European Journal of Clinical Pharmacy

Print ISSN: 2385-409X **Online ISSN**: 3105-0409

Website: https://farmclin.com/

Original Research Article

Exploring the association between magnesium status and other minerals in thyroid dysfunction -A cross sectional study

Article History:

Name of Author:

Indumathi Dhanajayan [1]*, Ramiya Dharman[2], Senthil Kumar Thangavelu[1], Amala Deepa Vincent[1]

Affiliation: *[1]Faculty of Allied Health Science, Dr.M.G.R. Educational and Research Institute, Chennai-600077, Tamilnadu, India.*

[2] M.Sc. Medical Laboratory Technology, Faculty of Allied Health Science, Dr.M.G.R. Educational and Research Institute, Chennai-600077, Tamilnadu, India.

Corresponding Author:

Dr. D. INDUMATHI

Received: 12-01-2026

Revised: 05-02-2026

Accepted: 20-02-2026

Published: 19-03-2026

Abstract: ***Background:*** Thyroid dysfunction, which includes both hypothyroidism and hyperthyroidism, is a common noncommunicable endocrine condition with wide-ranging metabolic implications. According to emerging research, thyroid hormone imbalances have a substantial impact on mineral and electrolyte homeostasis, notably magnesium, which is essential for thyroid hormone production, activation, and cellular metabolism.. However, magnesium imbalances are often overlooked in routine thyroid assessments. ***Objective:*** This study seeks to evaluate serum magnesium levels in patients with thyroid dysfunction, while exploring their interactions with key thyroid hormones TSH, T3, and T4 and other essential electrolytes, including calcium, sodium, potassium, chloride, and bicarbonate. ***Methods:*** This six-month cross-sectional investigation was carried out at the Central Laboratory of the A.C.S. Medical College and Hospital. A total of 90 participants were separated into three groups: control, hyperthyroid, and hypothyroid. Blood samples were taken and serum levels of magnesium, calcium, sodium, potassium, chloride, and bicarbonate were measured using a fully automated Beckman Coulter AU480 analyzer. Thyroid hormones (TSH, T3, and T4) were quantified with the Beckman Coulter Access 2 Immunoassay System. Statistical analysis included descriptive statistics, Mann-Whitney U test, Spearman's correlation, and Chi-square test, with $p < 0.05$ indicating statistical significance. ***Results:*** Both hyperthyroid and hypothyroid patients had significantly lower serum magnesium levels than controls ($p < 0.01$). Serum calcium, sodium and chloride levels were likewise significantly lower in thyroid dysfunction groups, although potassium and bicarbonate levels did not change appreciably. There is significant positive correlation of serum T3 with serum magnesium in hypothyroid patient. The (r value is +0.321) there is also strong positive correlation of serum T4 with serum magnesium in thyroid patients (r value +0.312) and there is strong negative correlation between TSH and serum magnesium levels in thyroid patients (r value -0.117). A negative correlation was found between serum magnesium and TSH, but a positive correlation with T3 and T4 levels and this dysfunction was most common in people aged between 51 to 60 with a fairly equal gender distribution. ***Conclusion:*** The study found that magnesium decreases is substantially related with both hyperthyroidism and hypothyroidism, as well as changes in thyroid hormone levels. These findings emphasize the need of routine test of serum magnesium and other electrolytes in patients with thyroid disease. Examination of electrolyte monitoring in thyroid may help with early detection, better management, of metabolic problems associated with thyroid disorders.

Keywords: Thyroid dysfunction, Magnesium, Electrolytes, T3, Hypothyroidism.

INTRODUCTION

Non-communicable diseases (NCDs) including thyroid problems are impacted by dietary, lifestyle, environmental and hereditary variables. Because they are chronic, they require lifelong care and early detection. Over 200 million individuals are thought to be impacted globally, according to the World Health Organization (WHO), with many going untreated or receiving insufficient treatment (Taylor et al., 2018). The systemic aspect of thyroid dysfunction is highlighted by the fact that it not only modifies hormone regulation but also interferes with electrolyte balance, specifically with regard to magnesium, calcium, sodium, potassium, chloride, and bicarbonate (Akter et al., 2021; Islam et al., 2021). If thyroid disorders can alter the balance of minerals and electrolytes, which results in symptoms like weakness, exhaustion, arrhythmias, and cognitive problems (Brent et al., 2012).

Thyroxine (T4) and triiodothyronine (T3), that are primarily produced, stored, and released by the gland (Brent, 2012). These hormones are stored in the thyroid follicles' colloid and are made from iodine and tyrosine. Thyroid function is strictly regulated by the hypothalamic-pituitary-thyroid (HPT) axis. Thyrotropin-releasing hormone (TRH), which is secreted by the brain, triggers the pituitary gland to release thyroid-stimulating hormone (TSH). The thyroid gland is then stimulated by TSH to create and release T3 and T4. According to Ortiga-Carvalho et al. (2016), these hormones control their own levels by means of negative feedback on the pituitary and hypothalamus.

The basal metabolic rate is crucial for controlling metabolism, oxygen intake, glucose utilization, lipid breakdown, and protein turnover are all increased by thyroid hormones (T3 and T4), which control metabolism. They improve cardiovascular function by raising heart rate, contractility and cardiac output, and also, they promote thermogenesis by heat production through mitochondrial activity (Mullur et al., 2014). T3 is essential for the development of the fetal and newborn brains in the nervous system, helping with myelination and the proliferation of neurons (Bernal et al., 2005). Thyroid hormones work with GH and IGF-1 to support bone mineralization and skeletal maturation for growth and bone development (Mullur et al., 2014).

Since thyroid dysfunction can have a substantial impact on the neurological, cardiovascular, metabolic, and reproductive systems, an accurate diagnosis is crucial (Biondi & Cooper, 2008). Thyroid function testing, which mainly involves measuring blood TSH, the most sensitive marker for identifying primary thyroid failure, is the cornerstone of thyroid diagnosis. Primary hypothyroidism is usually indicated by elevated TSH, whereas primary hyperthyroidism is suggested by suppressed TSH (Garber et al., 2012). Measurements of T4 and T3, in addition to TSH, offer direct insight into the amounts of thyroid hormones in the blood. Primary hypothyroidism is confirmed by a low Free T4 in the presence of high TSH, while primary hyperthyroidism is shown by higher T3 and/or T4 levels with suppressed TSH.

