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CLINICO-BIOCHEMICAL INSIGHTS INTO THYROID DYSFUNCTION IN TYPE 2 DIABETES MELLITUS: A STUDY IN KUMAON, UTTARAKHAND

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Abstract

Objective: This study aims to explore the clinico-biochemical profile of new-onset thyroid dysfunction in patients with type 2 diabetes mellitus (T2DM) attending a tertiary care center in the Kumaon region, focusing on sociodemographic characteristics, types of thyroid dysfunction, and correlations with glycemic and lipid profiles.

Methods: A prospective cross-sectional study was conducted over 24 months, involving 150 T2DM patients presenting with new-onset thyroid dysfunction. Participants were recruited from outpatient, inpatient, and emergency departments. Data were collected on demographic characteristics, clinical presentations, thyroid function tests, glycemic parameters, and lipid profiles. Thyroid dysfunction was categorized into subclinical hypothyroidism, overt hypothyroidism, subclinical hyperthyroidism, and overt hyperthyroidism based on TSH, T3, and T4 levels. Statistical analysis was performed to identify significant associations among variables.

Results: Hypothyroidism was the most prevalent thyroid dysfunction (43.3%), followed by subclinical hypothyroidism (34%) and hyperthyroidism (22.7%). Females constituted 78.67% of the study population. Significant correlations were observed between thyroid dysfunction and glycemic control, with higher fasting blood sugar, postprandial blood glucose, and HbA1C levels in hypothyroid patients. Lipid abnormalities, including elevated total cholesterol, triglycerides, and LDL levels, were more pronounced in hypothyroidism. Subclinical hypothyroidism showed intermediate values, while hyperthyroidism was associated with lower lipid levels.

Conclusion: The study highlights the high prevalence of thyroid dysfunction in T2DM patients, emphasizing the need for routine thyroid screening and integrated management of glycemic and lipid parameters to prevent complications. These findings underscore the importance of targeted interventions and awareness campaigns, especially in resource-limited settings like the Kumaon region.

Keywords: T2DM, Hypothyroidism, Thyroid Dysfunction.

Introduction

Type 2 diabetes mellitus (T2DM) is a chronic and complex metabolic disorder characterized by persistent hyperglycemia resulting from a combination of insulin resistance and impaired insulin secretion. It accounts for over 90% of all diabetes cases globally and has become a significant public health concern, especially in India, which ranks second worldwide in terms of diabetes prevalence[6]. Rapid urbanization, changing lifestyle patterns, and dietary shifts have contributed to an alarming rise in T2DM cases, with substantial socioeconomic and health impacts. Beyond its well-known complications, such as cardiovascular disease, nephropathy, neuropathy, and retinopathy, T2DM has also been associated with thyroid dysfunction (TD), another major endocrine disorder that significantly affects metabolic health.

Thyroid dysfunction encompasses a range of conditions affecting the thyroid gland, including hypothyroidism, hyperthyroidism, subclinical thyroid dysfunction, and thyrotoxicosis. These conditions lead to alterations in circulating thyroid hormone levels and thyroid-stimulating hormone (TSH), influencing numerous metabolic processes, including carbohydrate metabolism, lipid profiles, and pancreatic function. The coexistence of T2DM and TD has been well-documented in literature, with studies showing that individuals with T2DM are at a higher risk of developing thyroid abnormalities compared to the general population. The prevalence of TD in T2DM patients has been reported to range from 5% to 30%, with subclinical hypothyroidism being the most commonly observed form.

The bidirectional relationship between T2DM and TD is complex and multifactorial. On one hand, thyroid hormones play a pivotal role in regulating basal metabolic rate, insulin secretion, and glucose utilization. Hyperthyroidism, for instance, increases hepatic glucose production and insulin clearance, while hypothyroidism reduces insulin sensitivity and exacerbates dyslipidemia. On the other hand, diabetes-induced chronic hyperglycemia can alter thyroid function through mechanisms such as impaired TSH response, reduced peripheral conversion of thyroxine (T4) to triiodothyronine (T3), and increased oxidative stress. These interactions often lead to poorer glycemic control and increased cardiovascular risk in affected individuals, underscoring the need for integrated management approaches. It is necessary to diagnose TD in T2DM patients as early as possible for the provision of effective treatment since undiagnosed TD in diabetic people can adversely affect metabolism in such patients, thereby causing an elevation in the risk of diabetic complications[7].

In the Kumaon region of Uttarakhand, a unique socio-demographic and geographic context presents specific challenges for addressing the dual burden of T2DM and TD. Limited healthcare access, late diagnoses, and low awareness levels among the population exacerbate the risk of undiagnosed and untreated thyroid dysfunction in diabetic patients. Despite the growing recognition of this association, there is a dearth of comprehensive studies examining the clinico-biochemical profile of new-onset thyroid dysfunction in T2DM patients in this region.

