

Original Article

Exploring Ultrasonography Reliability and Affordability for NAFLD Grading: Insights From Liver Biomarker's Correlation in Pakistan

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ABSTRACT

Background: Non-alcoholic fatty liver disease (NAFLD) is a common metabolic liver disorder associated with diabetes mellitus, hypertension, dyslipidemia, obesity, sedentary lifestyle, and unhealthy dietary patterns. In resource-limited settings, abdominal ultrasonography and routine liver function tests may provide a practical approach for early assessment and monitoring of NAFLD. **Objective:** This study aimed to evaluate the relationship between ultrasound-based NAFLD grading and selected biochemical liver parameters among adults in Pakistan. **Methods:** This retrospective cross-sectional analytical study included 190 adults aged 18–70 years who underwent abdominal ultrasonography and liver function testing at selected hospitals and laboratories in Punjab, Pakistan. Patients with hepatitis B or C, alcoholic fatty liver disease, chronic liver disease, or drug-related liver disease were excluded. NAFLD was graded on ultrasound as Grade I, II, or III. Biochemical parameters included alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, total bilirubin, and serum albumin. Descriptive statistics and correlation analysis were performed using SPSS. **Results:** Of 190 participants, 96 (50.5%) were female and 94 (49.5%) were male, with a mean age of 40.84 ± 13.79 years. Grade I NAFLD was most frequent, affecting 115 participants (60.5%), followed by Grade II in 56 (29.5%) and Grade III in 19 (10.0%). ALT showed the strongest positive correlation with NAFLD grade ($r = 0.494$, $p < 0.05$), while AST ($r = 0.055$) and ALP ($r = 0.109$) showed weaker positive associations. Albumin showed a weak negative correlation ($r = -0.181$, $p = 0.013$), whereas bilirubin was not significantly correlated ($r = 0.136$, $p = 0.138$). **Conclusion:** Ultrasound-based NAFLD severity was associated with selected liver biochemical changes, particularly ALT elevation. Combining abdominal ultrasonography with routine liver function tests may support practical early assessment and monitoring of NAFLD in resource-limited clinical settings. **Keywords:** Non-alcoholic fatty liver disease, ultrasonography, liver enzymes, alanine aminotransferase, metabolic syndrome, Pakistan.

"Cite this Article" | Received: 10 November 2025; Accepted: 15 December 2025; Published: 31 December 2025

Author Contributions: Concept: MP; Methodology: MP; Data Collection: MP, HA, AA, DN, MK and SA; Analysis: MP; Drafting: HA; Supervision and Critical Review: QA and AJ. **Ethical Approval:** University of Management and Technology, Lahore, Pakistan. **Informed Consent:** Written informed consent was obtained from all participants; **Conflict of Interest:** The authors declare no conflict of interest; **Funding:** No external funding; **Data Availability:** Available from the corresponding author on reasonable request; **Acknowledgments:** N/A.

INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) is one of the most common chronic liver disorders worldwide and represents a growing metabolic health burden. It is characterized by excessive hepatic fat accumulation in individuals without significant alcohol intake or other secondary causes of liver disease. Although NAFLD is frequently associated with obesity, insulin resistance, type 2 diabetes mellitus, dyslipidemia, hypertension, and metabolic syndrome, it may also occur in individuals with normal body mass index, particularly in Asian populations where metabolic risk may develop at comparatively lower adiposity thresholds (1). The disease begins with hepatic steatosis driven largely by insulin resistance, increased free fatty acid flux, oxidative stress, and inflammatory pathways, and may progress from simple steatosis to non-alcoholic steatohepatitis, fibrosis, cirrhosis, liver failure, and hepatocellular carcinoma if not detected and managed early (2).

The clinical importance of NAFLD extends beyond the liver because it is closely linked with systemic metabolic dysfunction and cardiovascular risk. Many patients with NAFLD have coexisting metabolic syndrome, and the presence of hepatic steatosis may reflect broader cardiometabolic disease activity rather than an isolated hepatic abnormality (3). In Asia, NAFLD has become a major cause of persistent liver disease, with increasing prevalence attributed to urbanization, sedentary behavior, dietary transition, obesity, and rising rates of diabetes and dyslipidemia (4). Since cardiovascular disease is among the leading causes of morbidity and mortality in patients with NAFLD, early identification of hepatic steatosis and its metabolic associations is clinically important for risk stratification, lifestyle intervention, and prevention of disease progression (5).

