Journal of Carcinogenesis
Covering Genesis to Therapeutics

Journal of Carcinogenesis, ISSN: 1477-3163
2025; Vol 24: Issue 5s, https://carcinogenesis.com/

Triglyceride Glucose Index Combined with Anthropometric Indices as Predictors for Non-alcoholic Fatty Liver Disease in Overweight and Obese individuals

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ABSTRACT

Background: Non-Alcoholic Fatty Liver Disease linked to obesity and metabolic disorders with global health risks, leading to severe complications like cirrhosis and cancer. Presently, diagnosing it lacks specific biomarkers. Identifying at-risk individuals early is vital for prevention and treatment. The Triglyceride Glucose Index, indicating insulin resistance, along with waist circumference (WC) and body mass index (BMI), are potential predictors due to their association with fat metabolism. Evaluating their combined effectiveness can enhance early NAFLD diagnosis, reducing future adverse outcomes. ***Aim:*** To evaluate the role of Triglyceride Glucose Index with anthropometric indices as predictors for Non-alcoholic fatty liver disease in overweight and obese individuals. ***Methods:*** This cross-sectional study was done at The Department of Biochemistry and Molecular Biology, BSMMU, Dhaka (March 2023 to February 2024) included 253 adults (18-75 years, both genders) with overweight or obese. Ethical approval was obtained, and subjects were selected from the Hepatology outpatient department using purposive sampling. Informed written consent was taken after explaining the study purpose. Detailed history, examinations, and anthropometric measurements were recorded. Upper abdominal Ultrasonography was done at the Radiology department of BSMMU for detecting NAFLD characteristics. Fasting blood samples were taken for estimation of lipid profile, fasting plasma glucose, and ALT. BMI categorization defined overweight (BMI 23-24.9 kg/m2) and obesity (BMI ≥25 kg/m2). Study subjects were categorized into two groups based on USG findings- NAFLD group and the non-NAFLD group (Reference group). NAFLD group further classified as Grade-I, Grade-II and Grade-III depending on usg grading. TyG-index and TyG combined with anthropometric indices (TyG-BMI, TyG-WC) were compared between NAFLD and non-NAFLD groups. Further, TyG combined with anthropometric indices was compared across NAFLD grades. ROC curves were constructed for TyG-index, TyG-BMI, and TyG-WC to predict NAFLD. SPSS version 27.0 was used for data analysis. ***Results:*** The NAFLD group had more TG, FPG, and ALT than the non-NAFLD group. However, TG, FPG, and ALT increased with NAFLD grade, peaking in Grade III. NAFLD group had significantly higher TyG-index, TyG-BMI, and TyG-WC than non-NAFLD group, regardless of gender. Receiver operating characteristic (ROC) curve showed each of the indicators were significant NAFLD AUC predictors. AUCs showed that TyG-WC predicted NAFLD most effectively followed by TyG-BMI and TyG-index. TyG-WC has good sensitivity and specificity. TyG-index and TyG-BMI diagnostic performance showed excellent sensitivity but low specificity. In contrast, the TyG-WC has good sensitivity and specificity. ***Conclusion:*** Our study found that the TyG-index, TyG-BMI, and TyG-WC as valuable predictors of NAFLD, with TyG-WC being the most effective. It showed satisfactory results in terms of combined sensitivity and specificity, making it the optimal predictor for NAFLD in overweight and obese individuals.

Keywords: *Non-alcoholic fatty liver disease (NAFLD), Triglyceride-glucose index (TyG), TyG-BMI, TyG-WC, Overweight, Obesity, Insulin resistance, Anthropometric indices, ROC curve, Disease severity*.

