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Original Article

Association Between Plasma Thyroid Hormone Concentration and Hepatic Triglyceride Content in Patients with Type 2 Diabetes Mellitus: A Retrospective Cross-Sectional Study.

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Abstract

Background:
Thyroid hormones play an important role in regulating lipid metabolism and hepatic fat homeostasis. Alterations in thyroid hormone levels may contribute to hepatic triglyceride accumulation and the development of non-alcoholic fatty liver disease (NAFLD) in patients with type 2 diabetes mellitus (T2DM).

Objective:
To evaluate the association between plasma thyroid hormone concentration and hepatic triglyceride content in patients with T2DM.

Methods:
This retrospective cross-sectional study included 90 patients with T2DM evaluated over a 10-month period. Patients were categorized into a low T3 group (n=40) and a normal T3 group (n=50) based on plasma triiodothyronine levels. Hepatic triglyceride content was assessed using imaging studies, and demographic and clinical variables, including age and body mass index (BMI), were recorded. Group comparisons were performed using the independent t-test.

Results:
Patients with low T3 levels had significantly higher hepatic triglyceride content compared with those with normal T3 levels (18.2 ± 3.7% vs. 12.4 ± 2.7%, $p<0.001$). Plasma T3 concentrations were significantly lower in the low T3 group (2.77 ± 0.29 pg/mL) than in the normal T3 group (3.57 ± 0.34 pg/mL, $p<0.001$). No significant difference in age was observed between the groups (56.0 ± 8.2 vs. 54.2 ± 7.5 years, $p=0.290$), while BMI showed borderline statistical significance (29.2 ± 2.6 vs. 27.9 ± 3.1 kg/m², $p=0.051$).

Conclusion:
Lower plasma T3 concentrations are associated with increased hepatic triglyceride accumulation in patients with T2DM, suggesting a potential role of thyroid function in the development of hepatic steatosis.

Recommendation:
Routine thyroid function assessment may help identify diabetic patients at increased risk of hepatic steatosis and guide early intervention strategies.

Keywords: *Type 2 diabetes mellitus, triiodothyronine, hepatic triglyceride content, non-alcoholic fatty liver disease, thyroid hormones, hepatic steatosis.*
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Introduction

Insulin resistance, poor glucose metabolism, and other systemic consequences are the hallmarks of type 2 diabetes mellitus (T2DM), a chronic metabolic disease. Non-alcoholic fatty liver disease (NAFLD) has become one of the most common and clinically significant comorbidities among its metabolic effects. (1). One of the main characteristics of NAFLD is the buildup of hepatic triglycerides, which is an indication of underlying metabolic dysregulation. The development of steatohepatitis and fibrosis, chronic inflammation, and increasing insulin resistance are all influenced by excessive fat deposition in hepatocytes (2).

Thyroid hormones are essential for controlling lipid metabolism and energy homeostasis. They have an impact on lipogenesis, cholesterol metabolism, hepatic fatty acid oxidation, and mitochondrial activity. Metabolic equilibrium can be upset by even minute changes in the amounts of thyroid hormones in the blood. Decreased thyroid hormone activity can lead to triglyceride buildup in the liver, hinder hepatic lipid clearance, and reduce β-oxidation (3).

The association between plasma thyroid hormone concentrations and hepatic triglyceride content in patients with type 2 diabetes is still unclear, despite the fact that overt hypothyroidism is known to impact serum lipid profiles. Since slight changes in thyroid function may affect the likelihood of hepatic steatosis, it is clinically significant to comprehend this link. (4) The objective of this study was to compare hepatic triglyceride content between patients with low and normal plasma T3 concentrations and to evaluate the association between thyroid hormone status and hepatic steatosis in patients with type 2 diabetes mellitus.

