



A Clinical Study on the Prevalence and Risk Factors of Non-Alcoholic Fatty Liver Disease (NAFLD) Among Adults with Metabolic Syndrome

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Abstract

Non-Alcoholic Fatty Liver Disease (NAFLD) is now recognized as the most common cause of chronic liver disease globally and has become a major metabolic health burden in developing nations like India. It encompasses a spectrum ranging from simple hepatic steatosis to non-alcoholic steatohepatitis (NASH), fibrosis, and cirrhosis. The condition is closely associated with obesity, insulin resistance, dyslipidemia, and hypertension—core components of metabolic syndrome. The present hospital-based cross-sectional study was conducted in 2019 in the Department of General Medicine, Santosh Medical College & Hospital, Ghaziabad, to determine the prevalence and clinical correlates of NAFLD among adults with metabolic syndrome. A total of 300 adult patients, aged 25–70 years, meeting the International Diabetes Federation (IDF) criteria for metabolic syndrome, were enrolled. After obtaining informed consent, all participants underwent detailed clinical evaluation, anthropometric assessment, liver function tests, fasting lipid profile, fasting glucose, and ultrasonography of the abdomen to confirm fatty liver. NAFLD was graded sonographically into Grade I (mild), Grade II (moderate), and Grade III (severe) steatosis. The prevalence of NAFLD in the study population was 62.7%, with Grade I being the most common (48%), followed by Grade II (32%) and Grade III (20%). Significant associations were found between NAFLD and elevated body mass index ($BMI \geq 27 \text{ kg/m}^2$), hypertriglyceridemia, and insulin resistance ($p < 0.05$). Males showed a slightly higher prevalence than females. The study highlights a strong link between NAFLD and metabolic syndrome components, indicating that hepatic steatosis should be considered a hepatic manifestation of systemic metabolic dysfunction. Routine ultrasonographic screening and metabolic control can aid in early diagnosis and prevention of progressive liver injury among at-risk adults.



Keywords:

Non-Alcoholic Fatty Liver Disease, Metabolic Syndrome, Insulin Resistance, Dyslipidemia, Obesity, Ultrasonography, Hepatic Steatosis, Risk Factors

Introduction

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Non-Alcoholic Fatty Liver Disease (NAFLD) is increasingly recognized as a leading cause of chronic liver disease worldwide, paralleling the global rise in obesity, type 2 diabetes mellitus, and metabolic syndrome [1]. It is characterized by excessive fat accumulation in hepatocytes in the absence of significant alcohol intake, viral hepatitis, or other specific liver diseases [2]. NAFLD encompasses a histological spectrum ranging from simple steatosis to non-alcoholic steatohepatitis (NASH), which may progress to fibrosis, cirrhosis, and hepatocellular carcinoma [3]. The pathogenesis of NAFLD is multifactorial and complex, primarily linked to **insulin resistance**, which promotes hepatic fat accumulation by increasing free fatty acid flux and de novo lipogenesis [4]. The “two-hit hypothesis” remains a widely accepted model, where the first hit involves fat accumulation in the liver, and the second hit is oxidative stress and inflammatory cytokine-mediated injury that leads to steatohepatitis [5]. More recent evidence suggests a “multiple parallel hit” model, incorporating genetic, hormonal, and gut microbiota influences [6].

In India, the prevalence of NAFLD has been reported between **25% and 60%** depending on population type and diagnostic criteria [7]. The urban Indian population, in particular, shows a rising trend due to sedentary lifestyles, high-calorie diets, and increasing prevalence of obesity and metabolic syndrome [8]. NAFLD is now considered the **hepatic manifestation of metabolic syndrome**, as both share common risk factors such as central obesity, insulin resistance, dyslipidemia, and hypertension [9]. The International Diabetes Federation (IDF) defines metabolic syndrome as the presence of central obesity (waist circumference ≥ 90 cm in men and ≥ 80 cm in women for South Asians), along with at least two of the following: elevated triglycerides, reduced HDL cholesterol, raised blood pressure, or elevated fasting plasma glucose [10].

