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Original Research Article

STUDY OF NON ALCOHOLIC FATTY LIVER DISEASE IN HYPOTHYROIDISM

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ABSTRACT

Background: Non-alcoholic fatty liver disease (NAFLD) is a prevalent liver condition, often linked with metabolic disorders, while hypothyroidism is a common endocrine disorder characterized by insufficient thyroid hormone production. Both conditions have significant implications for overall health. The objective is to investigate the presence of NAFLD in individuals with overt and subclinical hypothyroidism at a tertiary care centre in South India.

Materials and Methods: This prospective observational study was conducted among 160 patients aged 18 years and older with overt or subclinical hypothyroidism. Patients with excessive alcohol consumption, BMI greater than 25 kg/m², pre-existing liver disease, diabetes mellitus, chronic kidney disease and other factors were excluded. Data collected included thyroid function tests (T3, T4, TSH), liver function tests (LFTs), anthropometric measurements, and abdominal ultrasonography for NAFLD diagnosis.

Results: The study population's mean age was 48.9 years, with a significant female predominance (94.4%). The prevalence of NAFLD in hypothyroid patients was 60.6%. Patients with NAFLD had significantly higher mean TSH levels and lower mean T3 levels compared to those without NAFLD ($p<0.001$). While there was no significant difference in T4 levels, AST levels were significantly higher in the NAFLD group ($p<0.001$).

Conclusion: This study demonstrates a high prevalence of NAFLD in hypothyroid patients and identifies distinct associations between thyroid hormone levels and NAFL. These results underscore the importance of considering NAFLD in the management of hypothyroid individuals.

Keywords: Hypothyroidism, Non-alcoholic fatty liver disease, Thyroid hormones, Liver function tests, NAFLD.

INTRODUCTION

Chronic liver diseases (CLDs) pose a major global health threat, contributing to substantial illness and death.[1] While various factors such as viral hepatitis and alcohol are implicated, non-alcoholic fatty liver disease (NAFLD) has become an increasingly dominant cause worldwide.[2] NAFLD, characterized by hepatic fat accumulation in the absence of excessive alcohol consumption, affects approximately 24% globally, with higher prevalence in South America, the Middle East, Asia, the USA, and Europe.[3] In India, NAFLD prevalence ranges considerably (5-30%), representing a significant public health issue.[4] The spectrum of NAFLD spans from benign steatosis to non-alcoholic steatohepatitis (NASH), potentially progressing to fibrosis, cirrhosis, and hepatocellular carcinoma (HCC). Notably, NAFLD is closely linked with metabolic syndrome and elevated cardiovascular risk.[5]

Hypothyroidism encompasses a spectrum of clinical presentations, broadly categorized as overt hypothyroidism, defined by elevated thyroid-stimulating hormone (TSH) levels coupled with low free T4 levels, and subclinical hypothyroidism, characterized by elevated TSH with free T4 levels within the normal range.[6] Both conditions, however, signify inadequate thyroid hormone action at the tissue level, albeit to varying degrees. The deficiency of thyroid hormones has well-established

systemic effects, particularly impacting metabolism, often leading to a decreased basal metabolic rate, alterations in lipid profiles (dyslipidaemia), and a propensity for weight gain.[7]

The liver assumes a critical role in the regulation of systemic metabolism, functioning centrally in the processing of dietary lipids, the synthesis of lipoproteins, and the control of fatty acid oxidation. Furthermore, it is indispensable for maintaining glucose homeostasis through processes such as gluconeogenesis and glycogenolysis, thereby acting as a key metabolic regulator within the body.[8]

Thyroid hormones (THs) are well-recognized for their influence on overall energy homeostasis, and they exert significant direct and indirect effects on the liver, particularly concerning hepatic lipid metabolism.[9] THs are known to modulate various aspects of lipid handling within the liver, including the uptake, synthesis, oxidation, and export of lipids. These effects are mediated through the regulation of key metabolic enzymes and gene expression, ultimately linking thyroid hormone action in the liver to the broader context of systemic lipid metabolism and energy balance.[10] Given the crucial role of both the liver in lipid metabolism and thyroid hormones in its regulation, it is biologically plausible to hypothesize that reduced thyroid hormone signalling, as observed in hypothyroidism, could disrupt this delicate balance within the liver. This hormonal deficiency might potentially lead to diminished lipid utilization, increased lipid accumulation, or impaired export of lipids from the liver, thereby contributing to hepatic steatosis.[11]

