ORIGINAL RESEARCH

Evaluating Non-Alcoholic Liver Disease in Type 2 Diabetic Patients: Correlations with Age, Body Mass Index, and Diabetes Duration

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ABSTRACT

Background: Non-alcoholic fatty liver disease (NAFLD) has emerged as a common comorbidity in individuals with Type 2 Diabetes Mellitus (T2DM), with shared metabolic risk factors such as obesity, insulin resistance, and poor glycaemic control. Despite its high prevalence, NAFLD often remains undiagnosed, especially in asymptomatic patients. Understanding its association with age, body mass index (BMI), and duration of diabetes is vital for early detection and intervention. **Aim:** To screen for Non-alcoholic Fatty Liver Disease in patients with Type 2 Diabetes Mellitus and to evaluate its association with age, BMI, and duration of diabetes. **Material and Methods:** This hospital-based, cross-sectional observational study was conducted over 18 months at a tertiary care teaching hospital. A total of 180 adult patients (aged 30–75 years) with a confirmed diagnosis of T2DM were enrolled consecutively. Exclusion criteria included significant alcohol consumption, known liver disease, and use of hepatotoxic medications. Clinical and anthropometric data including age, BMI, and diabetes duration were recorded. Liver ultrasonography was performed to detect and grade NAFLD. Statistical analysis included chi-square test, t-test, Pearson's correlation, and multiple regression analysis. **Results:** NAFLD was detected in 124 out of 180 patients (68.89%). Among them, 35.00% had mild, 23.33% moderate, and 10.56% severe steatosis. NAFLD prevalence increased with age (from 52.63% in 30–44 years to 74.42% in 45–59 years), BMI (from 42.86% in BMI <23.00 to 82.98% in BMI ≥30.00), and diabetes duration (from 49.02% in 1–4 years to 77.50% in 5–9 years). Multiple regression analysis revealed BMI ($\beta = 0.361$, $p < 0.001$) and diabetes duration ($\beta = 0.314$, $p < 0.001$) as significant predictors of NAFLD severity. Age showed only marginal association ($p = 0.063$). **Conclusion:** There is a high prevalence of NAFLD among T2DM patients, with significant associations with higher BMI and longer diabetes duration. Routine liver screening, especially in overweight or long-term diabetic patients, is crucial to enable early diagnosis and prevent progression to severe liver disease.

Keywords: Non-alcoholic fatty liver disease, Type 2 diabetes mellitus, Body mass index, Age, Diabetes duration

INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) is a progressive hepatic disorder that has become increasingly prevalent worldwide, particularly in individuals with Type 2 Diabetes Mellitus (T2DM). Characterized by hepatic steatosis in the absence of significant alcohol intake or secondary causes of fat accumulation, NAFLD ranges from simple steatosis to non-alcoholic steatohepatitis (NASH), which can progress to fibrosis, cirrhosis, and hepatocellular carcinoma. As the burden of diabetes rises globally, so does

the prevalence of NAFLD, with estimates suggesting that more than half of all T2DM patients have underlying hepatic steatosis.[1]

The pathophysiological relationship between NAFLD and T2DM is intricate and bidirectional. On one hand, chronic insulin resistance, a hallmark of T2DM, facilitates hepatic lipid accumulation. On the other, NAFLD exacerbates systemic insulin resistance, impairing glycaemic control and increasing the risk of diabetic complications. Emerging evidence suggests that NAFLD is not only a hepatic condition but also an indicator of widespread metabolic dysfunction[1]. Given this mutual aggravation, screening for NAFLD in diabetic populations has become a critical concern for endocrinologists, hepatologists, and primary care providers alike.

Aging has been identified as a significant factor influencing the progression of NAFLD in patients with diabetes. As individuals age, the liver undergoes structural and functional changes, which may predispose it to fat accumulation. Studies have shown that the prevalence of NAFLD increases with age among diabetic individuals, suggesting that older patients are more susceptible to hepatic metabolic stress.[2] However, the role of age is complex, as it often interacts with other risk factors such as BMI, glycaemic control, and comorbidities, which together influence disease progression.