How to Cite: Md. Sunjidul Haque, Broti Proma Biplab, Md. Tahmidul Islam, Md. Shaikhul Islam Shuja, Sumaiya Bashar, Ayesha Ferdous Jesun, Rehnuma Tarannum, Rowsan Ara Begum, Md. Mozammel Hoque (2025). Triglyceride Glucose Index Combined with Anthropometric Indices as Predictors for Non-alcoholic Fatty Liver Disease in Overweight and Obese individuals, *Journal of Carcinogenesis*, *Vol.24*, *No.5s*, 1248-1258

INTRODUCTION

Non-communicable diseases (NCDs) have existed throughout human history, although their recognition and understanding have evolved over time. Today, NCDs represent the leading global public health challenge and are responsible for the majority of deaths and disability worldwide. Chronic respiratory diseases, cancers, diabetes, and cardiovascular diseases account for nearly 74% of global mortality, and this figure is projected to rise to 80% by 2030 [1,2]. Low- and middle-income countries (LMICs) are witnessing a rapid escalation of NCDs, including in rural populations [3]. Bangladesh is undergoing significant demographic and epidemiological transitions, resulting in an aging population and a rising burden of NCDs. Currently, 67% of deaths in Bangladesh are attributed to NCDs, while infectious, maternal, and pediatric diseases contribute to 26% [4]. Among NCDs, non-alcoholic fatty liver disease (NAFLD) has emerged as a major public health issue worldwide. It is now recognized as the most frequent cause of chronic liver disease (CLD), affecting approximately one billion people globally [5,6]. In Western countries, NAFLD prevalence ranges from 20% to 30%, with comparable rates reported in the Middle East, Japan, and China [7,8]. Prevalence rates vary across Asia: in the Indian subcontinent, estimates range from 9–16% in rural areas to 16–32% in urban settings [9,10]. Bangladesh is also facing a growing NAFLD burden, fueled by dietary transitions and increasingly sedentary lifestyles [11,12]. Liver diseases account for 2.82% of all deaths in Bangladesh, making liver disorders the eighth leading cause of mortality, with an age-adjusted death rate of 19.26 per 100,000 population [1,13]. NAFLD contributes substantially to CLD in Bangladesh, and recent data suggest that nearly one in three Bangladeshis is affected [14]. NAFLD is defined by abnormal lipid accumulation (>5–10% hepatocyte fat content) in the absence of significant alcohol consumption. It encompasses a spectrum ranging from simple steatosis to non-alcoholic steatohepatitis (NASH), fibrosis, cirrhosis, and hepatocellular carcinoma (HCC) [15,16]. NAFLD is strongly associated with obesity, dyslipidemia, hypertension, insulin resistance (IR), and type 2 diabetes mellitus (T2DM). While the precise mechanisms underlying NAFLD pathogenesis remain incompletely understood, early models proposed a “two-hit” hypothesis in which hepatic lipid accumulation sensitizes the liver to inflammatory and oxidative injury [17]. More recent evidence supports a “multiple-hit” model involving metabolic imbalance, genetic susceptibility, environmental exposures, gut microbiome alterations, and adipose-tissue dysfunction [18]. Insulin resistance plays a central role in NAFLD development. Compensatory hyperinsulinemia impairs mitochondrial fatty-acid oxidation, promotes lipid peroxidation, increases reactive oxygen species (ROS), and induces hepatocellular damage [19]. Central obesity contributes further by dysregulating adipokines such as adiponectin, leptin, TNF-α, and IL-6, which in turn promote steatosis, inflammation, and fibrosis [20,21]. Genetic predisposition also influences susceptibility: polymorphisms in PNPLA3 and TM6SF2 have been linked to increased NAFLD risk [22,23]. Despite genetic factors, weight gain and metabolic syndrome remain the strongest determinants of NAFLD onset and progression [24]. Given its association with obesity and T2DM, NAFLD prevalence is expected to rise further. NAFLD is now a leading indication for liver transplantation and is linked not only to liver-related morbidity but also to cardiovascular disease, chronic kidney disease, and certain malignancies [25]. Early identification of high-risk individuals is therefore essential. Diagnostic methods for NAFLD include invasive and non-invasive approaches. Liver biopsy remains the gold standard but is limited by invasiveness, cost, sampling error, and inter-observer variability [26]. Ultrasonography is widely used due to its availability and low cost, with sensitivity of 60–94% and specificity of 66–95% [27]. However, it cannot reliably distinguish simple steatosis from NASH or identify fibrosis. MRI and CT provide more accurate quantification but are expensive and less accessible. Since NAFLD is often asymptomatic in early stages, simple and accessible predictors are needed. The triglyceride-glucose (TyG) index, calculated as Ln [fasting triglycerides (mg/dL) × fasting glucose (mg/dL) / 2], was proposed as a surrogate marker for insulin resistance [28]. TyG correlates with IR because hypertriglyceridemia increases fatty-acid flux to the liver, promoting hepatic glucose production and metabolic dysregulation [29,30]. As NAFLD is strongly linked to IR, TyG has been explored as a potential biomarker for NAFLD prediction [31]. Anthropometric indices such as body mass index (BMI) and waist circumference (WC) are simple, non-invasive indicators of adiposity. Combining these with the TyG index yields composite markers such as TyG-BMI and TyG-WC, which have shown stronger associations with NAFLD risk than TyG alone [32,33]. Given that obesity particularly central obesity is a major driver of NAFLD, these combined indices may serve as more powerful predictors. Bangladesh has a rapidly rising prevalence of overweight (39%) and obesity (18.2%) [34]. The strong link between obesity, metabolic dysfunction, and NAFLD underscores the need for simple, cost-effective screening tools suitable for routine clinical settings. Composite indices such as TyG-BMI and TyG-WC may help identify individuals at high risk before advanced liver disease develops. However, large-scale data evaluating these indices in South Asian populations remain limited. Therefore, the present study aims to assess the role of the TyG index and its combined anthropometric derivatives (TyG-BMI, TyG-WC) as predictors of NAFLD among overweight and obese individuals.

