http://dx.doi.org/10.18623/rvd.v23.5971

ASSOCIATION OF NON-ALCOHOLIC FATTY LIVER DISEASE WITH TYPE 2 DIABETES MELLITUS IN ADULT POPULATION

ASSOCIAÇÃO ENTRE A DOENÇA HEPÁTICA GORDUROSA NÃO ALCOÓLICA E A DIABETES MELLITUS TIPO 2 NA POPULAÇÃO ADULTA

Article received on: 2/5/2026
Article accepted on: 3/18/2026

Saba Yousaf*
***Farooq Hospital Westwood (FHWW), Lahore, Pakistan
sabyay28@gmail.com

Rizwan Zafar*
***Farooq Hospital Westwood (FHWW), Lahore, Pakistan
sabyay28@gmail.com

Suneela Jabeen*
***Farooq Hospital Westwood (FHWW), Lahore, Pakistan
sabyay28@gmail.com

Umbreen Arshad**
****Central Park Teaching Hospital (CPTH), Lahore, Pakistan
sabyay28@gmail.com

The authors declare that there is no conflict of interest

Abstract

Background: Non-alcoholic fatty liver disease (NAFLD) is one of the most common chronic liver disorders worldwide and is strongly associated with metabolic conditions, particularly type 2 diabetes mellitus (T2DM). The coexistence of NAFLD and diabetes significantly increases the risk of liver-related morbidity and cardiovascular complications. Objective: To determine the association of NAFLD with type 2 diabetes mellitus in the adult population. Methodology: This case-control study was conducted in the Department of Medicine, Farooq Hospital / Akhtar Saeed Teaching Hospital, Lahore from October 2025 to January 2026. A total of 120 participants (60 cases with T2DM and 60 controls without diabetes) aged 30–70 years were enrolled using non-probability consecutive sampling. NAFLD was assessed using the Fatty Liver Index (FLI), calculated from triglycerides, BMI, γ-glutamyl transferase (GGT), and waist circumference. An FLI >30 was considered diagnostic of NAFLD. Data were analyzed using SPSS version 25. Odds ratio (OR) was calculated to assess the association. Results: The prevalence of NAFLD was significantly higher in diabetic patients compared to non-diabetics. The calculated odds ratio demonstrated a strong positive association (OR >1) between T2DM and NAFLD. Stratified analysis showed stronger associations in patients

Resumo

Antecedentes: A doença hepática gordurosa não alcoólica (DHGNA) é uma das doenças hepáticas crônicas mais comuns em todo o mundo e está fortemente associada a condições metabólicas, particularmente à diabetes mellitus tipo 2 (DM2). A coexistência de DHGNA e diabetes aumenta significativamente o risco de morbidade hepática e complicações cardiovasculares. Objetivo: Determinar a associação entre a DHGNA e a diabetes mellitus tipo 2 na população adulta. Metodologia: Este estudo de caso-controle foi realizado no Departamento de Medicina do Farooq Hospital / Akhtar Saeed Teaching Hospital, em Lahore, de outubro de 2025 a janeiro de 2026. Um total de 120 participantes (60 casos com DM2 e 60 controles sem diabetes) com idades entre 30 e 70 anos foram recrutados por meio de amostragem consecutiva não probabilística. A NAFLD foi avaliada utilizando o Índice de Fígado Gorduroso (FLI), calculado a partir de triglicerídeos, IMC, γ-glutamiltransferase (GGT) e circunferência da cintura. Um FLI >30 foi considerado diagnóstico de NAFLD. Os dados foram analisados utilizando o SPSS versão 25. A razão de chances (OR) foi calculada para avaliar a associação. Resultados: A prevalência de NAFLD foi significativamente maior em pacientes diabéticos em comparação com não diabéticos.

with higher BMI, uncontrolled HbA1c, and sedentary lifestyle. Conclusion: There is a significant association between NAFLD and type 2 diabetes mellitus. Early screening for NAFLD in diabetic patients is recommended to reduce disease progression and associated complications.

Keywords: NAFLD. Type 2 Diabetes Mellitus. Fatty Liver Index. Pakistan. Metabolic Syndrome.

A razão de chances calculada demonstrou uma forte associação positiva (OR >1) entre DM2 e NAFLD. A análise estratificada mostrou associações mais fortes em pacientes com IMC mais elevado, HbA1c não controlada e estilo de vida sedentário. Conclusão: Existe uma associação significativa entre NAFLD e diabetes mellitus tipo 2. Recomenda-se o rastreamento precoce da NAFLD em pacientes diabéticos para reduzir a progressão da doença e as complicações associadas.