Nerve transmission, fluid balance and metabolic regulation all depend on electrolytes such as magnesium, calcium, sodium, potassium, chloride and bicarbonate. (Brent et al., 2012; Islam et al., 2021). More than 300 enzymatic functions, such as the conversion of T4 to T3, ATP synthesis and neuromuscular function depend on magnesium. It facilitates iodide transport via NIS and Na+/K+-ATPase, which in turn supports thyroid hormone production, activated and cellular uptake. Additionally, glucose metabolism, and insulin signaling all depend on magnesium, furthermore it maintains the generation of ATP in the mitochondria, stabilizes cell membranes, and controls the hypothalamic-pituitary-thyroid axis (Barbagallo & Dominguez, 2010; Romani, 2013). Even when thyroid hormone levels are adequate, a shortfall of magnesium may affect these processes and exacerbate symptoms (Dasgupta & Klein, 2012; de Baaij et al., 2015).

Magnesium is primarily stored in bones and soft tissues; therefore, serum levels may not reflect whole body storage. Magnesium insufficiency in thyroid dysfunction, exacerbated by increased renal loss and metabolic demands, can produce muscle cramps, arrhythmias, and tremors, particularly in hyperthyroidism (Rude, 1998; Islam et al., 2021). Symptoms of deficiency include tremors, cramps, and arrhythmias (Swaminathan 2003; Rosanoff et al. 2012).

Thyroid hormones, plays a role in maintaining calcium levels. Hyperthyroidism frequently causes hypercalcemia due to bone resorption, whereas hypothyroidism is associated with hypocalcemia. Magnesium regulates PTH function, therefore a deficit might cause secondary hypocalcemia and neuromuscular symptoms (Reddy et al., 2017). Sodium is necessary for iodide transport and hormone production. Hypothyroidism can result in hyponatremia due to decreased water clearance. Magnesium is required for ATPase function, which links sodium and magnesium levels in thyroid regulation (Nicola et al., 2015). Potassium supports cellular function and membrane potential. T3 increases Na^+/K^+-ATPase, which promotes potassium absorption. Magnesium shortage inhibits this pump, resulting in potassium loss and lethargy or weakness in thyroid patients (Kohrle et al., 2009).

Chloride maintains acid-base equilibrium and promotes the operation of the deiodinase enzyme, which activates T3. Low chloride levels can limit magnesium reabsorption, which affects thyroid hormone metabolism (Kaptein et al., 1997). Bicarbonate aids in preserving pH for the best possible enzyme function. Metabolic acidosis, or low bicarbonate, affects hormone receptor sensitivity and T4-to-T3 conversion. Magnesium emphasizes the connection of bicarbonate conservation and enzymatic function in thyroid health (Kaptein et al., 1997; Romani, 2013).

Materials and methods:

This cross-sectional investigation lasted six months and was carried out at A.C.S. Medical College and Hospital's Central Laboratory. 90 people were enlisted and separated into three groups based on thyroid function tests (TSH, T3, T4). Subjects (≥18 years) diagnosed with thyroid dysfunction were included in the study. Patients with kidney, liver, or chronic systemic illnesses were eliminated.

Venous blood (5 mL) was drawn under aseptic conditions. Serum was separated by centrifugation at 3000 rpm for 10 minutes. Magnesium, calcium, sodium, potassium, chloride, and bicarbonate levels were measured with a Beckman Coulter AU480 analyzer. Thyroid hormones (TSH, T3 and T4) were measured using a chemiluminescent immunoassay on the Beckman Coulter Access 2 system.

Statical Analysis:

Quality controls were applied to all assay runs. Statistical analysis was carried out using descriptive statistics, the Mann-Whitney U test for group comparisons, the Spearman correlation for magnesium and thyroid hormones, and the Chi-square test for categorical variables. A p-value of <0.05 was judged to be statistically significant.

RESULTS

The study participants are separated into three groups: control, hyperthyroid, hypothyroid. The gender distribution was nearly equal, with females making up 51.10% and males 48.90% of the study population. Thyroid problems were most common among people aged between51 to 60, an age-dependent in the Case group. This may reflect cumulative exposure to risk factors or age-related vulnerability. The relative increase from the 31–40 to 51–60 age groups emphasize the importance of targeted interventions, screenings, or preventive strategies for older adults. In contrast, the Control group shows a more even distribution across age ranges, peaking at 26% in the 31–40 age group. (figure 1)

Serum magnesium levels were considerably lower in hyperthyroid and hypothyroid patients than in controls, with p-values < 0.005. Similarly, serum calcium, sodium and chloride levels were significantly lower in thyroid dysfunction groups, but potassium and bicarbonate levels showed no statistically significant differences.

Comparative study of hyperthyroid patients with control:

Thyroid Hormones:

Table 1 and figure 2 shows that the mean T3 level in patients was significantly lower (1.08 ± 0.77) compared to controls (2.88 ± 0.43) with a p-value of <0.001. Similarly, T4 level were significantly higher in patients (9.19 ± 4.45) compared to controls (0.89 ± 0.18) (p < 0.001). The difference in TSH levels between patients (1.99 ± 1.45) and controls (2.5 ± 1.24) was not statistically significant (p = 0.126).

Electrolytes and Minerals:

Table 1 and figure 3 & 4 shows that the patients showed significantly lower levels of magnesium (1.77 ± 0.47 vs. 1.99 ± 0.20; p = 0.001), calcium (8.63 ± 1.46 vs. 9.22 ± 0.46; p = 0.027), sodium (132.9 ± 6.76 vs. 137.6 ± 1.6; p < 0.001), and chloride (97.56 ± 8.92 vs. 103.46 ± 2.35; p < 0.001) compared to controls. However, potassium levels (3.86 ± 0.99 in patients vs. 4.05 ± 0.44 in controls) showed no significant difference (p = 0.554), and neither did bicarbonate levels (24.7 ± 5.96 in patients vs. 25.7 ± 3.15 in controls; p = 0.362).