MATERIALS AND METHODS

This cross-sectional analytical study was conducted in the Department of Biochemistry and Molecular Biology, Bangabandhu Sheikh Mujib Medical University, over a period of one year from March 2023 to February 2024. The study population consisted of apparently healthy overweight and obese individuals attending the Outpatient Department of Hepatology, BSMMU. Participants were selected based on predefined inclusion and exclusion criteria and were grouped according to ultrasonographic findings into NAFLD and Non-NAFLD (reference) groups. The NAFLD group was further categorized into Grade I, Grade II, and Grade III based on hepatic echogenicity.

A purposive sampling technique was used. Sample size was estimated using the formula: $n = Z^2P(100–P)/d^2$, where Z = 1.96 at 95% confidence level, P = 72.2% (expected sensitivity of TyG-index for detecting NAFLD), and d = 10% of P. The calculated minimum sample size was 147. Adjusting for a 58% prevalence of NAFLD among obese individuals in Bangladesh, the final required sample size was 253, which was adopted for this study.

Inclusion criteria

1. Apparently healthy overweight and obese individuals attending the hepatology OPD of BSMMU.
2. Age 18–75 years.
3. Both male and female participants.
4. BMI ≥ 23 kg/m².

Exclusion criteria

1. History of alcohol consumption >20 g/day in men and >10 g/day in women.
2. History of jaundice, HBsAg positivity, or Anti-HCV positivity.
3. Known liver cirrhosis or hepatocellular carcinoma.
4. Use of drugs such as steroids, aspirin, heparin, valproic acid, oral contraceptives, methotrexate, or other hepatotoxic medications.

Variables

The independent variables were the triglyceride–glucose index (TyG-index) and TyG combined with anthropometric indices (TyG-BMI and TyG-WC). Dependent variables included age, gender, BMI, waist circumference, and NAFLD status.

Operational Definitions

NAFLD was defined as hepatic lipid accumulation of 5–10% in the absence of significant alcohol intake. Overweight was defined as BMI 23–24.9 kg/m² and obesity as BMI ≥ 25 kg/m². Waist circumference ≥ 90 cm in men and ≥ 80 cm in women was considered obese. The TyG-index was calculated as ln [fasting triglycerides (mg/dL) × fasting glucose (mg/dL)/2]. TyG-BMI and TyG-WC were calculated by multiplying the TyG-index with BMI and WC, respectively.

NAFLD grading by ultrasonography included:

- **Grade I:** Mild increased echogenicity with normal visualization of diaphragm and intrahepatic vessels.
- **Grade II:** Moderate echogenicity with slightly impaired visualization.
- **Grade III:** Marked echogenicity with poor posterior beam penetration and loss of vascular and diaphragmatic clarity.