Another key risk factor for NAFLD in T2DM is elevated body mass index (BMI), reflecting the role of adiposity in hepatic steatosis. Obesity and overweight status contribute significantly to increased free fatty acid flux to the liver, impaired lipid oxidation, and hepatic insulin resistance. In fact, the majority of T2DM patients with NAFLD are either overweight or obese, and BMI has been shown to correlate strongly with both the presence and severity of liver fat accumulation.[3] This makes BMI a crucial parameter in screening strategies, particularly in resource-limited settings where advanced imaging modalities may not be readily available.

The duration of diabetes is another important determinant of NAFLD risk and severity. Prolonged exposure to hyperglycaemia, insulin resistance, and low-grade inflammation contributes to hepatocellular injury and fibrosis over time. Longer-standing diabetes has been associated with more advanced stages of NAFLD, including NASH and fibrosis. Hence, it is essential to assess the timeline of diabetes when evaluating the likelihood of hepatic involvement.[4]

Despite the high burden of NAFLD among diabetic patients, the condition often remains underdiagnosed due to its asymptomatic nature in early stages. Routine liver enzyme testing lacks sensitivity, and liver biopsy, while definitive, is invasive and impractical for large-scale screening. As a result, non-invasive methods such as imaging-based assessments and serum-based scoring systems have gained traction. Among imaging tools, ultrasonography remains the most accessible and cost-effective initial modality. More advanced techniques like transient elastography and controlled attenuation parameter (CAP) offer quantitative assessment of liver fat and stiffness, enhancing diagnostic accuracy and staging capabilities.[5]

CAP, in particular, has emerged as a valuable non-invasive tool for quantifying liver steatosis. By measuring the attenuation of ultrasound signals, CAP provides objective information about hepatic fat content, which correlates well with histological findings. Studies have validated CAP against liver biopsy in multiple populations, demonstrating its utility in identifying even mild steatosis.[6] Moreover, CAP can be integrated with transient elastography to simultaneously evaluate liver stiffness, thereby facilitating comprehensive hepatic assessment during a single session.[7] These advancements in non-invasive diagnostics have significantly improved the feasibility of population-wide NAFLD screening in T2DM patients.

AIM AND OBJECTIVES

Aim

The primary aim of the study was to screen individuals with Type 2 Diabetes Mellitus (T2DM) for Non-Alcoholic Fatty Liver Disease (NAFLD) and evaluate its association with age, Body Mass Index (BMI), and duration of diabetes.

Objectives:

1. To determine the prevalence of NAFLD among patients with T2DM.
2. To assess the relationship between NAFLD and the following factors:
   - Age
   - Body Mass Index (BMI)
   - Duration of Diabetes Mellitus

MATERIALS AND METHODS

Study Design

- Type: Hospital-based, cross-sectional, observational study.
- Nature: Descriptive and analytical.

- Objective: To screen for Non-alcoholic Fatty Liver Disease (NAFLD) in patients with Type 2 Diabetes Mellitus (T2DM) and determine its association with age, BMI, and duration of diabetes.

Study Population

- Sample Size: 180 patients with confirmed Type 2 Diabetes Mellitus.
- Recruitment: Consecutive sampling from outpatient and inpatient departments.

Study Place

- Location: Department of General Medicine in collaboration with Department of Physiology, Narayan Medical College and Hospital**,** Jamuhar, Rohtas, Bihar, India..

Study Duration

- Period: Conducted over 18 months from January 2020 to June 2021.

Inclusion Criteria

- Adults aged between 30–75 years.
- Diagnosed with Type 2 Diabetes Mellitus for at least 1 year.
- Willing to undergo liver ultrasonography for NAFLD screening.
- Ability to provide informed consent.

