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Original Research Article

Association of Glycemic and Lipid Parameters with Severity of Non-Alcoholic Fatty Liver Disease

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Abstract

Background: Non-alcoholic fatty liver disease (NAFLD) is closely associated with metabolic abnormalities, including dysglycemia and dyslipidemia.

Objective: To assess the association of glycemic and lipid parameters with ultrasonographic severity of NAFLD.

Materials and Methods: This was a hospital-based cross-sectional observational study conducted over 10 months from September 2025 to June 2026 in the Department of General Medicine, Farookh Academy of Medical Education Hospital & Research Institute, Mysuru, Karnataka. A total of 65 patients with NAFLD fulfilling the predefined eligibility criteria were included. FBS, PPBS, HbA1c, triglycerides, HDL cholesterol, total cholesterol, LDL and VLDL were assessed. NAFLD severity was graded by ultrasonography as grade 1, 2 or 3. Statistical analysis was performed using one-way ANOVA and Fisher's exact test.

Results: Grade 1, Grade 2 and Grade 3 NAFLD were present in 47.7%, 36.9% and 15.4% of participants, respectively. FBS, PPBS, HbA1c, triglycerides, LDL and VLDL increased significantly with increasing severity, while HDL decreased. Total cholesterol also differed significantly across grades.

Conclusion: Greater NAFLD severity was associated with progressively adverse glycemic and lipid profiles, highlighting the importance of metabolic assessment in these patients.

Keywords: NAFLD, glycemic parameters, lipid profile, HbA1c, triglycerides, HDL, ultrasonography.

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Introduction

Non-alcoholic fatty liver disease (NAFLD) is one of the most common chronic liver disorders worldwide and has become an important public health concern in parallel with increasing obesity and metabolic disease. Recent estimates indicate a substantial and continuing rise in its global prevalence [1,2]. NAFLD encompasses a spectrum ranging from simple hepatic steatosis to steatohepatitis, fibrosis and cirrhosis. Its development is closely related to insulin resistance, obesity, type 2 diabetes and other cardiometabolic abnormalities [3].

The burden of NAFLD is also substantial in India, where the increasing prevalence of obesity, central adiposity, diabetes and metabolic syndrome has contributed to a growing number of affected individuals. Indian studies have demonstrated strong associations of NAFLD with increased body mass index, waist circumference, hyperglycemia, hypertriglyceridemia and elevated VLDL levels [4,5]. Importantly, NAFLD is increasingly considered a hepatic manifestation of systemic metabolic dysfunction rather than an isolated liver disorder.

Abnormal glucose metabolism has an important role in the development and progression of NAFLD. Insulin resistance increases adipose-tissue lipolysis and hepatic delivery of free fatty acids, while hyperglycemia and compensatory hyperinsulinemia promote de novo lipogenesis and hepatic triglyceride accumulation. Persistent metabolic dysfunction may subsequently contribute to lipotoxicity, oxidative stress and inflammatory pathways involved in progression of liver disease

[6]. Similarly, dyslipidemia, characterized by increased triglycerides and LDL cholesterol and reduced HDL cholesterol, is frequently associated with NAFLD. The relationship between NAFLD and glucose dysregulation is clinically important because diabetes and hepatic steatosis may reinforce adverse metabolic outcomes. Indian evidence has demonstrated a close association between NAFLD, type 2 diabetes and obesity, with a greater metabolic burden among affected individuals [7]. Consequently, evaluation of glycemic and lipid abnormalities may provide useful information regarding the metabolic risk accompanying increasing hepatic steatosis.

Ultrasonography is a widely available, non-invasive and practical method for detecting and grading hepatic steatosis in routine clinical practice. Although it has limitations in quantifying hepatic fat and detecting mild steatosis, its accessibility makes it particularly useful for clinical assessment and epidemiological studies. Assessment of metabolic parameters across different grades of ultrasound-detected NAFLD may help identify patients with a greater metabolic burden and facilitate early cardiometabolic risk stratification.

Therefore, the present study was undertaken to evaluate the association of glycemic and lipid parameters with the ultrasonographic severity of NAFLD.

Materials and Methods

This was an hospital-based cross-sectional observational study conducted over 10 months from September 2025 to June 2026 in the Department of General Medicine, Farookh Academy of Medical Education Hospital & Research Institute, Mysuru, Karnataka. A total of 65 patients with NAFLD fulfilling the predefined eligibility criteria were included. The sample size was calculated using an anticipated fatty-liver proportion of 60%, 95% confidence level and 12% absolute precision, giving a required sample size of 65 participants.

Inclusion Criteria

- Adults aged >18 years.
- Patients diagnosed with NAFLD on abdominal ultrasonography.