Given the substantial public health burden posed by the high prevalence of both NAFLD and hypothyroidism in India, and the plausible metabolic interplay mediated by thyroid hormones on the liver, a clearer understanding of their association in the South Indian context is warranted.[12] This study aims to investigate the presence of NAFLD in individuals diagnosed with overt and subclinical hypothyroidism within a tertiary care center in this region, while carefully excluding other recognized causes of hepatic steatosis. The findings of this research are anticipated to provide valuable data that could inform future clinical strategies regarding screening, risk stratification, and potential management approaches for hypothyroid patients concerning their risk of developing NAFLD within this specific population.[13]

MATERIALS AND METHODS

This prospective observational study was conducted among patients visiting the outpatient department (OPD) or admitted to the Department of General Medicine at K.R. Hospital, Mysore Medical College and Research Institute (MMCRI), Mysore, a tertiary care center in South India. The study was carried out from April 2023 to October 2024. The study obtained ethical clearance from the Institutional Ethics Committee of Mysore Medical College and Research Institute, Mysore

Inclusion Criteria:

- Patients aged more than 18 years.
- Individuals with overt and subclinical hypothyroidism.

Exclusion Criteria:

- Alcohol consumption exceeding 14 units/week for males and 7 units/week for females.
- BMI greater than 25 kg/m².
- Pre-existing liver disease.
- Diabetes mellitus.
- Chronic kidney disease.
- Use of steatosis-causing drugs.
- Pregnant women.

Sample Size Calculation

The sample size for the study was 160.

Relevant history was recorded, and a clinical examination was performed for each participant. The following investigations were conducted:

- TSH, T3, T4 (Thyroid Function Tests)
- LFT (Liver Function Tests)
- CBC (Complete Blood Count)
- FBS (Fasting Blood Sugar)
- PPBS (Postprandial Blood Sugar)
- Lipid Profile
- HBsAg (Hepatitis B surface antigen)
- Antibody to HCV (Hepatitis C Virus antibody)
- RFT (Renal Function Test)
- NAFLD by Ultrasonography

The diagnosis of NAFLD was made based on the ultrasonographic pattern, specifically the presence of increased echogenicity, i.e., high ultrasonographic contrast between hepatic and renal parenchyma.

Anthropometric assessments were also performed, including: Height (cm), Weight (kg), BMI (Body Mass Index), calculated as weight (kg) / height (m²), Waist Circumference (cm), measured at the midpoint between the lower border of the last rib and the highest point of the iliac crest.

Statistical Analysis: The collected data were entered into MS Excel and analyzed using SPSS trial version. Descriptive statistics were presented using mean, standard deviation (SD), frequency, percentage, and proportion. The association between categorical variables was analyzed using the Chi-Square test. A P-value of less than 0.05 was considered to indicate a statistically significant association. Differences in continuous variables between groups were analyzed using the One-Sample T-test, with a P-value of less than 0.05 indicating statistical significance.

RESULTS

The largest segment of the patient population fell within the 46–50-year age range, accounting for 74 patients, or 46.3% of the total. Following this, the 51–55-year age group comprised 47 patients, representing 29.4% of the cohort. Patients aged ≤45

years made up 20% of the total, with 32 individuals. The smallest group was those aged ≥56 years, with only 7 patients, or 4.4% of the total population. The mean age of the study participants was 48.9 years with a SD of 3.83 years.

A significant majority of the participants were female, with 151 patients accounting for 94.4% of the total sample. In contrast, only 9 patients were male, representing 5.6% of the overall patient population.

The majority of patients in each age group were female. Notably, all patients in the ≥56 age group were female. The 46-50 age group had the highest total number of patients (79), with 72 females (97.3%) and 2 males (2.7%). The ≤45 age group contained 32 patients, with 30 females (93.8%) and 2 males (6.3%). In the 51-55 age group, there were 42 females (89.4%) and 5 males (10.6%).