Study Procedures

Ethical approval was obtained from the Institutional Review Board of BSMMU. After informed written consent, demographic and clinical information was recorded. Anthropometric measurements included height, weight, and waist circumference using standardized protocols. Participants were instructed to consume a regular carbohydrate-containing diet for three days prior to testing, avoid medications affecting lipid levels, and undergo 10–12 hours of overnight fasting.

Fasting blood samples (5 mL) were collected using aseptic techniques. Two milliliters were placed in sodium fluoride tubes for glucose estimation and three milliliters in plain tubes for serum separation. Samples were centrifuged at 3000 rpm for 10 minutes. Biochemical analyses including fasting plasma glucose, lipid profile, and ALT were performed using standard enzymatic methods on the Atellica CH analyzer. Participants with elevated ALT were excluded. All subjects underwent upper abdominal ultrasonography performed by an experienced sonologist.

Among the 253 participants, 129 were classified as NAFLD and 124 as non-NAFLD. TyG-index, TyG-BMI, and TyG-WC were calculated for all participants, and their diagnostic performance was assessed.

Statistical Analysis

Data were processed using SPSS version 27. Quantitative variables were expressed as mean ± SD for normally distributed data or median (IQR) for skewed data. Group comparisons were performed using unpaired Student's t-test or Mann-Whitney U-test. One-way ANOVA or Kruskal-Wallis test was used for comparisons across NAFLD grades. Diagnostic accuracy of TyG-index, TyG-BMI, and TyG-WC was evaluated using ROC curve analysis. Sensitivity, specificity, PPV, NPV, and optimal cutoff values were determined. A p-value ≤ 0.05 was considered statistically significant.

Ethical Considerations

Informed consent, confidentiality, anonymity via unique ID codes, voluntary participation, and the right to withdraw were ensured. Universal precautions were followed during blood collection, and no experimental drug or placebo was used.

RESULTS AND OBSERVATIONS

A total 253 apparently healthy overweight and obese individuals (129 NAFLD & 124 Non- NAFLD) were enrolled from the Hepatology outpatient department of Bangabandhu Sheikh Mujib Medical University (BSMMU). All the information was collected and tabulated in the mentioned formats.

Table I. Distribution of study subjects in different groups and grades of NAFLD on the basis of ultrasonography finding (n= 253)

Group	Number	Percentage (%)
Non- NAFLD	124	49%
NAFLD	129	51%
Grade -I	89	69%
Grade-II	29	22%
Grade-III	11	09%

Data were expressed in frequency and percentage. NAFLD: Non-Alcoholic Fatty Liver Disease, Grade I: Grade -I Non-Alcoholic Fatty Liver Disease Grade II: Grade -II Non-Alcoholic Fatty Liver Disease Grade III: Grade -III Non-Alcoholic Fatty Liver Disease

Among the total study subjects (n=253), the majority were subjects with NAFLD (129, 51%), in which Grade-I was found to dominate (89, 69%).

Table II. Gender distribution of study subjects (n=253)

Gender	**Non-NAFLD** (n=126)	**NAFLD** (n=129)				**P value**
	Total	**Grade-1 (n=89)**	**Grade2 (n=29)**	**Grade-3 (n=11)**	**Total**	
Male (n=108) Frequency (43%)	**44**	**44**	**15**	**05**	**64**	
Female (n=145) Frequency (57%)	**80**	**45**	**14**	**06**	**65**	**0.023**

Chi-square test was done to find out the P value. Data were expressed in frequency and percentage. NAFLD: Non-Alcoholic Fatty Liver Disease More than half of the study subjects were female (n=145, 57%) significant difference seen in gender distribution with respect to diagnosis of NAFLD.

Table III: Age and anthropometric measurements of study population (n=253)

Variables	**Non-NAFLD (Reference group) (n=124) Median (IQR)**	**NAFLD (n=129) Median (IQR)**	**P value**
Age (years)	32 (25-43)	40 (33-50)	<0.001
WC (cm)	84 (79-90)	95 (89-100)	<0.001
BMI (22 kg/m²)	24.3 (23.7-26.0)	27.4 (25.3-29.7)	<0.001

Mann-Whitney U test was done to find out the P value Data were expressed as median with (IQR)
IQR: Interquartile range
NAFLD: Non-Alcoholic Fatty Liver Disease WC: Waist circumference
BMI: Body mass index
Median of age, WC and BMI were found to be significantly higher in subjects with NAFLD.