This study aims to bridge this gap by investigating the clinical and biochemical characteristics of thyroid dysfunction in newly diagnosed T2DM patients presenting to a tertiary care center in the Kumaon region. By analyzing the patterns of thyroid hormone abnormalities, their correlation with glycemic control, lipid profiles, and demographic factors, this research seeks to provide valuable insights into the interplay between these two conditions. The findings will contribute to a better understanding of the regional burden of T2DM and TD and guide the development of targeted screening protocols, early diagnostic strategies, and effective management interventions to improve patient outcomes and reduce the associated morbidity and mortality.

Radaideh et al[1] Screening for asymptomatic thyroid dysfunction in type 2 diabetic patients is crucial due to its significant prevalence and potential metabolic impact. Palma et al[2] Routine thyroid screening in diabetic patients is essential to detect prevalent and newly diagnosed thyroid dysfunction, mitigating exacerbation of associated risk factors. Talwalkar et al[3] Routine screening for hypothyroidism in patients with T2DM, hypertension, and their co-occurrence is vital for early diagnosis and effective management. Ogbonna SU and Ezeani IU[4] Female gender, central obesity, nephropathy, elevated HbA1c levels, and longer diabetes duration are significant risk factors for

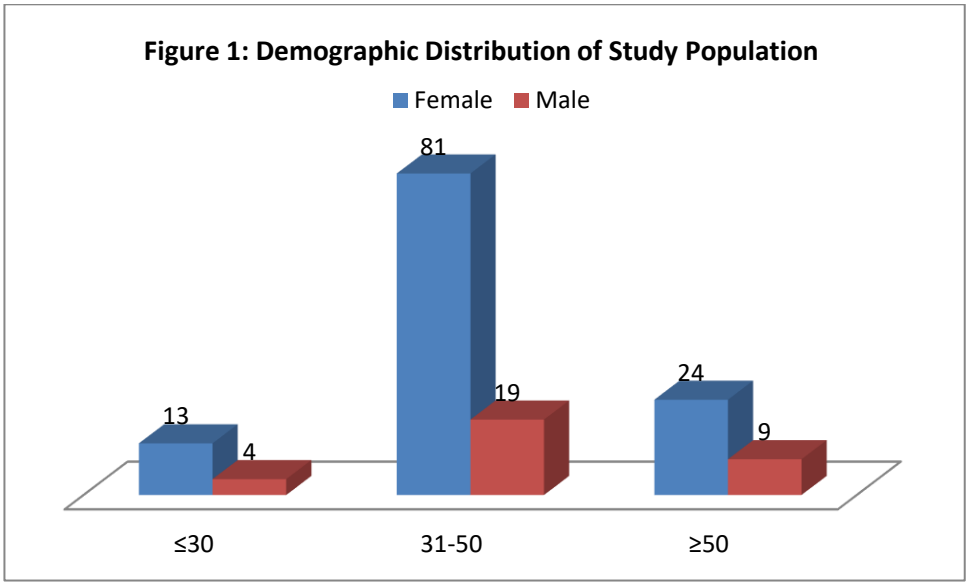
thyroid dysfunction in T2DM patients. Mehalingam V et al[5] in 2020 depicts Thyroid dysfunction is prevalent in 17.5% of type 2 diabetic patients, but it shows no significant association with diabetic complications.

Material & Methods:

This prospective cross-sectional study was conducted at the Department of General Medicine, Government Medical College and Dr. Susheela Tiwari Hospital, Haldwani, Nainital, Uttarakhand, over a 24-month period following approval from the Institutional Ethics Committee. The study aimed to evaluate the clinico-biochemical profile of new-onset thyroid dysfunction in patients with type 2 diabetes mellitus (T2DM). A total of 150 patients, aged 18 years and above, diagnosed or newly detected with T2DM as per the American Diabetes Association guidelines, were recruited using consecutive sampling. Exclusion criteria included patients with Type 1 diabetes mellitus, known thyroid disease, chronic kidney disease (eGFR <60 mL/min/1.73m²), hepatic dysfunction, acute illness, pregnancy, lactation, or those on medications affecting thyroid function. Detailed demographic and medical histories, including duration of diabetes, were collected alongside physical examinations and anthropometric measurements. Laboratory investigations included fasting blood glucose, HbA1C, lipid profile, thyroid function tests (TSH, T3, T4), renal function tests, and liver function tests. Thyroid dysfunction was categorized into subclinical hypothyroidism, overt hypothyroidism, subclinical hyperthyroidism, and overt hyperthyroidism based on specific TSH and T4 levels. Data were anonymized and analyzed using SPSS version 20.0, employing chi-square tests for categorical variables and t-tests or ANOVA for continuous variables, with a significance level set at $p<0.05$. This comprehensive methodology provided valuable insights into the relationship between thyroid dysfunction and glycemic and lipid profiles in T2DM patients within the Kumaon region.