Exclusion Criteria

- Age below 18 years or above 85 years.
- History of jaundice or HBsAg positivity.
- Alcohol intake >30 g/day in males or >20 g/day in females.
- Use of drugs associated with hepatic steatosis, including steroids, synthetic oestrogens, heparin, calcium-channel blockers, amiodarone, valproic acid and antiviral agents.

Clinical and Anthropometric Assessment

Detailed history, physical examination and anthropometric measurements were obtained after informed consent. Weight and height were measured using standardized procedures, and BMI was calculated as weight in kilograms divided by height in metres squared. Waist and hip circumferences were measured, and blood pressure was recorded three times after adequate rest; the mean of the three readings was used.

Biochemical Assessment: Investigations included fasting blood glucose, 2-hour post-prandial blood glucose, glycated haemoglobin, lipid profile and liver function tests. The lipid profile included triglycerides, HDL cholesterol, total cholesterol, LDL and VLDL.

Ultrasonographic Assessment: Abdominal ultrasonography was performed by an experienced radiologist using a high-resolution B-mode system with a 3–5 MHz transducer. NAFLD was diagnosed on the basis of characteristic increased hepatic echogenicity and associated sonographic features in the absence of findings suggestive of chronic liver disease. Hepatic steatosis was graded as grade 1 (mild), grade 2 (moderate) or grade 3 (severe).

Assessment of Metabolic Syndrome: Metabolic syndrome was assessed using NCEP ATP III criteria with Asian-Indian waist circumference thresholds. The five components included increased waist circumference, elevated triglycerides, reduced HDL cholesterol, and elevated blood pressure and elevated fasting glucose. The presence of three or more components was considered diagnostic of metabolic syndrome.

Statistical Analysis: Data were summarized using means, standard deviations, medians and proportions. Differences in continuous variables across the three grades of NAFLD were evaluated using one-way analysis of variance (ANOVA). Fisher's exact test was used to assess the association between categorical variables and NAFLD severity. A P value <0.05 was considered statistically significant.

Ethical Approval: The study was conducted after clearance and approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants before inclusion in the study.

Results

A total of 65 patients with ultrasonographically diagnosed NAFLD were included in the study. The study population comprised 38 (58.5%) males and 27 (41.5%) females, with a mean age of 54.14±10.11 years. Most participants belonged to the 51–60-year age group. Obesity was common in the study population, with 27 (41.5%) participants

classified as obese class I and 24 (36.9%) as obese class II. Ten (15.4%) participants were overweight, while 4 (6.2%) had normal BMI.

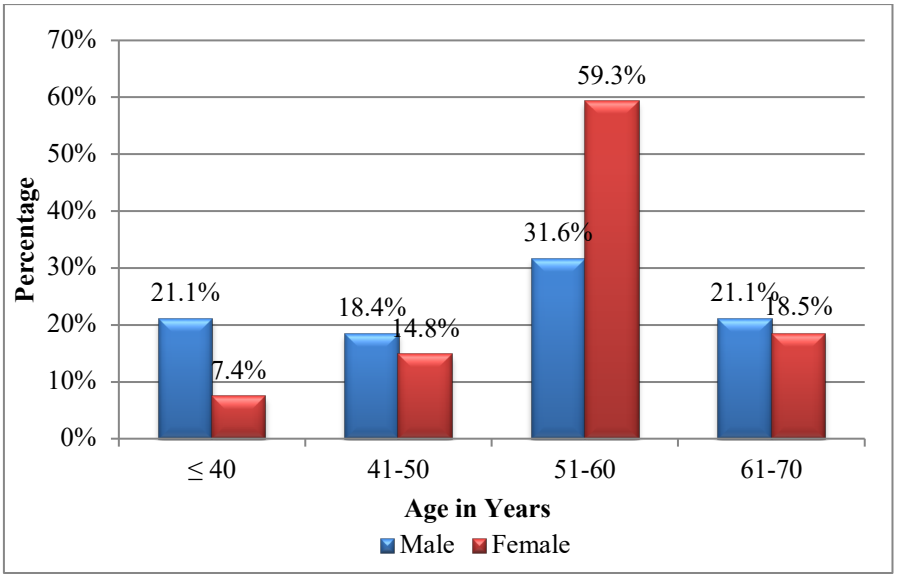

Figure 1: Age- and sex-wise distribution of study participants

The age distribution showed that the largest proportion of both study participants overall and female participants belonged to the 51–60-year age group. The mean age was comparable between males and females, being 53.58±11.49 years and 54.93±7.89 years, respectively.

