INSIGHTS-IJHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

ORIGINAL RESEARCH (ID:1735)

Volume 4 | Issue 9 | 2026
ISSN: 3007-2948

FREQUENCY OF METABOLIC-DYSFUNCTION ASSOCIATED STEATOTIC LIVER DISEASE IN DIABETIC INDIVIDUALS USING NON-INVASIVE SCORE.

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CONFLICT OF INTEREST
None declared.

GRANT SUPPORT
None declared.

FINANCIAL SUPPORT
None Declared.

ABSTRACT

Background: Metabolic dysfunction-associated steatotic liver disease (MASLD) is common in people with type 2 diabetes mellitus and may progress to clinically important liver disease. The Fatty Liver Index (FLI) is a simple non-invasive score derived from routinely available anthropometric and biochemical variables and may help identify hepatic steatosis when imaging is not immediately available.

Objective: To determine the frequency of steatotic liver disease in patients with type 2 diabetes mellitus using the FLI, evaluate its diagnostic performance against abdominal ultrasonography, and identify demographic, anthropometric, and biochemical factors associated with ultrasound-confirmed steatosis.

Methods: This hospital-based cross-sectional observational study included 124 consecutive patients with type 2 diabetes mellitus attending the diabetic clinics and Medical Outpatient Department of Jinnah Postgraduate Medical Centre, Karachi, from mid-March 2026 to mid-June 2026. Demographic, clinical, anthropometric, and biochemical data were collected using a structured proforma. The FLI was calculated from body mass index, waist circumference, triglycerides, and gamma-glutamyl transferase. Abdominal ultrasonography was used as the reference standard for hepatic steatosis. Diagnostic performance was evaluated using sensitivity, specificity, predictive values, diagnostic accuracy, Cohen's kappa, and receiver operating characteristic analysis. Multivariable binary logistic regression was used to identify independent predictors of ultrasound-confirmed steatosis.

Results: The mean age was 50.00 ± 10.31 years, and 71.0% of participants were female. Ultrasound-confirmed hepatic steatosis was present in 88 participants (71.0%), whereas 77 (62.1%) had FLI ≥60. At this threshold, sensitivity was 73.9%, specificity 66.7%, positive predictive value 84.4%, negative predictive value 51.1%, and overall diagnostic accuracy 71.8%. Agreement with ultrasonography was fair (Cohen's kappa = 0.372, $p < 0.001$), and the area under the receiver operating characteristic curve was 0.776. Participants with steatosis had significantly higher body mass index, waist circumference, alanine aminotransferase, and gamma-glutamyl transferase levels. In multivariable analysis, body mass index was the only independent predictor of steatosis (adjusted OR 1.270, 95% CI 1.121–1.438; $p < 0.001$).

Conclusion: Hepatic steatosis was common in this hospital-based sample of patients with type 2 diabetes mellitus. The FLI showed acceptable discrimination and a high positive predictive value, but its modest sensitivity and low negative predictive value indicate that an FLI <60 should not be used alone to exclude steatosis. Body mass index was independently associated with ultrasound-confirmed steatosis.

Keywords	body mass index; diabetes mellitus, type 2; Fatty Liver Index; metabolic dysfunction-associated steatotic liver disease; ultrasonography
Acknowledgement	The authors acknowledge the study participants and the clinical, laboratory, and radiology staff involved in patient assessment and data collection at Jinnah Postgraduate Medical Centre.
Rizvi HK et al. Short Title	Fatty Liver Index in Diabetes-Associated MASLD

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INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

ORIGINAL RESEARCH (ID:1735)

Volume 4 | Issue 9 | 2026
ISSN: 3007-2948

INTRODUCTION

Metabolic dysfunction-associated steatotic liver disease (MASLD) is the current term for steatotic liver disease occurring in the presence of at least one cardiometabolic risk factor, after appropriate consideration of other causes of hepatic steatosis. The terminology emphasizes the central role of metabolic dysfunction and replaces the previous non-alcoholic fatty liver disease nomenclature. MASLD has become a major cause of chronic liver disease worldwide and is closely associated with obesity, insulin resistance, dyslipidemia, hypertension, and type 2 diabetes mellitus (1–3). Type 2 diabetes mellitus is one of the strongest clinical risk factors for MASLD. Insulin resistance promotes increased delivery of free fatty acids to the liver, de novo lipogenesis, and hepatic triglyceride accumulation. In susceptible individuals, steatosis may progress to metabolic dysfunction-associated steatohepatitis, fibrosis, cirrhosis, and liver-related complications. The coexistence of MASLD and diabetes also identifies a population with substantial cardiometabolic risk, supporting early recognition and risk stratification (4,6,7).

