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Original Research Article

Association of Metabolic Syndrome with Ultrasonographic Severity of Non-Alcoholic Fatty Liver Disease

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Conflict of interest: Nil

Abstract

Background: Non-alcoholic fatty liver disease (NAFLD) is closely associated with obesity, insulin resistance and other metabolic abnormalities. The presence of metabolic syndrome may influence the severity of hepatic steatosis.

Objective: To assess the association between metabolic syndrome and ultrasonographic severity of NAFLD.

Materials and Methods: This observational study included 65 adults with ultrasonographically diagnosed NAFLD. Clinical, anthropometric and biochemical parameters were recorded. Metabolic syndrome was assessed using NCEP ATP III criteria, while hepatic steatosis was graded by abdominal ultrasonography.

Results: Metabolic syndrome was present in 34 (52.3%) participants. Grade 1, grade 2 and grade 3 steatosis were observed in 31 (47.7%), 24 (36.9%) and 10 (15.4%) participants, respectively. Among participants with metabolic syndrome, 94.1% had grade 2 or 3 steatosis compared with 6.5% among those without metabolic syndrome (P<0.001).

Conclusion: Metabolic syndrome was significantly associated with greater ultrasonographic severity of NAFLD.

Keywords: Non-alcoholic fatty liver disease, metabolic syndrome, ultrasonography, hepatic steatosis, obesity, waist-hip ratio.

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Introduction

Non-alcoholic fatty liver disease (NAFLD) is one of the most common chronic liver disorders worldwide, and its prevalence has increased alongside obesity, diabetes and other metabolic risk factors [1]. A large systematic review estimated the global prevalence of NAFLD at approximately 32%, highlighting its substantial and growing health burden [2]. The disease encompasses a spectrum ranging from uncomplicated steatosis to steatohepatitis, fibrosis and cirrhosis.

NAFLD has a close biological and clinical relationship with metabolic syndrome. Central obesity, insulin resistance, dyslipidaemia and hypertension contribute to hepatic fat accumulation and may promote progression of liver disease [3,4]. Current clinical recommendations therefore emphasize assessment of cardiometabolic risk factors in individuals with NAFLD [5]. Ultrasonography remains a practical and widely available method for detecting hepatic steatosis and categorizing its severity in routine clinical settings. Previous studies have demonstrated associations between ultrasonographic NAFLD grades and anthropometric or metabolic abnormalities, particularly BMI and lipid disturbances [6]. However, the relationship between the overall presence of metabolic syndrome and the degree of ultrasonographically detected steatosis remains clinically relevant, particularly in resource-limited settings.

The present study was therefore undertaken to evaluate the association between metabolic syndrome and ultrasonographic severity of NAFLD in patients attending a tertiary care hospital.

Materials and Methods

This was an observational hospital-based study conducted from January 2026 to June 2026 in the Department of General Medicine, Farookh Academy of Medical Education Hospital & Research Institute, Mysuru. A total of 65 patients diagnosed with NAFLD were included after fulfilling the predefined eligibility criteria.

Inclusion Criteria

Participants were included if they:

- Were aged ≥18 years.
- Had NAFLD diagnosed by abdominal ultrasonography.

Exclusion Criteria

Participants were excluded if they had:

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

Clinical and Anthropometric Assessment: A detailed history and physical examination were performed after obtaining informed consent. Weight, height, BMI, waist circumference, hip circumference and waist-hip ratio were recorded. Blood pressure was measured after adequate rest, and the average of three readings was recorded.

Ultrasonographic Assessment: Abdominal ultrasonography was performed using a high-resolution B-mode system. NAFLD was diagnosed based on increased hepatic echogenicity with characteristic attenuation and vascular blurring. Hepatic steatosis was graded as Grade 1 (mild), Grade 2 (moderate) or Grade 3 (severe).

Metabolic Syndrome Assessment: Metabolic syndrome was assessed according to NCEP ATP III criteria. The presence of three or more components—central obesity, raised triglycerides, reduced HDL cholesterol, elevated blood pressure or elevated fasting glucose—was considered diagnostic. Asian-Indian waist circumference cut-offs (≥90 cm in men and ≥80 cm in women) were used.