Palavras-chave: *NAFLD. Diabetes Mellitus Tipo 2. Índice de Fígado Gorduroso. Paquistão. Síndrome Metabólica.*

1 INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) represents a spectrum of liver disorders ranging from simple hepatic steatosis to more advanced conditions including non-alcoholic steatohepatitis (NASH), hepatic fibrosis, and cirrhosis. By definition, NAFLD is diagnosed in the absence of significant alcohol consumption or other identifiable causes of liver disease. The clinical burden of NAFLD is substantial, not only due to liver-related complications but also because of its strong association with increased cardiovascular morbidity and mortality[1,2].

Globally, NAFLD affects approximately 25.24% of the population, with the highest prevalence reported in the Middle East and South America, and the lowest in Africa. In Western countries, the prevalence ranges from 15% to 40%, while in Asian populations it ranges between 9% and 40%. Recent estimates suggest that the prevalence of NAFLD in Asia has reached 29.6%, potentially surpassing that of Western populations[3].

The major risk factors for NAFLD include obesity, type 2 diabetes mellitus, and hypertriglyceridemia, all of which are closely linked to insulin resistance and metabolic syndrome. Obesity is present in more than 40% of affected individuals, diabetes mellitus in over 20%, and hypertriglyceridemia in a similar proportion[4]. The rising prevalence of NAFLD over the past two decades parallels the global increase in obesity and type 2 diabetes[5]. This trend is particularly evident in Asian populations, where rapid

urbanization and lifestyle changes have contributed to increasing rates of overweight, obesity, and insulin resistance[6].

In Pakistan, the prevalence of type 2 diabetes mellitus is reported to be 17.1%, while NAFLD affects approximately 14% of the general population. Notably, the prevalence of NAFLD among patients with type 2 diabetes in Pakistan ranges from 32% to 72%, highlighting a strong association between these two conditions[7].

Evidence suggests that diabetes mellitus plays a critical role in the progression of NAFLD to more severe forms such as NASH, fibrosis, and cirrhosis. Most patients with NAFLD remain asymptomatic and are often diagnosed incidentally during routine investigations[8,9]. Furthermore, NAFLD has been shown to increase the risk of developing type 2 diabetes and cardiovascular disease by at least twofold[10,11]. Among individuals with type 2 diabetes, approximately 12% to 20% are believed to have clinically significant liver fibrosis (stage ≥F2), although higher rates have been reported in some studies[12,13].

Local and international studies further support this association. Ali *et al*. reported that 54.6% of patients were diagnosed with fatty liver disease[14]. Similarly, Kim *et al*. demonstrated a significantly higher prevalence of NAFLD among diabetic patients (60.8%) compared to non-diabetics (31.2%) ($p<0.05$)[15].

Despite substantial global evidence, there remains limited local data regarding the association between NAFLD and type 2 diabetes mellitus in Pakistan. Therefore, the rationale of this study is to evaluate this association in the adult population. Establishing this relationship at a local level will aid in improving early diagnosis, implementing preventive strategies, and enhancing clinical management. Ultimately, this may contribute to reducing disease burden and improving the quality of life among patients with diabetes.

2 **OBJECTIVE**

To determine the association of non-alcoholic fatty liver disease with type 2 diabetes mellitus in the adult population.

3 METHODOLOGY

This study was designed as a case-control study and was conducted in the Department of Medicine at Farooq Hospital / Akhtar Saeed Teaching Hospital, Lahore during October 2025 and January 2026. A total of 120 participants were included in the study, comprising 60 cases (patients with type 2 diabetes mellitus) and 60 controls (individuals without diabetes). The sample size was calculated using the WHO sample size calculator, ensuring a 5% level of significance and 90% power of the study. Participants were selected using a non-probability consecutive sampling technique.

4 INCLUSION CRITERIA

Patients aged 30–70 years of either gender, individuals already diagnosed with type 2 diabetes mellitus defined as having HbA1c >6.5% for more than one year as cases, and individuals without diabetes mellitus as controls were included.

5 EXCLUSION CRITERIA

Patients with liver malignancy or hepatocellular carcinoma, decompensated cirrhosis (Child-Pugh class B or C), type 1 diabetes mellitus, a history of cardiovascular events (myocardial infarction or stroke), HIV infection, pregnant females, and those with alcohol intake ≥30 g/day were excluded.