Results:

The study investigated 150 type 2 diabetes mellitus (T2DM) patients, with thyroid dysfunction being a primary focus. The findings are detailed as demographic, clinical, biochemical, and associated parameters. The mean age of the study population was 42.64 ± 9.56 years. The highest proportion of patients (66.66%) was in the 31–50 years age group, followed by 22% in those aged ≥50 years and 11.33% in the ≤30 years group. Female participants (78.67%) significantly outnumbered males (21.33%).



The analysis of thyroid dysfunction across different age groups and genders reveals distinct patterns. Among the 150 patients, the 31–50 years age group exhibited the highest prevalence of

thyroid dysfunction (66.66%), followed by the ≥50 years group (22%) and the ≤30 years group (11.33%). Females showed a significantly higher prevalence across all age groups and types of dysfunction. Hypothyroidism was the most common type of thyroid dysfunction in all age groups, particularly in females aged 31–50 years (37%) and ≥50 years (30.30%). Hyperthyroidism was less frequent but still more prevalent in females, especially in the 31–50 years group (17%). Subclinical hypothyroidism was also notably observed in females aged 31–50 years (27%) and ≥50 years (24.24%). Among males, the prevalence of all thyroid dysfunction types was considerably lower, with hypothyroidism being the most common. The mean ages of patients with hyperthyroidism, hypothyroidism, and subclinical hypothyroidism were similar, with no statistically significant differences ($p > 0.05$). These findings suggest that thyroid dysfunction, particularly hypothyroidism, is more common in middle-aged females with T2DM.

Table 1: Age and Sex Wise Distribution For Type 2 Diabetes Mellitus Patients With New Onset Thyroid Dysfunctions

Study Population			**Thyroid Dysfunctions**						
	Total			Hyperthyroidism		Hypothyroidism		Subclinical-Hypothyroidism	
Age group (Years)	no	%	Sex	no	%	no	%	no	%
≤30	17	11.33%	Female	4	23.52%	7	41.17%	2	11.76%
			Male	0	0%	1	5.88%	3	17.6%
31-50	100	66.66%	Female	17	17%	37	37%	27	27%
			Male	6	6%	6	6%	7	7%
≥50	33	22%	Female	6	18.18%	10	30.30%	8	24.24%
			Male	1	3.03%	4	12.12%	4	12.12%
Mean ± SD				41.64±9.56		42.84±9.1		42.42±9.9	
P Value									
Between subclinical hypothyroidism and Hypothyroidism								0.061	
Between Hypothyroidism and Hyperthyroidism								0.067	
Between Hyperthyroidism and subclinical Hypothyroidism								0.054	
*P value < 0.05 – Significant, P < 0.01 Very Significant P value < 0.001 Highly Significant									

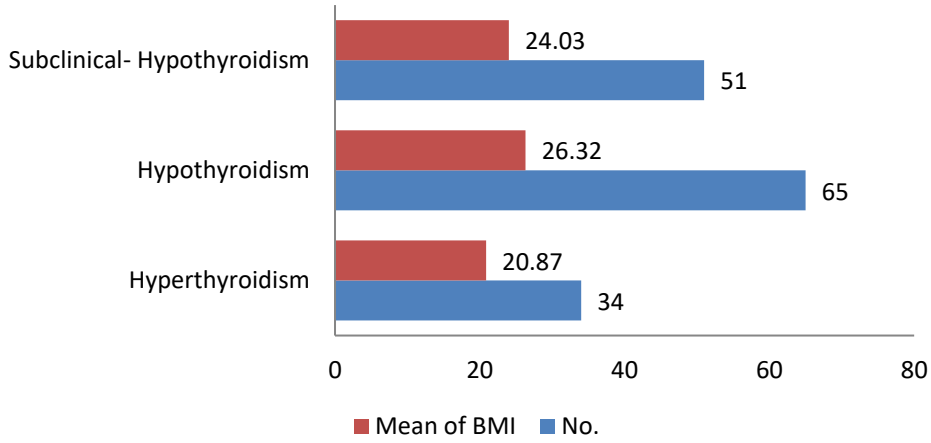
Table 2 presents the relationship between thyroid dysfunction and body mass index (BMI) in T2DM patients, highlighting significant variations across the groups. Hypothyroidism exhibited the highest mean BMI (26.32 ± 3.84 kg/m²), reflecting its association with weight gain and reduced metabolic rate. Subclinical hypothyroidism had an intermediate mean BMI (24.03 ± 4.12 kg/m²), while hyperthyroidism showed the lowest mean BMI (20.87 ± 3.54 kg/m²), consistent with increased metabolic activity and weight loss observed in hyperthyroid conditions. The range of BMI values also varied, with the hypothyroidism group showing the highest maximum BMI (33.90 kg/m²) and both the hyperthyroidism and subclinical hypothyroidism groups sharing the lowest minimum BMI (17.57 kg/m²).