Laboratory Investigations: Fasting and post-prandial blood glucose, HbA1c, lipid profile and liver function tests were assessed along with routine investigations.

Statistical Analysis: Categorical variables were expressed as frequencies and percentages, while continuous variables were summarized using means or medians. ANOVA was used to compare means across NAFLD grades, Fisher's exact test to assess the association between metabolic syndrome and NAFLD severity, and Kruskal-Wallis test for waist-hip ratio. $P<0.05$ was considered statistically significant.

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

Results

A total of 65 patients with NAFLD were included. There were 38 (58.5%) males and 27 (41.5%) females. The largest proportion of participants belonged to the 51–60-year age group, comprising 28 (43.1%) participants. The mean age was 54.14±10.11 years.

Table 1: Age-wise distribution of study participants according to gender

Age in years	Males	Females	Total
≤ 40	08 (21.1%)	02 (7.4%)	10 (15.4)
41-50	07 (18.4%)	04 (14.8%)	11 (16.9)
51-60	12(31.6%)	16 (59.3%)	28 (43.1)
61-70	08 (21.1%)	05 (18.5%)	13 (20.0)
>70	03(7.9%)	00 (0.0%)	03 (4.6)

Participants aged 51–60 years constituted the largest age group (43.1%). Females predominated within this age category, while males were more frequent in the remaining age groups.

Table 2: Distribution of study participants according to body mass index

Body Mass Index	Number (n=65)	Percent (%)
Normal range	04	6.2%
Overweight	10	15.4%
Obese–I	27	41.5%
Obese–II	24	36.9%

Obesity was predominant in the study population. Obese class I accounted for 41.5% of participants, followed by obese class II at 36.9%. Only 6.2% had a normal BMI. The mean BMI was 28.39±3.70 kg/m².

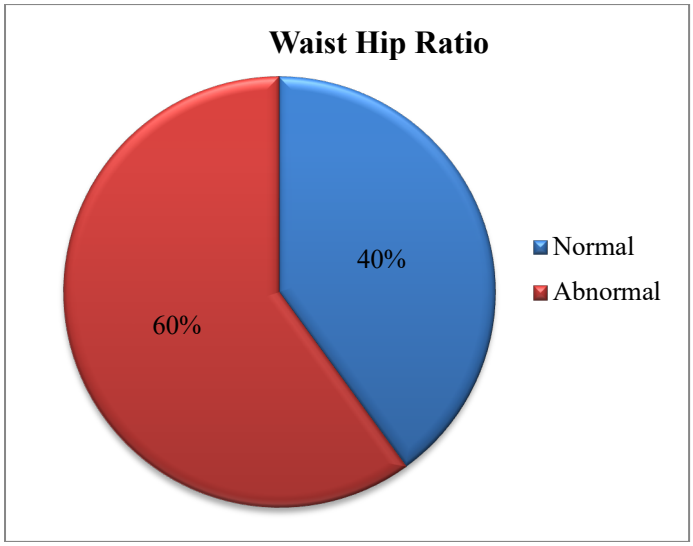

Figure 1: Distribution of study participants according to waist-hip ratio

The figure demonstrates that an abnormal waist-hip ratio was more common than a normal waist-hip ratio, being observed in 60% of the study population.

Table 3: Distribution of study participants according to ultrasonographic severity of NAFLD

USG	n (%)
Grade1(Mild steatosis)	31 (47.7%)
Grade2 (Moderate steatosis)	24 (36.9%)
Grade3 (Severe steatosis)	10 (15.4%)

Grade 1 mild steatosis was the most frequent ultrasonographic finding, affecting 47.7% of participants. Grade 2 and grade 3 steatosis were observed in 36.9% and 15.4%, respectively.

Table 4: Comparison of age and anthropometric measurements according to ultrasonographic severity of NAFLD

Parameters	Mean ± SD for Severity of NAFLD			P-value
	Grade 1	Grade 2	Grade 3	
Age	54.26 ± 9.05	54.46 ± 10.87	53.00 ± 12.24	0.927
Height	154.68 ± 6.66	154.00 ± 6.09	154.10 ± 5.89	0.92
Weight	67.26 ± 11.24	67.54 ± 11.64	70.50 ± 7.89	0.71
BMI	28.01 ± 3.79	28.37 ± 3.95	29.67 ± 2.74	0.47
Hip Circumference	100.61 ± 6.35	102.62 ± 6.55	102.90 ± 5.82	0.42

Mean weight, BMI and hip circumference showed a gradual increase with increasing ultrasonographic severity of NAFLD. However, none of the differences in age, height, weight, BMI or hip circumference across the three grades reached statistical significance (P>0.05).