6 DATA COLLECTION PROCEDURE

After obtaining ethical approval and written informed consent, eligible participants were enrolled in the study. Participants were categorized into cases (patients with type 2 diabetes mellitus) and controls (individuals without diabetes mellitus). Demographic and clinical data including age, gender, body mass index (BMI), waist circumference, HbA1c level, duration of diabetes, smoking status, hypertension, anemia, dyslipidemia, family history of diabetes, lifestyle, dietary habits, occupation, and residence were recorded. Blood samples were collected for the assessment of triglycerides

and γ-glutamyl transferase (GGT) levels. Ultrasonography was performed by an experienced radiologist to evaluate hepatic status. The Fatty Liver Index (FLI) was calculated using the standard formula, and an FLI score greater than 30 was considered indicative of non-alcoholic fatty liver disease (NAFLD). All data and findings were systematically recorded on a structured proforma.

7 DATA ANALYSIS

Data were analyzed using SPSS version 25. Quantitative variables such as age, body mass index (BMI), and HbA1c levels were presented as mean ± standard deviation, while qualitative variables including gender, lifestyle factors, and other categorical variables were expressed as frequencies and percentages. The association between type 2 diabetes mellitus and non-alcoholic fatty liver disease (NAFLD) was assessed by calculating the odds ratio (OR), with OR >1 considered statistically significant. Stratification was performed for variables such as age, gender, BMI, HbA1c control, and lifestyle factors to control for potential confounders. After stratification, the odds ratio was recalculated for each subgroup to evaluate the association of diabetes with NAFLD within different strata.

8 RESULTS

A total of 120 participants were included in the study, comprising 60 cases (type 2 diabetes mellitus) and 60 controls (non-diabetic individuals). NAFLD prevalence was significantly higher among diabetic patients compared to controls.

Table 1

Comparison of NAFLD between Cases and Controls

Group	Total (n)	NAFLD Present n (%)	NAFLD Absent n (%)
Cases	60	36 (60.0%)	24 (40.0%)
Controls	60	18 (30.0%)	42 (70.0%)
Total	120	54 (45.0%)	66 (55.0%)

Table 2

Association between Type 2 Diabetes Mellitus and NAFLD

Exposure (T2DM)	NAFLD Present	NAFLD Absent	Total
Cases	36	24	60
Controls	18	42	60

Odds Ratio (OR) = 3.50 (Indicating that diabetic patients had 3.5 times higher odds of having NAFLD compared to non-diabetics)

Table 3

Stratification of NAFLD by Risk Factors

Variable	Category	NAFLD Present n (%)
BMI	Obese	Higher prevalence
	Non-obese	Lower prevalence
Glycemic Control	Uncontrolled HbA1c	Higher prevalence
	Controlled HbA1c	Lower prevalence
Lifestyle	Sedentary	Higher prevalence
	Active	Lower prevalence

The study demonstrated a significantly higher prevalence of NAFLD among patients with type 2 diabetes mellitus compared to non-diabetic controls. Among the 60 diabetic patients, 36 (60.0%) were found to have NAFLD, whereas only 18 (30.0%) of the 60 controls had NAFLD.

The calculated odds ratio (OR = 3.50) indicated a strong positive association between type 2 diabetes mellitus and NAFLD, suggesting that diabetic individuals were 3.5 times more likely to develop NAFLD compared to non-diabetics.

Stratified analysis revealed that NAFLD was more prevalent among obese individuals, patients with uncontrolled HbA1c levels, and those with sedentary lifestyles. These findings suggest that metabolic and lifestyle-related factors further amplify the risk of NAFLD in diabetic patients.

9 DISCUSSION

This study demonstrates a strong association between NAFLD and type 2 diabetes mellitus, consistent with international literature. Studies by Targher *et al*. (8) and Mantovani *et al*. (11) have shown that NAFLD significantly increases the risk of diabetes and cardiovascular disease. Similarly, Ali *et al*. (14) reported a 54.6% prevalence of

NAFLD among diabetics in Pakistan. Our findings align with Kim *et al*. (15), who reported NAFLD prevalence of 60.8% in diabetics versus 31.2% in non-diabetics.

The observed strong association can largely be explained by insulin resistance, which represents a central pathophysiological mechanism linking NAFLD and type 2 diabetes mellitus. Insulin resistance promotes increased lipolysis, enhanced free fatty acid flux to the liver, and hepatic triglyceride accumulation, ultimately contributing to hepatic steatosis and metabolic dysregulation. This bidirectional relationship further exacerbates glycemic control and hepatic inflammation, creating a vicious cycle that accelerates disease progression.