Exclusion Criteria

- History of significant alcohol consumption (>20 g/day for women, >30 g/day for men).
- Known chronic liver diseases (e.g., viral hepatitis, autoimmune hepatitis, Wilson's disease).
- Use of hepatotoxic drugs or corticosteroids.
- History of malignancy or any systemic illness affecting liver function.

Ethical Considerations

- Approval: Institutional Ethics Committee (IEC) clearance obtained prior to the commencement of the study.
- Consent: Written informed consent was obtained from all participants.

Study Procedure

1. Data Collection:
   - Demographics: Age, sex.
   - Clinical history: Duration of diabetes, alcohol intake, medications.
2. Anthropometric Measurements:
   - Height and weight measured.
   - Body Mass Index (BMI) calculated and categorized per WHO Asian criteria.
3. Laboratory Investigations:
   - Fasting blood samples analyzed for:
     - Fasting blood glucose
     - Lipid profile
     - Liver function tests
     - HbA1c
4. Radiological Evaluation:
   - Abdominal ultrasonography performed by a radiologist blinded to clinical data.
   - NAFLD diagnosed and graded as mild, moderate, or severe based on hepatic echogenicity.

Outcome Measures

- Primary Outcome:
  - Prevalence of NAFLD in T2DM patients.
- Secondary Outcomes:
  - Association of NAFLD with:
    - Age
    - Body Mass Index (BMI)
    - Duration of Diabetes

Statistical Analysis

- Software Used: SPSS version 25.0
- Descriptive Statistics: To describe baseline characteristics (mean, standard deviation, frequencies).
- Comparative Tests:
  - Chi-square test for categorical variables.
  - Independent t-test for continuous variables.
- Correlation Analysis:
  - Pearson's correlation coefficient used to assess relationships between NAFLD and age, BMI, and diabetes duration.
- Significance Level:
  - A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (N = 180)

Characteristic	Value
Mean Age (years)	54.27 ± 9.83
Male : Female Ratio	102 : 78
Mean BMI (kg/m²)	27.92 ± 3.46
Mean Duration of T2DM	7.46 ± 3.21 years
Mean HbA1c (%)	8.24 ± 1.12

Table 1 shows the study included 180 patients with Type 2 Diabetes Mellitus (T2DM), of whom 102 (56.67%) were males and 78 (43.33%) were females, yielding a male-to-female ratio of 1.31:1. The mean age of the participants was 54.27 ± 9.83 years, indicating a middle-aged population. The average BMI was 27.92 ± 3.46 kg/m², which falls in the overweight range according to the WHO Asian classification. The mean duration of diabetes among the participants was 7.46 ± 3.21 years, suggesting a moderately chronic disease status. The mean HbA1c level was 8.24 ± 1.12%, indicating poor glycaemic control across the study population.

Table 2: Prevalence and Grading of NAFLD among T2DM Patients (N = 180)

NAFLD Status	Number of Patients	Percentage (%)
No NAFLD	56	31.11%
Mild NAFLD	63	35.00%
Moderate NAFLD	42	23.33%
Severe NAFLD	19	10.56%
Total	**180**	**100.00%**