Statistical analysis revealed significant differences in BMI between the groups: hyperthyroidism vs. hypothyroidism ($p = 0.03$), hyperthyroidism vs. subclinical hypothyroidism ($p = 0.02$), and hypothyroidism vs. subclinical hypothyroidism ($p = 0.04$). These findings underscore the influence of thyroid dysfunction on BMI, with hypothyroid patients demonstrating the highest susceptibility to weight gain, while hyperthyroid patients experience weight loss. The data reinforce the importance of monitoring BMI as part of the clinical assessment of T2DM patients with thyroid dysfunction.

Table 2: Distribution of new onset thyroid dysfunction in type 2 diabetes mellitus patients based on their BMI.

Thyroid dysfunction	no	Maximum	Minimum	Mean of BMI (Kg/m2)	Std. Deviation	P value
Hyperthyroidism	34	31.95	17.57	20.87	3.54	G1vs G20.03*
Hypothyroidism	65	33.90	19.14	26.32	3.84	G1vs G30.02*
Subclinical-Hypothyroidism	51	32.83	17.57	24.03	4.12	G2vs G30.04*
Total	150	32.89	18.09	24.57	4.03	
*P value < 0.05 – Significant	Significant P < ,		0.01 Very	Significant	P value <	0.001 Highly
Note: G1 represents Hyperthyroidism, G2 represents Hypothyroidism & G3 represents SubclinicalHypothyroidism.						

Figure 2: Distribution of new onset thyroid dysfunction in type 2 diabetes mellitus patients based on their BMI.



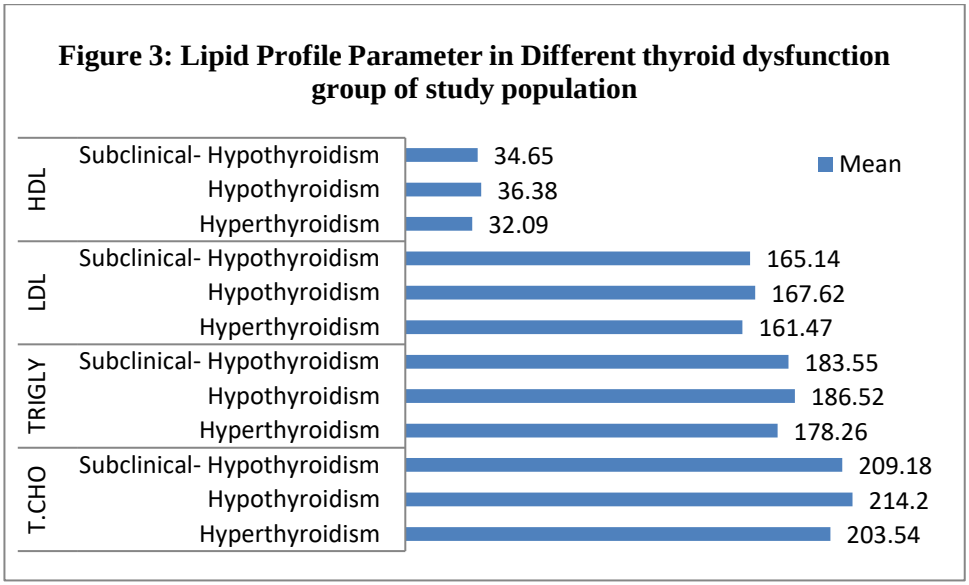
The analysis of glycemic parameters across thyroid dysfunction groups in T2DM patients highlights the significant impact of thyroid dysfunction on blood glucose regulation. Hypothyroidism was associated with the highest fasting blood sugar (FBS: 162.71 ± 14.54 mg/dL), postprandial blood glucose (PPBG: 254.66 ± 28.10 mg/dL), and HbA1C levels (8.15 ± 0.85%), indicating poor glycemic control. Subclinical hypothyroidism displayed intermediate glycemic values (FBS: 160.16 ± 12.90 mg/dL, PPBG: 247.94 ± 25.52 mg/dL, HbA1C: 8.02 ± 0.79%), while hyperthyroidism had the lowest levels (FBS: 155.38 ± 11.04 mg/dL, PPBG: 245.35 ± 21.01 mg/dL, HbA1C: 7.95 ± 0.68%). Significant differences were observed between hyperthyroidism and hypothyroidism for FBS ($p = 0.030$), PPBG ($p = 0.020$), and HbA1C ($p = 0.035$), highlighting the pronounced impact of hypothyroidism on worsening glycemic control. However, the comparisons involving subclinical hypothyroidism were not statistically significant, suggesting its intermediate influence on glucose metabolism. These findings emphasize the need for targeted glycemic management strategies in T2DM patients with hypothyroidism to mitigate potential complications.