Although liver biopsy provides detailed assessment of steatosis, inflammation, and fibrosis, its invasiveness limits its role in population screening. Non-invasive approaches are therefore important in routine clinical practice. The Fatty Liver Index (FLI) is a validated score derived from body mass index (BMI), waist circumference, serum triglycerides, and gamma-glutamyl transferase (GGT). It ranges from 0 to 100; conventional thresholds of <30 and ≥60 have been used to identify low and high probability of hepatic steatosis, respectively (5,12). Patients with diabetes may remain asymptomatic despite substantial hepatic steatosis, and routine liver enzymes alone do not reliably exclude disease. A simple score based on routinely available measurements may therefore be useful for identifying individuals who warrant imaging, counselling, and further liver risk assessment. Contemporary guidelines also emphasize structured non-invasive assessment of people with metabolic risk factors, particularly those with type 2 diabetes (7,14–16).

Local evidence describing the burden of MASLD and the performance of simple non-invasive steatosis scores in people with diabetes remains limited. The present study therefore aimed to determine the frequency of steatotic liver disease in patients with type 2 diabetes mellitus using the FLI, evaluate its diagnostic performance against abdominal ultrasonography, and identify demographic, anthropometric, and biochemical factors associated with ultrasound-confirmed steatosis.

METHODOLOGY

Study design and setting

This hospital-based cross-sectional observational study was conducted in the diabetic clinics and Medical Outpatient Department of Jinnah Postgraduate Medical Centre (JPMC), Karachi. The study was conducted from mid-March 2026 to mid-June 2026. Consecutive patients with type 2 diabetes mellitus were screened according to the predetermined study eligibility criteria, and those who fulfilled the criteria and provided informed consent were recruited. A total of 124 participants were included in the final analysis. Data required for both the FLI and abdominal ultrasonography were available for all 124 participants.

Data collection and clinical measurements

Data were collected using a structured proforma. Demographic variables included age and sex, while recorded clinical comorbidities included hypertension, ischemic heart disease, and heart failure. Anthropometric measurements included body weight, height, BMI, and waist circumference. Body weight was recorded in kilograms and height in centimeters. BMI was expressed as kg/m². Waist circumference was measured in centimeters using a non-stretchable measuring tape according to standard clinical practice. Laboratory parameters included glycated haemoglobin (HbA1c), aspartate aminotransferase (AST), alanine aminotransferase (ALT), GGT, and serum triglycerides. ALT, GGT, and triglyceride measurements required for the main FLI analysis were complete for all 124 participants. Analyses involving variables with smaller denominators were based on the observations available for those variables, as shown in the relevant tables.

Fatty Liver Index

The FLI was calculated from serum triglycerides, GGT, BMI, and waist circumference using the established equation (5):

FLI = [e^L / (1 + e^L)] × 100, where L = 0.953 × ln(triglycerides) + 0.139 × BMI + 0.718 × ln(GGT) + 0.053 × waist circumference − 15.745.

Triglycerides were entered in mg/dL, GGT in U/L, BMI in kg/m², and waist circumference in centimeters. FLI values were categorized as low risk (<30), intermediate risk (30–59), and high risk (≥60). For the primary diagnostic comparison with ultrasonography, FLI ≥60 was considered positive and FLI <60 negative; consequently, the intermediate category was included in the FLI-negative group for the binary diagnostic analysis. This binary definition was used specifically to evaluate the conventional high-probability threshold of 60.