Table IV: Comparison of Biochemical parameters between Non-NAFLD (Reference) and NAFLD groups (n=253)

Parameters	**Non-NAFLD (Reference) (n=126)**	**NAFLD(n=129)**	**P value**
TG (mg/dl)	135 (98-195)	187 (140-240)	<0.001
LDL-C (mg/dl)	96 (72-119)	100 (79-122)	0.885
HDL-C (mg/dl)	41 (34-50)	39 (34-45)	0.053
FPG (mg/dl)	98 (90-109)	106 (95-126)	<0.001
ALT (mg/dl)	20 (16-35)	33 (23-65)	<0.001

Mann-Whitney U test was done to find out the P value Data were expressed as median with (IQR)
IQR: Interquartile range
NAFLD: Non-Alcoholic Fatty Liver Disease TG: Triglyceride
LDL-C: Low Density Lipoprotein-Cholesterol HDL-C: High Density Lipoprotein-Cholesterol FPG: Fasting Plasma Glucose
ALT: Alanine Aminotransferase
NAFLD group showed significant elevations of TG, FPG & ALT compared to Reference group. No significant differences of LDL-C & HDL-C were found between the groups.

Table V: Comparison of Biochemical parameters among different grades of NAFLD (n=129)

Parameters	NAFLD			P value
	Grade-I (n=89) Median (IQR)	Grade-II (n=29) Median (IQR)	Grade-III (n=11) Median (IQR)	
TG (mg/dl)	187 (141-240)	172 (121-227)	351 (245-387)	<0.001
LDL-C (mg/dl)	99 (76-119)	103 (75-127)	80 (49-122)	0.698
HDL-C (mg/dl)	39 (33-44)	37 (35-44)	35 (33-44)	0.714
FPG (mg/dl)	104 (93-120)	110 (99-124)	129 (115-171)	0.012
ALT (mg/dl)	29 (20-51)	47 (34-73)	53 (32-114)	0.001

Kruskal-Wallis test was done to find out the P value Data were expressed as median with (IQR)
IQR: Interquartile range
NAFLD: Non-Alcoholic Fatty Liver Disease TG: Triglyceride
LDL-C: Low Density Lipoprotein-Cholesterol HDL-C: High Density Lipoprotein-Cholesterol FPG: Fasting Plasma Glucose
ALT: Alanine Aminotransferase

Significant elevation of TG, FPG and ALT with advancement of NAFLD grades were found with their highest values in Grade- III. LDL-C and HDL-C had no significant differences among different grades of NAFLD.

Table VI: Comparison of TyG, TyG-BMI and TyG-WC between Reference and NAFLD group (n=253)

Parameters	Non-NAFLD (Reference group) (n=126) (median (IQR)/(mean±SD)	NAFLD (n=129) (median (IQR)/(mean±SD)	p-value
TyG-index	8.8(8.6-9.3)	9.3(8.9-9.7)	<0.001a
TyG-BMI	218 (207-235)	258(230-279)	<0.001a
TyG-WC	(759±96)	(893± 106)	<0.001b

Mann Whitney U test and Unpaired student's t-test were done to find out the P value
Data were expressed as median (IQR)/ mean±SD SD= Standard deviation
P[a] Obtained from Mann Whitney U test
P[b] Obtained from Unpaired student's t-test NAFLD: Non-Alcoholic Fatty Liver Disease TyG-index: Triglyceride Glucose Index
TyG-BMI: Triglyceride Body Mass Index TyG-WC: Triglyceride Waist Circumference
TyG index, TyG-BMI, TyG-WC were found significantly higher in NAFLD group than the Non - NAFLD group.

Table VII: Comparison TyG, TyG-BMI and TyG-WC among different grades of NAFLD.