Methods

Study Design

This study was conducted as a **retrospective cross-sectional observational study** to evaluate the association between plasma thyroid hormone concentration and hepatic triglyceride content in patients with Type 2 Diabetes Mellitus (T2DM). Clinical and laboratory records of eligible patients were reviewed retrospectively, and patients were categorized according to their plasma triiodothyronine (T3) levels to determine the relationship between thyroid hormone status and hepatic fat accumulation.

Study Setting and Duration

The study was conducted in the Department of General Medicine at a tertiary care teaching hospital located in a region that provides specialized diabetes and endocrine care services to both urban and rural populations from the surrounding regions.

Medical records of patients attending the outpatient and inpatient services of the department between **1 January 2025 and 31 October 2025** were reviewed for eligibility. Data extraction and analysis were performed between **November 2025 and December 2025**.

Since this was a retrospective study, there was no active recruitment or follow-up period; all data were obtained from existing hospital records and electronic medical databases.

Participants and Sampling Technique

The study population consisted of adult patients diagnosed with T2DM who had undergone both thyroid function testing and hepatic imaging during routine clinical evaluation within the study period.

A **consecutive sampling technique** was used, whereby all eligible patient records meeting the inclusion criteria during the study period were included until the required sample size was achieved.

Initially, **112 patient records** were screened for eligibility. Of these:

- 5 patients were excluded because of known thyroid disease receiving treatment.
- 4 patients had chronic liver disease.
- 2 patients had alcohol-related liver disease.
- 10 patients lacked complete thyroid profile data.
- 1 patient had incomplete hepatic imaging information.

After applying the eligibility criteria, **90 patients** were included in the final analysis, comprising **40 patients with low T3 levels** and **50 patients with normal T3 levels**.

Sample Size Determination

The sample size was estimated using the formula for comparison of means between two independent groups:

Based on previously published studies evaluating thyroid hormone status and hepatic steatosis in patients with T2DM, a minimum sample size of approximately 84 participants was required. To improve statistical precision and compensate for incomplete records, 90 eligible patients were included in the final analysis.

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Eligibility Criteria

Inclusion Criteria

Patients were included if they:

- had a confirmed diagnosis of T2DM,
- were aged between 30 and 70 years,
- had available plasma thyroid hormone measurements,
- had hepatic imaging data allowing estimation of hepatic triglyceride content, and
- had complete clinical records available for analysis.

Exclusion Criteria

Patients were excluded if they:

- had known thyroid disease receiving treatment,
- had chronic liver disease, including viral hepatitis or alcoholic liver disease,
- were receiving hepatotoxic medications,
- had incomplete thyroid or imaging data, or
- had incomplete clinical records.

Data Collection

Relevant demographic, clinical, laboratory, and imaging information was extracted from hospital medical records using a standardized data collection form. Variables collected included age, body mass index (BMI), plasma T3 concentration, and hepatic triglyceride content measured using hepatic imaging studies.

Patients were subsequently classified into **low T3** and **normal T3** groups according to the laboratory reference range used by the institution.

Measures to Minimize Bias

Several measures were undertaken to reduce potential sources of bias. Consecutive inclusion of all eligible records minimized selection bias, while predefined inclusion and exclusion criteria ensured uniform participant selection. Standardized hospital laboratory methods were used for thyroid hormone measurements, reducing measurement bias.

To minimize information bias, only records with complete thyroid and imaging data were included in the analysis. Data extraction was performed using a structured collection form to ensure consistency and accuracy of recorded variables.

Statistical Analysis

Continuous variables were expressed as **mean ± standard deviation (SD)**, while categorical variables were presented as frequencies and percentages.

Quantitative variables, including age, BMI, plasma T3 concentration, and hepatic triglyceride content, were analyzed as continuous variables because categorization could lead to loss of information and statistical power.

Comparisons between the low T3 and normal T3 groups were performed using the **independent samples t-test** after assessment of data distribution. A **p-value <0.05** was considered statistically significant.

