TPOAb) and antibodies against thyroglobulin (TgAb). Numerous systematic reviews and meta-analyses have examined the effect of selenium supplementation on antibody levels in individuals with Hashimoto's thyroiditis. According to a meta-analysis of 35 randomized controlled trials by Huwiler et al., (2024), selenium supplementation significantly decreased TPOAb levels in Hashimoto's sufferers. As seen by the -0.96 standardized mean difference (SMD), the drop in TPOAb had a major effect. Both those not on hormone replacement therapy and patients on it saw a decline in antibody levels.

Time is also a significant factor in reducing antibody levels, Zhang et al., (2025) demonstrated that TPOAb levels decrease following selenium supplementation, both after three months (SMD = -0.46) and after six months (SMD = -0.80). However, the effect was greater with a longer duration. TgAb levels also decreased after three months, but this effect was less consistent after six months.

The effect of time was also shown in the results by Kong et al., (2023). They found that time influenced their findings, there was no clear drop in antibody levels after three months of treatment, but there was a significant decrease after six months. This means that treatment may need to last at least six months to significantly reduce thyroid antibody levels.

Effect on Thyroid Function

Numerous studies have also evaluated the effect of selenium supplementation on thyroid function. Studies have shown that supplementation with this element reduced TSH levels in patients with Hashimoto's thyroiditis who were not receiving hormone replacement therapy (SMD -0.21). However, no significant changes were observed in free and total T3 and T4 levels (Huwiler et al., 2024).

A decrease in TSH levels after 6 months of supplementation (SMD = -0.18) was shown in a meta-analysis by Zhang et al., (2025). This effect was not observed after three months. At the same time, no significant effect on free T3 and T4 levels was observed (Zhang et al., 2025). It suggests that selenium supplementation in patients with Hashimoto's thyroiditis may have a moderate effect on thyroid function, primarily manifested by a reduction in TSH levels.

Effect on markers of oxidative stress

Oxidative stress also has an important role in the development of autoimmune thyroid disorders. It has been demonstrated that selenium supplementation in patients with Hashimoto's disease reduces levels of markers of oxidative stress. Studies have shown (Huwiler et al., 2024) that the lipid peroxidation marker, malondialdehyde (MDA), decreased significantly following selenium supplementation (SMD = -1.16). Lowering oxidative stress markers may support the positive effects of selenium in autoimmune thyroid disorders.

Comparison of selenium preparations

Sodium selenate, selenium yeast, selenomethionine, and many other selenium preparations have been evaluated in clinical trials. The Table 2 compares selenium supplements. Selenomethionine appears to be most effective in treating Hashimoto's thyroiditis. This may be due to differences in the bioavailability, metabolism, and selenoprotein incorporation of different forms of selenium (Zhang et al., 2025).

Table 2. Characteristics of selenium supplements used in the adjunctive treatment of thyroid disorders

Selenium Formulation	Bioavailability	Efficacy in Thyroid Disease	Typical Dose	References
Selenomethionine	High	Most effective in Hashimoto's thyroiditis	200 μg/day	Zhang et al., 2025
Sodium Selenite	Moderate	Effective in Graves' orbitopathy	100-200 μg/day	Winther et al., 2020
Selenium Yeast	Variable	Less effective than selenomethionine	200 μg/day	Zhang et al., 2025

Selenium Supplementation in Grave's Disease and Grave's Orbitopathy

Graves' orbitopathy

Graves' orbitopathy is an autoimmune inflammatory disease that affects the tissues of the orbit and causes numerous health problems in individuals with Graves' disease. Oxidative stress and inflammatory processes play an important role in its pathogenesis, which justifies the use of antioxidant therapy involving selenium. A comprehensive review and meta-analysis conducted by Sharabati et al., (2024) assessed the effectiveness and safety of selenium supplementation for Graves' ophthalmopathy. This research, which featured four randomized controlled trials, demonstrated that selenium supplementation was superior to placebo in lowering clinical activity scores (CAS) after a period of six months, with a mean difference of -1. 27. Selenium also much improved the quality of life of people suffering from Graves' orbitopathy (GO-QOL), as seen by a risk ratio of 2.54 for improvement. People said great improvements in emotional well-being as well as visual ability. Over the 12-month follow-up period, selenium's positive benefits on Graves' orbitopathy continued. In addition, taking selenium supplements resulted in a significant reduction in eyelid opening after six months, with a mean difference of -1. 49. The study did not find significant changes in exophthalmos, soft tissue involvement, or eye movement.

Graves' Disease

Regarding Graves' disease without orbital involvement, the efficacy data on selenium supplementation are restricted. Though certain studies indicate selenium supplements—especially together with methimazole—help regulate thyroid hormone levels and boost antioxidant capacity, the findings of different studies differ greatly (Linn et al., 2025). Winther et al., (2020) suggested that selenium as a supplement may promote faster remission of hyperthyroidism and improve the quality of life for people with Graves' disease. They stressed, however, that the scientific evidence is still insufficient to formulate definitive recommendations regarding routine selenium supplementation for all patients with Graves' disease.

