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RESEARCH ARTICLE

Finnish diabetes risk score outperformed triglyceride-glucose index in diabetes risk prediction

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Abstract

Purpose Triglyceride-Glucose (TyG) index is a surrogate marker of insulin resistance. This study compared the performance of TyG index and the Finnish diabetes risk score (FINDRISC) in diabetes risk prediction.

Methods This cross-sectional study involved 122 young adults (aged 15–35 years) in Asaba, Delta State, Nigeria. Anthropometric measurements and biochemical analysis were done following standard protocols. Diabetes risk scoring was done using the FINDRISC questionnaire. TyG index was calculated logarithmically. Discrimination between TyG index and FINDRISC was done by plotting receiver operating characteristic (ROC) curves.

Results High risk participants had significantly ($p < 0.001$) higher mean values of body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR) relative to the lower risk categories. Participants in TyG index Quartile 4 had significantly higher mean values of triglyceride ($p < 0.001$) and fasting plasma glucose ($p < 0.05$). BMI and triglyceride had the most significant ($p < 0.001$) positive correlation with FINDRISC and TyG index, respectively. A moderately elevated to high risk (FINDRISC ≥ 12) of developing diabetes was found in 14.8% of the participants; with a female preponderance (20.6%) relative to males (7.4%). More than half of the participants (52.5%) had slightly elevated risk and differences in diabetes risk susceptibility were significant ($p < 0.001$) across gender. FINDRISC had an AUC value of 0.826 while TyG index had an AUC value of 0.628 for diabetes risk prediction.

Conclusion FINDRISC had a better performance than TyG index in the prediction of diabetes risk in this population. The use of other TyG-related parameters rather than TyG index is recommended in future studies.

Keywords FINDRISC · TyG index · Performance · Diabetes · Risk prediction

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Abbreviations

ANOVA	Analysis of variance
AUC	Area under curve
BMI	Body mass index
FINDRISC	Finnish diabetes risk score
HDL-C	High density lipoprotein-cholesterol
LDL-C	Low density lipoprotein-cholesterol
ROC	Receiver operating characteristic
SPSS	Statistical package for social sciences
TyG index	Triglyceride-Glucose index
T2DM	Type-2 diabetes mellitus
WC	Waist circumference

Introduction

Diabetes mellitus (DM) has emerged as one of the fastest growing global health menace that has reached epidemic proportions [1]. The currently estimated global burden of 537 million cases and a projected increase to 783 million cases by 2045 validates its public health significance [2]. Diabetes is a chronic metabolic disorder resulting from impaired glucose, fat and protein metabolism due to a relative or absolute lack of insulin [3]. The most prevalent form of the condition is the type-2 diabetes mellitus (T2DM) with the highest percentage of about 90–95% of all diabetes patients [4] and mostly results from the interactions among genetic, environmental and other risk factors. The main risk factors of diabetes mellitus include an unhealthy diet, obesity, sedentary behaviours and reduced physical activity [5].

Although it was previously thought to occur exclusively in the middle-aged and elderly, young adults are now facing the condition, thus presenting a new public health concern [6]. T2DM diagnosed during youth and early adulthood is aggressive and associated with a high burden of vascular complications [7]. Also, the onset of T2DM in young adults may have a more rapid and disruptive natural history than T2DM presenting later in life, leading to early morbidity and poor quality of life [8].

Current efforts at reduction of diabetes burden are now being targeted at early identification of individuals at risk for developing the disease using diabetes risk scoring tools. The Finnish Diabetes Risk Scoring (FINDRISC) questionnaire is a widely accepted diabetes risk scoring tool with its non-invasive, fast, reliable, cheap, and simple characteristics [9]. The tool was designed in Finnish population cohorts for the assessment of diabetes risk on the basis of eight variable scoring components and has a good validity in the prediction of future diabetes onset over a 10-year period [10]. The FINDRISC tool has been previously utilized in diabetes risk assessment in a young adult Nigerian population [6].