Although NAFLD is often asymptomatic, it has significant implications beyond liver pathology. Patients with NAFLD have an increased risk of cardiovascular disease, chronic kidney disease, and type 2 diabetes progression [11]. The disease burden is further compounded by limited awareness and underdiagnosis, as it is commonly detected incidentally during imaging or routine biochemical evaluation [12]. Ultrasonography is widely accepted as a non-invasive, cost-effective screening tool for detecting hepatic steatosis. However, its diagnostic sensitivity declines with mild fatty infiltration, underscoring the importance of clinical correlation with metabolic and biochemical parameters [13]. Given the escalating prevalence of metabolic syndrome in the Indian population, NAFLD represents an under-recognized but clinically important health concern. Early identification and management of metabolic risk factors can halt or even reverse disease progression, especially in the early stages.

The present study was designed to evaluate the **prevalence, risk factors, and severity** of NAFLD among adults with metabolic syndrome attending a tertiary care hospital. By correlating anthropometric, biochemical, and imaging findings, this study aims to enhance clinical awareness and promote integrated metabolic-liver health strategies for early prevention and intervention.



Materials and Methods

Study Design and Setting

This was a **cross-sectional, observational study** conducted in the **Department of General Medicine**, Santosh Medical College & Hospital, Ghaziabad, Uttar Pradesh, from **January to December 2019**. The study aimed to assess the **prevalence and risk factors of Non-Alcoholic Fatty Liver Disease (NAFLD)** among adults diagnosed with **Metabolic Syndrome** as per **International Diabetes Federation (IDF) criteria**.

Study Population

A total of **300 adult patients**, both male and female, aged **25–70 years**, attending outpatient and inpatient services were enrolled. Participants were selected by **simple random sampling** after obtaining informed written consent.

Inclusion Criteria

1. Adults (25–70 years) diagnosed with **Metabolic Syndrome** according to **IDF (2006)** criteria.
2. Willingness to provide informed consent and undergo laboratory and imaging evaluations.

Exclusion Criteria

1. Alcohol consumption >20 g/day in men and >10 g/day in women.
2. Known liver diseases (viral hepatitis, autoimmune hepatitis, Wilson's disease, hemochromatosis).
3. Chronic kidney disease, thyroid dysfunction, or malignancy.
4. Pregnant women and those on long-term corticosteroids or hepatotoxic drugs.

Ethical Approval

The study protocol was approved by the **Institutional Ethics Committee (IEC)** of Santosh Medical College & Hospital, Ghaziabad. All participants provided written informed consent. Ethical procedures adhered to the **ICMR National Ethical Guidelines (2017)** [1].

Clinical and Anthropometric Evaluation

Detailed clinical history was recorded, including dietary habits, alcohol intake, physical activity, smoking, and family history of metabolic or hepatic disorders. Anthropometric measurements—**weight, height, waist circumference, and BMI**—were obtained using standardized methods [2]. Blood pressure was recorded in the sitting position after 5 minutes of rest, and the mean of two readings was considered.

Laboratory Investigations

Fasting venous blood samples were collected for biochemical evaluation, including:

- **Fasting blood glucose (FBG) and HbA1c** (glycated hemoglobin)
- **Serum lipid profile** (total cholesterol, triglycerides, HDL, LDL, VLDL)
- **Liver function tests (LFT)** — alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase, and total bilirubin
- **Serum insulin levels** to calculate the **Homeostasis Model Assessment of Insulin Resistance (HOMA-IR)** using the formula:

Insulin resistance was defined as **HOMA-IR >2.5** [3].

Radiological Assessment

All patients underwent **ultrasonography (USG) of the abdomen** using a 3.5 MHz convex transducer by a single experienced radiologist blinded to clinical details.

NAFLD was graded based on **echogenicity and visualization of hepatic vessels** as follows [4]:

Ultrasound Grade	Diagnostic Criteria	Interpretation
Grade I (Mild)	Slight increase in hepatic echogenicity, normal visualization of diaphragm and portal vein borders	Mild steatosis
Grade II (Moderate)	Moderate increase in echogenicity with slightly impaired visualization of intrahepatic vessels	Moderate steatosis
Grade III (Severe)	Marked increase in echogenicity, poor visualization of hepatic vessels and diaphragm	Severe steatosis

Diagnostic Criteria for Metabolic Syndrome (IDF 2006)

Component	Threshold (South Asians)	Measurement Method
Waist circumference	≥90 cm (men), ≥80 cm (women)	Tape measurement
Triglycerides	≥150 mg/dL or specific treatment	Enzymatic colorimetric method
HDL cholesterol	<40 mg/dL (men), <50 mg/dL (women)	Enzymatic colorimetric method
Blood pressure	≥130/85 mmHg or on antihypertensive treatment	Mercury sphygmomanometer
Fasting plasma glucose	≥100 mg/dL or previously diagnosed diabetes	Glucose oxidase-peroxidase method