Comparative Study of Hypothyroid patients with control:

Thyroid Hormones:

Table 2 and figure 5 patients exhibited a markedly elevated TSH level (11.64 ± 12.36) compared to controls (2.5 ± 1.24), with a p-value of <0.001. Similarly, T3 levels were significantly lower in patients (2.13 ± 0.9) than controls (2.88 ± 0.43) (p < 0.001). T4 levels were significantly higher in patients (2.3 ± 3.87) than in controls (0.89 ± 0.18) (p < 0.001), indicating a significant disruption in thyroid function.

Electrolytes and Minerals:

Table 2 and figure 6 & 7 the magnesium level in patients (1.81 ± 0.35) was significantly lower than in controls (1.99 ± 0.20) (p = 0.005). Calcium was also reduced in patients (8.56 ± 0.94 vs. 9.22 ± 0.46; p = 0.006). A significant difference was also observed in sodium levels (127.73 ± 18.97 in patients vs. 137.6 ± 1.6 in controls; p < 0.001), though the clinical relevance may be limited due to similar mean values and high variance in patients. Chloride was significantly lower in patients (100.73 ± 5.38) compared to controls (103.46 ± 2.35; p < 0.001). statistically no significant differences were observed in potassium (4.2 ± 0.61 in patients vs. 4.05 ± 0.44 in controls; p = 0.162) and bicarbonate (23.23 ± 5.12 in patients vs. 25.7 ± 3.15 in controls; p = 0.191).

Correlation of Serum Magnesium With TSH, T3, And T4 Among hyperthyroidism and hypothyroidism patients.

Figure 8 represent there is significant positive correlation of serum T3 with serum magnesium in hypothyroid patient. the r value is +0.321(p value=0.02) there is also strong positive correlation of serum T4 with serum magnesium in thyroid patients r value +0.312 (p value 0.03)and there is strong negative correlation between TSH and serum magnesium levels in thyroid patients r value -0.117(p value=0.231).

Comparison of TSH, T3 and T4 Levels in Hyperthyroid and Hypothyroid Patients with Controls

Table 4 and figure 9 shows that TSH is significantly increased in hypothyroid patients (P = 0) whereas there is no altered level of TSH in hyperthyroidism patients, while T3 and T4 levels are significantly altered in both hyperthyroid and hypothyroid groups (P = 0), indicating

clear hormonal disruptions in thyroid dysfunctions.

Comparison of Mg2+, Ca2+, Na+, K+, Cl−, HCO_3^- Levels in Hyperthyroid and Hypothyroid Patients with Controls

Figure 10 Graphical chart represent the Mg^{2+}, Ca^{2+}, K^+, HCO_3^- levels in hyperthyroid and hypothyroid patients with control and Figure 11 Graphical chart represent Na+, Cl− levels in hyperthyroid and hypothyroid patients with control, Magnesium, calcium, sodium and chloride levels show significant alterations in both hyperthyroid and hypothyroid patients ($P < 0.05$), while potassium and bicarbonate levels do not differ significantly from controls.

Table:1 The comparison of biochemical parameters between the patient and the control group.

S.no	Parameter	Controls		Patients		P value
		Mean	S.D	Mean	S.D	
1	TSH	2.5	1.24	1.99	1.45	0.126
2	T3	2.88	0.43	1.08	0.77	0*
3	T4	0.89	0.18	9.19	4.45	0*
4	Magnesium	1.99	0.2	1.77	0.47	0.001
5	Calcium	9.22	0.46	8.63	1.46	0.027
6	Sodium	137.6	1.6	132.9	6.76	0*
7	Potassium	4.05	0.44	3.86	0.99	0.554
8	Chloride	103.46	2.35	97.56	8.92	0*
9	Bicarbonate	24.70	3.15	24.7	5.96	0.362

p<0.05 is statistically significant. (*is highly significant).

Table:2 Represent the thyroid hormones and electrolytes level in hypothyroid patients with control.

S.no	Parameter	Patients		Controls		P value
		Mean	S.D	Mean	S.D	
1	TSH	11.64	12.36	2.5	1.24	0.001
2	T3	2.13	0.9	2.88	0.43	0*
3	T4	2.3	3.87	0.89	0.18	0*
4	Magnesium	1.81	0.35	1.99	0.2	0.005
5	Calcium	8.56	0.94	9.22	0.46	0.006
6	Sodium	127.73	18.97	137.63	1.6	0*
7	Potassium	4.2	0.61	4.05	0.44	0.162
8	Chloride	100.73	5.38	103.46	2.35	0*
9	Bicarbonate	23.23	5.12	25.7	3.15	0.191

p<0.05 is statistically significant. (*is highly significant).

European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: 3105-0409
Website: https://farmclin.com/

Table:3 Correlation of Serum Magnesium With TSH, T3, And T4 Among hyperthyroidism and hypothyroidism patients.

Parameters	Correlation
	Coefficient (r value)
Serum TSH Vs Serum magnesium	r value= -0.117
Serum T3 Vs Serum magnesium	r value= +0.321
Serum T4 Vs Serum magnesium	r value= +0.312

Table:4 Comparison of TSH, T3 and T4 Levels in Hyperthyroid and Hypothyroid Patients with Controls.

S.no	Parameter	control		Hyperthyroid			Hypothyroid		
		Mean	S.D	Mean	S.D	P'value	Mean	S.D	P'value
1	TSH	2.5	1.24	1.99	1.45	0*	11.64	12.36	0.126
2	T3	2.88	0.43	1.08	0.77	0*	2.13	0.9	0*
3	T4	0.89	0.18	9.19	4.45	0*	2.3	3.87	0*

Table:5 Comparison of Mg2+, Ca2+, Na+, K+, Cl−, HCO_3^- Levels in Hyperthyroid and Hypothyroid Patients with Controls.