Lifestyle-related factors play a central role in the development and progression of NAFLD. Diets rich in fried foods, refined carbohydrates, and energy-dense processed foods, together with reduced physical activity, contribute to obesity, insulin resistance, dyslipidemia, and hepatic fat deposition (6). Lifestyle modification, including weight control, dietary improvement, and regular physical activity, remains the cornerstone of NAFLD management because no single pharmacological therapy is universally recommended for all patients (7). However, timely diagnosis is essential because patients with more advanced fibrosis are at greater risk of liver-related complications, and early-stage disease is more responsive to behavioral and metabolic intervention (8).

Despite the clinical importance of NAFLD, its diagnosis and grading remain challenging in many low- and middle-income healthcare settings. Liver biopsy is considered a reference standard for identifying steatohepatitis and fibrosis, but it is invasive, costly, prone to sampling error, and unsuitable for routine screening. Advanced imaging methods such as magnetic resonance imaging proton-density fat fraction and transient elastography provide more detailed assessment, but their availability and cost may limit their use in routine clinical practice. Ultrasonography, by contrast, is widely available, non-invasive, affordable, and commonly used as a first-line imaging modality for detecting hepatic steatosis. However, ultrasound-based grading is operator-dependent and may have reduced sensitivity for mild steatosis, making it important to evaluate its relationship with routinely available biochemical markers (9,10).

Routine liver biochemical parameters, including alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, bilirubin, and albumin, are inexpensive and easily accessible tests used in clinical assessment of liver function and injury. These markers may provide additional information when interpreted alongside ultrasonographic findings, particularly in settings where advanced diagnostic tools are unavailable. However, liver enzymes may remain normal in some patients with NAFLD, and abnormal values are not specific to fatty liver disease. Therefore, the clinical value of combining ultrasound grading with biochemical parameters depends on whether these markers show meaningful associations with increasing ultrasonographic severity.

In Pakistan, where the burden of metabolic disorders is increasing and access to advanced imaging may be limited, a practical diagnostic approach using abdominal ultrasonography and routine liver function tests could support early detection and monitoring of NAFLD in high-risk populations. Nevertheless, local evidence remains limited regarding how ultrasound-based NAFLD grades correlate with liver biochemical markers among Pakistani adults with metabolic risk factors. Addressing this gap may help clarify whether routine blood parameters can strengthen the interpretation of ultrasound findings and guide early clinical decision-making in resource-constrained settings.

Therefore, this study was conducted among adults in Pakistan undergoing abdominal ultrasonography and liver function testing to evaluate the relationship between ultrasonographic grades of NAFLD and selected biochemical blood parameters. The study population comprised adults with metabolic risk factors such as diabetes mellitus, hypertension, dyslipidemia, obesity, sedentary lifestyle, or normal body mass index with suspected fatty liver disease; the index assessment was ultrasound-based NAFLD grading; the biochemical comparison included liver function parameters such as alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, bilirubin, and albumin; and the

primary outcome was the strength and direction of association between ultrasound grade and biochemical markers. The objective of the study was to determine whether increasing ultrasonographic severity of NAFLD is associated with measurable changes in routine liver biochemical parameters in a Pakistani clinical population.

MATERIALS AND METHODS

This retrospective cross-sectional analytical study was conducted to evaluate the association between ultrasonographic grading of non-alcoholic fatty liver disease and selected biochemical liver parameters among adult patients in Pakistan. The study used an observational design because the exposure and outcome variables had already been recorded as part of routine clinical assessment, and no intervention was assigned by the investigators. The primary analytical objective was to determine whether increasing ultrasonographic severity of fatty liver was associated with measurable changes in liver function parameters, including alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, total bilirubin, and serum albumin.

The study was carried out in hospital and laboratory settings in Punjab, Pakistan, including Hameed Latif Hospital, Ghurki Trust Hospital, Shalamar Hospital Lahore, and Niazi Hospital Sargodha. These centres were selected because they had functional radiology departments with abdominal ultrasonography facilities and clinical laboratories capable of performing routine liver function testing. Data were obtained from patient questionnaires, ultrasound reports, and biochemical laboratory reports. All records were reviewed using a standardized data collection approach to ensure uniform extraction of demographic, clinical, lifestyle, imaging, and biochemical variables.