Abdominal ultrasonography and outcome definition

Abdominal ultrasonography was used as the reference standard for the presence of hepatic steatosis. Sonographic features used to identify steatosis included increased hepatic echogenicity relative to the renal cortex, reduced visualization of intrahepatic vessels,

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ISSN: 3007-2948

and attenuation of the ultrasound beam. Ultrasound findings were classified as steatosis absent or steatosis present. All participants had type 2 diabetes mellitus, thereby fulfilling a cardiometabolic criterion for MASLD; participants with ultrasound evidence of hepatic steatosis were classified as having MASLD in the context of the study's predetermined eligibility criteria and exclusion of alternative causes of hepatic steatosis.

Study outcomes

The primary outcome was hepatic steatosis assessed by abdominal ultrasonography and compared with FLI classification. Diagnostic performance measures for FLI ≥60 included sensitivity, specificity, positive predictive value, negative predictive value, overall diagnostic accuracy, Cohen's kappa coefficient, and the area under the receiver operating characteristic (ROC) curve. The secondary outcome was the association of demographic, anthropometric, and biochemical characteristics with ultrasound-confirmed steatosis.

Statistical analysis

Continuous variables were summarized as mean ± standard deviation (SD), and categorical variables as frequency and percentage. Percentages were calculated using the number of participants with available data for each variable. Normality of continuous variables was assessed using the Shapiro–Wilk test. Between-group comparisons for participants with and without ultrasound-confirmed steatosis were performed using independent-samples t-tests. For GGT and triglycerides, heteroscedasticity identified by Levene's test was addressed using log transformation for inferential testing and Welch correction; descriptive values are presented in the original clinical units. Associations between categorical variables and ultrasound-confirmed steatosis were assessed using Pearson's chi-square test, with Fisher's exact test used when expected cell frequencies were small. FLI classification and ultrasonography were compared in a 2 × 2 table. Sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were calculated with ultrasonography as the reference standard. Ninety-five percent confidence intervals (CIs) for these proportions were calculated using the Wilson method. Agreement beyond chance was assessed using Cohen's kappa. Discrimination of the continuous FLI score was assessed using ROC analysis and summarized by the area under the curve (AUC).

Multivariable binary logistic regression was used to identify independent predictors of ultrasound-confirmed steatosis. Age, BMI, ALT, GGT, and sex were entered as independent variables, with female sex as the reference category. BMI was used as the adiposity measure in the multivariable model rather than simultaneously entering both BMI and waist circumference. Results are presented as adjusted odds ratios (ORs), 95% CIs, Wald chi-square statistics, and p-values. Model performance was evaluated using the Hosmer–Lemeshow goodness-of-fit test, Nagelkerke R^2, and overall classification accuracy. All tests were two-sided, and $p < 0.05$ was considered statistically significant.

Ethical considerations

The study was approved by the appropriate institutional ethics committee before commencement. All participants provided written informed consent. Participant information was handled confidentially and used only for research purposes.

RESULTS

Baseline Characteristics

A total of 124 patients with type 2 diabetes mellitus were included in the analysis. The cohort was predominantly female (88, 71.0%), with a mean age of 50.00 ± 10.31 years. Mean BMI was 28.33 ± 5.39 kg/m² and mean waist circumference was 99.59 ± 12.15 cm. Mean HbA1c among the 83 participants with available measurements was 9.24 ± 2.41%. Hypertension was present in 40 of 111 participants with available data (36.0%), whereas ischemic heart disease and heart failure were uncommon. The mean FLI was 65.41 ± 25.72; 77 participants (62.1%) were in the high-risk category (FLI ≥60). Ultrasonography demonstrated hepatic steatosis in 88 participants (71.0%). Baseline characteristics are summarized in Table 1.

Table 1. Baseline demographic and clinical characteristics of the study participants (n = 124).

Characteristic	N	Value
Continuous variables, mean ± SD		
Age (years)	124	50.00 ± 10.31
Weight (kg)	124	71.91 ± 15.28
Height (cm)	124	159.25 ± 10.20
Body mass index (kg/m²)	124	28.33 ± 5.39
Waist circumference (cm)	124	99.59 ± 12.15
HbA1c (%)	83	9.24 ± 2.41