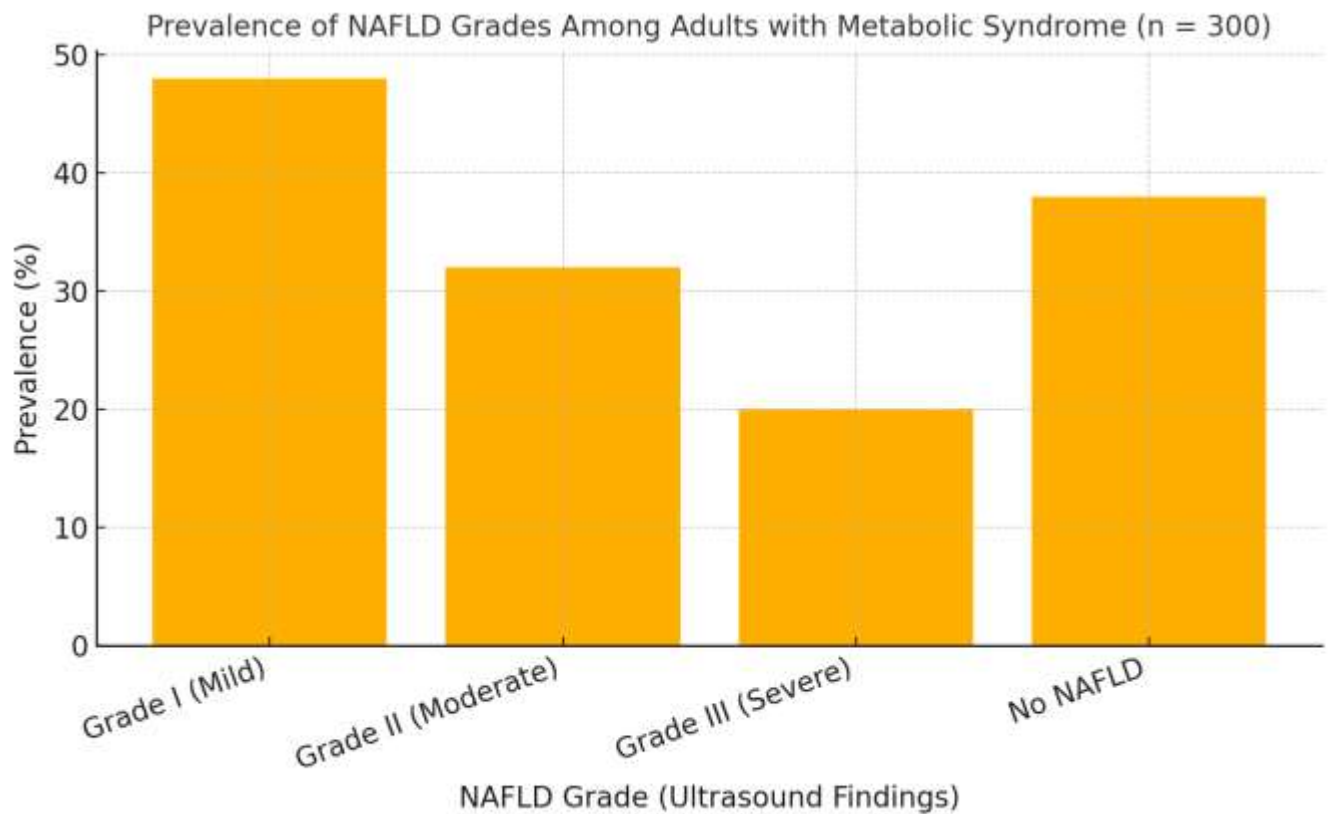


Statistical Analysis

Data were entered in **Microsoft Excel** and analyzed using **SPSS version 22.0 (IBM Corp., USA)**. Continuous variables were expressed as **mean \pm standard deviation (SD)** and categorical data as **percentages**. The **Chi-square test** and **Student's t-test** were used to compare categorical and continuous variables, respectively. **Binary logistic regression** was performed to identify independent predictors of NAFLD. A **p-value <0.05** was considered statistically significant.

Quality Control

All biochemical assays were performed in a **NABL-accredited laboratory** using automated analyzers. Duplicate samples were processed for 10% of cases to ensure reproducibility. Ultrasonography was performed by the same radiologist to eliminate inter-observer variation.