The study population consisted of adult male and female patients aged 18 to 70 years who were referred for abdominal ultrasonography and liver function testing and were diagnosed with fatty liver on ultrasound. Eligible participants included individuals with clinical or lifestyle risk factors associated with NAFLD, such as type 2 diabetes mellitus, hypertension, dyslipidemia, metabolic syndrome, increased body mass index, sedentary lifestyle, frequent consumption of fried or junk foods, or suspected fatty liver despite normal body mass index. Patients were excluded if they had a known history of hepatitis B or hepatitis C infection, alcoholic fatty liver disease, chronic liver disease of another established cause, history of addictive drug use, or fatty liver attributable to prolonged alcohol exposure or other secondary causes. Written informed consent was obtained from participants before inclusion, and only patients fulfilling the eligibility criteria were included in the final analysis.

A total of 190 participants were included. The sample size was estimated using the single population proportion formula based on the reported prevalence range of NAFLD in Pakistan. A prevalence estimate of 14% was selected as the lower bound, with a 95% confidence level, a Z value of 1.96, and a margin of error of 5%. The minimum calculated sample size was 185 participants, and the final sample was increased to 190 to account for incomplete or unusable records. Both male and female participants were included to allow assessment of the distribution of NAFLD grades across sex and age categories (11).

Ultrasonographic assessment of the liver was performed using a standardized abdominal scanning technique. The liver was examined in longitudinal and transverse planes, with assessment of hepatic echogenicity, liver size, visualization of intrahepatic vascular structures, diaphragm definition, and the presence of associated abnormalities such as hepatomegaly, coarse hepatic echotexture, or portal vein dilatation. NAFLD severity was categorized into Grade I, Grade II, and Grade III according to the degree of increased hepatic echogenicity and visibility of intrahepatic vessels and posterior hepatic structures. Grade I represented mild fatty infiltration, Grade II represented moderate fatty infiltration, and Grade III represented severe fatty infiltration. Ultrasound grade was treated as an ordinal outcome variable for statistical analysis.

Biochemical data were obtained from liver function test reports performed as part of the participants' clinical evaluation. The biochemical variables included alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, total bilirubin, and serum albumin. These parameters were selected because they are routinely available, clinically relevant indicators of hepatocellular injury, cholestatic change, bilirubin metabolism, and hepatic synthetic function. Demographic and clinical variables included age, sex, history of type 2 diabetes mellitus, hypertension, hyperlipidemia, current medication use for diabetes or hypertension, history of other liver disease, family history of liver disease or metabolic disorders, smoking or tobacco use, special dietary practice, frequency of junk or fried food consumption, and frequency of physical activity. The principal exposure variable was ultrasonographic NAFLD grade, categorized as Grade I, Grade II, or Grade III. The main biochemical outcome variables were serum ALT, AST, ALP, total bilirubin, and albumin. Lifestyle variables were operationally categorized according to reported frequency, including daily, two to three times per week, rarely, or never for junk food or fried food intake and physical activity. Clinical comorbidities were recorded as present or absent based on patient history and available clinical information. Age was analyzed as a continuous variable for mean estimation and was also grouped into age categories for descriptive presentation.

Data were entered and analyzed using SPSS software. Descriptive statistics were calculated for all study variables. Continuous variables were summarized using mean and standard deviation, while categorical variables were summarized using frequencies and percentages. The distribution of NAFLD grades was presented as frequency and percentage. Mean age was compared across NAFLD grades, and the distribution of demographic, clinical, and lifestyle characteristics was described according to the study objectives. Correlation analysis was performed to assess the direction and strength of association between ultrasound-based NAFLD grade and biochemical liver parameters. Because NAFLD grade is an ordinal variable, rank-based correlation was the preferred analytical approach for assessing relationships with biochemical markers. A p-value of less than 0.05 was considered statistically significant.

To reduce selection bias, participants were selected according to predefined inclusion and exclusion criteria from multiple centres rather than a single facility. To reduce information bias, data were extracted from documented ultrasound and laboratory reports rather than relying only on self-reported clinical information. Patients with viral hepatitis, alcoholic fatty liver disease, chronic liver disease, and drug-related liver disease were excluded to reduce confounding by alternative causes of abnormal liver echogenicity or altered biochemical parameters. Relevant metabolic and lifestyle variables, including diabetes, hypertension, dyslipidemia, dietary pattern, physical activity, smoking, and family history, were recorded to describe potential clinical factors associated with NAFLD severity. Data quality was maintained through standardized data collection from questionnaires, ultrasound reports, and laboratory records. Each participant record was reviewed for eligibility before entry into the dataset. Variables were coded consistently before analysis, and categorical responses were grouped using predefined categories. The final dataset included only participants with ultrasound-confirmed NAFLD grading and available liver function test results. Participant confidentiality was maintained throughout data handling and analysis by using study records only for research purposes. The study was conducted after approval from the Ethics Committee of the University of Management and Technology, Lahore, under approval number RE-112-2025. Written informed consent was obtained from all participants before data inclusion. The study received no external funding, and the authors declared no conflict of interest.