S.no	Parameter	Controls		Hyperthyroid			Hypothyroid		
		Mean	S.D	Mean	S.D	P'value	Mean	S.D	P'value
1	Magnesium	1.99	0.2	1.77	0.47	0.001	1.81	0.35	0.005
2	Calcium	9.22	0.46	8.63	1.46	0.027	8.56	0.94	0.006
3	Sodium	137.6	1.6	132.9	6.76	0*	127.73	18.97	0*
4	Potassium	4.05	0.44	3.86	0.99	0.554	4.2	0.61	0.162
5	Chloride	103.46	2.35	97.56	8.92	0*	100.73	5.38	0*
6	Bicarbonate	25.7	3.15	24.7	5.96	0.362	23.23	5.12	0.191

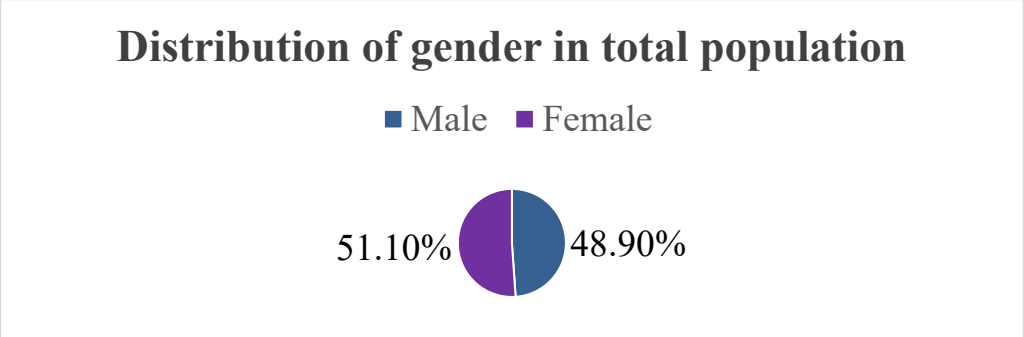


Figure:1 graphical representation of gender population

Figure:2 Graphical chart represents the thyroid levels in hyperthyroid patients with controls

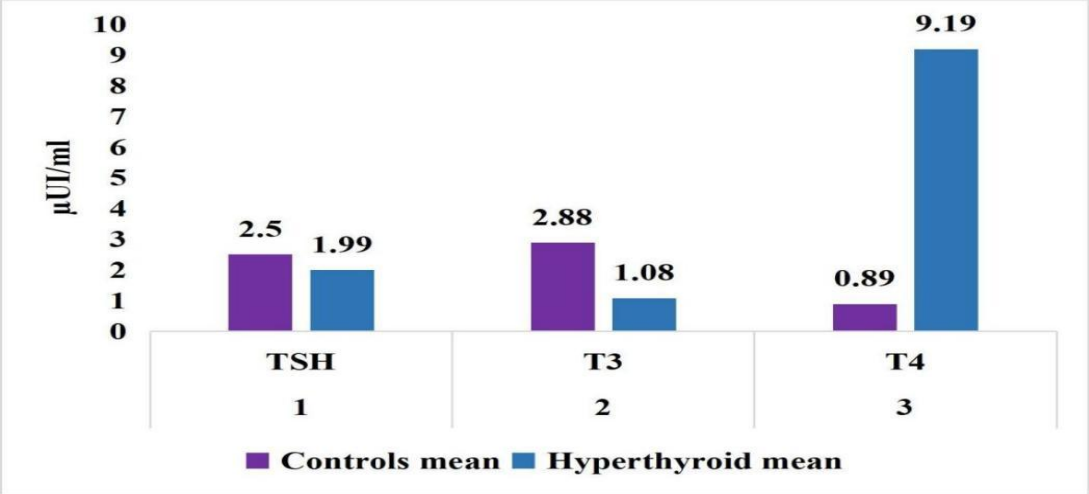


Figure:3 Graphical chart represents the electrolytes levels in hyperthyroid patients with controls

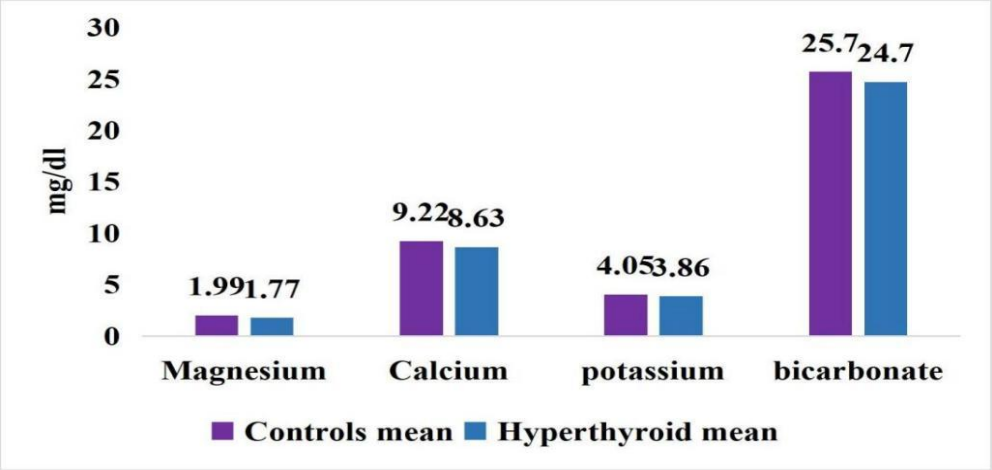


Figure:4 Graphical chart represents the sodium and chloride levels in hyperthyroid patients with controls

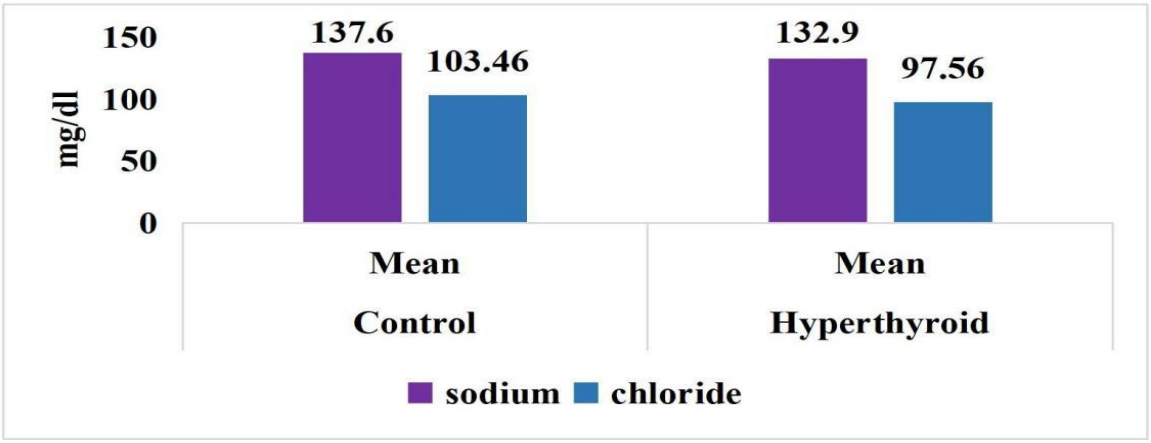


Figure:5 Graphical chart represents the thyroid levels in hypothyroid patients with controls