Fasting plasma glucose (FPG) and triglyceride (TG) levels are associated with the onset of type-2 diabetes mellitus [11, 12]. TyG index, a natural logarithm product of triglyceride and fasting plasma glucose has been validated as a surrogate marker of insulin resistance that precedes and significantly predicts type 2 diabetes mellitus in several epidemiological studies [13–15]. Insulin resistance is defined by impaired tissue sensitivity or responsiveness to circulating insulin [16]. Early use of TyG index may be important in the assessment of potential diabetes risk and could be an initiative for preventive measures of type 2 diabetes mellitus [17].

The utilization of TyG index in diabetes risk prediction is yet to be investigated in any specific young adult Nigerian population. Therefore, this study was designed as a novel attempt in predicting diabetes risk in a young adult Nigerian population using the TyG index and to compare its performance with the FINDRISC tool.

Methods

Recruitment of participants This cross-sectional study was conducted amongst young adults who have been fully resident in Asaba, Delta State, Nigeria, for at least one year prior to the study. The participants were recruited by convenience sampling.

Sample size Sample size was determined based on the Vaughan and Morrow's formula [18].

$$\mathbf{N} = \frac{\mathbf{PQ}}{\left(\mathbf{E}/1.96\right)^2}$$

Where:

N = sample size; P = maximum expected prevalence rate of diabetes mellitus; Q = 100 – P; and E = margin of sample error tolerated in percentage (5% being the maximum accepted value).

With a 5% error margin and a diabetes prevalence rate of 5.4% in Delta State, Nigeria [19, 20], the minimum sample size of 78 participants was recommended for the study. However, the minimum sample size was increased in order to make adequate provisions for errors in filling of questionnaires due to inconsistency and possible data losses that may occur during the study. Thus, a sample size of 122 participants was adopted.

Exclusion criteria Potential participants were excluded from the study based on previous diagnosis of diabetes, pregnancy, drug addiction, physical disability that impedes anthropometric measurements as well as a decline of consent.

Blood pressure measurement Blood pressure measurement was done by a trained personnel following a five minutes rest using a digital blood pressure monitor (Omron M2 Eco, Vietnam). The average of two separate readings taken after an interval of two minutes was eventually recorded.

Anthropometric measurement All anthropometric measurements were done by trained research assistants. Participants were dressed in light clothing, with bare feet in an erect posture prior to undergoing anthropometric measurements. To eliminate bias, participants were not allowed to do self-measurement. Waist circumference was measured midway between the lowest rib and the iliac crest while hip

circumference was measured at the widest part of the hip between the greater trochanter and the lower buttock level using a non-stretchable measuring tape. From these measurements, waist-to-hip ratio and waist-to-height ratio were determined as arithmetic ratios. Participants' weight and height were measured using a weighing scale (Hana, China) and stadiometer, respectively. Body mass index (BMI) was calculated by dividing weight (in kilogram) by the square of height (in metres).

Lipid Profile Analysis Fasting blood plasma obtained following an overnight fast of 10–12 h was used for lipid profile analysis. The plasma concentration of total cholesterol, high density lipoprotein (HDL)-cholesterol and triglycerides were determined using enzymatic colorimetric methods [21–23] while low density lipoprotein (LDL)-cholesterol was determined by calculation [24].

Fasting plasma glucose determination Fasting plasma glucose concentration was determined by the glucose oxidase method [25].

Triglyceride-glucose index determination TyG index was calculated as a logarithmic product of fasting triglycerides (Trig) (in mg/dl) and fasting plasma glucose (FPG) (in mg/dl).

$TyGIndex = ln\,[Trig(\,mg/dl) \times \frac{FPG(mg/dl)}{2}]$ [26]. TyG index values were stratified according to quartiles following the method of Fritz et al. [27]

Risk Scoring: Diabetes risk scores were determined using the FINDRISC tool as exhaustively described in a previous paper [6]. From their diabetes risk scores, participants were stratified as follows: < 7 (low risk); 7–11 (slightly elevated risk); 12–14 (moderately elevated risk); 15–20 (high risk).