RESULTS

A total of 190 participants with ultrasound-diagnosed non-alcoholic fatty liver disease were included in the analysis. The study population showed an almost equal sex distribution, with 96 females (50.5%) and 94 males (49.5%). The mean age of the participants was 40.84 ± 13.79 years. When age was assessed according to ultrasonographic NAFLD grade, participants with Grade I disease had a mean age of 39.99 ± 14.15 years, those with Grade II disease had a mean age of 42.43 ± 12.89 years, and those with Grade III

disease had a mean age of 41.26 ± 14.41 years, indicating that moderate-grade NAFLD was observed in participants with a slightly higher mean age compared with mild and severe grades.

Table 1. Demographic Characteristics and Mean Age Across NAFLD Grades

Variable	Category / Grade	Frequency (n)	Percentage (%)	Mean Age \pm SD, years
Sex	Female	96	50.5	
Sex	Male	94	49.5	
Total participants	Overall	190	100.0	40.84 \pm 13.79
NAFLD grade by age	Grade I / Mild	115	60.5	39.99 \pm 14.15
NAFLD grade by age	Grade II / Moderate	56	29.5	42.43 \pm 12.89
NAFLD grade by age	Grade III / Severe	19	10.0	41.26 \pm 14.41

The age distribution showed that the largest proportion of participants belonged to the 30–39-year age group, comprising 43 participants (22.6%), followed closely by the 20–29-year age group with 42 participants (22.1%). Participants aged 50–59 years accounted for 37 cases (19.5%), while those aged 40–49 years accounted for 36 cases (18.9%). The youngest age category, 18–19 years, represented only 8 participants (4.2%), whereas 24 participants (12.6%) were aged 60–69 years. These findings show that NAFLD was most frequently observed in early and middle adulthood within this sample.

Table 2. Age Distribution of Study Participants

Age Group, years	Frequency (n)	Percentage (%)
18–19	8	4.2
20–29	42	22.1
30–39	43	22.6
40–49	36	18.9
50–59	37	19.5
60–69	24	12.6
Total	190	100.0

Ultrasonographic grading demonstrated that Grade I NAFLD was the most common category, observed in 115 participants (60.5%). Grade II NAFLD was identified in 56 participants (29.5%), while Grade III NAFLD was present in 19 participants (10.0%). This pattern indicates that most patients were diagnosed at a mild stage, with progressively fewer participants presenting with moderate and severe ultrasonographic grades.

Table 3. Distribution of NAFLD Grades on Ultrasonography

Ultrasound-Based NAFLD Grade	Severity Category	Frequency (n)	Percentage (%)
Grade I	Mild	115	60.5
Grade II	Moderate	56	29.5
Grade III	Severe	19	10.0
Total	—	190	100.0

Correlation analysis was performed to assess the relationship between ultrasonographic NAFLD grade and liver biochemical parameters. Alanine aminotransferase showed the strongest positive correlation with NAFLD grade ($r = 0.494$, $p < 0.05$), indicating that ALT levels increased as ultrasonographic severity increased. Aspartate aminotransferase showed a very weak positive correlation with NAFLD grade ($r = 0.055$, $p < 0.05$), while alkaline phosphatase also showed a weak positive correlation ($r = 0.109$, $p < 0.05$). Albumin demonstrated a weak negative correlation with NAFLD grade ($r = -0.181$, $p = 0.013$), suggesting that albumin levels tended to decrease slightly with increasing NAFLD severity. Total bilirubin showed a weak positive but statistically non-significant correlation with NAFLD grade ($r = 0.136$, $p = 0.138$).