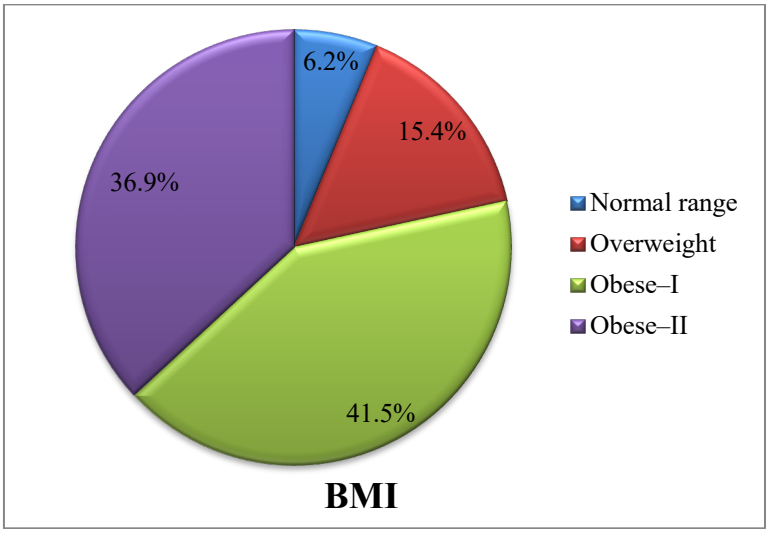

Figure 2: Distribution of study participants according to BMI

Most participants were obese, with obese class I being the most frequent BMI category (41.5%), followed by obese class II (36.9%). Overweight participants constituted 15.4%, whereas only 6.2% had normal BMI.

Table 1: Distribution of Study Subjects Based on Components of Metabolic Syndrome

Components of Metabolic Syndrome		Number	Percentage
Waist circumference	Males ≥ 90cms	24	63.2%
	Females≥ 80cms	26	96.3%
Triglycerides	≥150mg/dL or on specific treatment	39	60%
HDL Cholesterol	Men < 40mg/dL	26	50%
	Women < 50mg/dL	26	50%
Blood pressure	≥ 130/85 mm of Hg (or known Hypertensives)	23	35.4%
Fasting glucose	≥100 mg/dL (or known diabetics)	33	50.8%

Among the five metabolic syndrome components, raised triglycerides were present in 39 (60.0%) participants, while elevated fasting glucose was present in 33 (50.8%). Increased waist circumference was observed in 50 (76.9%) participants, with females accounting for 52.0% of those with increased waist circumference. Reduced HDL cholesterol was present in 52 (80.0%) participants, with an equal contribution from males and females. Elevated blood pressure or known hypertension was present in 23 (35.4%) participants.

Table 2: Distribution of Study Subjects According to Selected Glycemic and Lipid Parameters

Parameters	Number	Percentage
PPBS		
Normal	33	50.8%
Abnormal	32	49.2%
HbA1C		
Normal	32	49.2%
Diabetic	33	50.8%
Total Cholesterol		
Normal	51	78.5%
Abnormal	14	21.5%
LDL		
Normal	34	52.3%
Abnormal	31	47.7%
VLDL		
Normal	36	55.4%
Abnormal	29	44.6%

PPBS was abnormal in 32 (49.2%) participants, while 33 (50.8%) had diabetic-range HbA1c. Abnormal total cholesterol was observed in 14 (21.5%) participants. Abnormal LDL and VLDL levels were present in 31 (47.7%) and 29 (44.6%) participants, respectively. Thus, abnormalities in glycemic and lipid parameters were frequent among the study participants.

Table 3: Comparison of Means of Various Components of Metabolic Syndrome Based on Severity of NAFLD

Parameters	Mean ± SD for Severity of NAFLD			P Value
	Grade 1	Grade 2	Grade 3	
Waist Circumference	91.13 ± 9.51	97.33 ± 10.43	99.30 ± 10.38	0.026*
Triglycerides	119.16 ± 31.65	180.21 ± 22.28	263.80 ± 42.12	<0.001*
HDL	40.61 ± 5.89	32.96 ± 5.72	26.60 ± 3.73	<0.001*
Systolic BP	117.74 ± 2.24	129.00 ± 11.49	141.60 ± 3.63	<0.001*
Diastolic BP	77.94 ± 2.56	86.08 ± 7.75	93.00 ± 3.80	<0.001*
FBS	89.00 ± 5.86	186.08 ± 68.64	194.10 ± 93.01	<0.001*

There was a significant progressive increase in waist circumference, triglycerides, systolic blood pressure, diastolic blood pressure and fasting blood glucose with increasing severity of NAFLD. In contrast, HDL cholesterol showed a significant progressive decline from grade 1 to grade 3. The differences across NAFLD grades were statistically significant for all six parameters. The strongest gradient was observed for triglycerides and fasting blood glucose.