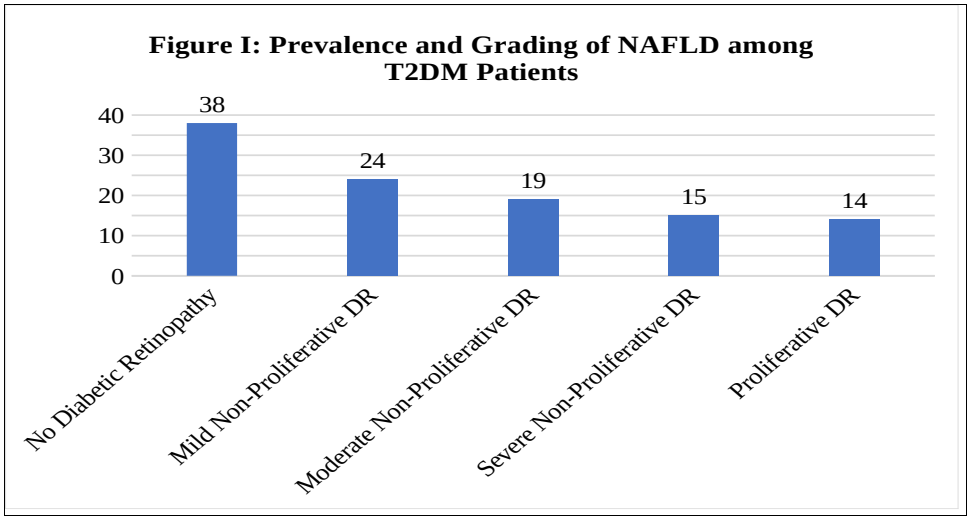

Table 2 and figure I, shows among the 180 patients screened, NAFLD was detected in 124 individuals, yielding an overall prevalence of 68.89%. The distribution of NAFLD severity showed that 63 patients (35.00%) had mild fatty liver, 42 (23.33%) had moderate, and 19 (10.56%) had severe fatty liver disease. Meanwhile, 56 patients (31.11%) did not show evidence of NAFLD. This highlights a high burden of NAFLD among T2DM patients, with a considerable proportion showing moderate to severe involvement.

Table 3: Association between NAFLD and Age Groups

Age Group (years)	NAFLD Present (n=124)	NAFLD Absent (n=56)	Total	% with NAFLD
30–44	20	18	38	52.63%
45–59	64	22	86	74.42%
60–75	40	16	56	71.43%

Table 3 shows the age stratification and revealed that the prevalence of NAFLD increased with age. In the youngest age group (30–44 years), 52.63% of participants had NAFLD, compared to 74.42% in the 45–59 years group and 71.43% in the 60–75 years group. While the prevalence rose notably between the first and second age groups, the increase plateaued in the oldest group. This trend suggests that advancing age is associated with an increased risk of developing NAFLD, though the difference becomes less marked after the age of 60.

Table 4: Association Between BMI and NAFLD

BMI Category (kg/m²)	NAFLD Present (n=124)	NAFLD Absent (n=56)	Total	% with NAFLD
< 23.00	12	16	28	42.86%
23.00–24.99	22	18	40	55.00%
25.00–29.99	51	14	65	78.46%
≥ 30.00	39	8	47	82.98%

Table 4 shows a clear positive association was observed between BMI and NAFLD prevalence. Participants with BMI < 23.00 kg/m² had the lowest prevalence (42.86%), whereas those in the 23.00–24.99 kg/m² and 25.00–29.99 kg/m² categories showed increased prevalence at 55.00% and 78.46%, respectively. The highest prevalence was observed in those with BMI ≥ 30.00 kg/m² (82.98%). These findings strongly support the role of obesity and overweight status as major risk factors for the development of NAFLD in individuals with T2DM.

Table 5: Association between Duration of T2DM and NAFLD

Duration of Diabetes	NAFLD Present (n=124)	NAFLD Absent (n=56)	Total	% with NAFLD
1–4 years	25	26	51	49.02%
5–9 years	62	18	80	77.50%
≥10 years	37	12	49	75.51%