Table 4. Correlation Between Ultrasonographic NAFLD Grade and Liver Biochemical Parameters

Biochemical Parameter	Correlation Coefficient (r)	Direction of Association	Strength of Association	p-value
Alanine aminotransferase	0.494	Positive	Moderate	<0.05
Aspartate aminotransferase	0.055	Positive	Very weak	<0.05
Alkaline phosphatase	0.109	Positive	Weak	<0.05
Total bilirubin	0.136	Positive	Weak	0.138
Serum albumin	-0.181	Negative	Weak	0.013

Clinical and lifestyle characteristics showed a high burden of metabolic and behavioral risk factors among participants. Type 2 diabetes mellitus was present in 51 participants (26.8%), hypertension in 72

participants (37.9%), and hyperlipidemia in 74 participants (38.9%). A total of 68 participants (35.8%) were taking specific medications for diabetes or hypertension. A history of liver disease other than fatty liver was reported by 10 participants (5.3%), while 58 participants (30.5%) had a family history of liver disease or metabolic disorders. Smoking or tobacco use was reported by 57 participants (30.0%), and 37 participants (19.5%) were following a special diet for diabetes or hypertension. Regarding dietary pattern, 114 participants (60.0%) consumed junk food or fried items two to three times per week, while 14 participants (7.4%) consumed these foods daily. Physical activity was reported daily by 8 participants (4.2%), two to three times per week by 112 participants (58.9%), rarely by 60 participants (31.6%), and never by 10 participants (5.3%).

Table 5. Clinical, Lifestyle, and Dietary Characteristics of Participants

Variable	Category	Frequency (n)	Percentage (%)
Type 2 diabetes mellitus	Present	51	26.8
Hypertension	Present	72	37.9
Hyperlipidemia	Present	74	38.9
Medication for diabetes or hypertension	Present	68	35.8
Other liver disease history	Present	10	5.3
Family history of liver disease/metabolic disorder	Present	58	30.5
Smoking or tobacco use	Present	57	30.0
Special diet for diabetes or hypertension	Present	37	19.5
Junk/fried food intake	Daily	14	7.4
Junk/fried food intake	2-3 times/week	114	60.0
Junk/fried food intake	Rarely	46	24.2
Junk/fried food intake	Never	16	8.4
Physical activity	Daily	8	4.2
Physical activity	2-3 times/week	112	58.9
Physical activity	Rarely	60	31.6
Physical activity	Never	10	5.3

Overall, the results indicate that mild NAFLD was the predominant ultrasonographic grade in this study population, accounting for more than three-fifths of all cases. ALT showed the clearest biochemical relationship with increasing NAFLD severity, while albumin showed a weak inverse relationship. Metabolic comorbidities, particularly hypertension, hyperlipidemia, and diabetes, were common among participants, and frequent intake of junk or fried foods was reported by most patients. These findings support the clinical relevance of combining ultrasonographic grading with routine biochemical and metabolic assessment in patients with NAFLD.

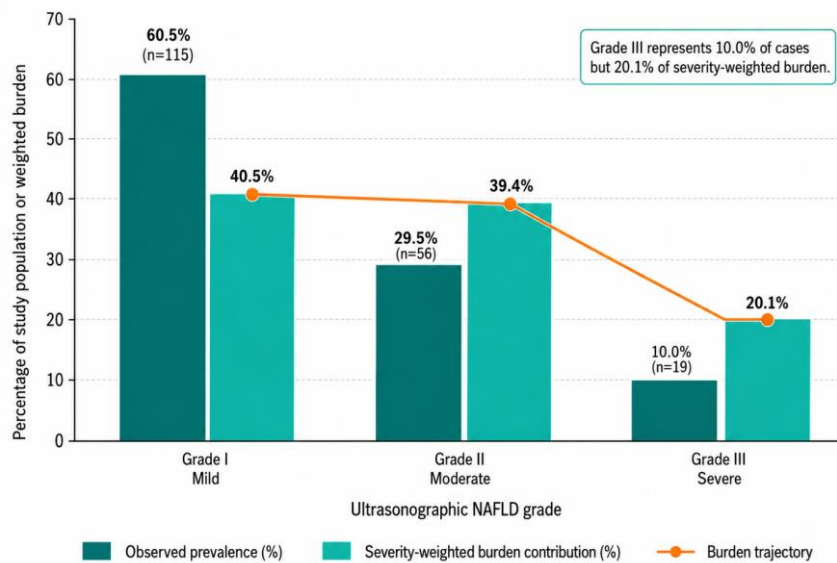


Figure 1. Distribution of Ultrasound-Graded NAFLD and Severity-Weighted Disease Burden

Figure description: Grade I NAFLD represented the largest observed proportion of cases, accounting for 115 of 190 participants (60.5%), whereas Grade II and Grade III accounted for 56 cases (29.5%) and 19 cases (10.0%), respectively. After weighting each category by ultrasonographic severity, the relative

contribution shifted substantially: Grade I contributed 40.5% of the total severity-weighted disease burden, Grade II contributed 39.4%, and Grade III contributed 20.1%. This pattern shows that although severe NAFLD was less frequent, its proportional clinical burden was approximately double its observed prevalence, highlighting the importance of interpreting NAFLD distribution not only by case frequency but also by severity-weighted impact.