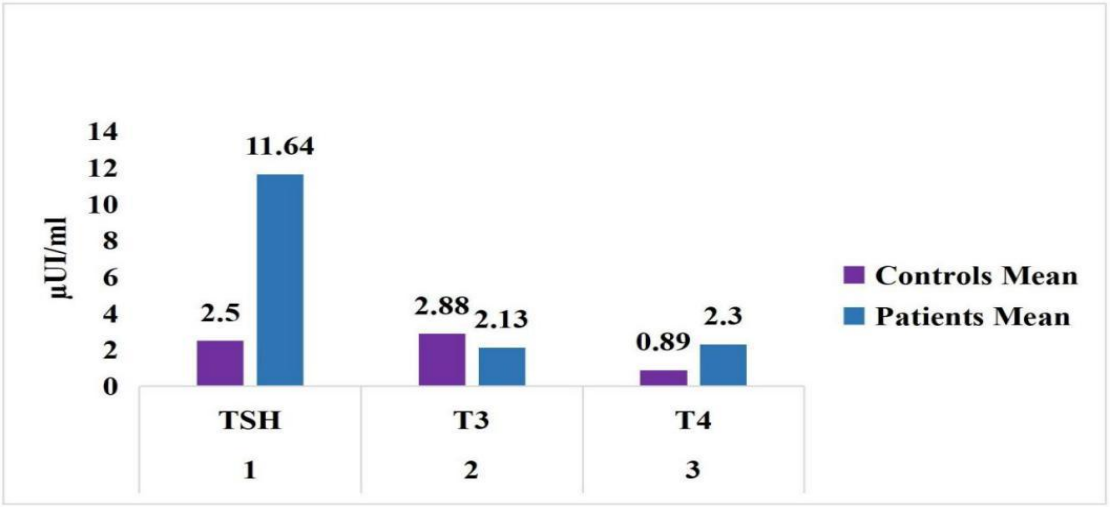


Figure:6 Graphical chart represents the electrolytes levels in hypothyroid patients with controls

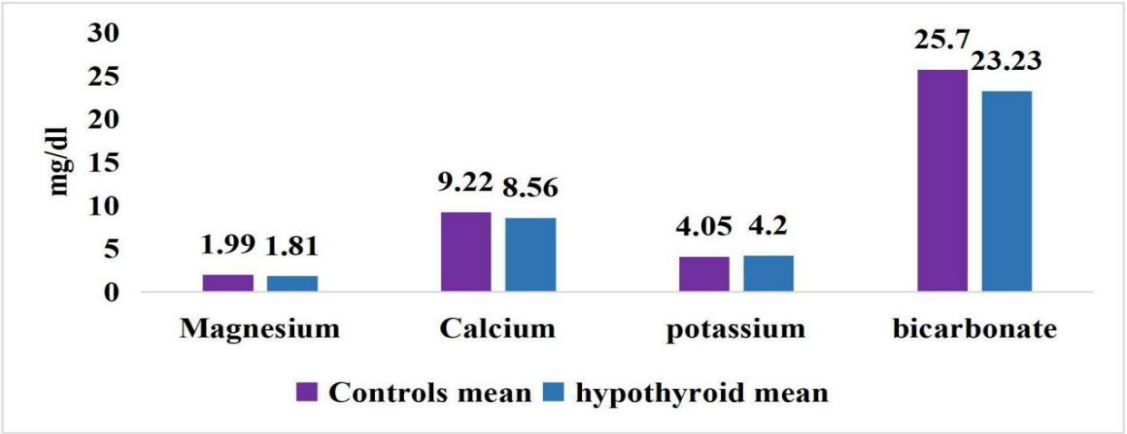


Figure:7 Graphical chart represents the sodium and chloride levels in hypothyroid with controls

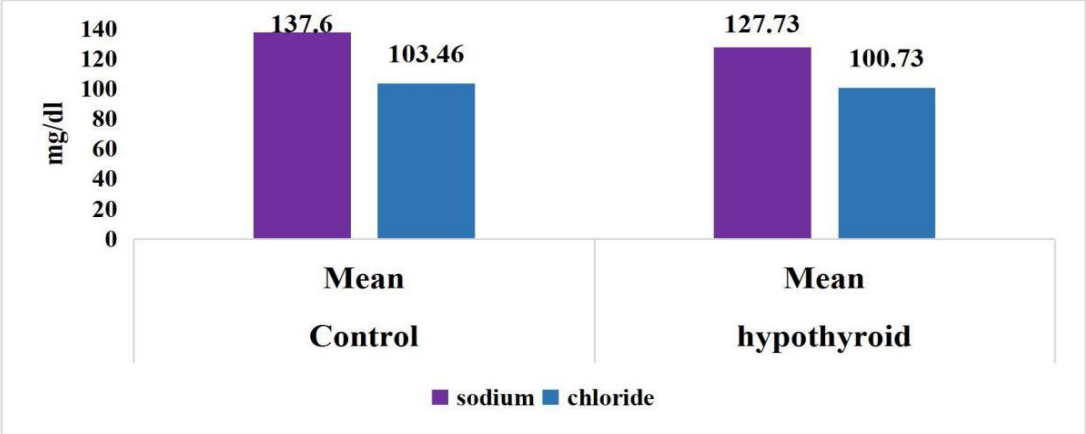
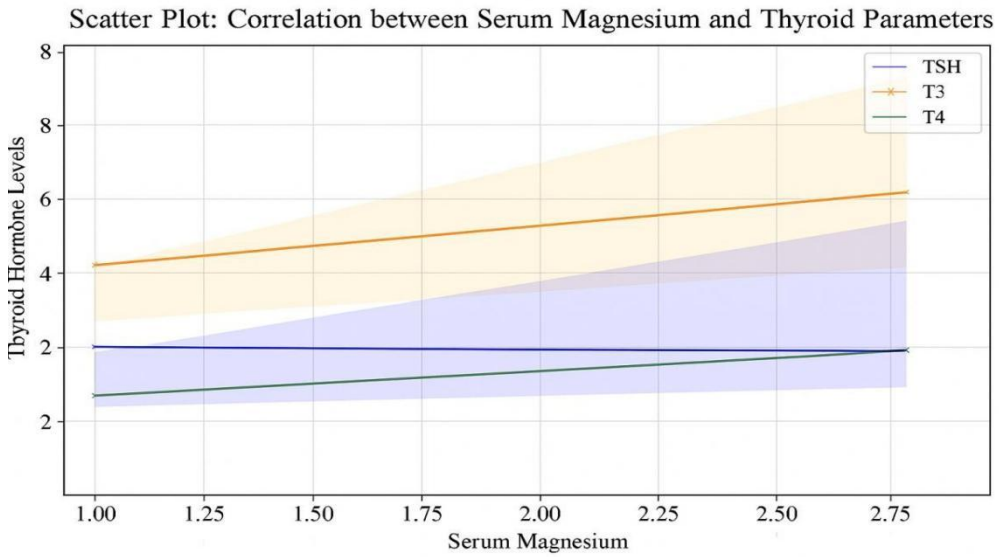