Table 5: Association of ultrasonographic severity of NAFLD with metabolic syndrome

Metabolic syndrome	Grade 1	Grade 2/3	Total
Present	2 (5.9%)	32 (94.1%)	34
Absent	29 (93.5%)	2 (6.5%)	31

The table clearly demonstrates the concentration of moderate-to-severe NAFLD among participants with metabolic syndrome, in contrast to the predominance of mild steatosis among participants without metabolic syndrome.

Discussion

The present study demonstrates a strong association between metabolic syndrome and greater ultrasonographic severity of NAFLD. Metabolic syndrome was present in 34 of 65 participants (52.3%), and 94.1% of those with metabolic syndrome had grade 2 or 3 hepatic steatosis. In contrast, 93.5% of participants without metabolic syndrome had only grade 1 steatosis. The association was highly significant (P<0.001). This finding supports the close metabolic relationship between NAFLD and the cluster of obesity, dysglycaemia, hypertension and dyslipidaemia [7]. Obesity was prominent in the present cohort, with most participants classified as obese class I or II. Although BMI increased progressively from grade 1 to grade 3 NAFLD, the difference was not statistically significant. Similar studies have

demonstrated an association between BMI and ultrasonographic fatty liver grade, supporting the contribution of excess adiposity to hepatic fat accumulation [6]. The absence of statistical significance in our study may be related to the relatively small sample size and the high prevalence of obesity across all severity groups.

The study also showed that abnormal waist-hip ratio was present in 60.0% of participants. Central adiposity is particularly relevant to NAFLD because visceral fat is closely related to insulin resistance and abnormal lipid metabolism. Contemporary literature describes NAFLD and metabolic syndrome as interconnected conditions sharing several metabolic pathways, rather than independent disorders [3]. Current clinical guidance similarly recommends assessment of cardiometabolic risk factors in individuals with NAFLD [5].

The ultrasonographic distribution showed that mild steatosis was the most frequent category, followed by moderate and severe steatosis. Importantly, increasing severity was accompanied by a numerical rise in body weight, BMI and hip circumference. Although these differences were not statistically significant, the direction of change was consistent with previous ultrasonographic studies in which higher BMI and metabolic abnormalities were associated with more advanced grades of fatty liver [6].

The most clinically important finding was the marked difference in severity according to metabolic syndrome status. Participants with metabolic syndrome were overwhelmingly represented in the moderate-to-severe NAFLD group. Similar findings have been reported in studies evaluating ultrasonographic NAFLD severity, where increasing hepatic steatosis was associated with abnormalities in BMI and metabolic parameters [8]. The bidirectional relationship between NAFLD and metabolic syndrome has also been emphasized in contemporary reviews, with metabolic dysfunction contributing to hepatic steatosis while NAFLD may further increase cardiometabolic risk [3,9].

The findings have practical implications because ultrasonography is relatively accessible and can identify patients with hepatic steatosis, while simple clinical assessment can detect metabolic syndrome. Identifying both conditions together may therefore help clinicians recognize patients who require more intensive lifestyle and metabolic risk-factor management [10].

The study should, however, be interpreted in light of its limitations. Ultrasonography was used rather than liver biopsy, and the ultrasound grading was performed by a single expert. The purposive hospital-based sampling and relatively small sample size also limit generalizability.

Conclusion

Metabolic syndrome was significantly associated with greater ultrasonographic severity of NAFLD. Moderate-to-severe steatosis was present in 94.1% of participants with metabolic syndrome, compared with only 6.5% of those without metabolic syndrome. Obesity and abnormal waist-hip ratio were common among the study participants, while BMI showed a gradual, although statistically non-significant, increase with increasing NAFLD grade.

These findings suggest that patients with NAFLD should be routinely assessed for metabolic syndrome, as its presence may identify individuals with a greater burden of hepatic steatosis and cardiometabolic risk.

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