Selenium Supplementation in Pregnant Women and Autoimmune Thyroiditis

Pregnancy presents a distinctive medical situation regarding selenium supplementation in autoimmune thyroid conditions. Women who are pregnant and have autoimmune thyroiditis, especially those with positive thyroid peroxidase antibodies (TPOAb), face a

higher risk of experiencing postpartum thyroid issues (PPTD) and long-term hypothyroidism. The natural suppression of the immune system during pregnancy usually results in lower levels of thyroid autoantibodies, which then tend to rise again after childbirth, potentially causing thyroid problems (Minnetti et al. , 2022).

Several randomized controlled trials have evaluated the role of selenium supplementation in this population. A landmark study was conducted by Mantovani et al., (2019) showed that selenomethionine at a dose of 200 μg/day administered during pregnancy and the postpartum period significantly reduced the incidence of PPTD (28.6% vs. 48.6%, $p < 0.01$) and persistent hypothyroidism (11.7% vs. 20.3%, $p < 0.01$) compared to placebo. The SERENA research, which is a multi-center randomized double-blind study with a placebo control, verified these results by utilizing a reduced amount of L-selenomethionine (83 μg/day). It showed notable decreases in TPOAb and thyroglobulin antibody (TgAb) levels during the postpartum phase, and it also helped avoid the usual increase in antibodies that occurred in the placebo group.

However, the studies' results remain inconclusive. This is indicated, for example, by a randomized controlled trial conducted by Minnetti et al., (2022) in which British pregnant women with mild iodine deficiency were given 60 μg of selenium daily. No effect on TPO antibody levels was observed during pregnancy. These conflicting results may be attributed to differences in selenium dosage, baseline selenium and iodine status, and study populations.

A useful method for selenium supplementation in pregnant women with autoimmune thyroiditis was suggested by Minnetti et al., (2022). The authors advise that supplementation be approached on an individual level based on selenium level, area, iodine intake, and thyroid autoimmunity severity. Beginning in the first trimester and continuing until the postpartum stage, the advised form is selenomethionine at levels between 83 and 200 g/day. To maximize treatment and reduce possible risks, selenium levels and thyroid function should be monitored.

However, these promising results are not sufficient because the current guidelines from the American Thyroid Association (ATA) do not recommend routine selenium supplementation in TPOAb-positive pregnant women due to conflicting data and potential risks, including an association with increased risk of type 2 diabetes mellitus observed in some studies. The ATA recommendation is classified as weak with moderate-quality evidence acknowledging the need for further well-designed trials to clarify the role of selenium in this population (Alexander et al., 2017).

Geographic Factors

Selenium concentrations differ markedly by geographic region, and this may affect the effectiveness of selenium supplementation. Most positive studies have been conducted in populations with selenium deficiency or insufficiency; therefore, the applicability of these results within regions with sufficient selenium is still unclear (Linn et al., 2025).

Dosage, Duration, and Safety

Recommended Doses

The selenium doses used in various clinical studies most often ranged from 100 to 200 micrograms daily. Patients with Hashimoto's disease were most often given 200 micrograms of selenium per day in the form of selenomethionine or sodium selenite (Huwiler et al., 2024; Zhang et al., 2025). Commonly utilized doses for Graves' ophthalmopathy were 100 micrograms twice daily (Sharabati et al., 2024).

Baseline selenium levels in the body might influence the best dose. Those living in selenium-deficient areas might need more to have a therapeutic impact. But one has to be careful since too much selenium can be bad (Linn et al., 2025).

Duration of Treatment

The length of time selenium is given seems to be an important element affecting the success of the treatment. Typically, treatment continues for a minimum of six months to see a notable decrease in thyroid-specific antibodies and TSH levels in individuals with Hashimoto's disease. A shorter therapy duration of three months might impact antibody levels, but it is not as likely to induce considerable alterations in thyroid function metrics.

In the case of Graves' disease, clinical trials have evaluated treatment lasting six to twelve months, with sustained benefits observed over longer follow-up periods (Sharabati et al., 2024). The Table 3 lists the selenium dosage, treatment duration, and clinical outcomes for selected thyroid conditions.

Table 3. Selenium dosage, treatment duration, and clinical effects on selected thyroid conditions

Thyroid Condition	Selenium Dose	Treatment Duration	Primary Outcomes	References
Hashimoto's Thyroiditis	200 μg/day	6 months	Reduced TPOAb, decreased TSH, reduced oxidative stress	Huwiler et al., 2024; Zhang et al., 2025; Kong et al., 2023
Graves' Orbitopathy	100-200 μg/day	6-12 months	Reduced CAS, improved GO-QOL, decreased palpebral aperture	Sharabati et al., 2024
Graves' Disease	100-200 μg/day	6 months	Variable effects on hormone normalization, improved antioxidant capacity	Linn et al., 2025; Winther et al., 2020

Safety and Adverse Effects

The amounts of selenium administered in clinical studies showed a positive safety record. For instance, a meta-analysis by Huwiler et al., (2024) looking at Hashimoto's thyroiditis revealed that the rate of negative events was comparable in both the selenium group and the placebo group (odds ratio 0. 89). Likewise, Sharabati et al., (2024) observed no notable differences in the occurrence of adverse reactions between the selenium and placebo groups in research concerning Graves' ophthalmopathy.