Figure:8 represent the correlation between serum magnesium and thyroid



Blue(TSH)- slight negative trend, Green(T3) and Orange(T4)-positive trend

Figure: 9 Graphical chart represents the TSH, T3 and T4 levels in hyperthyroid and hypothyroid patients with control

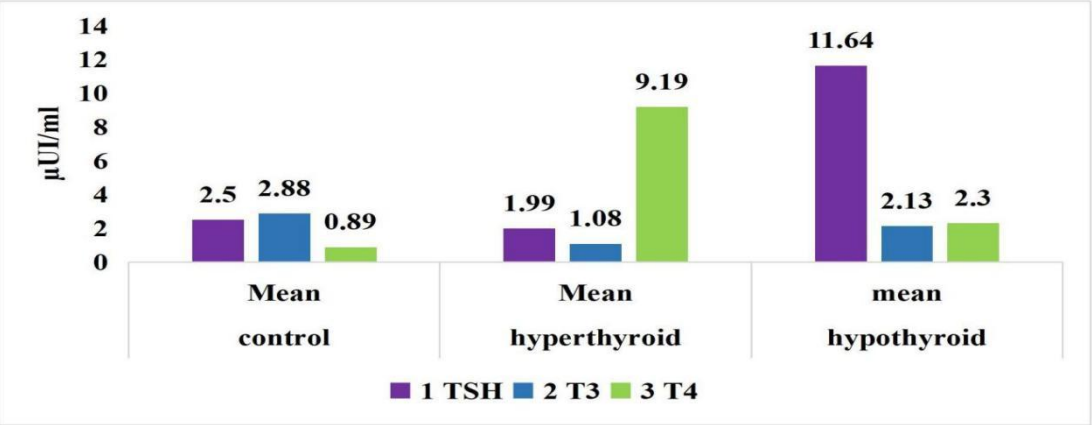


Figure:10 Graphical chart represents the Mg, Ca, K+, HCO_3^- levels in hyperthyroid and hypothyroid patients with control

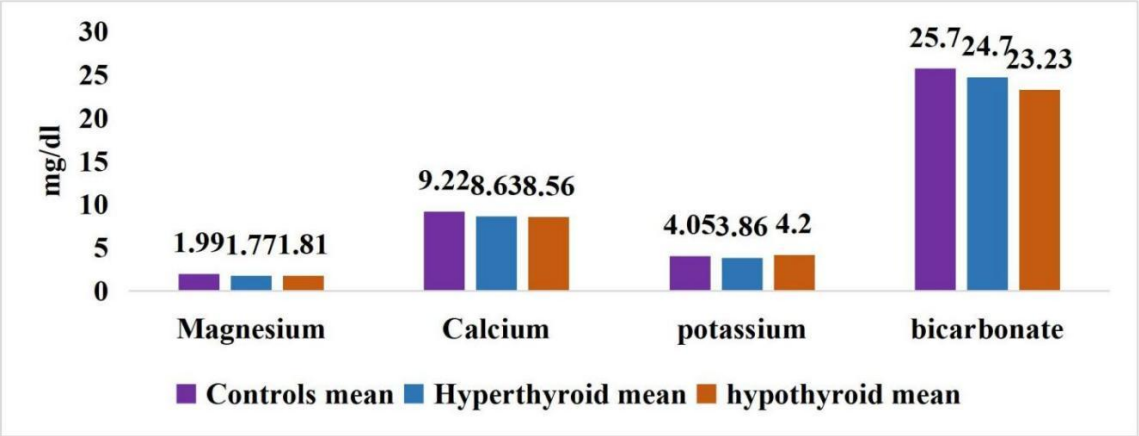
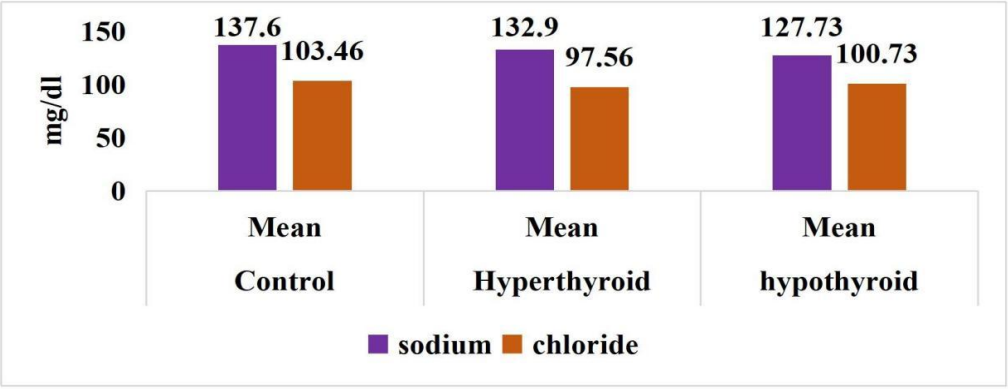


Figure:11 Graphical chart represents Na+, Cl– levels in hyperthyroid and hypothyroid patients with control



DISCUSSION

In this study, subjects from various ages were included to assess the systemic impact of thyroid dysfunction. Thyroid problems, which include both hypothyroidism and hyperthyroidism, are well established to have wide-ranging

metabolic and physiological effects, many of which can be impacted or aggravated by micronutrient imbalances. Magnesium is an essential mineral for thyroid gland function and metabolism. This study, therefore, explores the link between thyroid hormone status and serum magnesium levels in order to provide insight into their possible diagnostic and therapeutic significance.