The majority of patients, 127 individuals, or 79.4% of the total, reported having no comorbidities. Conversely, 33 patients, representing 20.6% of the study population, were diagnosed with hypertension.

Table 1: Distribution of patients according to the body mass index in kg/m^2

S No	Body mass index in kg/m2	No of Patients	Percentage
1	18.5-22.9	83	51.9
2	23.0-24.9	77	48.1
Total		160	100

The patient population was nearly evenly split between two BMI categories. 83 patients, representing 51.9% of the total, had a BMI within the range of 18.5-22.9 kg/m². The remaining 77 patients, accounting for 48.1% of the cohort, had a BMI in the 23.0-24.9 kg/m² range. The mean BMI was noted as 22.7 with a SD of 1.09 kg/m^2.

Table 2: Distribution of patients according to the waist hip ratio

WHR	Gender		Total	Chi square value P value
	Male	Female		
	N (%)	N (%)	N (%)	
≤0.84	9 (5.8)	146 (94.2)	155 (100.0)	0.308
0.85-0.90	0 (0.0)	5 (100.0)	5 (100.0)	
Total	9 (5.6)	151 (94.4)	160 (100.0)	0.579

The majority of patients (155, or 96.9%) had a WHR ≤0.84, with 146 of those patients being female (94.2%) and 9 being male (5.8%). Only 5 patients (3.1%), all of whom were female (100%), had a WHR between 0.85 and 0.90. A Chi-square test revealed no significant association between WHR category and gender (Chi-square = 0.308, p = 0.579).

For TSH, the values ranged from 7.00 to 45.00, with a median of 14.0 and a mean of 16.17, and a standard deviation of 6.68. T3 values varied from 26.0 to 89.0, with a median of 64.0, a mean of 63.55, and a standard deviation of 13.26. T4 values ranged from 1.00 to 8.00, with a median of 3.40, a mean of 3.49, and a standard deviation of 0.78. This table provides an overview of the central tendency and variability of the thyroid function parameters within the patient population.

Table 3: Distribution of patients according to the findings on USG abdomen

S No	USG abdomen	No of Patients	Percentage
1	Normal	63	39.4
2	Grade 1 fatty liver	62	38.8
3	Grade 2 fatty liver	31	19.4
4	Grade 3 fatty liver	4	2.5
Total		160	100

A significant portion of the patients, 63 individuals (39.4%), had normal USG results. A nearly equal number, 62 patients (38.8%), were diagnosed with Grade 1 fatty liver. Grade 2 fatty liver was observed in 31 patients (19.4%), while Grade 3 fatty liver was found in 4 patients (2.5%).

Total bilirubin levels ranged from 0.50 to 1.40, with a median of 0.98 and a mean of 0.9885, and a standard deviation of 0.15747. Direct bilirubin levels varied from 0.01 to 0.36, with a median of 0.21, a mean of 0.2071, and a standard deviation of 0.07158. Serum ALT values ranged from 21.00 to 55.00, with a median of 38.80, a mean of 37.8894, and a standard deviation of 6.76522. Serum AST values ranged from 10.00 to 45.00, with a median of 26.0, a mean of 26.9844, and a standard deviation of 7.07431.

Table 4: Distribution of patients according to the findings on USG and thyroid status

S No	Group	No of Patients	Percentage
1	Hypothyroidism with NAFLD	97	60.6
2	Hypothyroidism without NAFLD	63	39.4
Total		160	100

A majority of the patients, 97 individuals (60.6%), were diagnosed with hypothyroidism in conjunction with non-alcoholic fatty liver disease (NAFLD). The remaining 63 patients (39.4%) had hypothyroidism but did not have NAFLD, as determined by their USG results.