Statistical analysis was performed using **SPSS version XX (IBM Corporation, Armonk, NY, USA).**

Results

Table 1: Baseline Characteristics

Variable	Low T3 Group	Normal T3 Group	p-value
Age (years)	56.0 ± 8.2	54.2 ± 7.5	0.290
BMI (kg/m²)	29.2 ± 2.6	27.9 ± 3.1	0.051
Plasma T3 (pg/mL)	2.77 ± 0.29	3.57 ± 0.34	<0.001

Table 2: Hepatic Triglyceride Content Comparison

Outcome	Low T3 Group	Normal T3 Group	p-value
Hepatic Triglyceride Content (%)	18.2 ± 3.7	12.4 ± 2.7	<0.001

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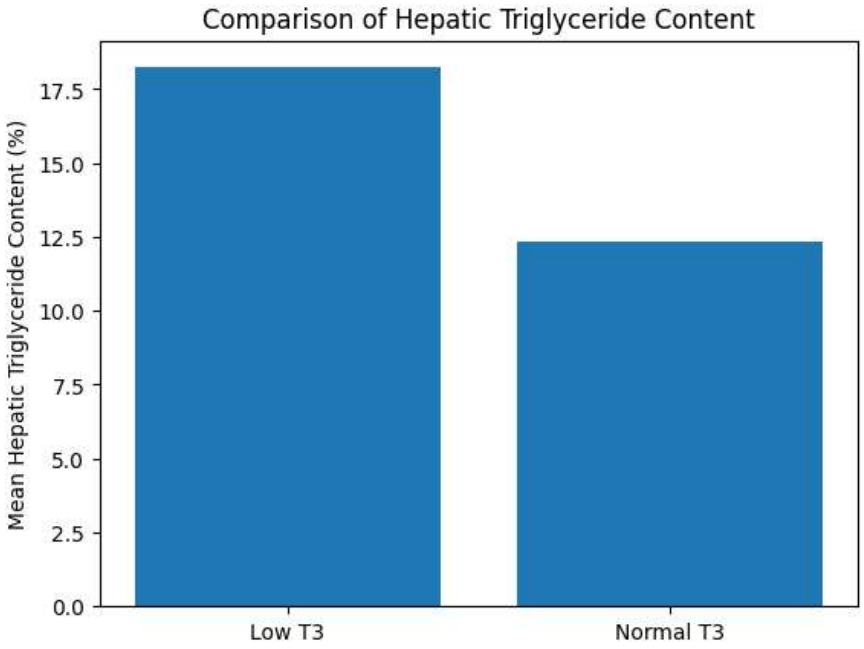

Figure 1: Comparison of Hepatic Triglyceride Content

Discussion

The present retrospective cross-sectional study evaluated the association between plasma thyroid hormone concentration and hepatic triglyceride content in patients with Type 2 Diabetes Mellitus (T2DM). A total of 90 patients were included, comprising 40 patients with low plasma T3 concentrations and 50 patients with normal T3 concentrations. As shown in **Table 1**, the two groups were comparable with respect to age, with no statistically significant difference observed between them (56.0 ± 8.2 years vs. 54.2 ± 7.5 years, p=0.290). Although body mass index (BMI) was slightly higher in the low T3 group, this difference only approached statistical significance (29.2 ± 2.6 kg/m² vs. 27.9 ± 3.1 kg/m², p=0.051). Importantly, plasma T3 concentrations differed significantly between the groups (2.77 ± 0.29 pg/mL vs. 3.57 ± 0.34 pg/mL, p<0.001) (**Table 1**). The principal finding of the study was that patients with lower plasma T3 concentrations demonstrated significantly higher hepatic triglyceride content compared with patients with normal T3 concentrations (18.2 ± 3.7% vs. 12.4 ± 2.7%, p<0.001), as presented in **Table 2**.

These findings support the study objective of evaluating the association between thyroid hormone status and hepatic triglyceride accumulation in patients with T2DM. The significantly higher hepatic triglyceride content observed among patients with low T3 levels suggests that even relatively mild reductions in thyroid hormone activity may contribute to hepatic lipid accumulation and metabolic dysfunction in diabetic individuals.