Figure II: Association between Duration of T2DM and NAFLD

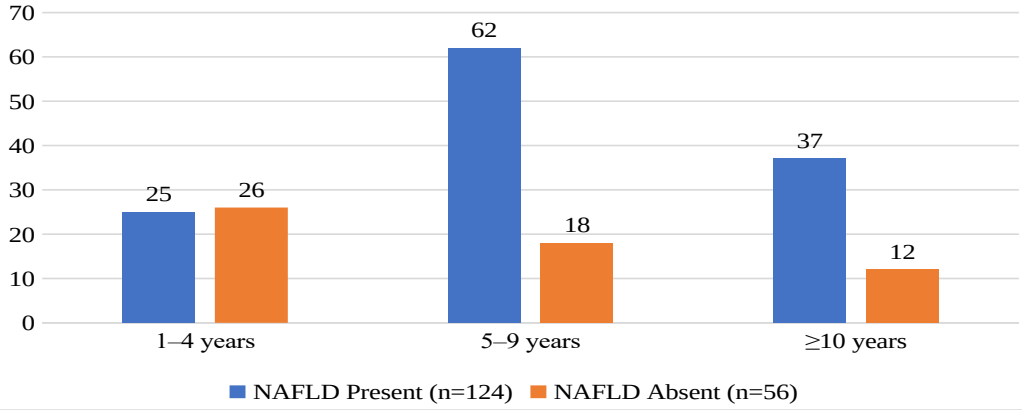

Table 5, figure II shows the prevalence of NAFLD increased with the duration of diabetes. Among patients with diabetes duration of 1–4 years, only 49.02% had NAFLD, whereas this figure rose to 77.50% in those with 5–9 years of diabetes and remained high (75.51%) in those with a duration of ≥10 years. This demonstrates a significant temporal relationship, suggesting that the longer the duration of diabetes, the higher the likelihood of developing hepatic steatosis.

Table 6: Multiple Linear Regression Analysis for Predictors of NAFLD Severity (N = 180)

Predictor Variable	Unstandardized Coefficient (B)	Standard Error (SE)	Standardized Beta (β)	t-value	p-value
Age (years)	0.015	0.008	0.108	1.875	0.063
BMI (kg/m²)	0.112	0.019	0.361	5.895	<0.001**
Duration of Diabetes (years)	0.084	0.017	0.314	4.941	<0.001**
Constant	-1.486	0.573	—	-2.593	0.011*

Table 6 shows the regression analysis examined the independent contribution of age, BMI, and duration of diabetes to the severity of NAFLD. The model was statistically significant ($p < 0.001$) and explained 41.7% of the variance in NAFLD severity (Adjusted $R^2 = 0.417$). BMI emerged as the strongest independent predictor ($\beta = 0.361$, $p < 0.001$), followed by duration of diabetes ($\beta = 0.314$, $p < 0.001$). Age showed a marginal association ($\beta = 0.108$, $p = 0.063$), which did not reach statistical significance. This indicates that while age may play a role, BMI and diabetes duration are the dominant risk factors for increasing NAFLD severity among diabetic patients.

DISCUSSION

The demographic and clinical characteristics observed in the present study reflect a typical metabolic profile of T2DM patients prone to hepatic complications. The mean age was 54.27 years, with a slight male predominance (56.67%). A similar demographic pattern was reported by **Tewari et al.[8] (2021)**, whose cohort had a mean age of 52.4 years and a male-to-female ratio of 1.4:1. The mean BMI in our study was 27.92 kg/m², consistent with findings by **Bhatt et al.[9] (2015)**, who reported a mean BMI of 28.1 kg/m² in diabetic individuals with NAFLD. Glycaemic control was poor in our population (mean HbA1c: 8.24%), comparable to the levels reported by **Kwok et al.[10] (2016)**, where the mean HbA1c was 8.1%, further highlighting the metabolic instability commonly associated with hepatic steatosis.

In our cohort of 180 patients, the prevalence of NAFLD was 68.89%, with 35.00% having mild, 23.33% moderate, and 10.56% severe disease. This prevalence closely mirrors the findings of **Tewari et al.[8] (2021)**, who observed NAFLD in 70.3% of diabetic patients in a similar Indian setting. Internationally, **Kwok et al.[10] (2016)** reported a slightly lower prevalence of 63.7% using transient elastography in a Chinese diabetic population. In contrast, **Jacqueminet et al.[11] (2008)** reported NAFLD prevalence at 61.1% using non-invasive biomarkers in a French population. These small variations could be attributed to regional differences in obesity, dietary patterns, and genetic predispositions.

