Med. J. Cairo Univ., Vol. 93, No. 3, Accepted 16/3/2025
DOI: 10.22608/MJCU. 1213-1223, September 2025
www.medicaljournalofcairouniversity.net

Prediction of Non-Alcoholic Fatty Liver Disease Using Triglycerides/ Fasting Blood Glucose Index in Type 2 Diabetic Patients

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Abstract

Background: Since NAFLD is a growing global public health concern and is the most common cause of chronic liver disease worldwide and has a strong associated with insulin resistance, metabolic syndrome, and type 2 diabetes mellitus, also being a multisystemic disease early identification of NAFLD in high-risk population is necessary. NAFLD also has no specific clinical manifestations, so diagnosing the disease early is difficult. A liver biopsy is the "gold standard" to diagnose NAFLD, but its complications limit its use Therefore, it was important to identify a proper marker for early diagnosis, evaluation, and prognosis of NAFLD.

Aim of Study: This study aims to use the triglyceride–glucose (TyG) index as an ideal marker for early detection of NAFLD in type 2 diabetic patients. Comparing the sensitivity of (TyG) index to (FLI) in early prediction of Non-alcoholic Fatty liver disease.

Patients and Methods: This case-control study involved 188 individuals aged 18 to 70 who attended the Internal medicine clinic at Saud Kafafy University Hospital and National Hepatology and Tropical Medicine institute. Approval of the ethical committee was granted before starting the work. The study will span a period of time from August 2023 to December 2024.

Results: This study included 188 individuals classified according to body mass index into two groups, each included 94 individuals: Group I (NAFLD group), Group II (non-NAFLD group). Our results showed that the TyG index, HOMA-IR, and FLI were all significantly elevated in the NAFLD group, reinforcing their utility in identifying NAFLD. Correlations showed that these indices were strongly associated with waist circumference, BMI, FBG, triglycerides, and liver enzyme levels. Notably, the TyG index exhibited the highest diagnostic accuracy with an AUC of 0.838, followed by FLI (AUC = 0.766) and HOMA-IR (AUC = 0.593). The NAFLD group's mean TyG index (9.3±0.6) was significantly higher than the non-NAFLD group (8.6±0.3) (p<0.001). This robust distinction highlights the diagnostic reliability of the TyG index.

Conclusion: According to our study, the TyG index is a trustworthy method for identifying people who are at risk of NAFLD since it performs better than other indices like FLI and HOMA-IR in terms of diagnostic accuracy, specificity, and positive predictive value.

Key Words: *NAFLD – Type 2 Diabetic patients – TyG index – FLI index.*

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Introduction

NONALCOHOLIC fatty liver disease (NAFLD) has emerged as a growing global public health concern and is the most common cause of chronic liver disease worldwide **[1].**

NAFLD is strongly associated with overweight/ obesity, insulin resistance (IR), metabolic syndrome (MetS), and type 2 diabetes mellitus (T2DM) **[2].**

Previous studies suggested that Nonalcoholic fatty liver disease (NAFLD) increases the risk of developing T2DM and worsens glycemic and lipid control **[3].**

NAFLD is a multisystemic disease, it has baeen connected with a spectrum of extrahepatic conditions, including T2DM, obesity, chronic kidney disease (CKD), hypothyroidism, extrahepatic malignancies, polycystic ovarian syndrome (PCOS), and obstructive sleep apnea (OSA) **[3].**

NAFLD has no specific clinical manifestations, so diagnosing the disease early is difficult. A liver biopsy is the "gold standard" to diagnose NAFLD.

However, its disadvantages greatly limit its application in the diagnosis [5].

NAFLD must be recognised early as liver inflammation can trigger more severe hepatic complications such as fibrinogenesis, cirrhosis and finally hepatocarcinoma. NAFLD/NASH diagnosis relies solely on histopathological analysis of a liver biopsy, and routine liver tests, e.g., ALAT and gamma-glutamyl transferase (GGT) do not correlate with necro-inflammatory activity and fibrosis in patients with NAFLD. For this reason, a noninvasive tools is obviously needed [6].

The recently developed triglyceride–glucose (TyG) index, which is easily calculated using fasting blood glucose (FBG) and triglyceride (TG) levels, is considered an ideal substitutional marker of Insulin resistance (IR) in general population [7].

Additionally, the TyG index is more suitable for determining Insulin resistance (IR) than other surrogate indices, such as the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) [8].

The TyG index was closely associated with Body Mass Index(BMI), total Cholesterol (TC), Triglyceride (TG), Fasting Blood Glucose (FBG), Glycosylated Hemoglobin (HbA1c) levels, HOMA-IR, and increased incidence of MetS and NAFLD [3].

Studies have shown that the (TyG) index has a high diagnostic value for NAFLD in adults, and a higher TyG index corresponds to significantly increased morbidity from NAFLD [9]. Thus, the (TyG) index has been recommended as a simple and reliable indicator to identify individuals at risk for NAFLD [10].

Fatty liver index (FLI) is an algorithm combining body mass index (BMI), waist circumference (WC), gamma-glutamyl transferase (GGT), and triglyceride (TG) levels [11].

Aim of the study:

This study aims to use the triglyceride–glucose (TyG) index as an ideal marker for early detection of NAFLD in type 2 diabetic patients, to compare the sensitivity of (TyG) index to (FLI) in early prediction of Non-alcoholic Fatty liver disease and strong association between NAFLD, Metabolic syndrome and type 2 diabetes.

