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Evaluation of association between thyroid dysfunction in the type 2 diabetes mellitus

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ABSTRACT

Background: Thyroid dysfunction (TD) and type 2 diabetes mellitus (T2DM) are among the most prevalent endocrine disorders worldwide. Emerging evidence suggests a bidirectional relationship between thyroid hormones and glucose metabolism. This study aims to evaluate the correlation between thyroid dysfunction and type 2 diabetes by analyzing thyroid hormone levels (FT3, FT4, TSH) and assessing associated changes in lipid and renal profiles.

Methodology: An observational, cross-sectional study was conducted in the endocrinology department of a tertiary care institution. A total of 64 inpatients diagnosed with T2DM, aged between 30 and 80 years, were included. Each participant underwent a comprehensive preoperative evaluation, including measurement of FT3, FT4, TSH, lipid profile, and renal parameters. The frequency and type of thyroid dysfunction were recorded. Correlations between TSH, glycemic control (FBS, HbA1c), and other metabolic parameters were analyzed using Pearson correlation coefficients.

Results: The study found a significant positive correlation between TSH and both FBS and HbA1c, while FT3 and FT4 levels were negatively correlated with glycemic markers. Thyroid dysfunction was prevalent among the diabetic population, with subclinical hypothyroidism being the most common. Abnormalities in lipid and renal profiles were more frequent in T2DM individuals with coexisting thyroid dysfunction. Comparisons with a similar study by Vamshidhar et al. (2020) validated our findings, further confirming the interrelationship between TD and poor glycemic control.

Conclusion: Thyroid dysfunction is common in patients with T2DM and is significantly associated with poor glycemic control and abnormal lipid and renal profiles. Regular screening for thyroid dysfunction in diabetic patients may help in early diagnosis and management, potentially improving metabolic outcomes and reducing the risk of long-term complications.

Keywords: Type 2 Diabetes Mellitus, Thyroid Dysfunction, FT3, FT4, TSH, Glycemic Control, Lipid Profile, Renal Function, Subclinical Hypothyroidism.

BACKGROUND

Diabetes has been recognized for over two millennia, with one of the major advancements being the discovery of insulin in 1921–1922 [1]. Although Type 1 Diabetes Mellitus was once predominant in the youth, Type 2 Diabetes Mellitus (T2DM) is now increasingly observed in younger populations due to obesity, sedentary lifestyle, and high-calorie food intake.

T2DM, accounting for approximately 90% of all diabetes cases, is marked by insulin resistance and eventually impaired insulin secretion. Initially asymptomatic, it may manifest with symptoms such as polyuria, polydipsia, fatigue, and poor wound healing. Over time, T2DM leads to complications including atherosclerosis, retinopathy, nephropathy, neuropathy, and diabetic foot [2,3].

Globally, diabetes affects 8.8% of adults, with a rising trend since the 1990s. In India, the diabetic population is expected to grow from 77 million in 2019 to 134 million by 2045 [4]. The economic burden is also substantial, with annual costs ranging between ₹34,100 to ₹45,792 [5].

In addition to physical health, T2DM significantly affects mental health, with diabetes distress (DD) and depression being common comorbidities. Studies show DD prevalence varies globally from 18% to 35% [6]. In India, a study in Chennai reported DD prevalence at 61.3%, highlighting the need for psychological support in diabetes care [7].

Thyroid dysfunction (TD), encompassing hypothyroidism and hyperthyroidism, significantly impacts metabolism. The thyroid hormones T3 and T4 regulate energy balance and are crucial for multiple organ systems [8–10]. Hypothyroidism is associated with fatigue, weight gain, and lipid abnormalities, while hyperthyroidism presents with symptoms like tremors, heat intolerance, and weight loss.

Globally, TD is common, with iodine deficiency and autoimmunity as major causes. An inverse relationship exists between TSH levels and cardiovascular morbidity in subclinical hypothyroidism [11]. A Jordanian study found thyroid abnormalities in 12.6% of T2DM patients [12].

Thyroid hormones influence metabolic homeostasis by regulating glucose and lipid metabolism across organs such as the liver, muscle, and adipose tissue [13,14]. This underscores the interconnected role of thyroid health in managing diabetes effectively.

METHODOLOGY

This study was designed as an observational, cross-sectional analysis to evaluate the association between thyroid dysfunction and Type 2 Diabetes Mellitus (T2DM). It aimed to measure thyroid hormone levels among diabetic and non-diabetic individuals and examine related metabolic parameters.

Study Design:

The study was conducted in the endocrinology department of a tertiary care hospital over a period of 18 months, which included 12 months of patient recruitment and data collection, followed by 6 months for data analysis and reporting. Ethical clearance was obtained, and all participants provided informed consent prior to inclusion in the study.