Table 3: Distribution of Diabetic patients with new onset thyroid dysfunction (study population) according to glycemic parameters							
	Thyroid dysfunction	no	Maximum	Minimum	Mean	Std. Deviation	P value
FBS (mg/dl)	Hyperthyroidism	34	171	138	155.38	11.04	G1 vs G2 0.030*
	Hypothyroidism	65	190	146	162.71	14.54	G1 vs G3 0.070
	Subclinical-Hypothyroidism	51	182	142	160.16	12.90	G2 vs G3 0.060
PPBG (mg/dl)	Hyperthyroidism	34	310	204	245.35	21.01	G1 vs G2 0.020*
	Hypothyroidism	65	352	220	254.66	28.10	G1 vs G3 0.090
	Subclinical-Hypothyroidism	51	330	210	247.94	25.52	G2 vs G3 0.070
HbA1C (%)	Hyperthyroidism	34	9.2	6	7.95	0.68	G1 vs G2 0.035*
	Hypothyroidism	65	12	8	8.15	0.85	G1 vs G3 0.080
	Subclinical-Hypothyroidism	51	10	7	8.02	0.79	G2 vs G3 0.099
Note: G1 represents Hyperthyroidism, G2 represents Hypothyroidism & G3 represents Subclinical Hypothyroidism.							
*P value < 0.05 – Significant , P < 0.01 Very Significant P value < 0.001 Highly Significant							

The lipid profile analysis across thyroid dysfunction groups in T2DM patients highlights distinct variations in lipid metabolism. Hypothyroidism was associated with the most adverse lipid profile, characterized by the highest mean levels of total cholesterol (214.20 ± 29.37 mg/dL), triglycerides (186.52 ± 26.56 mg/dL), and LDL cholesterol (167.62 ± 41.81 mg/dL), and a relatively higher mean HDL cholesterol (36.38 ± 11.79 mg/dL). Subclinical hypothyroidism showed intermediate lipid abnormalities, while hyperthyroidism demonstrated the least deranged lipid profile, with the lowest mean total cholesterol (203.54 ± 26.24 mg/dL) and triglyceride levels (178.26 ± 24.92 mg/dL). Significant differences were observed between hyperthyroidism and hypothyroidism for all lipid parameters ($p < 0.05$), indicating a pronounced metabolic impact of hypothyroidism. Comparisons involving subclinical hypothyroidism, while less significant, suggest its intermediate influence. These findings underscore the importance of routine lipid monitoring and management in T2DM patients, especially those with hypothyroidism, to mitigate cardiovascular risk.

Table 4: Lipid Profile Parameter in Different thyroid dysfunction group of study population							
Lipid profile	Thyroid dysfunction	n	Maximum	Minimum	Mean	Std. Deviation	P value
T.CHO (mg/dl)	Hyperthyroidism	34	235	160	203.54	26.238	G1 vs G2 0.03*
	Hypothyroidism	65	310	170	214.20	29.374	G1 vs G3 0.04*
	Subclinical-Hypothyroidism	51	285	168	209.18	27.050	G2 vs G3 0.060
TRIGLY (mg/dl)	Hyperthyroidism	34	190	135	178.26	24.917	G1 vs G2 0.02*
	Hypothyroidism	65	250	160	186.52	26.556	G1 vs G3 0.04*
	Subclinical-Hypothyroidism	51	200	145	183.55	25.329	G2 vs G3 0.054
LDL (mg/dl)	Hyperthyroidism	34	142	101	161.47	34.928	G1 vs G2 0.04*
	Hypothyroidism	65	220	118	167.62	41.810	G1 vs G3 0.04*
	Subclinical-Hypothyroidism	51	200	108	165.14	38.052	G2 vs G30.07
HDL	Hyperthyroidism	34	55	32	32.09	8.769	G1 vs G2 0.03*

(mg/dl)	Hypothyroidism	65	40	20	36.38	11.786	G1 vs G3 0.070
	Subclinical-Hypothyroidism	51	45	30	34.65	9.903	G2 vs G3 0.090
Note: G1 represents Hyperthyroidism, G2 represents Hypothyroidism & G3 represents Subclinical Hypothyroidism.							
*P value < 0.05 – Significant , P < 0.01 Very Significant P value < 0.001 Highly Significant							