Patients and Methods

Study setting:

This study was conducted in the Internal Medicine clinic, at Saud Kafafy University Hospitalas well as National Hepatology and Tropical Medicine institute from August 2023 till December 2024.

Study population:

A group of 188 individuals and theirage ranging from 18 to 70 years old were enrolled in this study, the participants were subdivided into two groups: Group I: Included 94 NAFLD individuals and Group II: Included 94 non-NAFLD individuals as a control group.

Study design:

This study is a case-control study that was conducted on 188 individuals and their age ranging from 18 to 70 years old, attending the Internal medicine clinic, at Saud Kafafy University Hospital and National Hepatology and Tropical Medicine institute, from August 2023 to December 2024.

Ethical consideration:

The Faculty of Medicine Research Ethics Committee (REC) FWA 00025577 of Must University granted ethical approval for the present investigation design. The Declaration of Helsinki, the World Medical Association's code of ethics for investigations human related, guided the conduct of this research. An informed consent will be obtained from all participants in the study.

Inclusion criteria:

Type 2 diabetes mellites, Overweight (BMI ≥25 kg/m^2), Waist circumference >88cm in females and >102cm in male, Dyslipidemia, Suggestive Ultrasound picture of NAFLD (bright liver in the ultrasound).

Exclusion criteria:

Patients who refused to participate in the study, Pediatric patients (less than 16 years), history of Viral hepatitis (HBV, HCV), Clinical features/ history of other metabolic liver diseases, Alcohol consumption greater than 140 g/week in men and 70 g/week in women, Liver cirrhosis, History of autoimmune hepatitis, drug induced liver injury or Vascular liver diseases, Hypothyroidism, history of Familial dyslipidemia, history of Cholestasis and biliary diseases, Nephrotic syndrome.

Methods: All study participants were subjected to the following:

1- Medical consent: Informed consents were taken from all patients and controls.

2- Detailed medical history: Age, chronic metabolic disorders, cardiac diseases, chronic hepatic disease, and drug history.

3- Thorough clinical examination which included:

• Anthropometric measures include:

- Body mass index (BMI) will be calculated by the followingformula: BMI kg/m^2. Overweight was defined as BMI ≥25kg/m.

- Waist circumference (WC) of >88cm in females and >102cm in males.

4- Laboratory investigation: CBC, HbA1c, Fasting Blood Glucose, Fasting Insulin level, Thyroid Stimulating Hormone (TSH), Serum Uric Acid, Kidney Functions Tests (Creatinine, Urea), Albumin/Creatinine (A/C) ratio, Liver function tests (AST, ALT, GGT), Serum Lipid Levels (Cholesterol, Triglycerides, HDL-C, LDL-C).

• The homeostasis model assessment of insulin resistance (HOMA IR): Was calculated using the following equation: [fasting plasma insulin (mIU/L) × fasting plasma glucose (mg/dL) ×405].

• The TyG index:Was calculated as ln [(TG (mg/dL) × FBG (mg/dL)) /2].

• Fatty liver index (FLI):Was calculated as (e(0.953×ln (TG) + 0.139×BMI + 0.718×ln (GGT)+ 0.053×WC15.745))/(1+e(0.953×ln(TG)+0.139×BMI+0.718×ln(GGT)+0.053×WC15.745))×100

5- Abdominal ultrasonography:

Fatty liver was determined by ultrasound scan, the presence of increased echogenicity of the liver compared to renal cortex.

Statistical methods:

The collected data were coded, tabulated, and statistically analyzed using IBM SPSS Statistics (Statistical Package for Social Sciences) soft ware version 28.0, IBM Corp., Chicago, USA, 2021.

• Quantitative data is described as mean ± SD (standard deviation) as well as minimum and maximum of the range, and then compared using an independent *t*-test.

• Qualitative data is described as numbers andpercentages and then compared using Fisher's Exact test. The ROC curve was used to evaluate the performance of metabolic indices in predicting NAFLD. The levelof significance was taken at *p*-value ≤0.050 was significant, otherwise was non-significant.

Diagnostic characteristics were calculated as follows:

• Sensitivity = (True positive test / Total positive golden) x 100

• Specificity = (True negative test / Total negative golden) x 100

• Diagnostic accuracy = ([True positive test + True negative test] / Total cases) x 100

• Youden's index = sensitivity + specificity – 1

• Predictive positive value = (True positive test / Total positive test) x 100

• Predictive negative value = (True negative test / Total negative test) x 100

Results

Table (1): Demographic characteristics between the studied groups.

Variables	NAFLD group (Total=94)	Non-NAFLD group (Total=94)	*p*-value
Age (years):			
Mean ± SD	42.6±8.3	41.4±8.4	^0.343
Range	23.0–61.0	24.0–64.0	
Sex (n, %):			
Male	25 (26.6%)	31 (33.0%)	#0.339
Female	69 (73.7%)	63 (67.0%)	
Duration of DM (years):			
Mean ± SD	6.2±2.0	6.4±1.6	^0.370
Range	1.0–10.0	2.0–9.0	

^Independent *t*-test. #Fisher's Exact test.

Table (1) showed that No statistically significant difference between the studied groups regarding age, sex, and duration of DM.

Table (2): Anthropometric measures between the studied groups.