Parameters	NAFLD (n=129)			P value
	Grade-I (n=89) median (IQR)/mean ±SD	Grade-II (n=29) median (IQR)/mean ±SD	Grade-III (n=11) median (IQR)/mean ±SD	
TyG	9.3 (8.9-9.5)	9.3(8.9-9.7)	9.9 (9.8-10.6)	**<0.001[a]**
TyG-BMI	251 (227-279)	259 (242-280)	271(268-284)	0.118[a]
TyG-WC	882±110	900±87	970±86	**<0.001[b]**

Kruskal-Wallis test and One way anova test were done to find out the P value Data were expressed as median (IQR)/ mean ±SD
SD= Standard deviation
P[a] Obtained from Kruskal-Wallis test P[b] Obtained from One way anova test
NAFLD: Non-Alcoholic Fatty Liver Disease TyG-index: Triglyceride Glucose Index
TyG-BMI: Triglyceride Body Mass Index TyG-WC: Triglyceride Waist Circumference

Statistically significant elevation of TyG-index and TyG-WC were found with their highest values in Grade- III. TyG-BMI had no significant differences among different grades of NAFLD.

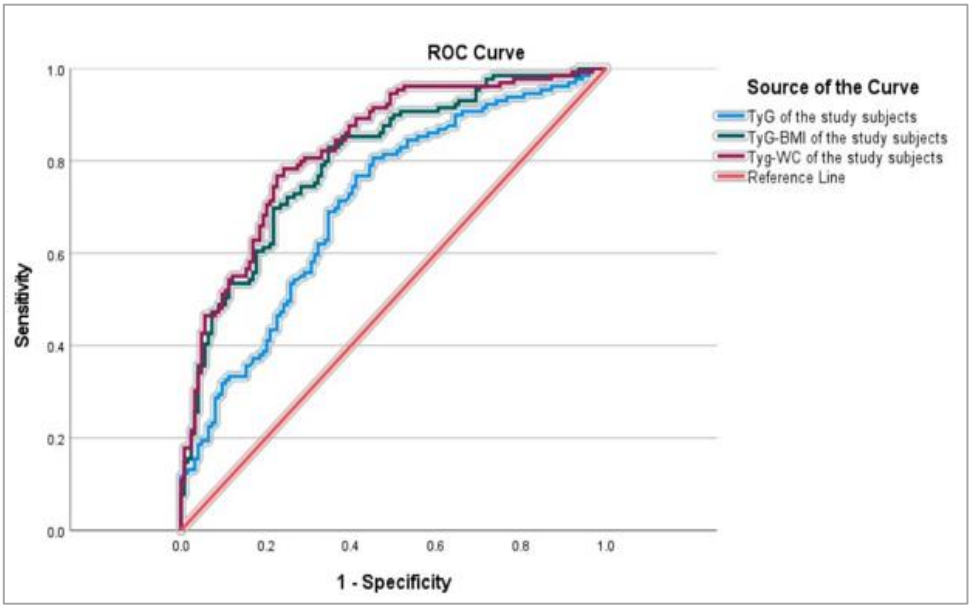

Figure 1: ROC curve of TyG, TyG-BMI and TyG-WC as predictors of NAFLD in total study subjects (n=253)

Table VIII: AUCs of different predictors of NAFLD in total study subjects (n=253)

Parameter	AUC	p-value
TyG	.708	0.000
TyG-BMI	.803	0.000
TyG-WC	.829	0.000

AUCs of ROC curve for TyG, TyG-BMI and TyG-WC shows that, all parameters are promising predictors for NAFLD in total study subjects (as AUC > 0.5). Among them, TyG- WC was found to be the best predictor for NAFLD followed by TyG-BMI and TyG. Performance of TyG for prediction of NAFLD found to be poor compared to others.

Table IX: Cut-off point of different predictors determined by Youden index in total study subjects (n=253):

Parameter	Optimal cut-off
TyG	8.9
TyG-BMI	238.3
TyG-WC	822.3

Optimal cut-off value was calculated by Youden index.