Table 1 Socio-demographic Characteristics of Study Participants

Variables	n (%)
Gender	
Male	54 (44.26)
Female	68 (55.74)
Occupational Status	
Unemployed	104 (85.25)
Employed	18 (14.75)
Marital Status	
Married	25 (20.49)
Single	97 (79.51)
Literacy level	
Primary education	4 (3.28)
Secondary education	46 (37.70)
Tertiary education	72 (59.02)

Data is presented as number (frequency) except otherwise indicated

Outcome Prediabetes (a high risk state of diabetes); the outcome of interest was defined according to the 2018 guidelines of American Diabetes Association [28].

Data Analysis Data analysis was done using *Statistical Package for the Social Sciences* (SPSS) version 23.0 (SPSS Inc Chicago IL). Descriptive statistics were expressed as Means (Standard Deviation) for continuous variables and as proportions for categorical variables. Chi-square (for categorical variables), t-test or one-way analysis of variance (ANOVA) followed by Duncan test (for continuous variables) was used for comparison. Pearson correlation analysis was used to determine the association between parameters. To obtain the receiver operating characteristic (ROC) curve, sensitivity and 1-specificity was plotted on the y-axis and x-axis, respectively, while area under curve (AUC) and optimal cut-off points were determined.

Results

Socio-demographic characteristics

The socio-demographic characteristics of participants are presented in Table 1. There were more females (n = 68) than males (n = 54). There were more participants who had attained tertiary education level than those who had not, although most of the participants were single and unemployed.

Participants' characteristics according to gender

Male participants had significantly higher mean values of diastolic blood pressure ($p < 0.001$), systolic blood pressure ($p < 0.05$), pulse ($p < 0.001$) while female participants had significantly higher mean values of cholesterol ($p < 0.05$) and FINDRISC score ($p < 0.001$) as shown in Table 2.

Participants' characteristics according to FINDRISC categories

High risk participants had significantly higher mean values of body mass index, waist circumference, waist-to-hip ratio (all $p < 0.001$) relative to the lower risk categories (Table 3).

Participants' characteristics according to TyG Quartiles

Participants in Quartile 4 had significantly higher mean values of triglyceride ($p < 0.001$) and fasting plasma glucose

Table 2 Anthropometric and Clinical Characteristics of Study Participants according to Gender

Variables	Total	Male	Female	t	*p*
Body Mass Index (Kg/m^2)	24.64 ± 3.87	25.18 ± 3.82	24.21 ± 3.88	1.382	0.170
Waist Circumference (cm)	84.57 ± 9.39	85.07 ± 9.41	84.18 ± 9.42	0.523	0.602
Waist-to-hip ratio (cm)	0.87 ± 0.05	0.86 ± 0.06	0.87 ± 0.06	-0.599	0.550
Diastolic BP (mmHg)	77.23 ± 9.77	80.30 ± 10.84	74.79 ± 8.11	3.207	< 0.001
Systolic BP (mmHg)	124.31 ± 16.37	133.96 ± 15.72	116.65 ± 12.41	6.800	0.002
Pulse	72.21 ± 11.85	80.07 ± 9.40	65.97 ± 9.72	8.078	< 0.001
Cholesterol (mg/dl)	251.31 ± 47.68	241.23 ± 45.06	259.31 ± 48.50	-2.109	0.037
HDL-C (mg/dl)	93.60 ± 27.71	91.75 ± 35.01	95.08 ± 20.30	-0.658	0.512
LDL-C (mg/dl)	135.04 ± 54.69	126.11 ± 53.85	142.14 ± 54.71	-1.619	0.108
Triglycerides (mg/dl)	113.30 ± 41.29	116.87 ± 47.18	110.46 ± 36.05	0.851	0.397
Fasting blood sugar (mg/dl)	101.08 ± 9.24	99.52 ± 8.62	102.32 ± 9.59	-1.678	0.096
TyG Index	8.59 ± 0.34	8.60 ± 0.38	8.58 ± 0.31	0.173	0.863
FINDRISC score	8.36 ± 3.42	6.87 ± 3.48	9.54 ± 2.90	-4.633	< 0.001