The observed findings are biologically plausible because thyroid hormones are important regulators of lipid metabolism, mitochondrial activity, and hepatic fatty acid oxidation. Reduced T3 activity may impair β-oxidation, decrease lipid mobilization, and increase hepatic lipogenesis, resulting in triglyceride accumulation within hepatocytes and progression of hepatic steatosis. This metabolic imbalance may further aggravate insulin resistance and worsen metabolic outcomes in patients with T2DM.

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The present findings are consistent with previous studies that have reported significant associations between thyroid hormone status and fatty liver disease in diabetic populations. Zhang et al. demonstrated an inverse relationship between thyroid hormone concentrations and non-alcoholic fatty liver disease among euthyroid patients with T2DM. Similarly, Tingbo Bi and colleagues reported that lower thyroid hormone activity was associated with a greater prevalence of metabolic dysfunction-associated steatotic liver disease. The current study extends these findings by demonstrating significantly greater hepatic triglyceride content among diabetic patients with lower plasma T3 concentrations.

An important observation in the present study was that age did not differ significantly between the groups, reducing the likelihood that age-related metabolic changes explained the findings. Similarly, although BMI showed borderline statistical significance, the substantial difference in hepatic triglyceride content suggests that thyroid hormone status may independently contribute to hepatic lipid accumulation beyond the effect of adiposity alone.

Generalizability

The study was conducted in a tertiary care teaching hospital managing a large number of patients with T2DM from both urban and rural populations. Consequently, the findings are likely to be applicable to similar tertiary care hospitals and diabetic clinics in low- and middle-income countries with comparable patient characteristics and disease profiles. However, caution should be exercised when extrapolating these findings to community populations, pediatric patients, patients with overt thyroid disease, or populations with substantially different metabolic characteristics.

Limitations

The present study has several limitations that should be considered when interpreting the findings. First, the retrospective cross-sectional design limits the ability to establish causality or determine temporal relationships between thyroid hormone concentrations and hepatic triglyceride accumulation. Second, the study was conducted at a single center, which may reduce the external validity of the findings and limit generalizability to other populations. Third, the relatively modest sample size may have reduced the precision of effect estimates and limited subgroup analyses. Fourth, residual confounding cannot be excluded because important metabolic variables such as insulin resistance indices, glycemic control parameters, dietary factors, physical activity levels, and medication use were not evaluated. Finally, selection bias may have occurred because only patients with available thyroid profiles and hepatic imaging data were included in the analysis, potentially limiting the representativeness of the broader diabetic population.

Recommendations

Routine assessment of thyroid function may be considered in patients with T2DM who are at risk of hepatic steatosis or metabolic dysfunction. Early identification of patients with lower plasma thyroid hormone concentrations may facilitate risk stratification and implementation of targeted metabolic interventions. Future prospective multicenter studies involving larger populations and longitudinal follow-up are required to determine whether correction of thyroid dysfunction can reduce hepatic triglyceride accumulation and improve long-term metabolic outcomes.

Conclusion

Patients with type 2 diabetes mellitus have a considerably higher hepatic triglyceride content when their plasma thyroid hormone concentration is lower, suggesting a possible metabolic relationship between thyroid function and hepatic lipid buildup. This correlation implies that hepatic steatosis may be exacerbated by even mild decreases in thyroid hormone levels. As a result, regular thyroid function testing may assist in identifying individuals who are more likely to develop progressive liver involvement and provide insightful information on metabolic risk stratification.

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Conflict of Interest

The authors declare that there are no conflicts of interest related to this study.

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List of Abbreviations

Abbreviation	Full Form
T2DM	Type 2 Diabetes Mellitus
T3	Triiodothyronine
NAFLD	Non-Alcoholic Fatty Liver Disease
BMI	Body Mass Index
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences

Author Contributions

All authors read and approved the final manuscript.

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