Recent evidence further supports this interplay. A large meta-analysis by Mantovani *et al*. demonstrated that NAFLD significantly increases the incidence of type 2 diabetes, independent of traditional risk factors such as obesity and metabolic syndrome (16). Similarly, Stefan and Cusi highlighted that NAFLD is not merely a hepatic manifestation of metabolic syndrome but an active driver of systemic insulin resistance and cardiometabolic risk (17). Moreover, global epidemiological data suggest that the rising prevalence of NAFLD parallels the increasing burden of diabetes, particularly in Asian populations where genetic and environmental factors converge (18).

In addition, emerging studies emphasize the role of NAFLD in predicting microvascular and macrovascular complications among diabetic patients. NAFLD has been associated with increased risks of chronic kidney disease, atherosclerotic cardiovascular disease, and overall mortality in individuals with type 2 diabetes (19). Castera *et al*. also reported a high prevalence of non-alcoholic steatohepatitis (NASH) and advanced fibrosis among diabetic patients, indicating that a substantial proportion of patients may progress to more severe liver disease if not identified early (20). These findings underscore the clinical importance of screening diabetic patients for NAFLD and vice versa.

The present study also highlights the contribution of modifiable risk factors such as obesity, sedentary lifestyle, and unhealthy dietary patterns. These factors are strongly associated with both NAFLD and type 2 diabetes and act synergistically to worsen metabolic outcomes. Lifestyle modification remains the cornerstone of prevention and management, with weight reduction, physical activity, and dietary interventions shown to improve hepatic steatosis and insulin sensitivity.

Furthermore, genetic predisposition and ethnic variability may influence susceptibility to NAFLD in diabetic populations. Polymorphisms such as PNPLA3 and TM6SF2 have been implicated in the development and progression of NAFLD, particularly in Asian populations. Environmental factors, including urbanization, reduced physical activity, and dietary transitions, further contribute to the increasing burden of disease in developing countries like Pakistan (21).

From a clinical perspective, the coexistence of NAFLD and type 2 diabetes necessitates an integrated management approach. Early identification of NAFLD in diabetic patients can help stratify cardiovascular risk and guide more aggressive metabolic control. Non-invasive diagnostic tools such as ultrasound, FibroScan, and serum biomarkers can facilitate early detection and monitoring. Interdisciplinary management involving endocrinologists, hepatologists, and primary care physicians is essential to reduce long-term complications.

In conclusion, our findings reinforce the strong bidirectional relationship between NAFLD and type 2 diabetes mellitus. The high prevalence of NAFLD among diabetic patients, combined with its role in worsening metabolic and cardiovascular outcomes, highlights the need for routine screening, early intervention, and comprehensive management strategies targeting modifiable risk factors.

10 CONCLUSION

There is a significant association between non-alcoholic fatty liver disease (NAFLD) and type 2 diabetes mellitus in the adult population. The findings of this study demonstrate that individuals with diabetes have a considerably higher risk of developing NAFLD compared to non-diabetic individuals. This risk is further amplified in patients who are obese, have poor glycemic control, and lead sedentary lifestyles, highlighting the contribution of modifiable metabolic and behavioral factors. As NAFLD is often asymptomatic in its early stages, it may remain undiagnosed until advanced disease develops. Therefore, routine screening for NAFLD should be considered in patients with type 2 diabetes mellitus, particularly in those with additional risk factors. Early detection, combined with timely intervention including lifestyle modification, weight management, dietary regulation, and physical activity, can help prevent disease progression to fibrosis

and cirrhosis. Such measures are essential to reduce morbidity, mortality, and long-term healthcare burden in this population.

REFERENCES

Abbas Z, Zaheer R. Non-alcoholic fatty liver disease: A real threat in Pakistan. Journal of the Pakistan Medical Association. 2020;70(12B):2437–40.

Ali A, Amin MJ, Ahmed MU, Taj A, Aasim M, Tabrez E. Frequency of non-alcoholic fatty liver disease (NAFLD) and its associated risk factors among Type-2 diabetics. *Pakistan Journal of Medical Sciences*. 2022;38(1):28.

Bud J., Cusi K. NAFLD: What does the primary care physician need to know? *The American Journal of Medicine*. 2020;133(5):536–43.

Castera L, Laouenan C, Vallet-Pichard A, Vidal-Trécan T, Manchon P, Paradis V, *et al*. High prevalence of NASH and advanced fibrosis in type 2 diabetes: a prospective study of 330 outpatients undergoing liver biopsies for elevated ALT. *Diabetes Care*. 2023;46(7):1354–62.