Variables	NAFLD group (Total=94)	Non-NAFLD group (Total=94)	*p*-value
Waist circumference (cm):			
Mean ± SD	114.5±8.0	105.28±10.33	<0.001*
Range	101.0–140.0	90.0–127.0	
BMI (kg/m^2):			
Mean ± SD	30.4±2.4	27.4±1.4	<0.001*
Range	26.0–34.4	24.7–30.1	

BMI: Body Mass Index. ^Independent *t*-test.

Table (2) showed that Waist circumference and BMI were significantly higher in the NAFLD group.

Table (3): CBC between the studied groups.

Variables	NAFLD group (Total=94)	Non-NAFLD group (Total=94)	*p*-value
Hemoglobin (gm/dL):			
Mean ± SD	12.8±1.2	13.1±1.1	0.075
Range	10.8–15.8	10.7–15.4	
Leucocytes (x10^3/mL):			
Mean ± SD	7.1±1.9	6.7±1.8	0.209
Range	3.9–13.0	4.0–13.1	
Platelets (x10^3/mL):			
Mean ± SD	290.3±71.5	308.7±83.1	0.106
Range	145.0–503.0	144.0–443.0	

^Independent *t*-test.

Table (3) showed that: No statistically significant difference between the studied groups regarding hemoglobin, leucocytes, and platelets.

Table (4): Liver function between the studied groups.

Variables	NAFLD group (Total=94)	Non-NAFLD group (Total=94)	*p*-value
ALT (IU/L):			
Mean ± SD	36.9±14.5	23.2±3.2	<0.001*
Range	19.0–78.0	18.0–30.0	
AST (IU/L):			
Mean ± SD	35.4±11.6	23.1±3.0	<0.001*
Range	19.0–76.0	18.0–28.0	
GGT (IU/L):			
Mean ± SD	41.8±17.0	29.1±6.0	<0.001*
Range	21.0–77.0	8.0–37.0	

^Independent *t*-test.

Table (4) showed that: ALT, AST, and GGT were significantly higher in NAFLD group.

Table (5): Kidney function between the studied groups.

Variables	NAFLD group (Total=94)	Non-NAFLD group (Total=94)	*p*-value
Urea (mg/dL):			
Mean ± SD	10.2±3.7	11.1±3.7	0.113
Range	5.0–17.0	5.0–18.0	
Creatinine (mg/dL):			
Mean ± SD	0.76±0.21	0.72±0.17	0.137
Range	0.40–1.40	0.40–1.00	
ACR:			
Mean ± SD	9.9±6.0	9.1±3.3	0.267
Range	1.9–25.2	3.4–15.0	
Uric acid (mg/dL):			
Mean ± SD	5.3±0.7	5.2±0.7	0.271
Range	4.1–6.5	3.6–6.5	

^Independent *t*-test.

Table (5) showed that No statistically significant difference between the studied groups regarding age urea, creatinine, ACR and uric acid.

Table (6): Glycemic control between the studied groups.

Variables	NAFLD group (Total=94)	Non-NAFLD group (Total=94)	*p*-value
HbA1c (%):			
Mean ± SD	7.1±1.1	6.8±0.4	<0.001*
Range	4.9–12.4	6.2–8.8	
FBG (mg/dL):			
Mean ± SD	133.7±59.9	97.8±11.4	<0.001*
Range	69.0–387.0	69.0–120.0	

^Independent *t*-test.

Table (6) showed that: HbA1c and FBG were significantly higher in NAFLD group.

Table (7): Lipid profile between the studied groups.

Variables	NAFLD group (Total=94)	Non-NAFLD group (Total=94)	*p*-value
Total cholesterol (mg/dL):			
Mean ± SD	213.8±41.7	155.3±10.0	<0.001*
Range	144.0–358.0	132.0–178.0	
Triglycerides (mg/dL):			
Mean ± SD	186.3±88.6	113.4±24.8	<0.001*
Range	57.0–548.0	64.0–148.0	
LDL (mg/dL):			
Mean ± SD	131.9±37.8	84.9±8.9	<0.001*
Range	66.0–225.0	67.0–97.0	
HDL (mg/dL):			
Mean ± SD	44.3±9.8	47.6±6.8	0.008*
Range	17.0–67.0	35.0–67.0	

^Independent *t*-test.

Table (7) and Fig. (1) showed that: Total cholesterol, triglycerides and LDL were significantly higher in NAFLD group, while HDL was significantly lower in NAFLD group.

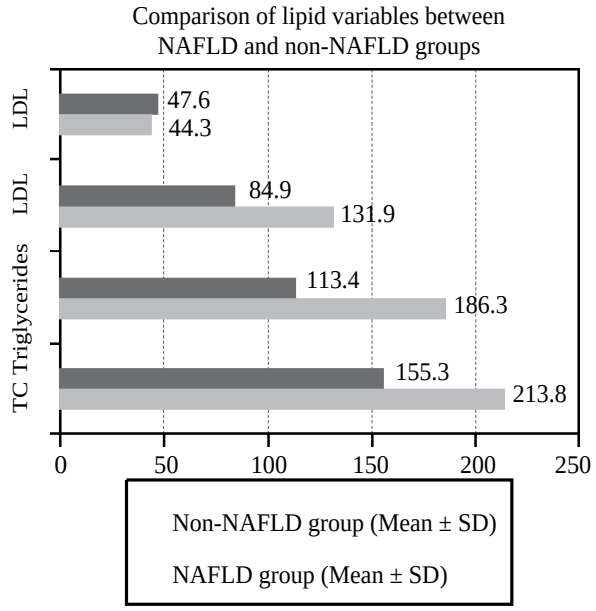

Fig. (1): Lipid variables between the studied groups.