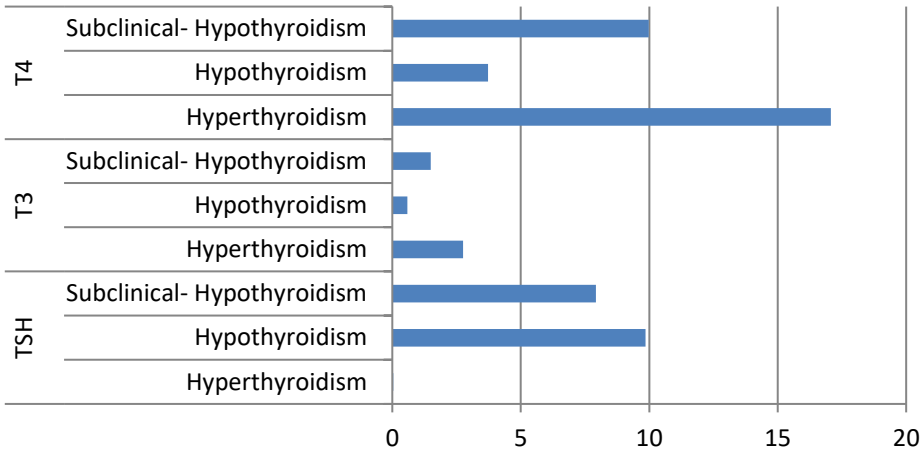
The thyroid function test results reveal distinct hormonal patterns across the thyroid dysfunction groups in T2DM patients, reflecting their underlying pathophysiology. Hyperthyroidism was characterized by the lowest mean TSH levels (0.04 ± 0.05 µIU/mL) and the highest mean T3 (2.76 ± 0.33 ng/mL) and T4 (17.07 ± 1.13 µg/dL) levels, consistent with increased thyroid activity. In contrast, hypothyroidism displayed the highest mean TSH levels (9.85 ± 2.07 µIU/mL) and the lowest T3 (0.59 ± 0.17 ng/mL) and T4 (3.72 ± 1.42 µg/dL) levels, indicative of diminished thyroid function. Subclinical hypothyroidism exhibited intermediate TSH levels (7.92 ± 1.20 µIU/mL) with normal T3 (1.50 ± 0.36 ng/mL) and T4 (9.98 ± 2.00 µg/dL) levels.

Statistical analysis showed significant differences between all pairwise group comparisons for TSH, T3, and T4 ($p < 0.05$), highlighting the biochemical distinctions among hyperthyroidism, hypothyroidism, and subclinical hypothyroidism. These findings emphasize the utility of thyroid function tests in identifying and differentiating thyroid dysfunction types in T2DM patients, guiding appropriate management strategies.

Table 5: T3, T4, TSH Values in different thyroid dysfunction groups.

	Thyroid dysfunction	N	Mean	P value
TSH (0.27-4.20IU /ml)	Hyperthyroidism	34	0.04	G1 vs G2 0.03*
	Hypothyroidism	65	9.85	G1 vs G3 0.04*
	Subclinical-Hypothyroidism	51	7.92	G2 vs G3 0.03*
T3 (0.85-2.02ng /ml)	Hyperthyroidism	34	2.76	G1 vs G2 0.02*
	Hypothyroidism	65	0.59	G1 vs G3 0.01*
	Subclinical-Hypothyroidism	51	1.50	G2 vs G3 0.02*
T4 (5.13-14.06mg/dL)	Hyperthyroidism	34	17.07	G1 vs G2 0.03*
	Hypothyroidism	65	3.72	G1 vs G3 0.04*
	Subclinical-Hypothyroidism	51	9.98	G2 vs G3 0.01*

Figure 4: T3,T4,TSH Values in different thyroid dysfunction groups.



The analysis of symptoms and signs in hypothyroid T2DM patients reveals a high prevalence of fatigue-related and metabolic symptoms, with notable gender differences. Among the 65 patients, **tiredness/weakness** (90.8%), **feeling cold** (80%), and **weight gain with loss of appetite** (76.9%) were the most common symptoms, particularly in females. Menstrual irregularities were reported by 74.1% of females, underscoring the impact of hypothyroidism on reproductive health. **Hair loss** was more frequent in males (72.7%) than females (57.4%), highlighting a gender-specific variation. Signs such as **dry skin** (84.6%) and **cool peripheral extremities** (73.8%) were prevalent, with higher rates in females than males. Notably, **bradycardia** and **peripheral edema** were observed in over half of the patients, slightly more frequent in males. These findings underscore the systemic nature of hypothyroidism in T2DM, with fatigue, metabolic disturbances, and dermatological changes being hallmark features, emphasizing the importance of gender-sensitive clinical assessments.