Table X: Summary of diagnostic performance of TyG, TyG-BMI and TyG-WC as predictor for NAFLD in total study subjects (n=253)

Predictors	Cut-off	Sensitivity	Specificity	PPV	NPV	Accuracy
TyG	8.9	79%	54%	65%	72%	68%
TyG-BMI	238.3	69%	78%	77%	71%	74%
TyG-WC	822.3	78%	76%	77%	77%	77%

DISCUSSION

This cross-sectional study evaluated the predictive performance of triglyceride-glucose–derived indices TyG-index, TyG-BMI, and TyG-WC in identifying non-alcoholic fatty liver disease (NAFLD) among overweight and obese adults attending the Hepatology outpatient department of BSMMU. A total of 253 apparently healthy individuals aged 18 to 75 years were enrolled through purposive sampling. NAFLD was diagnosed by abdominal ultrasonography and further categorized into Grade I, II, or III steatosis. The principal aim was to determine whether modified TyG indices incorporating anthropometric measures outperform the traditional TyG index in predicting NAFLD in this high-risk population. In the present study, NAFLD was detected in 129 participants (51%), indicating a higher frequency compared to community-based Bangladeshi prevalence estimates. Alam et al [14] reported a national prevalence of 33.86%, substantially lower than the proportion

observed here. This discrepancy likely reflects selection from a hepatology clinic rather than a general population sample, thereby enriching the cohort with individuals at higher metabolic risk. Among NAFLD cases, Grade I steatosis predominated (69%), followed by Grade II (22%) and Grade III (9%). Comparable grade distributions have been documented in studies from Nepal [35], where early-grade NAFLD was similarly the most common presentation. These findings collectively suggest that mild steatosis constitutes the majority of NAFLD burden in South Asian and Middle Eastern populations. Female participants constituted 57% of the study population, consistent with global evidence that women make greater use of outpatient health services [36]. Despite their higher representation, NAFLD was significantly more common in males (59%) compared to females (45%). This sex disparity aligns with the well-established male predominance of NAFLD described across epidemiological studies. Hormonal protection, particularly estrogen-mediated effects on insulin sensitivity and hepatic lipid handling, may partially explain this phenomenon [37, 38] highlighted the protective metabolic roles of estrogens in premenopausal females, which may contribute to the lower NAFLD rates observed among women of reproductive age. Notably, a sizable proportion of women in the present study were within reproductive age range (median 38 years), potentially reinforcing this hormonal advantage. Differences in fat distribution also contribute to the gender gap in NAFLD prevalence. Males typically exhibit a higher waist-to-hip ratio (WHR), indicating greater visceral adiposity a strong driver of hepatic fat deposition and insulin resistance. Multicountry studies in Asian populations echo the present findings, with consistently higher NAFLD prevalence among men [39-42]. Reports from Iran [43] and Italy [44] further support this pattern, though isolated studies such as Khan et al [45] have documented female predominance, likely influenced by sample characteristics or regional metabolic profiles. Regarding NAFLD severity, most participants with NAFLD had Grade I steatosis. This agrees with previous findings from Nepal [35] and other regional studies that observed similar grade distributions, albeit with minor differences attributed to sample sizes and study methodologies. Overall, both global and regional research point toward Grade I NAFLD as the most frequent phenotype among overweight and obese adults. Anthropometric and metabolic markers demonstrated clear differences between NAFLD and non-NAFLD groups. Participants with NAFLD exhibited significantly higher age, weight, waist circumference (WC), and body mass index (BMI). These observations are in line with findings from Lee et al [31] and Singh et al [46], who similarly reported elevated anthropometric measures in NAFLD adults compared with controls. WC reflects visceral fat a key contributor to insulin resistance while BMI captures overall adiposity. Evidence indicates that visceral fat is more strongly linked to hepatic steatosis than subcutaneous fat [47]. Previous studies have consistently shown associations between BMI, WC, and NAFLD severity [5,48]. The current findings also align with Bangladeshi data from Alam et al [14], who reported rising NAFLD prevalence with increasing BMI categories. Significant metabolic derangements including elevated triglycerides (TG), fasting plasma glucose (FPG), total cholesterol (TC), and alanine aminotransferase (ALT) were observed in individuals with NAFLD. These results mirror the findings of Song et al [30], Kim et al [49]. However, HDL-C and LDL-C did not differ significantly between groups, consistent with findings by Khamesh et al [50]. Some studies [51] demonstrated LDL-C and HDL-C differences between NAFLD and non-NAFLD individuals, though inconsistencies may stem from small sample sizes or population differences. Importantly, TG, FPG, and ALT levels increased progressively from Grade I to Grade III steatosis, supporting patterns observed in studies by Pardhe et al [52] and Kasapoğlu et al [53], suggesting metabolic worsening with advancing NAFLD severity. Given NAFLD's strong association with insulin resistance [54,55], the TyG index an established surrogate marker of insulin resistance has been increasingly employed in metabolic research. Modified TyG indices TyG-BMI and TyG-WC were developed to enhance predictive power by incorporating obesity-related parameters. In our study, TyG-WC and TyG-index increased significantly across NAFLD grades, while TyG-BMI did not differ significantly between grades. Although Song et al [30] documented significant increases across all modified indices, the current findings may reflect narrower anthropometric variability or ethnic differences. ROC curve analysis demonstrated that all three indices the TyG index, TyG-BMI, and TyG-WC had AUC values above 0.5, indicating acceptable diagnostic utility. TyG-WC exhibited the highest AUC (0.751), followed closely by TyG-BMI (0.750), with the TyG index showing lower discriminatory power (0.625). These results align with Lee et al & Song et al [30,31], all of whom identified TyG-WC as the strongest predictor of NAFLD. Variations in AUC values across studies likely result from ethnic differences, sample size variations, and methodological differences including ultrasound criteria and fasting sample measurements. Optimal cut-off points (OCPs) determined using the Youden index further supported TyG-WC as the strongest predictor. The OCPs for predicting NAFLD were 8.9 for TyG index, 238.3 for TyG-BMI, and 822.3 for TyG-WC. These values are broadly comparable to findings from Sheng et al [56], Lee et al [31], and Wang et al [57], though slight differences underscore the importance of population-specific calibration. Ethnic variations in body composition likely influence TyG-related thresholds, emphasizing that universal cutoff points may not be applicable across diverse populations. Sensitivity, specificity, PPV, NPV, and diagnostic accuracy analyses reinforced the superiority of TyG-WC. At the selected OCP, TyG-WC showed 78% sensitivity, 76% specificity, 77% PPV, 77% NPV, and 77% overall accuracy, outperforming both TyG-BMI and the TyG index. TyG-index demonstrated reasonable sensitivity (79%) but poor specificity (54%), increasing the likelihood of false positives. These performance patterns resonate with observations from Khamesh et al [50] and other similar studies [56]; Song et al [30]; Wang et al [57], although these prior studies did not measure PPV, NPV, or accuracy. Using the criterion of combined sensitivity and specificity exceeding 150 for adequate test performance [58], only TyG-WC met the threshold [54]. This further establishes TyG-WC as the most reliable marker for NAFLD prediction among overweight and obese individuals in this study population. Taken together, the findings indicate that TyG-WC an inexpensive, easily obtained, and