Table (8): Metabolic indices between the studied groups.

Variables	NAFLD group (Total=94)	Non-NAFLD group (Total=94)	*p*-value
TyG index:			
Mean ± SD	9.3±0.6	8.6±0.3	<0.001*
Range	7.9–11.4	8.0–9.0	
HOMA-IR:			
Mean ± SD	2.8±1.8	1.3±0.2	<0.001*
Range	0.5–5.9	1.0–1.6	
FLI:			
Mean ± SD	79.5±13.4	68.5±7.7	<0.001*
Range	45.4–98.2	49.4–84.2	

^Independent *t*-test.

Table (8) and Figs. (2,3,4) showed that: TyG index, HOMA-IR and FLI were significantly higher in NAFLD group.

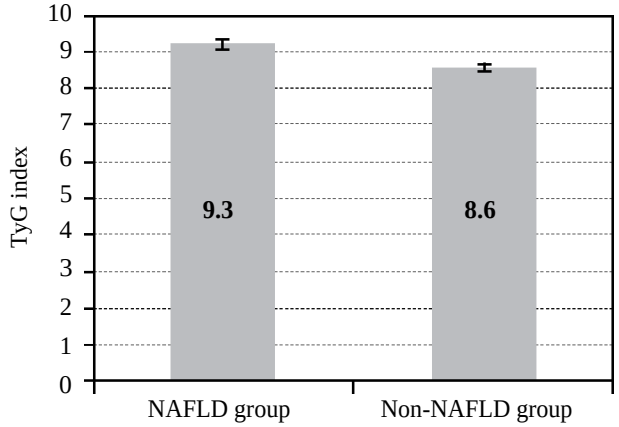

Fig. (2): TyG index between the studied groups.

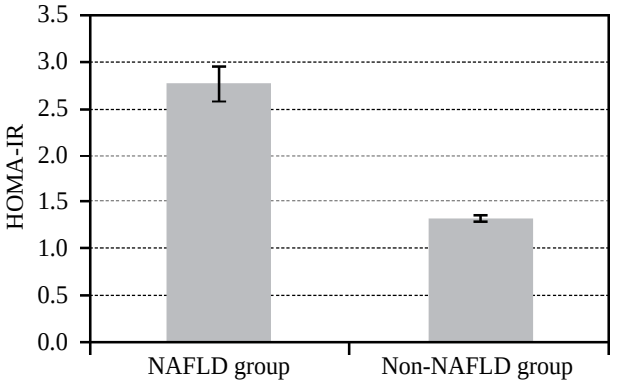

Fig. (3): HOMA-IR between the studied groups.

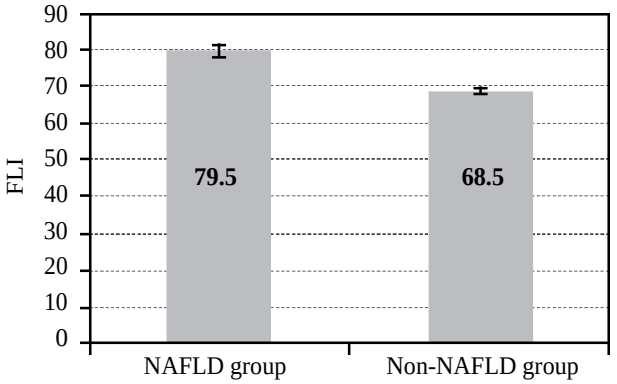

Fig. (4): FLI between the studied groups.

Table (9) showed that: Among NAFLD group TyG index had significant positive correlations with HOMA-IR, FLI, Waist circumference, BMI, GGT, HbA1c, FBG, Total cholesterol and Triglycerides. HOMA-IR had significant positive correlations with FLI, Waist circumference, BMI, GGT, HbA1c, FBG, and Triglycerides. FLI had significant positive correlations with Waist circumference, BMI, ALT, AST, GGT, HbA1c, FBG, Total cholesterol, Triglycerides and LDL.

Table (10) showed that: Among non-NAFLD group TyG index had significant positive correlations with HOMA-IR, FLI, Waist circumference, ALT, FBG, Total cholesterol and Triglycerides. HOMA-IR had significant positive correlations with FLI, FBG, total cholesterol and Triglycerides. FLI had significant positive correlations with Waist circumference, BMI, GGT and Triglycerides.

Table (11) and Figs. (5,6) showed that: TyG index, HOMA-IR and FLI had FLI significant diagnostic performance in predicting NAFLD, was high in TyG index, moderate in FLI and poor in HOMA-IR. TyG index ›_9.0 and FLI ›_80.0 had high specificity and positive predictive value, but low other characteristics. HOMA-IR ›_1.3 had low characteristics.

Table (9): Correlations of metabolic indices among NAFLD group.