DISCUSSION

The present study evaluated the relationship between ultrasonographic grading of non-alcoholic fatty liver disease and selected liver biochemical parameters among 190 adults in Pakistan. The findings showed that Grade I NAFLD was the most frequent ultrasonographic category, affecting 115 participants, followed by Grade II in 56 participants and Grade III in 19 participants. This distribution suggests that most patients were identified at a mild stage of fatty liver disease, which is clinically important because early-stage NAFLD offers a greater opportunity for lifestyle modification, metabolic risk control, and prevention of progression to steatohepatitis, fibrosis, and cirrhosis. The mean age of the study population was 40.84 years, and the highest number of participants belonged to the 30–39-year age group, indicating that NAFLD is not limited to older adults but is increasingly observed during early and middle adulthood.

A key finding of this study was the positive relationship between increasing ultrasound grade and liver enzyme elevation, particularly alanine aminotransferase. ALT showed the strongest correlation with ultrasonographic severity, with a moderate positive association, indicating that ALT levels tended to rise as NAFLD grade increased. This finding is biologically plausible because ALT is primarily associated with hepatocellular injury and is commonly elevated in metabolic liver disease. In contrast, AST and ALP showed weaker positive correlations with ultrasound grade, suggesting that although these markers may rise with worsening fatty infiltration, their relationship with ultrasonographic severity is less pronounced than that of ALT. Albumin showed a weak negative correlation with NAFLD grade, indicating a slight decline with increasing disease severity, while bilirubin did not show a statistically significant association. These findings support the interpretation that routine biochemical markers, especially ALT, may provide useful supportive information when interpreted alongside ultrasound-based NAFLD grading, but they should not be considered stand-alone indicators of disease severity.

The predominance of Grade I NAFLD in this study is consistent with the concept that many patients with fatty liver disease are detected during earlier stages through routine abdominal ultrasound or metabolic evaluation. This pattern may also reflect increasing clinical awareness of fatty liver disease among patients with diabetes, hypertension, dyslipidemia, obesity, or sedentary lifestyle. However, the presence of Grade II and Grade III NAFLD in nearly two-fifths of the sample highlights that a substantial proportion of patients already had moderate to severe ultrasonographic involvement. Because ultrasonography detects hepatic steatosis through echogenic changes, reduced visualization of intrahepatic vessels, and attenuation of the ultrasound beam, higher grades are likely to reflect more extensive fat accumulation. When supported by abnormal biochemical markers, these findings may help clinicians identify patients who require closer metabolic assessment and follow-up.

The results also showed a considerable burden of metabolic comorbidities. Type 2 diabetes mellitus was present in 26.8% of participants, hypertension in 37.9%, and hyperlipidemia in 38.9%. These findings reinforce the close clinical relationship between NAFLD and metabolic dysfunction. Insulin resistance promotes increased lipolysis, hepatic free fatty acid influx, de novo lipogenesis, and triglyceride accumulation within hepatocytes, thereby contributing to hepatic steatosis and progressive metabolic injury. Hypertension and dyslipidemia further indicate systemic cardiometabolic risk, which is important because NAFLD is increasingly recognized not only as a liver disorder but also as a marker of broader metabolic and cardiovascular disease risk. Therefore, identifying NAFLD through ultrasound should

prompt evaluation of associated metabolic conditions rather than being treated as an isolated hepatic finding (12,13).

Lifestyle factors were also prominent in the study population. Frequent consumption of junk or fried foods was reported by most participants, with 60.0% consuming these foods two to three times per week and 7.4% consuming them daily. Physical activity patterns also suggested insufficient regular activity in a considerable proportion of participants, as only 4.2% reported daily physical activity, while 31.6% reported rare activity and 5.3% reported no activity. These patterns are clinically relevant because energy-dense diets and reduced physical activity contribute to obesity, insulin resistance, dyslipidemia, and hepatic fat deposition. The clustering of unhealthy dietary patterns limited physical activity, and metabolic comorbidities in this population supports the need for integrated lifestyle-focused management strategies for NAFLD.