Table 5: Comparison of mean age of patients with and without NAFLD

Group	N	Mean TG level	SD	T statistic	P value
Hypothyroidism with NAFLD	97	49.05	3.57	0.646	0.519
Hypothyroidism without NAFLD	63	48.65	4.22		

The mean age of patients with NAFLD (n=97) was 49.05 years, with a standard deviation of 3.57 years. The mean age of patients without NAFLD (n=63) was 48.65 years, with a standard deviation of 4.22 years. An independent samples t-test revealed no statistically significant difference in mean age between the two groups ($t = 0.646$, $p = 0.519$). This suggests that age is not a significant factor differentiating patients with hypothyroidism who have NAFLD from those who do not.

Notably, all male patients (9, 100%) were in the hypothyroidism with NAFLD group, and there were no females in this group. In the hypothyroidism without NAFLD group, 88 patients (58.3%) were female, and 63 patients (41.7%) were male. A Chi-square test revealed a significant association between gender and group (Chi-square = 6.194, $p = 0.013$). This indicates a statistically significant difference in gender distribution between the NAFLD groups, with a distinct male predominance in the Hypothyroidism with NAFLD group.

In the hypothyroidism with NAFLD group, 79 patients (62.2%) had no comorbidities, while 48 patients (37.8%) had hypertension. In the hypothyroidism without NAFLD group, 18 patients (54.5%) had no comorbidities, and 15 patients (45.5%) had hypertension. A Chi-square test revealed no significant association between the presence of hypertension and the NAFLD group (Chi-square = 0.644, $p = 0.422$). This suggests that the distribution of hypertension is similar between the two groups.

Table 6: Comparison of Body Mass Index and Waist-Hip Ratio Between Two Groups

Variable	Group	N	Mean	SD	t-statistic	p-value
Body Mass Index (kg/m²)	Hypothyroidism with NAFLD	97	22.55	1.16	-2.616	0.01
	Hypothyroidism without NAFLD	63	23.0	0.92		
Waist-Hip Ratio	Hypothyroidism with NAFLD	97	0.80	0.02	-1.693	0.092
	Hypothyroidism without NAFLD	63	0.81	0.02		

Patients with hypothyroidism without NAFLD had a significantly higher mean BMI (23.0 kg/m²) compared to patients with hypothyroidism with NAFLD (22.55 kg/m²), as indicated by a t-statistic of -2.616 and a p-value of 0.01. However, there was no significant difference in waist-hip ratio between the two groups. The mean waist-hip ratio was 0.80 for the hypothyroidism with NAFLD group and 0.81 for the hypothyroidism without NAFLD group ($t = -1.693$, $p = 0.092$). This table suggests a statistically significant difference in BMI, but not waist-hip ratio, between the two groups.

Patients with hypothyroidism with NAFLD had a significantly higher mean TSH level (18.89) compared to those without NAFLD (11.96), with a t-statistic of 7.433 and a p-value less than 0.001. Conversely, patients with hypothyroidism without NAFLD had a significantly higher mean T3 level (73.71) compared to those with NAFLD (56.93), with a t-statistic of -9.948 and a p-value less than 0.001. There was no statistically significant difference in T4 levels between the two groups ($t = -1.925$, $p = 0.056$). This table highlights significant differences in TSH and T3 levels between the two groups, suggesting potential associations between thyroid hormone levels and NAFLD in hypothyroid patients.

There were no statistically significant differences in total bilirubin ($t = -1.146$, $p = 0.253$), direct bilirubin ($t = -0.233$, $p = 0.816$), or ALT ($t = -0.381$, $p = 0.704$) between the two groups. However, patients with hypothyroidism and NAFLD had a significantly higher mean AST level (28.5928) compared to those without NAFLD (24.5079), with a t-statistic of 3.709 and a p-value less than 0.001. This indicates that AST levels differ significantly between the two groups, while the other LFT parameters are comparable.

Body mass index (BMI) exhibited a strong positive correlation with waist-hip ratio (WHR) ($r = 0.495$, $p < 0.01$). Thyroid-stimulating hormone (TSH) showed a significant negative correlation with triiodothyronine (T3) ($r = -0.463$, $p < 0.01$) and a significant positive correlation with aspartate aminotransferase (AST) ($r = 0.157$, $p < 0.05$). Conversely, T3 demonstrated a significant negative correlation with AST ($r = -0.159$, $p < 0.05$). These correlations highlight notable relationships between BMI, WHR, thyroid hormone levels, and AST within the study population.