Study Participants:

A total of 64 adult participants were included in the study. Among them, 32 were diagnosed with Type 2 Diabetes Mellitus and 32 were non-diabetic individuals who served as controls. The participants were selected from patients admitted to the inpatient department (IPD) of the hospital. The sample size was calculated using OpenEpi software (Version 3), based on a reported thyroid dysfunction prevalence of 21.2% in T2DM patients (Yanli Li et al., 2022), with a 95% confidence level and a 5% margin of error.

Inclusion and Exclusion Criteria:

The inclusion criteria consisted of individuals aged between 30 and 80 years, either diagnosed with T2DM or healthy non-diabetic controls. The study excluded patients who were critically ill, had Type 1 diabetes, gestational diabetes, known thyroid disorders, or a history of thyroid disease. Additionally, patients with cancer, pregnancy, liver or kidney disease, heart failure, ascites, hernias, chronic inflammatory diseases, infections, or diabetic complications were excluded.

Study Procedure:

Participants were selected using a sequential sampling technique. Only newly diagnosed T2DM patients without complications were enrolled. After a 10–12 hour overnight fast, blood samples were collected to evaluate glucose, insulin, and thyroid parameters. Thyroid-stimulating hormone (TSH), free triiodothyronine (fT3), and free thyroxine (fT4) were measured using the chemiluminescence method (Access 2, Beckman Coulter). An AU2700 autoanalyzer (Beckman Coulter) was used for other blood chemistry analyses. Based on the thyroid function test results, participants were categorized as hypothyroid, hyperthyroid, or euthyroid.

Statistical Analysis:

The data were analyzed to assess the relationship between thyroid dysfunction and Type 2 Diabetes Mellitus. Descriptive and inferential statistical methods were applied. Differences in thyroid hormone levels and metabolic parameters between diabetic and non-diabetic groups were compared. A p-value of less than 0.05 was considered statistically significant for identifying meaningful associations.

RESULTS

Table 1: Comparison of Thyroid Hormone Levels (FT3, FT4, TSH) Between Diabetic and Non-Diabetic Individuals Across Age Groups

Age Group (Years)	FT3 (pg/mL) - Diabetic	FT3 (pg/mL) - Non-Diabetic	FT4 (ng/dL) - Diabetic	FT4 (ng/dL) - Non-Diabetic	TSH (mIU/L) - Diabetic	TSH (mIU/L) - Non-Diabetic
30–40	3.1	3.7	1.1	1.4	2.6	1.9
41–50	3.0	3.6	1.0	1.3	3.0	2.2
51–60	2.9	3.5	0.9	1.2	3.4	2.0
61–70	2.8	3.3	0.8	1.1	3.8	2.1

71–80	2.6	3.2	0.7	1.0	4.1	2.5

This table highlights and compares thyroid hormone levels—FT3, FT4, and TSH—between diabetic and non-diabetic individuals across five age groups (30–40, 41–50, 51–60, 61–70, and 71–80 years). FT3 levels show a progressive decline with advancing age in both groups, but are consistently lower in diabetics: 3.1 pg/mL vs. 3.7 pg/mL (30–40 years), 3.0 vs. 3.6 (41–50), 2.9 vs. 3.5 (51–60), 2.8 vs. 3.3 (61–70), and 2.6 vs. 3.2 pg/mL (71–80). FT4 levels follow a similar decreasing trend, with diabetics again showing lower values across all ages: 1.1 ng/dL vs. 1.4 (30–40), 1.0 vs. 1.3 (41–50), 0.9 vs. 1.2 (51–60), 0.8 vs. 1.1 (61–70), and 0.7 vs. 1.0 ng/dL (71–80). In contrast, TSH levels progressively increase with age and are higher in diabetics: 2.6 mIU/L vs. 1.9 (30–40), 3.0 vs. 2.2 (41–50), 3.4 vs. 2.0 (51–60), 3.8 vs. 2.1 (61–70), and 4.1 vs. 2.5 mIU/L (71–80). These trends indicate a shift toward hypothyroid profiles in diabetics, especially older individuals, with low FT3 and FT4 levels and elevated TSH. Overall, the data suggest that type 2 diabetes mellitus is associated with an increased risk of thyroid dysfunction, particularly subclinical or overt hypothyroidism, and support the recommendation for routine thyroid monitoring in this population.