Characteristics	TyG index		HOMA-IR		FLI	
	r	*p*-value	*r*	*p*-value	*r*	*p*-value
HOMA-IR	0.567	<0.001*				
FLI	0.499	<0.001*	0.507	<0.001*		
Age (years)	0.118	0.258	0.161	0.120	0.167	0.107
Duration of DM (years)	0.036	0.733	0.139	0.182	0.047	0.653
Waist circumference (cm)	0.409	<0.001*	0.563	<0.001*	0.486	<0.001*
BMI (kg/m^2)	0.411	<0.001*	0.671	<0.001*	0.485	<0.001*
Hemoglobin (gm/dL)	-0.098	0.347	0.038	0.717	0.159	0.127
Leucocytes ($x10^3$/mL)	-0.083	0.428	0.100	0.337	0.148	0.155
Platelets ($x10^3$/mL)	0.016	0.877	-0.011	0.916	0.071	0.499
ALT (IU/L)	0.037	0.725	-0.030	0.772	0.328	0.001*
AST (IU/L)	0.035	0.739	-0.037	0.721	0.305	0.003*
GGT (IU/L)	0.341	0.001*	0.268	0.009*	0.484	<0.001*
Urea (mg/dL)	0.065	0.535	-0.145	0.163	-0.163	0.117
Creatinine (mg/dL)	0.105	0.313	-0.104	0.320	0.074	0.475
ACR	-0.019	0.854	0.131	0.209	0.120	0.248
Uric acid (mg/dL)	0.141	0.176	0.158	0.129	0.108	0.299
HbA1c (%)	0.544	<0.001*	0.589	<0.001*	0.367	<0.001*
FBG (mg/dL)	0.721	<0.001*	0.620	<0.001*	0.380	<0.001*
Total cholesterol (mg/dL)	0.370	<0.001*	0.173	0.096	0.484	<0.001*
Triglycerides (mg/dL)	0.801	<0.001*	0.231	0.025*	0.342	0.001*
LDL (mg/dL)	0.022	0.830	0.045	0.670	0.351	0.001*
HDL (mg/dL)	0.008	0.938	0.066	0.526	0.014	0.895

Pearson correlation test. *Significant.

Table (10): Correlations of metabolic indices among non-NAFLD group.

Characteristics	TyG index		HOMA-IR		FLI	
	r	*p*-value	*r*	*p*-value	*r*	*p*-value
HOMA-IR	0.995	<0.001*				
FLI	0.295	0.004*	0.251	0.015*		
Age (years)	0.094	0.369	0.112	0.284	0.190	0.067
Duration of DM (years)	0.124	0.235	0.114	0.273	0.011	0.917
Waist circumference (cm)	0.212	0.041*	0.167	0.107	0.852	<0.001*
BMI (kg/m^2)	0.141	0.174	0.128	0.219	0.508	<0.001*
Hemoglobin (gm/dL)	0.052	0.622	0.044	0.676	-0.017	0.874
Leucocytes ($x10^3$/mL)	-0.044	0.677	-0.065	0.535	-0.070	0.502
Platelets ($x10^3$/mL)	-0.194	0.061	-0.178	0.085	-0.012	0.905
ALT (IU/L)	0.128	0.127	-0.195	0.059	0.180	0.101
AST (IU/L)	-0.181	0.081	-0.148	0.156	0.194	0.204
GGT (IU/L)	0.003	0.979	-0.004	0.969	0.225	0.029*
Urea (mg/dL)	0.010	0.927	0.011	0.913	-0.017	0.868
Creatinine (mg/dL)	0.037	0.722	0.033	0.752	0.110	0.291
ACR	0.105	0.316	0.104	0.317	0.126	0.224
Uric acid (mg/dL)	0.180	0.082	0.175	0.091	-0.017	0.871
HbA1c (%)	0.171	0.100	0.150	0.149	0.093	0.371
FBG (mg/dL)	0.512	<0.001*	0.524	<0.001*	0.111	0.286
Total cholesterol (mg/dL)	0.288	0.005*	0.276	0.007*	-0.025	0.813
Triglycerides (mg/dL)	0.912	<0.001*	0.904	<0.001*	0.257	0.012*
LDL (mg/dL)	-0.085	0.418	-0.093	0.371	-0.087	0.405
HDL (mg/dL)	0.000	0.999	-0.006	0.955	0.098	0.348

Pearson correlation test. *Significant.

Table (11): Diagnostic performance and characteristics of metabolic indices in predicting NAFLD.

	TyG index		HOMA-IR		FLI	
	Value	95% CI	Value	95% CI	Value	95% CI
AUC	0.838	0.778–0.897	0.593	0.497–0.690	0.766	0.696–0.836
p-value	<0.001*		0.027*		<0.001*	
Cut point	≥9.0		≥1.3		≥80.0	
Sensitivity	64.9%	54.4%–74.5%	58.5%	47.9%–68.6%	54.3%	43.7%–64.6%
Specificity	96.8%	91.0%–99.3%	45.7%	35.4%–56.3%	95.7%	89.5%–98.8%
Diagnostic accuracy	80.9%	74.5%–86.2%	52.1%	44.7%–59.5%	75.0%	68.2%–81.0%
Youden's Index	61.7%	51.4%–72.0%	4.3%	-9.9%–18.4%	50.0%	39.1%–60.9%
Positive predictive value	95.3%	86.9%–99.0%	51.9%	42.0%–61.7%	92.7%	82.4%–98.0%
Negative predictive value	73.4%	64.7%–80.9%	52.4%	41.1%–63.6%	67.7%	59.0%–75.5%

AUC: Area under curve. CI: Confidence interval. *Significant.