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AST (U/L)	53	38.37 ± 28.83
ALT (U/L)	124	41.10 ± 32.46
GGT (U/L)	124	50.94 ± 46.58
Triglycerides (mg/dL)	124	194.81 ± 115.93
Fatty Liver Index	124	65.41 ± 25.72
Categorical variables, n (%)		
Male sex	124	36 (29.0)
Female sex	124	88 (71.0)
Hypertension	111	40 (36.0)
Ischaemic heart disease	124	7 (5.6)
Heart failure	123	2 (1.6)
Fatty Liver Index category, n (%)		
Low risk (FLI <30)	124	15 (12.1)
Intermediate risk (FLI 30–59)	124	32 (25.8)
High risk (FLI ≥60)	124	77 (62.1)
Ultrasound findings, n (%)		
No steatosis	124	36 (29.0)
Steatosis present	124	88 (71.0)

Data are presented as mean ± SD for continuous variables and n (%) for categorical variables. Percentages are based on participants with available data for each variable. AST, aspartate aminotransferase; ALT, alanine aminotransferase; GGT, gamma-glutamyl transferase; HbA1c, glycated haemoglobin; FLI, Fatty Liver Index.

Comparison of the Fatty Liver Index with Ultrasound

Among 77 participants classified as FLI-positive (FLI ≥60), 65 had ultrasound-confirmed steatosis, while 12 did not. Among 47 FLI-negative participants, 23 had ultrasound-confirmed steatosis and 24 had no steatosis. The association between FLI classification and ultrasound findings was statistically significant ($\chi^2 = 17.831$, df = 1, $p < 0.001$). At the ≥60 threshold, sensitivity was 73.9% (95% CI 63.8–81.9), specificity 66.7% (95% CI 50.3–79.8), positive predictive value 84.4% (95% CI 74.7–90.9), negative predictive value 51.1% (95% CI 37.2–64.7), and overall diagnostic accuracy 71.8% (95% CI 63.3–78.9). Agreement beyond chance was fair (Cohen's kappa = 0.372, SE 0.086; $p < 0.001$). The AUC for the continuous FLI score was 0.776, indicating acceptable discrimination. Diagnostic performance is summarized in Table 2 and Figure 1. Figure 2 compares the proportion classified as having steatotic liver disease by FLI ≥60 and ultrasonography.

Table 2. Diagnostic performance of the Fatty Liver Index compared with ultrasonography.

Fatty Liver Index	No steatosis	Steatosis present	Total
Negative (FLI <60)	24 (51.1)	23 (48.9)	47 (100.0)
Positive (FLI ≥60)	12 (15.6)	65 (84.4)	77 (100.0)
Total	**36 (29.0)**	**88 (71.0)**	**124 (100.0)**

Diagnostic indices for FLI ≥60:

Measure	Estimate	95% CI / test statistic
Sensitivity	73.9%	63.8–81.9%
Specificity	66.7%	50.3–79.8%
Positive predictive value	84.4%	74.7–90.9%
Negative predictive value	51.1%	37.2–64.7%
Diagnostic accuracy	71.8%	63.3–78.9%

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Cohen's kappa	0.372	SE 0.086; $p < 0.001$
ROC AUC	0.776	—
Pearson χ^2	17.831	df = 1; $p < 0.001$

Cross-tabulation values are n (row %). Ultrasonography was the reference standard. Confidence intervals for proportions were calculated using the Wilson method. FLI, Fatty Liver Index; ROC, receiver operating characteristic; AUC, area under the curve; SE, standard error.

Factors Associated with Ultrasound-confirmed Steatosis

Participants with ultrasound-confirmed steatosis were younger and had higher BMI, greater waist circumference, and higher ALT and GGT concentrations than participants without steatosis (all $p < 0.05$). HbA1c, AST, and triglyceride concentrations did not differ significantly between groups. Steatosis was present in 75.0% of male and 69.3% of female participants ($\chi^2 = 0.400$, $p = 0.527$). In the multivariable model containing age, BMI, ALT, GGT, and sex, BMI was the only statistically significant independent predictor: each 1 kg/m² increase in BMI was associated with 27% higher odds of ultrasound-confirmed steatosis (adjusted OR 1.270, 95% CI 1.121–1.438; $p < 0.001$). Age, ALT, GGT, and sex were not independently associated with steatosis after adjustment. Model fit was acceptable (Hosmer–Lemeshow $p = 0.590$), Nagelkerke R^2 was 0.339, and overall classification accuracy was 80.6%. Results are shown in Table 3.