Data is presented as Mean ± Standard deviation except otherwise indicated

Table 3 Characteristics of Study Participants according to FINDRISC Categories

Variables	< 7 (n = 40)	7–11 (n = 64)	12–14 (n = 10)	15–20 (n = 8)	f	*p*
Body Mass Index (Kg/m^2)	22.68 ± 2.14^a	24.45 ± 3.09^a	27.85 ± 4.89^b	32.03 ± 4.06^c	24.626	< 0.001
Waist Circumference (cm)	80.85 ± 4.63^a	83.47 ± 7.24^{a,b}	89.60 ± 11.22^b	105.75 ± 11.44^c	28.446	< 0.001
Waist-to-hip ratio (cm)	0.87 ± 0.05^a	0.85 ± 0.05^a	0.89 ± 0.07^a	0.95 ± 0.05^b	9.389	< 0.001
Diastolic BP (mmHg)	79.15 ± 10.22^a	75.31 ± 9.79^a	77.80 ± 7.89^a	82.25 ± 6.36^a	2.110	0.103
Systolic BP (mmHg)	130.05 ± 14.03^a	121.00 ± 18.14^a	118.70 ± 8.51^a	129.13 ± 11.06^a	3.312	0.023
Pulse	78.70 ± 10.39^b	70.09 ± 11.17^{a,b}	63.20 ± 7.33^a	68.00 ± 14.75^a	8.176	< 0.001
Cholesterol (mg/dl)	251.55 ± 48.10^a	255.93 ± 51.59^a	228.19 ± 26.26^a	242.00 ± 22.54^a	1.089	0.357
HDL-C (mg/dl)	96.41 ± 36.67^a	93.93 ± 23.32^a	81.68 ± 17.96^a	91.87 ± 14.90^a	0.763	0.571
LDL-C (mg/dl)	131.66 ± 65.72^a	139.07 ± 54.14^a	131.96 ± 21.96^a	123.57 ± 16.32^a	0.289	0.833
Triglycerides (mg/dl)	117.37 ± 34.46^b	114.66 ± 36.37^b	72.72 ± 17.41^a	132.79 ± 87.52^b	4.290	0.007
Fasting blood sugar (mg/dl)	96.60 ± 6.24^a	100.72 ± 8.23^a	113.70 ± 8.95^b	110.63 ± 9.96^b	17.108	< 0.001
TyG Index	8.59 ± 0.31^{a,b}	8.61 ± 0.34^{a,b}	8.30 ± 0.22^a	8.74 ± 0.53^b	3.110	0.029

Data is presented as Mean ± Standard deviation except otherwise indicated. Values bearing different superscript are significantly different at $p < 0.05$

($p < 0.05$) although HDL-c ($p < 0.001$) and DBP ($p < 0.05$) were significantly higher in Quartile 1 as shown in Table 4.

Correlation analysis

BMI and WC showed significant positive correlations with FINDRISC at the $p < 0.001$ level while triglyceride showed a significant positive correlation with TyG index at the $p < 0.001$ level (Table 5).

FINDRISC categories and TyG quartiles

Over 14.8% of the participants had a moderately elevated to high risk (FINDRISC ≥ 12) of developing diabetes with a female preponderance (20.6%) relative to males (7.4%). More than half of the participants (52.5%) had slightly elevated risk. In all cases, there were significant ($p < 0.001$) differences in the prevalence of diabetes risk susceptibility across both genders. The frequency of occurrence of both genders in the different TyG index quartiles were nearly approximate with the highest frequency of occurrence (42.6%) in Quartile 3 (Table 6).

Performance of FINDRISC and TyG Index

FINDRISC had AUC value of 0.826 with an optimal cut-off point of 8.50 whereas TyG Index had AUC value of 0.628 with an optimal cut-off point of 8.45 (Figs. 1 and 2).

Discussion

The key indicator adopted in the diagnosis of diabetes mellitus is insulin resistance [29]. The TyG index is a diagnostic biomarker of insulin resistance while the FINDRISC tool is a predictor of diabetes risk status. It is therefore necessary to compare the accuracy of the FINDRISC tool in identifying impaired glucose tolerance (a hallmark of insulin resistance and a risk marker for diabetes mellitus) against TyG index.