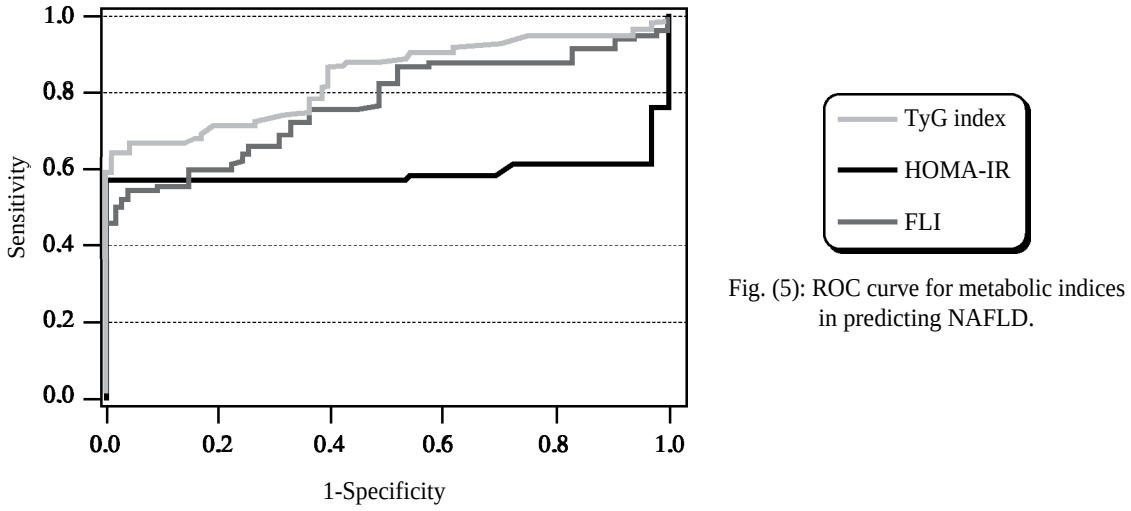

Fig. (5): ROC curve for metabolic indices in predicting NAFLD.

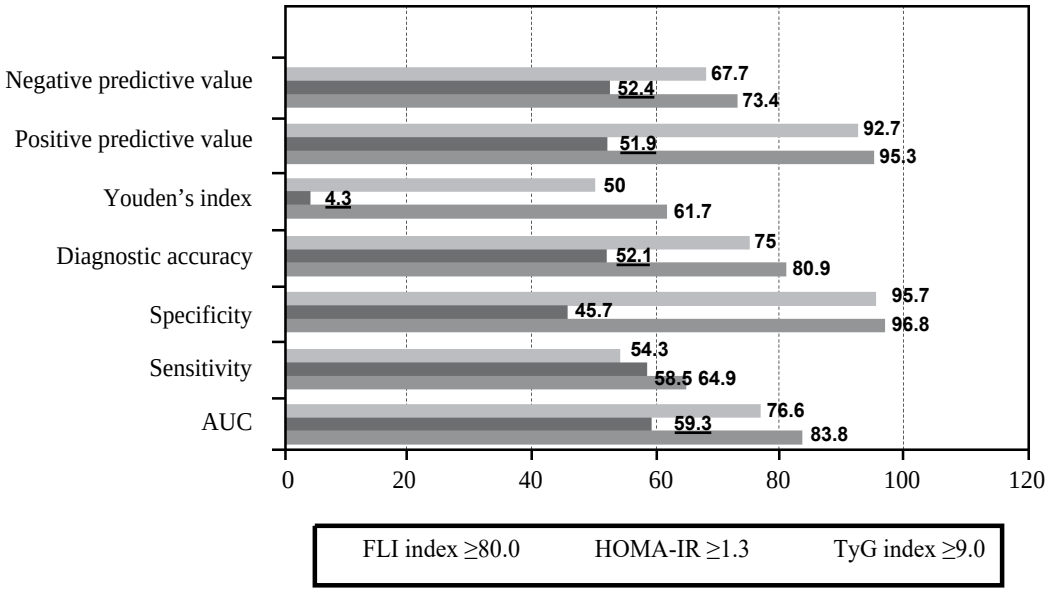

Fig. (6): Diagnostic characteristics of metabolic indices cut points in theprediction in predicting NAFLD.

Discussion

This case-control study was conducted at a tertiary care hospital at Soa'ad Kfafi University Hospital and National Hepatology and Tropical Medicine institute from August 2023 to December 2024. The study included 188 adult patients classified into two groups: NAFLD and non-NAFLD. During this study, 242 patients were assessed for eligibility, and 188 patients were included (94 in each group). Of all eligible patients, 24 were excluded from the study based on the inclusion criteria, 12 were excluded due to drug side effects on the liver (with the satins forming most of these drugs), and 18 refused participation. Ultimately, the analysis was based on the data from 188 adult patients attending the Internal Medicine Clinic at Soa'ad Kfafi University Hospital and National Hepatology and Tropical Medicine institute.

This study aimed to compare the sensitivity and specificity of the Triglyceride-Glucose (TyG) index to the Fatty Liver Index (FLI) in the early prediction of Non-Alcoholic Fatty Liver Disease (NAFLD). Additionally, it evaluated the strong associations between NAFLD, metabolic syndrome, and type 2 diabetes mellitus (T2DM).