Too much selenium, however, might lead to selenosis, which shows symptoms of exhaustion, neurological problems, hair loss, gastrointestinal problems, and changes in nail appearance. Usually, adults should not take more than 400 micrograms of selenium per day. Doctors should use caution when prescribing selenium supplements to those who already have a high baseline selenium consumption or to individuals on several selenium-containing supplements (Linn et al., 2025; Winther et al., 2020).

Clinical Implications and Recommendations

As the available data indicate, selenium supplementation may be beneficial in the treatment of some individuals with autoimmune thyroid diseases. For example, taking 200 micrograms of selenium daily for at least six months by patients with Hashimoto's disease may have positive effects. These reduced thyroid-specific antibody levels and a slight decrease in TSH levels. The best results are observed in patients who are not receiving thyroid hormone replacement therapy (Huwiler et al., 2024).

For patients with mild to moderate Graves' ophthalmopathy, selenium supplementation is a therapeutic option that may reduce disease activity, improve quality of life, and potentially slow disease progression. The evidence supporting the use of selenium in this condition is stronger than for other thyroid diseases (Sharabati et al., 2024; Winther et al., 2020).

Although certain issues should be considered, the clinical significance of reduced antibody levels in Hashimoto's thyroiditis remains unclear. This is because many studies show no improvement in thyroid structure or reduction in thyroid hormone requirements. Baseline selenium levels are also an important consideration. These levels likely influence the effectiveness of supplementation, and greater benefits may be observed in individuals with selenium deficiency. Furthermore, it is unclear which patients may benefit the most, as patient selection criteria are poorly defined.

When considering selenium supplementation in individuals with thyroid disease, baseline selenium concentrations should be assessed whenever possible, selenomethionine should be chosen as the preferred form, a dose of 200 micrograms per day should be used, supplementation should be continued for at least six months, and possible adverse effects should be monitored. Selenium supplementation should be considered an adjunct therapy, not a substitute for standard treatments such as thyroid hormone replacement therapy or antithyroid drugs.

Future Directions

To improve the use of selenium as a supplement in thyroid diseases, further research is needed in certain areas. Long-term clinical outcomes, such as quality of life or the need for hormone replacement therapy, should be evaluated. To this end, large-scale

randomized controlled trials are required. It is essential to identify biomarkers and genetic factors associated with response to selenium supplementation to enable a personalized treatment approach. Direct comparative studies are also needed to determine the optimal composition of selenium preparations, dosing, and treatment duration for various thyroid conditions. Another important aspect involves thyroid conditions not classified as autoimmune diseases, such as thyroid nodules, goiter, and thyroid cancer. It is important to determine the role of selenium supplementation in these conditions. Research should also be expanded to include interactions between selenium and other trace elements, particularly iodine. Finally, the cost-effectiveness of selenium supplementation in various clinical scenarios should be evaluated to provide information useful for making health policy decisions.

4. CONCLUSION

Selenium is important in the metabolic functions of thyroid hormones and in protecting against oxidative stress through incorporation into selenoproteins. Current evidence supports the use of selenium supplementation in selected patients with autoimmune thyroid diseases, particularly those with Hashimoto's thyroiditis and Graves' ophthalmopathy. Selenium supplementation leads to a reduction in thyroid antibody levels in Hashimoto's thyroiditis. It improves clinical outcomes in Graves' ophthalmopathy, while also showing a favorable safety profile when administered at recommended doses.

Nevertheless, many issues remain open and call for further study, primarily regarding patient selection, dosing regimens, and long-term health benefits. Selenium supplementation should be considered as an adjunct to treatment in appropriate patients, and the limitations of the current scientific evidence should not be disregarded. Future research needs to primarily focus on developing definitive treatment regimens for various thyroid diseases. It is also important to focus on identifying patients who may benefit most from supplementation with this trace element. As we increase our knowledge of selenium's role in thyroid health, an individualized approach—taking into account selenium concentrations and genetic factors—may become the optimal strategy for incorporating this essential trace element into the treatment of thyroid disorders.

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Authors' Contributions

Martyna Sarzyńska - contributed to the study conception and design, conducted the literature search and data analysis, wrote the manuscript, and approved the final version for publication.
Mateusz Szabat - conducted the literature search and data analysis.
Sylwia Lepak - conducted the literature search and data analysis.
Zuzanna Irzyk - conducted the literature search and data analysis.
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Julia Rogała - conducted the literature search and data analysis.
Katarzyna Markuszka - conducted the literature search and data analysis.
Kinga Polityńska - conducted the literature search and data analysis.
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Informed consent

Not applicable.

Ethical approval

Not applicable. This article does not contain any studies with human participants or animals performed by any of the authors.

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Conflict of interest

The authors declare that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data and materials availability

All data associated with this study will be available based on the reasonable request to corresponding author.

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