Table 3. Comparison of participants with and without ultrasound-confirmed steatosis and multivariable logistic regression analysis.

Part A. Comparison of participants with and without ultrasound-confirmed steatosis

Variable	No steatosis	Steatosis present	Mean difference	p-value
Age (years)	53.44 ± 10.36	48.59 ± 10.01	4.85	0.017
BMI (kg/m²)	25.10 ± 4.09	29.65 ± 5.32	−4.54	<0.001
Waist (cm)	93.30 ± 10.21	102.17 ± 11.99	−8.86	<0.001
HbA1c (%)	9.96 ± 2.46	8.97 ± 2.36	0.99	0.094
AST (U/L)	36.81 ± 42.49	39.05 ± 21.14	−2.24	0.798
ALT (U/L)	32.06 ± 32.02	44.81 ± 32.08	−12.75	0.047
GGT (U/L)	34.49 ± 28.80	57.67 ± 50.76	−23.18	0.002
Triglycerides (mg/dL)	198.33 ± 154.54	193.38 ± 96.88	4.96	0.859

Part B. Multivariable binary logistic regression for ultrasound-confirmed steatosis

Predictor	Adjusted OR	95% CI	Wald χ^2	p-value
Age (per year)	0.960	0.915–1.009	2.611	0.106
BMI (per kg/m²)	1.270	1.121–1.438	14.185	<0.001
ALT (per U/L)	1.001	0.982–1.021	0.013	0.908
GGT (per U/L)	1.012	0.995–1.028	1.876	0.171
Male sex (vs female)	2.764	0.899–8.497	3.147	0.076

Model performance: Nagelkerke $R^2 = 0.339$; Hosmer–Lemeshow $\chi^2 = 6.514$, df = 8, $p = 0.590$; overall classification accuracy = 80.6%. Part A values are mean ± SD. Group sizes were no steatosis n = 36 and steatosis n = 88; HbA1c was available in 23 and 60 participants and AST in 16 and 37 participants, respectively. GGT and triglyceride inferential tests used log-transformed values with Welch correction where appropriate, while descriptive values are shown in original units. OR, odds ratio; CI, confidence interval; BMI, body mass index; ALT, alanine aminotransferase; GGT, gamma-glutamyl transferase; AST, aspartate aminotransferase.

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HEALTH AND REHABILITATION

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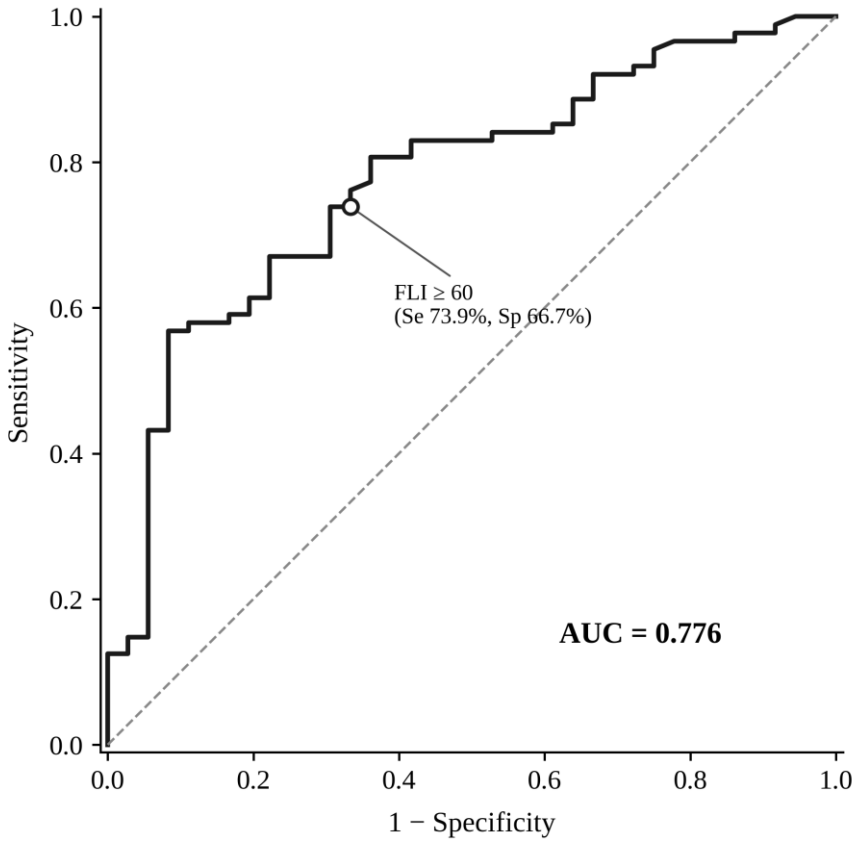