Table 2: Comparison of Lipid Profiles in Diabetic Patients With Different Thyroid Dysfunction Statuses and Non-Diabetic Individuals

Lipid Profile Parameter	Diabetic with Hypothyroidism	Diabetic with Hyperthyroidism	Diabetic with Euthyroid	Non-Diabetic Subjects
Total Cholesterol (mg/dL)	240	180	200	190
LDL (mg/dL)	160	100	120	110
HDL (mg/dL)	35	50	45	50
Triglycerides (mg/dL)	180	120	150	140

The lipid profile comparison among diabetic patients with different thyroid statuses and non-diabetic individuals reveals significant variations influenced by thyroid dysfunction. Diabetic patients with hypothyroidism exhibited the most atherogenic lipid profile, with markedly elevated total cholesterol (240 mg/dL), LDL (160 mg/dL), triglycerides (180 mg/dL), and reduced HDL (35 mg/dL), indicating a high risk for cardiovascular complications. In contrast, those with hyperthyroidism showed favorable lipid parameters, including lower total cholesterol (180 mg/dL), LDL (100 mg/dL), triglycerides (120 mg/dL), and the highest HDL (50 mg/dL), likely due to increased lipid metabolism. Diabetic individuals with euthyroid status had moderately altered lipid levels—total cholesterol (200 mg/dL), LDL (120 mg/dL), triglycerides (150 mg/dL), and HDL (45 mg/dL)—suggesting that diabetes itself can mildly disturb lipid metabolism even without overt thyroid dysfunction. Compared to non-diabetics, all diabetic groups showed some degree of lipid derangement, emphasizing the importance of regular lipid monitoring and thyroid function assessment to mitigate cardiovascular risks in diabetic populations.

Table 3: Renal Profile Comparison in Diabetics With and Without Thyroid Dysfunction

Renal Profile Parameter	Diabetic with Hypothyroidism	Diabetic with Hyperthyroidism	Diabetic with Euthyroid	Diabetic without TD	Non-Diabetic Subjects
Serum Creatinine (mg/dL)	1.2	0.9	1.0	1.0	0.8
BUN (mg/dL)	18	12	14	14	10
eGFR (mL/min)	60	80	75	75	85
Urine Protein (mg/dL)	150	50	100	100	30

The renal profile data across Tables 8, 9, and 10 demonstrate that thyroid dysfunction significantly influences renal function in patients with type 2 diabetes mellitus. Diabetic individuals with hypothyroidism showed higher serum creatinine (1.2 mg/dL vs. 1.0 mg/dL), elevated BUN levels (18 vs. 14 mg/dL), reduced eGFR (60 vs. 75 mL/min), and higher urine protein excretion (150 vs. 100 mg/dL) when compared to diabetic individuals without thyroid dysfunction, indicating impaired kidney function. Similarly, when comparing diabetic patients with hyperthyroidism to non-diabetics, the diabetic group had slightly higher serum creatinine (0.9 vs. 0.8 mg/dL), BUN (12 vs. 10 mg/dL), and urine protein levels (50 vs. 30 mg/dL), alongside a mildly reduced eGFR (80 vs. 85 mL/min), reflecting modest renal compromise. In

diabetic patients with euthyroid status versus those with any thyroid dysfunction, serum creatinine increased from 1.0 to 1.2 mg/dL, BUN from 14 to 18 mg/dL, eGFR decreased from 75 to 60 mL/min, and urine protein rose from 100 to 150 mg/dL in the TD group. Overall, the results underscore that thyroid abnormalities, particularly hypothyroidism, exacerbate renal impairment in diabetics, evident by consistently higher creatinine and BUN levels, reduced filtration rates, and greater proteinuria—highlighting the need for integrated thyroid and renal monitoring in diabetic care.

Table 4: Prevalence and Severity of Thyroid Dysfunction in Diabetic and Non-Diabetic Subjects

Thyroid Dysfunction	Group	Mild (n)	Moderate (n)	Severe (n)	Total Cases (n)
Euthyroid	Diabetic	0	0	0	18
	Non-Diabetic	0	0	0	22
Hypothyroidism	Diabetic	4	2	1	7
	Non-Diabetic	3	2	0	5
Hyperthyroidism	Diabetic	2	1	0	3
	Non-Diabetic	1	1	0	2
Subclinical Hypothyroidism	Diabetic	2	1	0	3
	Non-Diabetic	2	0	0	2
Subclinical Hyperthyroidism	Diabetic	1	0	0	1
	Non-Diabetic	1	0	0	1

This comprehensive table presents the distribution and severity of various types of thyroid dysfunctions (TD) in both diabetic and non-diabetic individuals. Among diabetics, 18 (56.25%) were euthyroid, while 14 (43.75%) had some form of thyroid dysfunction, most commonly hypothyroidism (n=7), including 4 mild, 2 moderate, and 1 severe case. In comparison, non-diabetics had a higher proportion of euthyroid individuals (22; 68.75%) and fewer total TD cases (10; 31.25%), primarily hypothyroidism (n=5), with no severe cases. Hyperthyroidism was found in 3 diabetics (2 mild, 1 moderate) and 2 non-diabetics (1 mild, 1 moderate). Subclinical hypothyroidism was slightly more frequent in diabetics (3 cases vs. 2), while subclinical hyperthyroidism was equally rare in both groups (1 mild case each). Overall, thyroid dysfunction—especially moderate to severe hypothyroidism—was more prevalent in diabetics, indicating a need for routine thyroid screening in this population to enable early detection and appropriate intervention.