Table 4: Comparison of Means of Various Biochemical Measurements Based on Severity of NAFLD

Parameters	Mean ± SD for Severity of NAFLD			P Value
	Grade 1	Grade 2	Grade 3	
PPBS	126.32 ± 6.59	277.62 ± 78.59	326.00±77.51	<0.001*
HbA1C	5.18 ± 0.27	8.84 ± 1.49	10.42±1.69	<0.001*
Total Cholesterol	143.45 ± 36.03	173.54 ± 43.98	170.50±44.93	0.019*
LDL	86.68 ± 17.53	119.38 ± 31.58	154.10±8.99	<0.001*
VLDL	25.81 ± 1.96	33.92 ± 3.27	58.50±11.96	<0.001*

Glycemic parameters demonstrated a marked increase with increasing NAFLD severity. Mean PPBS increased from 126.32±6.59 mg/dL in grade 1 to 326.00±77.51 mg/dL in grade 3, while mean HbA1c increased from 5.18±0.27% to 10.42±1.69%. These differences were highly

significant. LDL and VLDL also increased significantly across the three grades. Total cholesterol was significantly different across the groups, with higher values in grade 2 and grade 3 compared with grade 1.

Discussion

The present study demonstrated a clear metabolic gradient across increasing grades of ultrasonographic NAFLD. Grade 1 steatosis was most frequent, followed by grade 2 and grade 3. The participants were predominantly middle-aged, and obesity was common in the study population. The metabolic abnormalities observed across increasing ultrasound grades suggest a close relationship between hepatic steatosis and cardiometabolic risk [4,8].

The most prominent finding was the significant deterioration in glycemic parameters with increasing NAFLD severity. Mean FBS increased from 89.00 mg/dL in grade 1 to 194.10 mg/dL in grade 3, while PPBS increased from 126.32 to 326.00 mg/dL. HbA1c also increased markedly from 5.18% to 10.42%. These findings are consistent with the established bidirectional relationship between NAFLD and abnormal glucose metabolism. A global meta-analysis reported a high prevalence of NAFLD among individuals with type 2 diabetes and emphasized the important role of diabetes in the progression of fatty liver disease [8]. The close relationship between insulin resistance, hyperglycemia and hepatic fat accumulation has also been highlighted in contemporary reviews [3].

Lipid abnormalities showed a similar pattern. Triglycerides increased significantly from 119.16 mg/dL in grade 1 to 263.80 mg/dL in grade 3, whereas HDL declined from 40.61 to 26.60 mg/dL. LDL and VLDL also increased progressively with increasing severity.

These findings are consistent with the metabolic phenotype commonly observed in NAFLD. An Indian study among healthy urban male blood donors reported significantly higher BMI, waist circumference, blood pressure, total cholesterol, triglycerides, LDL and fasting glucose among individuals with NAFLD [9].

The present study also showed significant increases in waist circumference and both systolic and diastolic blood pressure with increasing NAFLD severity. These findings further support the close relationship between hepatic steatosis and the broader cluster of cardiometabolic risk factors [10]. NAFLD is increasingly recognized as a metabolic disorder closely linked to obesity, metabolic syndrome and diabetes [11]. The presence of NAFLD has also been associated with increased morbidity and mortality related to cardiometabolic complications [12]. Overall, the findings indicate that increasing ultrasound severity of NAFLD is accompanied by an adverse metabolic profile, particularly involving hyperglycemia, elevated triglycerides and atherogenic lipid abnormalities. This metabolic burden is clinically important because NAFLD has also been associated with increased cardiovascular risk [13].

Limitations: The study was conducted at a single centre with a relatively small sample size, particularly in the grade 3 NAFLD subgroup. Ultrasonography, although practical and widely available, has limited sensitivity for mild steatosis and does not reliably assess steatohepatitis or fibrosis. The cross-sectional nature of the study precludes inference of a causal relationship between metabolic abnormalities and NAFLD severity. Potential confounding factors such as medication use, duration of diabetes, dietary factors and physical activity were not comprehensively evaluated.

Conclusion

Increasing severity of NAFLD was significantly associated with worsening glycemic and lipid abnormalities. Higher grades of hepatic steatosis showed increased FBS, PPBS, HbA1c, and triglycerides, LDL and VLDL, along with reduced HDL levels. Waist circumference and blood pressure also increased with greater disease severity. These findings highlight the close relationship between NAFLD severity and metabolic abnormalities and emphasize the importance of early assessment and management of glycemic and lipid parameters in patients with NAFLD.

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