The TyG index, a metabolic marker combining fasting triglyceride (TG) levels and fasting blood glucose (FBG), estimates insulin resistance, a central factor in NAFLD development. NAFLD is typically asymptomatic and reversible with early treatment, underscoring the importance of early monitoring to prevent complications such as fibrosis, cirrhosis, or hepatocellular carcinoma.

In our study, the TyG index showed higher sensitivity and consistent associations with liver disorders, particularly NAFLD, metabolic syndrome, and T2DM. We performed a detailed statistical analysis of metabolic, anthropometric, and diagnostic indices to assess their predictive value for NAFLD. The TyG index demonstrated a higher sensitivity compared to FLI for early NAFLD detection.

Demographic and clinical characteristics:

Regarding demographic data, our study found no significant differences in age, sex, or diabetes duration between the NAFLD and non-NAFLD groups ($p>0.05$). However, anthropometric measures, including waist circumference and BMI, were significantly higher in the NAFLD group ($p<0.001$). These findings align with established evidence linking central obesity and increased BMI to NAFLD risk.

Laboratory and biochemical findings:

Routine laboratory investigations revealed no significant differences in hemoglobin, leukocytes, or platelets between the groups. However, liver enzyme levels ALT, AST, and GGT were significantly elevated in the NAFLD group ($p<0.001$), indicating liver dysfunction consistent with NAFLD pathology. Renal function markers such as urea, creatinine, albumin-to-creatinine ratio (ACR), and uric acid showed no significant differences between the groups.

In terms of glycemic control, HbA1c and FBG levels were significantly higher in the NAFLD group ($p=0.016$ and $p<0.001$, respectively), underscoring the link between poor glycemic control and NAFLD. Regarding lipid profiles, total cholesterol, triglycerides, and LDL were significantly higher in the NAFLD group, while HDL was significantly lower ($p<0.01$ for all measures).

Metabolic indices:

The TyG index, HOMA-IR, and FLI were all significantly elevated in the NAFLD group, reinforcing their utility in identifying NAFLD. Correlations showed that these indices were strongly associated with waist circumference, BMI, FBG, triglycerides, and liver enzyme levels. Notably, the TyG index exhibited the highest diagnostic accuracy with an AUC of 0.838, followed by FLI (AUC = 0.766) and HOMA-IR (AUC = 0.593). The NAFLD group's mean TyG index (9.3±0.6) was significantly higher than the non-NAFLD group (8.6±0.3) ($p<0.001$). This robust distinction highlights the diagnostic reliability of the TyG index.

The TyG index also demonstrated excellent specificity (96.8%) and a high positive predictive value (95.3%), confirming its reliability in identifying individuals with NAFLD. Compared to FLI and HOMA-IR, the TyG index emerged as the most accurate and practical tool due to its non-invasive nature and ease of calculation.

Clinical implications and comparative analysis:

Clinically, the TyG index offers a cost-effective, non-invasive screening tool for early NAFLD detection, especially in populations with metabolic syndrome, obesity, or T2DM. Its high specificity ensures that positive results strongly indicate NAFLD, reducing unnecessary further testing and enhancing diagnostic efficiency. Despite its high diagnostic accuracy, the TyG index's lower sensitivity suggests that other clinical assessments for comprehensive evaluation should complement it.

Supporting evidence from literature:

In agreement with our findings, a cross-sectional study involving 2,280 participants with T2DM highlighted a significant association between the TyG index and NAFLD. The study demonstrated that the TyG index outperformed HbA1c, FBG, and the AST/ALT ratio in predicting NAFLD risk, Li et al., **[3]**. Similarly, a cohort study with 2,056 participants reported that elevated TyG index levels were independently associated with a higher risk of incident NAFLD, reinforcing its utility in screening, and managing NAFLD patients **[12]**.

The TyG index's strong correlation with metabolic dysfunction and its high diagnostic accuracy establish it as a valuable marker for predicting NAFLD. Its ability to reflect insulin resistance and lipid abnormalities underscores its efficacy in identifying at-risk individuals. However, ethnic, age-related, and metabolic variations may influence its predictive power. Therefore, while the TyG index is promising, it should be used alongside other clinical assessments and diagnostic procedures to ensure comprehensive evaluation and accurate diagnosis of NAFLD.

Conclusion:

This case-control study discusses the TyG index's diagnostic potential as an affordable, non-invasive marker for the early detection of non-alcoholic fatty liver disease (NAFLD) in people with type 2 diabetes.

According to the study, the TyG index is a trustworthy method for identifying people who are at risk of NAFLD since it performs better than other indices like FLI and HOMA-IR in terms of diagnostic accuracy, sensitivity, specificity, and positive predictive value.

The TyG index's importance in detecting and treating NAFLD in populations with obesity, type 2 diabetes, and metabolic dysfunction is highlighted by thesignificant correlations it has with metabolic syndrome, glycaemic control, and the TyG index.

Further research, including longitudinal and multi-center studies, is required to validate these results across diverse populations, even though the findings are supported by prior studies. These limitations include the study's case-control design, single-center setting, and reliance on non-invasive diagnostic methods. Furthermore, for a thorough assessment of NAFLD, the TyG index should be used in combination with other clinical evaluations due to its reduced sensitivity although it has a high positive predictive value. By lowering the likelihood of serious liver problems in high-risk groups, the TyG index is an overall promising diagnostic tool that may improve early identification and intervention methods for NAFLD.