noninvasive indicator demonstrates the best diagnostic performance among the evaluated predictors. Incorporating both metabolic and anthropometric information, TyG-WC captures the dual contributions of insulin resistance and visceral obesity, providing a strong, practical tool for early identification of NAFLD in high-risk groups. Given the rising burden of metabolic diseases in South Asia, adopting such markers could enhance early detection, risk stratification, and public health screening strategies. In conclusion, TyG-WC emerged as the most effective index in predicting NAFLD among overweight and obese adults, outperforming both TyG-BMI and the TyG index. Its strong sensitivity, specificity, and accuracy underscore its potential value in clinical and epidemiological settings for early identification of NAFLD, particularly in resource-limited environments where advanced diagnostic modalities may not be readily available.

CONCLUSION

The study found that the TyG-index, when paired with anthropometric indices such as TyG- BMI and TyG-WC, showed significantly higher values in the NAFLD group compared to the non-NAFLD group. The TyG-WC parameter was identified as the most effective predictor of NAFLD, followed by TyG-BMI and TyG-index. So, the TyG-WC can be performed as an effective predictor of NAFLD in overweight and obese adults.

Limitations

1. NAFLD was not diagnosed via liver biopsy.
2. Abdominal ultrasonography exams were not done by a single sonologist.
3. NAFLD diagnosis and grading was made only on the basis of USG findings
4. Single centered study with shorter duration

Recommendations

1. Research with bigger sample sizes should be done to confirm the predictive accuracy of the TyG-index in relation to anthropometric indices for NAFLD.
2. NAFLD should be diagnosed with liver biopsy.

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