Table 4 Characteristics of Study Participants according to Quartiles of TyG Index

Variables	Q1 (< 8.02) (n = 2)	Q2 (8.02–8.38) (n = 30)	Q3 (8.39–8.81) (n = 52)	Q4 (≥ 8.82) (n = 38)	f	*p*
Body Mass Index (Kg/m^2)	25.26 ± 0.00^a	25.43 ± 4.36^a	23.85 ± 2.90^a	25.07 ± 4.56^a	4.223	0.268
Waist Circumference (cm)	87.00 ± 0.00^a	84.70 ± 11.29^a	85.10 ± 8.67^a	83.63 ± 9.10^a	1.329	0.880
Waist-to-hip ratio (cm)	0.90 ± 0.00^a	0.87 ± 0.06^a	0.88 ± 0.06^a	0.85 ± 0.05^a	0.223	0.215
systolic BP (mmHg)	144.00 ± 0.00^b	128.62 ± 20.25^{a,b}	124.04 ± 13.77^{a,b}	120.21 ± 15.50^a	1.512	0.058
Diastolic BP (mmHg)	89.00 ± 0.00^b	80.90 ± 11.48^{a,b}	76.71 ± 9.10^{a,b}	74.42 ± 8.22^a	2.567	0.014
Pulse	84.00 ± 0.00^b	69.50 ± 10.77^{a,b}	70.87 ± 10.43^a	75.58 ± 13.82^a	3.711	0.061
Cholesterol (mg/dl)	224.59 ± 0.00^a	241.37 ± 55.16^a	260.79 ± 45.58^a	247.59 ± 43.89^a	1.751	0.240
HDL-C (mg/dl)	163.72 ± 0.00^a	80.26 ± 25.43^a	95.52 ± 28.61^a	97.83 ± 21.03^a	0.066	< 0.001
LDL-C (mg/dl)	48.72 ± 0.00^a	146.88 ± 58.02^b	144.28 ± 54.42^b	117.60 ± 45.96^{a,b}	8.210	0.007
Triglycerides (mg/dl)	60.75 ± 0.00^a	71.13 ± 7.94^a	104.98 ± 13.52^b	160.76 ± 35.66^c	1.422	< 0.001
Fasting blood sugar (mg/dl)	99.00 ± 0.00^a	102.77 ± 9.67^a	97.75 ± 7.15^a	104.42 ± 10.30^a	4.660	0.004
FINDRISC score	6.00 ± 0.00^a	9.37 ± 3.31^a	7.77 ± 3.36^a	8.50 ± 3.55^a	4.660	0.160

Data is presented as Mean ± Standard deviation except otherwise indicated. Values bearing different superscript are significantly different at $p < 0.05$

Table 5 Correlation analysis of some parameters with FINDRISC and TyG Index

	FINDRISC		TyG index	
	r	*p*	r	*p*
Fasting blood sugar (mg/dl)	0.505**	< 0.001	0.134	0.140
Cholesterol (mg/dl)	0.000	0.998	0.045	0.622
Triglycerides (mg/dl)	-0.036	0.691	0.951**	< 0.001
HDL-C (mg/dl)	0.008	0.927	0.093	0.309
LDL-C (mg/dl)	0.001	0.991	-0.151	0.096
Body Mass Index (Kg/m^2)	0.629**	< 0.001	0.082	0.369
Waist Circumference (cm)	0.602**	< 0.001	0.017	0.853
Waist-to-hip ratio (cm)	0.236**	0.009	-0.055	0.551
Diastolic BP (mmHg)	-0.039	0.671	-0.197*	0.030
Systolic BP (mmHg)	-0.245**	0.007	-0.186*	0.041
Pulse	-0.391**	< 0.001	0.164	0.072

**Correlation is significant at the 0.001 level (2-tailed)

*Correlation is significant at the 0.05 level (2 –tailed)