Age-related stratification in our study revealed that NAFLD was most prevalent in the 45–59 age group (74.42%) and 60–75 age group (71.43%). Similar age-related patterns were seen in the Edinburgh Type 2 Diabetes Study by **Morling et al.[14] (2014)**, where NAFLD peaked in individuals aged 50–65 years. While **Kosmalski et al.[8] (2023)** acknowledged age as a contributory factor, they emphasized that age alone is insufficient to predict NAFLD severity without accounting for accompanying metabolic dysfunctions. This is consistent with our findings, where age showed only borderline significance in multivariate analysis.

BMI demonstrated a strong positive correlation with NAFLD prevalence in our study: patients with BMI ≥30.00 kg/m² had the highest NAFLD prevalence (82.98%). This aligns with the findings of **Casey et al.[12] (**, who reported an 85.5% NAFLD prevalence in diabetics with BMI >30 kg/m², and **de Lédinghen et al.[13] (2012)**, who emphasized BMI as a strong predictor of hepatic steatosis and fibrosis. The dose-response trend observed in our data—from 42.86% prevalence in those with BMI <23.00 to 82.98% in those ≥30.00—underscores the centrality of adiposity in hepatic fat accumulation. These findings reinforce global recommendations for prioritizing weight management in NAFLD prevention.

The relationship between diabetes duration and NAFLD was equally compelling. In our study, NAFLD prevalence rose from 49.02% in those with diabetes duration of 1–4 years to 77.50% in the 5–9 years group and 75.51% in those with ≥10 years. **Tewari et al.[8] (2021)** reported similar trends, with significantly higher NAFLD rates in patients with >5 years of T2DM. **Jacqueminet et al.[11] (2008)** and **Morling et al.[14] (2014)** also identified longer diabetes duration as a key determinant of hepatic fat accumulation and fibrosis. This indicates that chronic exposure to insulin resistance and hyperglycaemia gradually degrades hepatic function, necessitating early screening in patients with newly diagnosed diabetes.

Our multiple regression analysis demonstrated that BMI and diabetes duration were both significant independent predictors of NAFLD severity, with standardized beta coefficients of 0.361 and 0.314 respectively. Age showed only a borderline association ($p = 0.063$). These findings align with those of **Kwok et al.[10] (2016)**, who showed that BMI and diabetes duration were more predictive of liver fat burden than age in multivariate models. Similarly, **Tewari et al.[8] (2021)** highlighted that both increasing BMI and longer disease duration significantly contributed to higher NAFLD grades. Our model explained 41.7% of the variance in NAFLD severity (Adjusted R^2 =

0.417), further supporting the multifactorial but predominantly metabolic origin of liver fat accumulation in diabetic populations.

In light of these findings, NAFLD in T2DM should be recognized not merely as a hepatic complication but as a key component of the metabolic syndrome with shared etiological pathways. As emphasized by **Kosmalski et al.[8] (2023)**, the "chicken or the egg" dilemma between NAFLD and T2DM is clinically relevant, as each potentiates the progression of the other. Hence, early and routine liver screening, especially in overweight or long-standing diabetic patients, can facilitate timely intervention and prevent advanced liver disease.

LIMITATIONS OF THE STUDY

- Cross-sectional design limits the ability to establish causality or temporal relationships.
- Single-centre study, which may affect the generalizability of results.
- Ultrasonography may have lower sensitivity in detecting mild steatosis and is operator-dependent.
- Liver biopsy, the gold standard for diagnosing NAFLD, was not used due to ethical and feasibility concerns.
- Confounding factors such as dietary habits, physical activity, and genetic predisposition were not assessed.
- Self-reported alcohol intake may lead to underestimation and potential inclusion of undiagnosed alcoholic liver disease.

CONCLUSION

This study demonstrates a high prevalence of Non-Alcoholic Fatty Liver Disease (NAFLD) among patients with Type 2 Diabetes Mellitus, with severity significantly associated with increased BMI and longer duration of diabetes. Age showed a weaker association compared to other metabolic factors. These findings underscore the importance of routine NAFLD screening in diabetic patients, particularly those who are overweight or have longstanding diabetes. Early detection may aid in preventing progression to advanced liver disease.

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