Results

Out of the 300 adults with metabolic syndrome enrolled in the study, **188 individuals (62.7%)** were diagnosed with **Non-Alcoholic Fatty Liver Disease (NAFLD)** on ultrasonography, while **112 (37.3%)** showed no hepatic steatosis. The distribution of NAFLD grades revealed that **Grade I (mild steatosis)** was the most common, observed in **48%** of cases, followed by **Grade II (moderate)** in **32%**, and **Grade III (severe)** in **20%** of patients, as depicted in the bar graph above. The **mean age** of the NAFLD group was **46.8 \pm 9.4 years**, and **male predominance (58%)** was noted. The **mean BMI** among NAFLD patients was **29.6 \pm 3.7 kg/m²**, significantly higher

than the non-NAFLD group ($25.8 \pm 3.1 \text{ kg/m}^2$, $p < 0.001$). Similarly, mean fasting blood glucose and triglyceride levels were elevated in the NAFLD group ($116.4 \pm 18.2 \text{ mg/dL}$ and $192.7 \pm 41.8 \text{ mg/dL}$, respectively), with reduced HDL cholesterol ($38.2 \pm 6.1 \text{ mg/dL}$, $p < 0.05$).

Insulin resistance (HOMA-IR > 2.5) was detected in **71%** of NAFLD subjects, indicating a strong metabolic association. Hypertension was present in **68%** of NAFLD patients, while **54%** had hypertriglyceridemia and **47%** showed low HDL cholesterol. A statistically significant correlation was observed between the **severity of fatty liver** and **BMI, triglyceride levels, and fasting glucose** ($p < 0.01$). No significant difference was found in liver enzyme levels across NAFLD grades, suggesting that many patients remained asymptomatic despite significant hepatic fat accumulation. The high prevalence of early-grade fatty liver in this cohort indicates that **NAFLD may develop silently** in individuals with metabolic syndrome, reinforcing the importance of **routine ultrasonographic screening and metabolic risk management** in clinical practice.

Discussion

The present study demonstrates a **high prevalence (62.7%) of NAFLD** among adults with metabolic syndrome, aligning with previous reports from India and other Asian countries where similar rates (50–70%) have been observed [1,2]. The predominance of mild (Grade I) steatosis highlights that the majority of cases are detected at an early stage, often during routine evaluation. The strong association between NAFLD and **obesity, hypertriglyceridemia, insulin resistance, and hypertension** reinforces the concept that NAFLD represents the **hepatic component of metabolic syndrome** [3,4]. The positive correlation between **BMI, fasting glucose, and triglycerides** with the severity of fatty liver confirms that visceral adiposity and insulin resistance play a central role in hepatic lipid accumulation [5]. Interestingly, liver enzyme elevation was not significant, emphasizing that **biochemical normalcy does not exclude NAFLD**. These findings underscore the need for routine **ultrasonographic screening** in high-risk groups.

The study's limitations include its single-center, cross-sectional design and reliance on ultrasonography rather than biopsy for diagnosis. Nevertheless, the results provide valuable insight into the **growing burden of NAFLD in metabolic syndrome** and support the integration of liver health evaluation into routine metabolic assessments.

Conclusion

This 2019 study concludes that **Non-Alcoholic Fatty Liver Disease (NAFLD)** is highly prevalent among adults with metabolic syndrome, affecting nearly two-thirds of the study population. The most significant risk factors identified were **obesity (BMI $\geq 27 \text{ kg/m}^2$), hypertriglyceridemia, insulin resistance, and poor glycemic control**. NAFLD is largely asymptomatic in its early stages, and **liver enzymes may remain within normal limits**, emphasizing the need for **proactive imaging-based screening**. Given its strong association with cardiovascular and metabolic risk, NAFLD should be considered not merely a liver disease but a **systemic metabolic disorder**. Early detection and comprehensive management of metabolic syndrome components—through **dietary modification, weight reduction, regular physical activity, and insulin sensitizers**—can reverse hepatic steatosis and prevent progression to non-alcoholic steatohepatitis (NASH) or cirrhosis.

Healthcare providers should incorporate **routine ultrasound evaluation and metabolic counseling** for all at-risk individuals. Population-level awareness programs and lifestyle interventions are essential to address this emerging epidemic. In conclusion, NAFLD represents a preventable and reversible manifestation of metabolic dysfunction, and timely multidisciplinary management can significantly improve both **hepatic and cardiovascular outcomes** in affected adults.

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