Effect of thyroid hormones in thyroid dysfunction:

The clear differences in thyroid hormone levels between the control, hyperthyroid, and hypothyroid patients are highlighted in this study. Significant TSH suppression in hyperthyroid individuals is in line with known negative feedback processes, in which pituitary TSH release is inhibited by increased circulating thyroid hormones (Ross et al., 2016). Although the lack of statistical significance indicates variation in disease severity or the presence of subclinical hypothyroidism within the sample, the elevated mean TSH in hypothyroid patients represents the compensatory pituitary response to low circulating thyroid hormone levels (Sridevi et al., 2016).

These functional alterations are further supported by the thyroid hormone profiles. T4 levels were significantly higher in hyperthyroid patients and T3 significantly lower in hyperthyroid patients, which could be an indication of temporary thyrotoxicosis or problems with peripheral deiodination (Ross et al., 2016). Both T3 and T4 levels were markedly reduced in hypothyroid patients, exhibiting the characteristic biochemical pattern of thyroid hormone insufficiency (Sridevi et al., 2016). These results are consistent with earlier studies showing that a thorough assessment of TSH in addition to free T3 and T4 is necessary for precise thyroid disease diagnosis and classification (Ross et al., 2016).

According to this study, serum magnesium levels were inversely correlated with TSH levels and positively correlated with thyroid hormones T3 and T4. These results imply that magnesium promotes the synthesis and conversion of thyroid hormones. The sodium-iodide symporter (NIS), which is necessary for iodine uptake, is maintained, and it contributes to the activation of deiodinase enzymes, which change T4 into active T3 (Dasgupta & Klein, 2012; Nicola et al., 2015). Due to compensatory pituitary stimulation, low magnesium levels may disrupt these processes, resulting in decreased T3/T4 levels and increased TSH (Rude, 1998). Therefore, thyroid dysfunction, especially hypothyroidism, may be exacerbated by magnesium shortage. In order to better manage thyroid diseases, magnesium monitoring may be helpful.

Effect of thyroid on magnesium:

Magnesium levels were significantly lower in hyperthyroid patients compared to controls. Similarly, a statistically significant reduction was also observed in hypothyroid. (Kumar & Sinha et al., 2014). This may be due to decreased level of calcium was observed in the study. This decreased levels of calcium may influence in the decreased levels of magnesium or otherwise gastrointestinal absorption and altered renal conservation can also result in lower magnesium levels in both hyperthyroid and hypothyroid patients.

Effect of calcium in thyroid patients:

Additionally, compared to controls, calcium levels were considerably lower in hyperthyroid and hypothyroid patients. According to Reddy et al. (2017), hypocalcemia in thyroid dysfunction can be caused by parathyroid gland abnormalities as a result of thyroid disease, magnesium-dependent enzymatic activity, or decreased vitamin D metabolism.

Effect of sodium in thyroid patients:

Both hyperthyroid and hypothyroid patients had significantly lower sodium levels than controls. According to Islam et al. (2021), hyponatremia is commonly seen in hypothyroidism as a result of altered sodium management and reduced renal free water clearance, which can lead to systemic problems.

Effect of chloride in thyroid patients:

In comparison to controls, thyroid patients also had significantly lower chloride levels in hyperthyroid and hypothyroid which was attributed to electrolyte imbalances linked to altered acid-base homeostasis and renal function in thyroid disease (Islam et al., 2021).

Effect of potassium in thyroid patients:

According to Kung et al., (2006) potassium homeostasis and acid-base balance may remain relatively stable, at least in mild to moderate cases, despite the metabolic disruptions in thyroid dysfunction. This is supported by the fact that potassium and bicarbonate levels did not exhibit statistically significant differences between groups.

Effect of thyroid on bicarbonate:

In the present study, serum bicarbonate levels did not show any statistically significant difference in both hyperthyroid and hypothyroid patients when compared to controls. Despite this, studies have shown that unless thyroid dysfunction is severe or complicated by other systemic conditions (such as renal impairment or respiratory compromise), bicarbonate levels tend to remain within normal ranges (Larsson et al.,2002).

Conclusion:

This study indicates that thyroid dysfunction, including hyperthyroidism and hypothyroidism, is associated with considerable changes in serum magnesium and other electrolytes, particularly calcium, sodium, and chloride. Magnesium levels were significantly lower in affected people, indicating a potential function in thyroid hormone metabolism and conversion. Calcium and

electrolyte imbalances may contribute to common clinical symptoms such as neuromuscular irritation and exhaustion, particularly in hypothyroidism. A mild negative association between TSH and magnesium, as well as a slight positive correlation with T3 and T4, lends credence to magnesium's role in thyroid function. Despite these adjustments, potassium and bicarbonate levels remained fairly constant.

These findings emphasize the need of measuring magnesium and electrolyte levels in addition to thyroid hormones for a more complete assessment. Addressing these imbalances could improve symptom control and treatment outcomes. Further research is needed to understand their significance in long-term thyroid treatment.