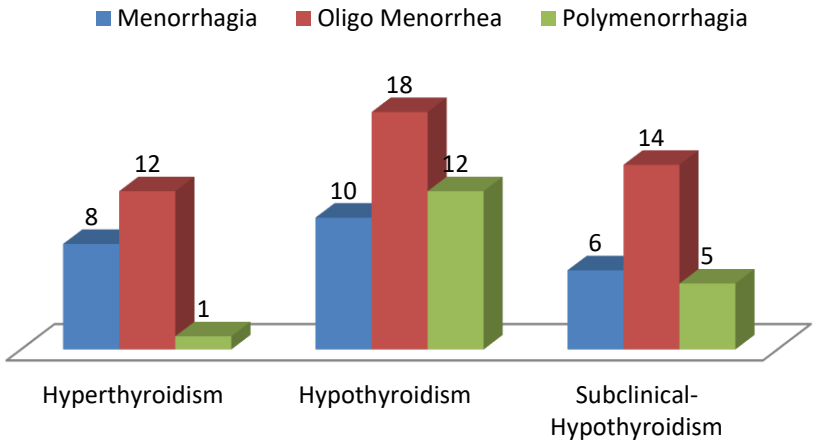
Table 6: Prevalence of Symptoms and Signs in Hypothyroidism Patients among type 2 diabetes mellitus patients according to their Gender

SYMPTOMS	TOTAL (N=65)		FEMALE(N=54)		MALE (N=11)	
	no	%	no	%	no	%
Tiredness /weakness	59	90.8%	50	92.6%	9	81.8%
Feeling cold	52	80%	45	83.3%	7	63.6%
Hair loss	39	60%	31	57.4%	8	72.7%
Constipation	45	69.2%	39	72.2%	6	54.5%
Weight gain with Loss of appetite	50	76.9%	43	79.6%	7	63.6%
Hoarse voice	33	50.8%	27	50%	6	54.5%
Menstrual irregularities	40	65.57%	40	74.1%	-	-
Dry skin	55	84.6%	47	87%	8	72.7%
Cool peripheral extremities	48	73.8%	41	75.9%	7	63.6%
Bradycardia	37	56.9%	30	55.6%	7	63.6%
PeripheralOedema	28	43.1%	24	44.4%	4	36.4%

The figure illustrates the distribution of menstrual abnormalities—**menorrhagia**, **oligomenorrhea**, and **polymenorrhagia**—across thyroid dysfunction categories in female patients with T2DM. Hypothyroidism displays the highest prevalence of abnormalities, with **oligomenorrhea** (18 cases) and **polymenorrhagia** (12 cases) being particularly prominent, followed by **menorrhagia** (10 cases). Subclinical hypothyroidism also shows a notable frequency, with **oligomenorrhea** (14

cases) being the most common, while **polymenorrhagia** (5 cases) and **menorrhagia** (6 cases) are less prevalent. Hyperthyroidism exhibits fewer abnormalities, with **oligomenorrhea** (12 cases) as the leading issue, followed by **menorrhagia** (8 cases) and a minimal occurrence of **polymenorrhagia** (1 case). This trend underscores the more profound impact of hypothyroid states on menstrual health compared to hyperthyroid conditions. The graphical representation effectively highlights these differences, emphasizing the need for targeted interventions based on the type of thyroid dysfunction.

Figure 5: Menstrual abnormalities among female (n=86) patients with new onset thyroid dysfunctions in study population



The analysis of blood pressure (BP) among individuals with thyroid dysfunction reveals notable variations in both systolic and diastolic BP levels. Hyperthyroidism is associated with the highest systolic BP (mean: 139.35 mmHg), followed by hypothyroidism (mean: 137.32 mmHg) and subclinical hypothyroidism (mean: 134.78 mmHg). The differences in systolic BP between hyperthyroidism and hypothyroidism (P = 0.030*) and between hypothyroidism and subclinical hypothyroidism (P = 0.04*) are statistically significant, indicating that hyperthyroidism might elevate systolic BP more than hypothyroid conditions.

For diastolic BP, hypothyroidism exhibits the highest mean value (86.40 mmHg), followed by subclinical hypothyroidism (84.37 mmHg) and hyperthyroidism (82.41 mmHg). Significant differences are observed between hyperthyroidism and hypothyroidism (P = 0.020*), though differences between hypothyroidism and subclinical hypothyroidism are not statistically significant (P = 0.060).

Overall, these results suggest that hypothyroid states are more strongly associated with elevated diastolic BP, while hyperthyroidism tends to raise systolic BP. This highlights the need for careful cardiovascular evaluation and management in patients with thyroid dysfunctions.

Table 7: Distribution of study population in different thyroid dysfunction groups according to their blood pressure (mmHg).