DISCUSSION

The present study cohort exhibited a mean age of 48.9 years with a standard deviation of 3.83 years. This predominantly middle-aged composition is consistent with several studies investigating the relationship between hypothyroidism and NAFLD. For instance, Mazo et al,[14] (2011) reported mean ages of 50.0 ± 1.5 years and 56.0 ± 1.1 years in their steatosis and NASH groups, respectively.

A striking feature of our study population was the significant female predominance (94.4%). This is a notable observation when compared to other studies. While some studies, such as that by Mazo et al. (2011),[14] also reported a majority of female participants in both their steatosis and NASH groups, the extent of female predominance in our cohort is considerably higher. Pagadala et al. (2012),[15] in their study, found female gender to be associated with hypothyroidism in NAFLD patients.

The prevalence of hypertension in our study population was 20.6%. When compared to other studies, Liangpunsakul et al. (2003),[16] in their case-control study on NASH, adjusted for hypertension as a potential confounder. The prevalence of comorbidities can vary significantly across different study populations.

The distribution of Body Mass Index (BMI) in our study cohort revealed a near-even representation in the 18.5-22.9 kg/m² (51.9%) and 23.0-24.9 kg/m² (48.1%) ranges, with an overall mean BMI of 22.7 kg/m². This mean BMI suggests that our cohort, on average, falls within the upper limit of the normal weight to the lower end of the overweight category based on standard classifications. When comparing this to other studies, Pagadala et al,[15] (2012) matched their control group by BMI, indicating the importance of this variable in NAFLD research.

Interestingly, our analysis revealed a statistically significant difference in mean BMI between the hypothyroidism with NAFLD and hypothyroidism without NAFLD groups. The group without NAFLD exhibited a slightly higher mean BMI (23.0 kg/m²) compared to the group with NAFLD (22.55 kg/m², p = 0.01). This finding is somewhat counterintuitive, as higher BMI is generally recognized as a significant risk factor for NAFLD in the general population. However, within our specific cohort of hypothyroid patients, this inverse association warrants careful consideration. Some studies, like that by Lee et al. (2015),[17] which found no increased incidence of NAFLD in subclinical and overt hypothyroidism groups, also suggest that the relationship might not be straightforward.

Regarding Waist-Hip Ratio (WHR), the majority of our patients (96.9%) had a WHR ≤0.84, indicating a relatively lower degree of central adiposity in the overall cohort. Gokmen et al,[18] (2016) found significantly higher mean waist circumference in patients with NAFLD compared to those without, highlighting the role of central adiposity.

The TSH levels ranged from 7.00 to 45.00 mIU/L, with a median of 14.0 mIU/L and a mean of 16.17 ± 6.68 mIU/L, indicating a clear hypothyroid state with considerable variability in the degree of thyroid dysfunction. T3 levels ranged from 26.0 to 89.0 ng/dL (mean 63.55 ± 13.26 ng/dL), and T4 levels ranged from 1.00 to 8.00 µg/dL (mean 3.49 ± 0.78 µg/dL).

Comparing TFT levels between the NAFLD and non-NAFLD groups revealed significant differences in TSH and T3. The hypothyroidism with NAFLD group exhibited a statistically significantly higher mean TSH level (18.89 ± 6.99 mIU/L) compared to the hypothyroidism without NAFLD group (11.96 ± 2.99 mIU/L, $p < 0.001$). This finding aligns with several studies that have reported a positive association between higher TSH levels and NAFLD (Chung et al,[19] (2012) even found a dose-dependent relationship between the severity of hypothyroidism and the prevalence of NAFLD. Conversely, we observed a statistically significantly lower mean T3 level in the hypothyroidism with NAFLD group (56.93 ± 11.68 ng/dL) compared to the group without NAFLD (73.71 ± 8.11 ng/dL, $p < 0.001$). While most studies have focused on TSH and T4, Wang et al,[20] (2021) in their study on hyperthyroidism, found lower free T3 and free T4 levels in patients with NAFLD.