Figure 1. *Receiver operating characteristic (ROC) curve showing the diagnostic performance of the Fatty Liver Index for ultrasound-confirmed steatotic liver disease. The area under the curve was 0.776. The marked point indicates the conventional FLI cut-off of 60 (sensitivity 73.9%, specificity 66.7%).*

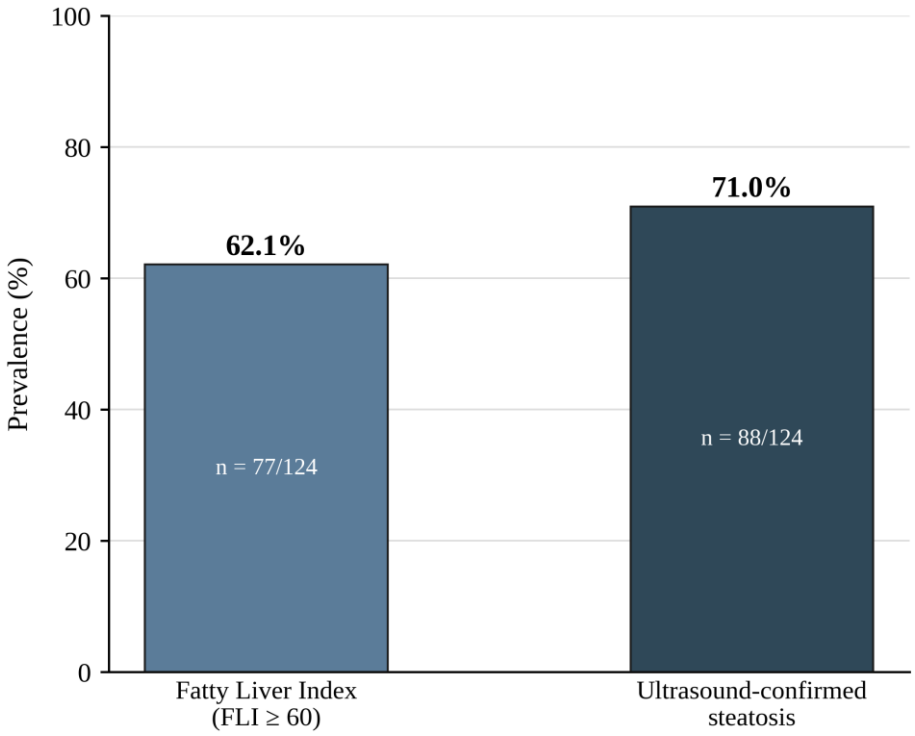

Figure 2. *Proportion of the study population (n = 124) classified as having steatotic liver disease by the Fatty Liver Index threshold of ≥60 and by abdominal ultrasonography.*

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DISCUSSION

This study demonstrated a substantial burden of hepatic steatosis among patients with type 2 diabetes mellitus: 71.0% had steatosis on ultrasonography and 62.1% had FLI ≥60. The FLI showed acceptable discrimination (AUC 0.776) but only fair agreement with ultrasonography. At the conventional ≥60 threshold, the high positive predictive value supported its usefulness for identifying participants likely to have steatosis, whereas the lower sensitivity and negative predictive value showed that an FLI below 60 could not reliably exclude disease. BMI was the only independent predictor of ultrasound-confirmed steatosis after adjustment for age, sex, ALT, and GGT. The observed prevalence is consistent with the recognized high burden of MASLD in people with type 2 diabetes. Recent studies have shown frequent ultrasound-detected steatosis and substantial previously unrecognized liver disease in diabetic populations. Hadadi et al. reported a high prevalence of MASLD among patients with type 2 diabetes using ultrasound, while Forlano et al. demonstrated that systematic community-based assessment in people with type 2 diabetes identifies many additional cases. Ajmera et al. similarly documented a high burden of steatosis, advanced fibrosis, and cirrhosis in prospectively assessed people with type 2 diabetes (18–20). These findings support targeted assessment in metabolically high-risk populations.