	Thyroid dysfunction	N	Mean	P value
Systolic BP (mmHg)	Hyperthyroidism	34	139.35	G1 vs G2 0.030*
	Hypothyroidism	65	137.32	G1 vs G3 0.070
	Subclinical- Hypothyroidism	51	134.78	G2 vs G3 0.04*
Diastolic BP (mmHg)	Hyperthyroidism	34	82.41	G1 vs G2 0.020*
	Hypothyroidism	65	86.40	G1 vs G3 0.080
	Subclinical- Hypothyroidism	51	84.37	G2 vs G3 0.060

The analysis reveals a strong association between thyroid dysfunctions and anemia, with notable differences in anemia types and gender distribution. Normocytic normochromic anemia emerges as the most prevalent type across all thyroid dysfunctions, followed by microcytic hypochromic anemia, while macrocytic anemia is comparatively rare. Among patients with hyperthyroidism, normocytic anemia is slightly more common (8 cases) than microcytic anemia (7 cases), with females showing a higher prevalence across all types. In hypothyroidism, anemia is more pronounced, with normocytic anemia affecting 50 cases and microcytic anemia 40 cases, again with a significant female predominance. Subclinical hypothyroidism shows a similar trend, with normocytic anemia being the most frequent (15 cases), followed by microcytic anemia (13 cases) and fewer cases of macrocytic anemia (5 cases). These findings underline the higher susceptibility of females to anemia in thyroid disorders and emphasize the need for targeted screening and management, especially in hypothyroid and subclinical hypothyroid patients.

Table 8: Distribution of Study Population According to the type of Anemia.

	Microcytic hypochromic			**Normocytic normochromic**			**Macrocytic**		
Thyroid dysfunction	no	Male	Female	no	Male	Female	no	Male	Female
Hyperthyroidism	7	2	5	8	2	6	2	0	2
Hypothyroidism	40	8	32	50	9	41	10	2	8
Subclinical- Hypothyroidism	13	4	9	15	4	11	5	1	4

Discussion:

The findings of this study provide critical insights into the interplay between thyroid dysfunction and associated hematological, biochemical, and clinical parameters in patients with type 2 diabetes mellitus (T2DM). Among the thyroid dysfunctions observed, hypothyroidism emerged as the most prevalent (43.3%), followed by subclinical hypothyroidism (34%) and hyperthyroidism (22.7%), with a marked predominance in females (78.67%). These results align with existing literature suggesting a higher susceptibility of females to thyroid abnormalities, potentially due to hormonal and autoimmune influences.

The study highlights a distinct pattern in anemia types across thyroid dysfunctions. Normocytic normochromic anemia was the most common type across all dysfunctions, reflecting its association with chronic illnesses like hypothyroidism. Microcytic hypochromic anemia followed, particularly in hypothyroid patients, indicating a potential link to impaired iron metabolism or chronic inflammation. Macrocytic anemia, while less frequent, was predominantly observed in hypothyroid and subclinical hypothyroid states, likely due to vitamin B12 or folate deficiencies. The higher prevalence of all anemia types in females underscores the need for gender-sensitive screening and interventions.

Biochemical analysis revealed significant associations between thyroid dysfunction and glycemic control, with hypothyroid patients exhibiting the poorest parameters, including elevated fasting blood sugar, postprandial glucose, and HbA1C levels. This highlights the detrimental impact of hypothyroidism on insulin sensitivity and glucose metabolism. Lipid profile abnormalities were most pronounced in hypothyroidism, characterized by elevated total cholesterol, LDL, and triglycerides, exacerbating cardiovascular risk. Subclinical hypothyroidism displayed intermediate biochemical derangements, while hyperthyroidism was associated with comparatively favorable lipid and glycemic profiles, reflecting its hypermetabolic state.

The study also identified significant correlations between thyroid dysfunction and body mass index (BMI). Hypothyroid patients exhibited the highest mean BMI, consistent with reduced metabolic rates and weight gain, while hyperthyroid patients had the lowest BMI due to increased metabolic activity. These findings reinforce the need to monitor BMI as part of thyroid and diabetes management.

In conclusion, the study underscores the critical role of routine thyroid screening in T2DM patients, particularly in resource-limited settings like Kumaon, where late diagnoses and limited healthcare

access may exacerbate complications. The data highlight the necessity of integrated management strategies targeting glycemic, lipid, and hematological parameters to reduce morbidity and improve quality of life in this vulnerable population.

Conclusion:

This study underscores the high prevalence of thyroid dysfunction, particularly hypothyroidism and subclinical hypothyroidism, in patients with type 2 diabetes mellitus (T2DM) in the Kumaon region. Significant correlations were observed between thyroid dysfunction and glycemic control, lipid abnormalities, anemia, and BMI, emphasizing the multifaceted impact of thyroid disorders on metabolic health. The predominance of thyroid dysfunction in females further highlights the need for gender-sensitive approaches in screening and management. These findings reinforce the importance of routine thyroid screening and integrated care strategies to optimize metabolic outcomes and reduce complications in T2DM patients, particularly in resource-limited settings.

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