Recommendations:

Conduct Large-Scale, Multi-Center Studies. Future studies should include diverse populations across multiple centers to improve generalizability and account for ethnic, geographic, and demographic variations in NAFLD prevalence and metabolic risk factors.

Assessment of the TyG Index in Disease Progression and Treatment Response, Future studies should evaluate how the TyG index changes over time in response to lifestyle modifications, pharmacological interventions, and metabolic improvements in NAFLD patients. TyG index is an overall promising diagnostic tool that may improve early identification and intervention methods for NAFLD.

Conflict of interest: The authors declared no conflict of interest.

Sources of funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contribution: Authors contributed equally in the study.

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التنبؤ بمرض الكبد الدهنى غير الكحولى باستخدام مؤشر الدهون الثلاثية /سكر الدم الصائم لدى مرضى السكرى من النوع الثانى

الخلفية: بما أن مرض الكبد الدهنى غير الكحولى يعد من المشكلات الصحية العامة العالمية المتزايدة وهو السبب الأكثر شيوعًا لأمراض الكبد المزمنة فى جميع أنحاء العالم ويرتبط ارتباطًا قويًا بمقاومة الأنسولين، ومتلازمة التمثيل الغذائى، وداء السكرى من النوع الثانى، وهو أيضًا مرض متعدد الأنظمة، فإن التعرف المبكر على مرض الكبد الدهنى غير الكحولى فى الفئات السكانية عالية المخاطر أمر ضرورى. كما أن مرض الكبد الدهنى غير الكحولى لا يحتوى على مظاهر سريرية محددة، مما يجعل تشخيص المرض مبكرًا أمرًا صعبًا. يعتبر أخذ خزعة من الكبد هو «المعيار الذهبى» لتشخيص مرض الكبد الدهنى غير الكحولى، ولكن مضاعفاته تحد من استخدامه. لذلك كان من المهم تحديد علامة مناسبة للتشخيص المبكر، والتقييم، والتنبؤ بمرض الكبد الدهنى غير الكحولى.

هدف الدراسة: تهدف هذه الدراسة إلى استخدام مؤشر الدهون الثلاثية–الجلوكوز كعلامة مثالية للكشف المبكر عن مرض الكبد الدهنى غير الكحولى فى المرضى المصابين بداء السكرى من النوع الثانى. مقارنة حساسية مؤشر الدهون الثلاثية–الجلوكوز مع مؤشر الكبد الدهنى فى التنبؤ المبكر بمرض الكبد الدهنى غير الكحولى.

المرضى الأساليب: شملت هذه الدراسة من نوع الحالة والشاهد ادراج١٨٨ فردًا تتراوح أعمارهم بين ١٨و٧٠ عامًا، الذين حضروا إلى عيادة الطب الباطنى فى مستشفى سعاد كفافى الجامعى المعهد القومى لأبحاث الامراض المتوطنة والكبد. تم الحصول على موافقة اللجنة الأخلاقية قبل بدء العمل. واستمرت الدراسة من أغسطس ٢٠٢٣ إلى ديسمبر ٢٠٢٤.

النتائج: شملت هذه الدراسة ١٨٨ فردًا تم تصنيفهم وفقًا لمؤشر كتلة الجسم إلى مجموعتين، كل مجموعة تشمل ٩٤ فردًا: المجموعة الأولى (مجموعة الكبد الدهنى)، المجموعة الثانية (مجموعة غير الكبد الدهنى) أظهرت نتائجنا أن مؤشر الدهون الثلاثية / سكر الدم الصائم وتقييم نموذج الاستتباب لمقاومة الأنسولين ومؤشر الكبد الدهنى كانت مرتفعة بشكل ملحوظ فى مجموعة الكبد الدهنى، مما يعزز من فائدتها فى التعرف على مرض الكبد الدهنى غير الكحولى. أظهرت الارتباطات أن هذه المؤشرات كانت مرتبطة ارتباطًا قويًا بمحيط الخصر، ومؤشر كتلة الجسم، وسكر الدم الصائم، والدهون الثلاثية، ومستويات إنزيمات الكبد. من الجدير بالذكر أن مؤشرالدهون الثلاثية /سكر الدم الصائم أظهر أعلى دقة تشخيصية مع AUC قدره ٠,٨٣٨، يليه مؤشر الكبد الدهنى (AUC = ٠,٧٦٦) وتقييم نموذج الاستتباب لمقاومة الأنسولين (AUC = ٠,٥٩٣). كان متوسط مؤشرالدهون الثلاثية /سكر الدم الصائم في مجموعة الكبد الدهنى (٩,٣ ± ٠,٦) أعلى بشكل ملحوظ مقارنةً بمجموعة غيرالكبد الدهني (٨,٦ ± ٠,٣) ($p < ٠,٠٠١$). هذا التمييز القوي يسلط الضوء على مصداقية التشخيص لمؤشرمؤشرالدهون الثلاثية /سكر الدم الصائم.

الخلاصة: وفقًا لدراستنا، يعد مؤشرالدهون الثلاثية /سكر الدم الصائم طريقة موثوقة للتعرف على الأشخاص الذين هم في خطر الإصابة بمرض الكبد الدهنى غير الكحولى، حيث أنه يتفوق على المؤشرات الأخرى مثل يليه مؤشر الكبد الدهنى وتقييم نموذج الاستتباب لمقاومة الأنسولين من حيث الدقة التشخيصية، والخصوصية، والقيمة التنبؤية الإيجابية.