The FLI classified fewer participants as affected than ultrasonography and missed 23 of 88 ultrasound-positive participants at the ≥60 threshold. This explains the observed sensitivity of 73.9% and the negative predictive value of 51.1%. Vamja et al. also reported useful diagnostic performance of FLI against ultrasound, although performance estimates differed from those observed in the present study (12). Differences in population characteristics, disease prevalence, ethnicity, degree of metabolic risk, and ultrasound interpretation can influence diagnostic indices. The present findings therefore support use of FLI as a risk-stratification tool rather than as a stand-alone replacement for imaging. The interpretation of FLI <60 requires particular caution because scores of 30–59 represent an intermediate category in the original FLI framework. In the present binary diagnostic analysis, intermediate scores were grouped with scores <30 so that the conventional high-probability cut-off of ≥60 could be tested directly. This approach is clinically transparent but lowers the ability of the negative category to rule out steatosis. When resources permit, retaining the three-category FLI interpretation may better distinguish low, indeterminate, and high probability groups.

Adiposity was strongly related to steatosis. Participants with steatosis had higher BMI and waist circumference, and BMI remained independently associated with steatosis in the adjusted model. This is biologically plausible because excess adiposity promotes insulin resistance, increased lipolysis, hepatic delivery of free fatty acids, and triglyceride accumulation. Contemporary MASLD guidance recognizes obesity and type 2 diabetes as major cardiometabolic drivers of steatotic liver disease (3,7,14,16). The finding that age was lower in the steatosis group on unadjusted comparison but not independently associated after adjustment also illustrates the importance of considering correlated metabolic factors rather than interpreting isolated group differences as causal. ALT and GGT were higher in participants with steatosis in unadjusted analyses but were not independently associated after multivariable adjustment. AST, HbA1c, and triglycerides were not significantly different between groups. These findings are consistent with the clinical principle that aminotransferase concentrations alone are insufficient to exclude steatotic liver disease. Current guidance recommends risk-based evaluation rather than reliance on liver enzymes alone, particularly in people with type 2 diabetes and obesity (7,14,16).

FLI estimates the probability of hepatic steatosis and does not determine the presence of steatohepatitis or clinically significant fibrosis. This distinction is important because fibrosis stage is a major determinant of liver-related prognosis. Individuals identified as being at increased risk by FLI and/or imaging may therefore require additional fibrosis risk stratification using validated blood-based scores and, when indicated, elastography. Contemporary guidance supports sequential non-invasive approaches for fibrosis assessment in metabolically at-risk populations (7,14–16). More advanced tools such as FAST and AGILE scores can further stratify selected patients when elastography data are available (8–10), while other validated scores may be useful in specific populations (11,17). The study has several limitations. Its cross-sectional design precludes causal or longitudinal inference, and the single-center hospital-based sample may limit generalizability to community populations. The sample was predominantly female, and the relatively small number of participants without steatosis may have reduced precision of some regression estimates. HbA1c and AST were available in smaller subsets than the main diagnostic variables. Conventional ultrasonography is operator dependent and has lower sensitivity for mild steatosis than more quantitative imaging methods. In addition, the analysis focused on steatosis and did not directly stage fibrosis. These limitations should be considered when interpreting the diagnostic performance and associated-factor analyses.

CONCLUSION

Steatotic liver disease was common among patients with type 2 diabetes mellitus in this hospital-based study. The Fatty Liver Index showed acceptable overall discrimination and a high positive predictive value at the conventional ≥60 threshold, but its modest sensitivity and low negative predictive value indicate that values below 60 should not be used alone to exclude steatosis. BMI was the only independent predictor of ultrasound-confirmed steatosis in the multivariable model. The FLI may therefore be useful for initial risk stratification, while imaging and fibrosis-focused assessment should be considered according to clinical risk and available resources.

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