DISCUSSION

This observational study explored the correlation between thyroid dysfunction (TD) and type 2 diabetes mellitus (T2DM) among hospitalized patients aged 30–80 years. The study aimed to estimate FT3, FT4, and TSH levels in diabetic individuals, analyze the prevalence and severity of TD, and evaluate the association of thyroid abnormalities with lipid and renal profiles in T2DM patients.

Our findings suggest that TSH levels were positively correlated with both fasting blood sugar (FBS) and HbA1c, while FT3 and FT4 showed a negative correlation with glycemic control parameters. This suggests that as glycemic control worsens, TSH tends to increase, and thyroid hormone levels (FT3, FT4) decline, potentially indicating an increasing trend of hypothyroid states in poorly controlled diabetics.

Elevated lipid and renal profile abnormalities were also noted more frequently in diabetic individuals with TD, indicating a multifactorial interplay that might exacerbate metabolic complications. However, no major clinical complications due to TD were observed in our diabetic participants during the study period.

To contextualize these results, we compared our findings with those of Vamshidhar et al., 2020, who conducted a cross-sectional study at Kakatiya Medical College and MGM Hospital, Warangal. Their study included 50 T2DM cases and an age- and sex-matched control group (15). They found that 16% of T2DM patients exhibited thyroid abnormalities compared to 8% in controls. Among the T2DM group, 10% of males and 6% of females had TD. Subclinical hypothyroidism (4%), overt hypothyroidism (2%), and hyperthyroidism (2%) were observed, aligning with the hypothyroid predominance seen in our study.

In the Vamshidhar study, a Pearson correlation coefficient of +0.70 was found between TSH and FBS, and +0.76 between TSH and HbA1c, both indicating a strong positive relationship between thyroid dysfunction and poor glycemic control in T2DM individuals. These findings reinforce our observation that TSH elevation may serve as an early indicator of dysregulated glucose metabolism in diabetic individuals.

The interplay between T2DM and TD may involve autoimmune mechanisms, especially in the context of Type 1 diabetes, or secondary consequences of chronic metabolic derangement in T2DM. Autoimmune thyroiditis, Grave's disease, and drug-induced hypothyroidism (e.g., with chlorpropamide) are well-documented contributors. Moreover, complications such as diabetic nephropathy can confound the diagnosis due to overlapping symptoms like facial puffiness and anemia, also seen in myxedema.

Additionally, differences in blood pressure and body weight were notable. Male participants with T2DM showed significantly higher SBP and DBP than controls, and female T2DM patients exhibited significantly higher SBP. These cardiovascular parameters may further compound the risk of comorbid conditions associated with TD in diabetes.

The loss of thyroxine-binding globulin (TBG) in chronic kidney disease—often a comorbidity in longstanding diabetes—can influence thyroid function test outcomes. Hence, measurement of free thyroid hormones (FT3, FT4) and TSH is more reliable than total hormone levels in this population.

Our findings, alongside those of Vamshidhar et al., highlight the need for **routine screening of thyroid function** in patients with T2DM. Early identification and management of TD in diabetic individuals may improve glycemic control, reduce cardiovascular risks, and prevent the progression of chronic complications.

CONCLUSION

The present study underscores a significant association between thyroid dysfunction and Type 2 Diabetes Mellitus (T2DM). Diabetic individuals demonstrated consistently lower levels of FT3 and FT4 and elevated TSH values compared to non-diabetics, especially in older age groups, pointing toward a higher prevalence of overt and subclinical hypothyroidism. Additionally, the study revealed that thyroid dysfunction in diabetics adversely affected lipid and renal profiles—patients with hypothyroidism exhibited the most atherogenic lipid changes and deteriorated renal parameters, including elevated serum creatinine, BUN, and proteinuria, alongside reduced eGFR. Furthermore, thyroid dysfunction was more common in diabetic individuals, with a greater severity of hypothyroidism compared to non-diabetics. These findings highlight the importance of routine thyroid function screening in patients with T2DM for early identification and management of thyroid abnormalities. Integrated monitoring and intervention strategies targeting both metabolic and endocrine health may improve clinical outcomes and reduce the burden of complications in diabetic populations.

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