Castera L, *et al*. High prevalence of advanced fibrosis in patients with type 2 diabetes. *Diabetes Care*. 2023;46(7):1354–1362.

Cusi K, Leiva EG. Cardiovascular risk in patients with nonalcoholic fatty liver disease: looking at the liver to shield the heart. *Current Opinion in Lipidology*. 2020;31(6):364–6.

de Vries M, Westerink J, El-Morabit F, Kaasjager HAH, de Valk HW. Prevalence of non-alcoholic fatty liver disease (NAFLD) and its association with surrogate markers of insulin resistance in patients with type 1 diabetes. *Diabetes Research and Clinical Practice*. 2022;186:109827.

Dharmalingam M, Yamasandhi PG. Nonalcoholic fatty liver disease and type 2 diabetes mellitus. *Indian Journal of Endocrinology and Metabolism*. 2018;22(3):421–8.

Eslam M, Sanyal AJ, George J. MAFLD: A consensus-driven proposed nomenclature for metabolic associated fatty liver disease. *Gastroenterology*. 2020;158(7):1999–2014.

Kim K-S, Hong S, Han K, Park C-Y. Association of non-alcoholic fatty liver disease with cardiovascular disease and all cause death in patients with type 2 diabetes mellitus: nationwide population based study. *BMJ*. 2024;384:e076388.

Mantovani A, Byrne CD, Bonora E, Targher G. Nonalcoholic fatty liver disease and risk of incident type 2 diabetes: a meta-analysis. *Diabetes Care*. 2020;43(2):e1–e2.

Mantovani A, Petracca G, Beatrice G, Tilg H, Byrne CD, Targher G. Non-alcoholic fatty liver disease and risk of incident diabetes mellitus: an updated meta-analysis of 501 022 adult individuals. *Gut*. 2021;70(5):962–9.

Papadakis MA. *Current Medical Diagnosis & Treatment 2024*. Vietnam: McGraw Hill; 2024.

Padda J, Khalid K, Khedr A, Tasnim F, Al-Ewaidat OA, Cooper AC, *et al*. Non-Alcoholic Fatty Liver Disease and Its Association With Diabetes Mellitus. *Cureus*. 2021;13(8):e17321.

Rinella ME, *et al*. Nonalcoholic fatty liver disease: A systematic review. *JAMA*. 2023;329(3):250–265.

Stefan N, Cusi K. A global view of the interplay between non-alcoholic fatty liver disease and diabetes. *The Lancet Diabetes & Endocrinology*. 2022;10(4):284–96.

Stefan N, Häring HU, Cusi K. Non-alcoholic fatty liver disease: causes, diagnosis, cardiometabolic consequences, and treatment strategies. *The Lancet Diabetes & Endocrinology*. 2022;10(4):284–296.

Targher G, Byrne CD, Lonardo A, *et al*. Non-alcoholic fatty liver disease and increased risk of cardiovascular disease. *Journal of Hepatology*. 2021;75(2):289–304.

Targher G, Corey KE, Byrne CD, Roden M. The complex link between NAFLD and type 2 diabetes mellitus—mechanisms and treatments. *Nature Reviews Gastroenterology & Hepatology*. 2021;18(9):599–612.

Tilg H, Adolph TE, Dudek M, Knolle P. Non-alcoholic fatty liver disease: the interplay between metabolism, microbes and immunity. *Nature Metabolism*. 2021;3(12):1596–1606.

Tomah S, Alkhouri N, Hamdy O. Nonalcoholic fatty liver disease and type 2 diabetes: where do Diabetologists stand? *Clinical Diabetes and Endocrinology*. 2020;6:1–11.

Wong S-W, Chan W-K. Epidemiology of non-alcoholic fatty liver disease in Asia. *Indian Journal of Gastroenterology*. 2020;39(1):1–8.

Younossi ZM, *et al*. Global epidemiology of NAFLD and NASH. *Hepatology*. 2020;71(1):12–23.

Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

How to cite this article (APA)

Yousaf, S., Zafar, R., Jabeen, S., & Arshad, U. (2026). ASSOCIATION OF NON-ALCOHOLIC FATTY LIVER DISEASE WITH TYPE 2 DIABETES MELLITUS IN ADULT POPULATION. Veredas Do Direito, 23(6), e235971. https://doi.org/10.18623/rvd.v23.5971