The findings align with regional evidence showing that ultrasound-based NAFLD grades are associated with metabolic and biochemical abnormalities. A recent Pakistani study reported significant correlations between ultrasonographic fatty liver grades and blood parameters, including triglycerides, cholesterol fractions, and fasting blood sugar, supporting the usefulness of combining imaging with routine biochemical assessment in clinical practice (14). Similarly, evidence from family-based NAFLD research has shown that first-degree relatives of patients with NAFLD have a high prevalence of fatty liver disease, with age, body mass index, and elevated liver enzymes acting as important predictors (15). These findings are consistent with the present study, where ultrasound-diagnosed NAFLD was frequently accompanied by metabolic risk factors and biochemical changes, particularly ALT elevation.

The local relevance of these findings is further supported by evidence showing a substantial burden of NAFLD in Pakistan. A recent systematic review and meta-analysis reported that NAFLD is highly prevalent in the Pakistani population and is especially common among individuals with metabolic risk factors such as obesity, diabetes, and hypertension (16). The present study adds clinically useful information by moving beyond prevalence alone and describing the distribution of ultrasound-based severity grades together with liver biochemical correlations. This is important because knowing the presence of NAFLD is not sufficient for clinical decision-making; understanding whether patients have mild, moderate, or severe involvement can help guide monitoring intensity, counseling, and risk-factor management.

The combined use of ultrasonography and routine liver function testing offers a practical approach in resource-limited settings. Ultrasound is non-invasive, widely available, relatively affordable, and suitable for first-line assessment of hepatic steatosis. Liver function tests are also inexpensive and repeatable, making them useful for follow-up and monitoring. In this study, the relationship between ultrasound grade and ALT was the clearest biochemical association, suggesting that ALT may be the most informative routine liver enzyme when evaluating increasing ultrasonographic severity. However, the weak associations observed for AST, ALP, and albumin indicate that biochemical tests should be interpreted as complementary tools rather than definitive measures of NAFLD severity.

Several methodological considerations should be acknowledged when interpreting these findings. The cross-sectional design allows assessment of association but does not establish temporal or causal relationships between metabolic risk factors, biochemical abnormalities, and increasing NAFLD grade. Ultrasonography is also operator-dependent and may be less sensitive for mild steatosis compared with advanced imaging modalities. In addition, liver biopsy and advanced quantitative imaging techniques were not used; therefore, histological features such as steatohepatitis, ballooning, inflammation, and fibrosis could not be assessed. Despite these limitations, the study provides clinically relevant evidence from a Pakistani population and supports the practical role of ultrasound combined with routine biochemical testing for initial NAFLD assessment.

Overall, the study demonstrates that mild NAFLD was the most common ultrasonographic grade, while ALT showed the strongest biochemical association with increasing severity. The high frequency of diabetes, hypertension, hyperlipidemia, frequent fried food intake, and low daily physical activity highlights the metabolic and lifestyle context in which NAFLD occurs. These findings emphasize the need for early screening among individuals with metabolic risk factors, structured lifestyle counseling, and routine biochemical monitoring (17). In settings where advanced imaging is not readily accessible, ultrasound-based grading supported by liver biochemical parameters may provide a clinically useful and feasible approach for identifying and monitoring patients with NAFLD.

CONCLUSION

This study demonstrated that Grade I NAFLD was the most common ultrasonographic finding among the study population, followed by Grade II and Grade III, indicating that most patients were identified at a mild stage of disease. Increasing ultrasound-based NAFLD severity showed a measurable relationship with liver biochemical parameters, particularly ALT, which demonstrated the strongest positive association with NAFLD grade, while AST and ALP showed weaker positive associations and albumin showed a weak inverse association. The frequent presence of diabetes mellitus, hypertension, hyperlipidemia, unhealthy dietary habits, and limited regular physical activity further supports the close relationship between NAFLD and metabolic risk factors. These findings suggest that abdominal ultrasonography, when interpreted alongside routine liver function tests and clinical risk assessment, provides a practical, accessible, and clinically useful approach for the early identification and monitoring of NAFLD in resource-limited settings. Early detection through this combined approach may support timely lifestyle modification, metabolic control, and follow-up strategies aimed at reducing progression to more advanced liver disease.

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