Interestingly, we found no statistically significant difference in mean T4 levels between the two groups ($p = 0.056$), although the mean T4 was slightly lower in the NAFLD group. This is in contrast to studies like Ludwig et al,[21] (2015) and Bano et al,[22] (2016) which reported associations between lower thyroxine levels and NAFLD risk.

Comparing LFTs between the NAFLD and non-NAFLD groups, we observed no statistically significant differences in total bilirubin ($p = 0.253$), direct bilirubin ($p = 0.816$), or ALT ($p = 0.704$). However, the mean AST level was significantly higher in the hypothyroidism with NAFLD group (28.59 ± 7.26 IU/L) compared to the group without NAFLD (24.51 ± 6.04 IU/L, $p < 0.001$). This finding aligns with the study by Mazo et al. (2011),[14] which found a positive correlation between hypothyroidism and AST levels. Elevated AST in the NAFLD group might reflect hepatocellular damage associated with steatosis and inflammation, even in the absence of significantly elevated ALT.

The distribution of abdominal ultrasound (USG) findings in our hypothyroid cohort revealed that a substantial proportion of patients had evidence of non-alcoholic fatty liver disease (NAFLD) of varying grades: Grade 1 (38.8%), Grade 2 (19.4%), and Grade 3 (2.5%). Overall, 60.7% (38.8% + 19.4% + 2.5%) of our hypothyroid patients were diagnosed with NAFLD based on USG criteria. This prevalence is within the range reported in the literature. For instance, Mazo et al,[14] (2011) found that 32.0% of their hypothyroid patients had steatosis.

In our study, 97 out of 160 (60.6%) of our hypothyroid patients had NAFLD as detected by ultrasound. This high prevalence underscores a significant association between hypothyroidism and the presence of NAFLD in our study population. Comparing this with the meta-analysis by Mantovani et al,[23] (2018) which found that hypothyroidism was associated with an increased risk of prevalent NAFLD (OR 1.42), our findings of a high co-occurrence support this association.

The significant positive correlation observed between Body Mass Index (BMI) and Waist-Hip Ratio (WHR) ($r = 0.495$, $p < 0.01$) is an expected finding. It reinforces the established link between overall adiposity (represented by BMI) and central adiposity (indicated by WHR). Individuals with a higher overall body mass tend to also exhibit a greater proportion of fat distribution around the waist.

The significant negative correlation between Thyroid-Stimulating Hormone (TSH) and Triiodothyronine (T3) ($r = -0.463$, $p < 0.01$) is consistent with the physiological regulation of thyroid hormones. In primary hypothyroidism, the thyroid gland's reduced ability to produce thyroid hormones (T3 and T4) leads to a compensatory increase in TSH secretion from the pituitary gland in an attempt to stimulate thyroid function. This inverse relationship is a hallmark of primary hypothyroidism.

The significant positive correlation between TSH and Aspartate Aminotransferase (AST) ($r = 0.157$, $p < 0.05$) suggests that higher TSH levels in our hypothyroid cohort are associated with higher AST levels. This finding is consistent with the observation by Mazo et al,[14] (2011) who also found a positive correlation between hypothyroidism and AST. The underlying mechanism for this association is not entirely clear but could involve the indirect effects of thyroid hormone deficiency on liver metabolism and enzyme activity.

The significant negative correlation between T3 and AST ($r = -0.159$, $p < 0.05$) indicates that lower levels of the more metabolically active thyroid hormone, T3, are associated with higher AST levels. This could be related to the role of T3 in hepatic lipid metabolism and overall liver function. Reduced T3 levels might contribute to increased liver fat accumulation and subsequent hepatocellular stress, leading to elevated AST.

CONCLUSION

This study demonstrates a significant association between hypothyroidism and NAFLD, revealing a high NAFLD prevalence (60.6%) in hypothyroid patients and identifying distinct thyroid hormone profiles characterized by elevated TSH and reduced T3 levels in those with NAFLD, along with higher AST levels, suggesting potential hepatocellular involvement. These results underscore the clinical relevance of considering NAFLD in hypothyroid patients and warrant further research to elucidate underlying mechanisms and optimize patient care, acknowledging the study's limitations in cross-sectional design and sample size.

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