REFERENCES

1. Anand, S., Kumar, S., Vidhayak, R. S. (2023). Alteration in levels of serum calcium, phosphorus and magnesium in patients of hypothyroidism. IOSR Journal of Dental and Medical Sciences, 11(6), 16–23.
2. Akter, S., Reza, M. M., & Alam, M. R. (2021). Study of serum magnesium, calcium and phosphorus levels in subclinical and overt hypothyroidism. Saudi Journal of Medicine, 6(12), 410–413.
3. Aranind, P., Mehta, M., & Joshi, M. (2015). Study of serum sodium levels in hypothyroid patients. International Journal of Medical Science and Public Health, 4(2), 180–183.
4. Bernal, J., Nunez, J. (2005). Thyroid hormones and brain development. Vitamins and Hormones, 71(1), 95–122.
5. Bernice, R., Madhura, T. L., Shruthi, B., Sohil, S., & Likhitha, B. (2021). Study of serum magnesium, calcium and phosphorus levels in subclinical and overt hypothyroidism. Scholars Academic and Scientific Journal of Medicine, 10(4), 521–526.
6. Bharti, A., Shrestha, S., Rai, R., & Singh, M. K. (2015). Assessment of serum minerals and electrolytes in thyroid patients. International Journal of Advances in Scientific Research, 1(6), 259–263.
7. Biondi, B., & Cooper, D. S. (2008). The clinical significance of subclinical thyroid dysfunction. Endocrine Reviews, 29(1), 76–131
8. Brent, G. A. (2012). Mechanisms of thyroid hormone action. The Journal of Clinical Investigation, 122(9), 3035–3043.
9. Charles, B. B., Benjamin, L. M., & Andre, P. K. (2022). Low serum triiodothyronine and potassium levels are associated with increased risk of eclampsia among women in the Eastern Cape Province of South Africa. Clinical and Experimental Obstetrics & Gynecology, 49(2), 32.
10. Chatterjee, S., Chakrabarti, P., Lokanathan, V. (2023). Calcium and magnesium levels in subclinical and overt hypothyroidism: A cross-sectional study. Journal of Clinical Diagnostic Research, 17(9), BV15–BC17
11. Dasgupta, A., & Klein, K. (2012). Role of magnesium in thyroid function. Journal of Thyroid Research, 2012, Article ID 740104.
12. de Baaij, J. H. F., Hoenderop, J. G. J., & Bindels, R. J. M. (2015). Magnesium in man: implications for health and disease. Physiological Reviews, 95(1), 1–46.
13. Dhananjay, T., Mohammad Mustufa, K. I., & Priyanka, T. (2022). A study on serum magnesium and zinc levels in patients with hypothyroidism. Biochemical and Cellular Archives, 22, 1493–1497.
14. Islam,(2021). Evaluation of serum electrolytes and trace elements in thyroid disorders. Biological Trace Element Research, 199(1), 38–45.
15. Jameson, J. L., & Weetman, A. P. (2018). Disorders of the thyroid gland. In J. L. Jameson., Harrison's Principles of Internal Medicine (20) 384–397.
16. Kaur, J., Ahmad, N., Gupta, A.(2014). Changes in the electrolyte profile of patients having hyperthyroidism. Journal of Scientific and Specialized Clinical Research, 2(4).
17. Kavitha, M. M., Chandrashekharyya, S. H., Kashinakunti, S. V., Sunitha, H., Neela, B. M., & Ratna, S. (2014). Alteration in levels of serum calcium, phosphorus and magnesium in patients of hypothyroidism. International Journal of Biological & Medical Research, 5(4), 4594–459.
18. Koehler, V. F., & Rautenstrauch, T. (2009). Thyroid dysfunction and acid–base balance. Journal of Clinical Endocrinology and Metabolism, 94(6), 2231–2236.
19. Kumar, S., & Sinha, R. A. (2014). Electrolyte disturbances in thyroid dysfunction. International Journal of Clinical Endocrinology, 18(3), 145–149.
20. Mani, V., Ramesh, R., & Kumar, P. (2019). Evaluation of serum calcium levels in hypothyroid patients: A case–control study. Journal of Clinical and Diagnostic Research, 13(2), BC01–BC03.
21. Mullur, R., Liu, Y. Y., & Brent, G. A. (2014). Thyroid hormone regulation of metabolism. Physiological Reviews, 94(2), 355–382.
22. Ortiga Carvalho, T. M., Chiamolera, M. I., Pazos Moura, C. C., & Wondisford, F. E. (2016). Hypothalamus–pituitary–thyroid axis. Comprehensive Physiology, 6(3), 1387–1428.
23. Paul, A. K., Miah, S. R., Mamun, A. A., & Islam, S. (2006). Thyroid disorders in Khulna district: A community based study. Bangladesh Medical Research Council Bulletin, 32, 66–71.
24. Sabera, S., Mosammad, A. J., Syed Minhaj, U. A., Rabeya, S., & Fatema, F. A. (2024). Calcium imbalance and hypothyroidism: Exploring the relationship. KYAMC Journal, 14, 194–197.

25. Sattar, N., & Greer, I. A. (2002). Thyroid disorders in pregnancy: Diagnosis and management. The Obstetrician & Gynaecologist, 4(4), 184–190.
26. Shivallela, M. B., Poomima, R. T., & Jayaprakash Murthy, D. S. (2012). Serum calcium and phosphorus levels in thyroid dysfunction. Indian Journal of Fundamental and Applied Life Science, 2, 179–183.
27. Sridevi, D., Dambal, A. A., Sridhar, S., Challah, A. S., Samatak, S., & Padaki, S. (2016). A study of serum magnesium, calcium and phosphorus in hypothyroidism. International Journal of Clinical Biochemistry and Research, 3(2), 236–239.
28. Taylor, P. N., Albrecht, D., Scholz, A., Gutierrez Buey, G., Lazarus, J. H., & Dayan, C. M. (2018). Global epidemiology of hyperthyroidism and hypothyroidism. Nature Reviews Endocrinology, 14, 301–316.
29. Vijayapriya, I., & Saravanan, S. (2019). A study of serum magnesium level in hypothyroid cases in a tertiary care hospital, Perambalur. International Journal of Medical Research & Review, 7(3), 195–199.
30. Zoccali, C., Mallamaci, F., & Tripepi, G. (2008). Thyroid function and survival in dialysis patients. Nephrology Dialysis Transplantation, 23(9), 2875–2880.

Conflict of Interest

The authors declare no conflict of interest related to this study.

Acknowledgement

We express our sincere gratitude to Dr. M.G.R. Educational and Research Institute for providing the necessary facilities, resources, and institutional support that made this study possible.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical Approvals

Ethical clearance number was obtained from the institutional ethical committee-
No.1438/2024/ICE/ACSMCH Dt.11.12.2024.

Declarations

The authors declare that this work is original and has not been submitted elsewhere for publication. All data, methodologies, and system components have been developed and reported in adherence to academic standards. All referenced materials have been duly cited, and the authors accept full responsibility for the integrity and accuracy of the findings presented.