Table 6 Gender Distribution of FINDRISC Categories and TyG Index Quartiles

	Male n (%)	Female n (%)	Total n (%)	x^2	*p*
FINDRISC Categories					
Low Risk (< 7)	30 (55.6)	10 (25.0)	40 (32.8)	27.759^a	< 0.001
Slightly Elevated Risk (7–11)	20 (37.0)	44 (64.7)	64 (52.5)		
Moderately Elevated Risk (12–14)	0 (0.0)	10 (14.7)	10 (8.2)		
High Risk (15–20)	4 (7.4)	4 (5.9)	8 (6.6)		
TyG Index Quartiles					
Quartile 1 (< 8.02)	2 (3.7)	0 (0.0)	2 (1.6)	2.969^a	0.396
Quartile 2 (8.02–8.38)	12 (22.2)	18 (26.5)	30 (24.6)		
Quartile 3 (8.39–8.81)	22 (40.7)	30 (44.1)	52 (42.6)		
Quartile 4 (≥ 8.82)	18 (33.3)	20 (29.4)	38 (31.1)		

Data is presented as number (frequency) except otherwise indicated

This study reported a prevalence of 8.2% moderate risk and 6.6% high risk of developing diabetes. These figures are lower than 12.3% moderate risk and 13.9% high risk reported in a Turkish population [30] but higher than the 5.2% moderate risk and 1.8% high risk reported in a young Jordanian population [31]. Taken together, 14.8% of the study participants had moderate to high risk of developing diabetes with a preponderance of females relative to males (20.8% vs. 7.4%) attaining that risk status. This finding is in agreement with previous Nigerian studies that also reported higher diabetes risk susceptibility in females relative to males [6, 32]. This finding may not be unconnected with the fact that the various T2DM risk factors constitute the various components of the FINDRISC tool and may have predominated in females as risk scores are aggregates of diabetes risk factors. It suffices to state that more of the females relative to males may have exceeded the BMI and waist circumference thresholds for overweight and obesity in addition to a reduced level of physical activity. Diabetes risk increases with increasing frequency of these important risk factors [29]. The pattern of diabetes risk susceptibility is further buttressed by the higher mean values of FINDRISC reported in females relative to males in this study. This is in agreement with the findings of a study conducted in a Turkish population [30]. In a general population study in Helsinki, Finland, a large proportion of participants with a moderate or high FINDRISC score eventually had undiagnosed T2DM [33]. It is therefore, not unlikely that a significant proportion of the general young adult Nigerian population from which the participants of this study were drawn, may likely develop T2DM [31]. The FINDRISC categorization of medium to high risk is lower than

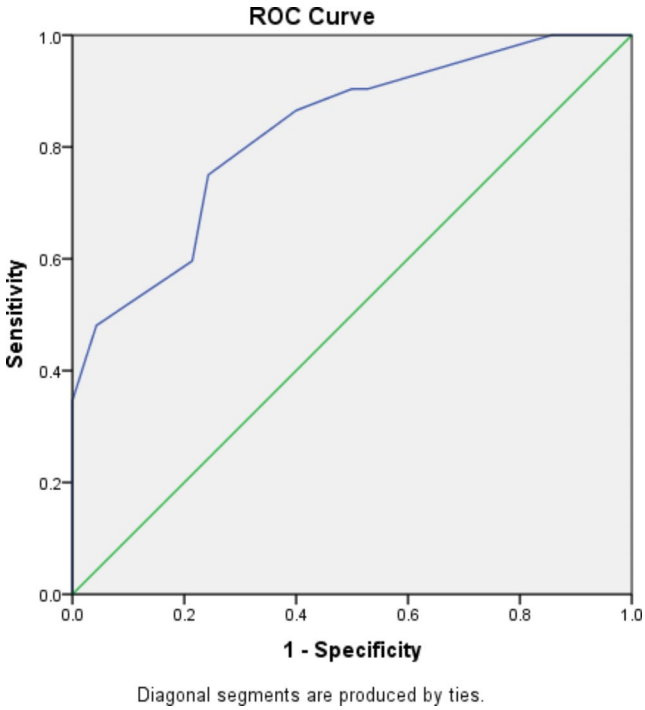

Fig. 1 ROC Curve for the Performance of FINDRISC Score
AUC for FINDRISC = 0.826; cut-point for FINDRISC = 8.50

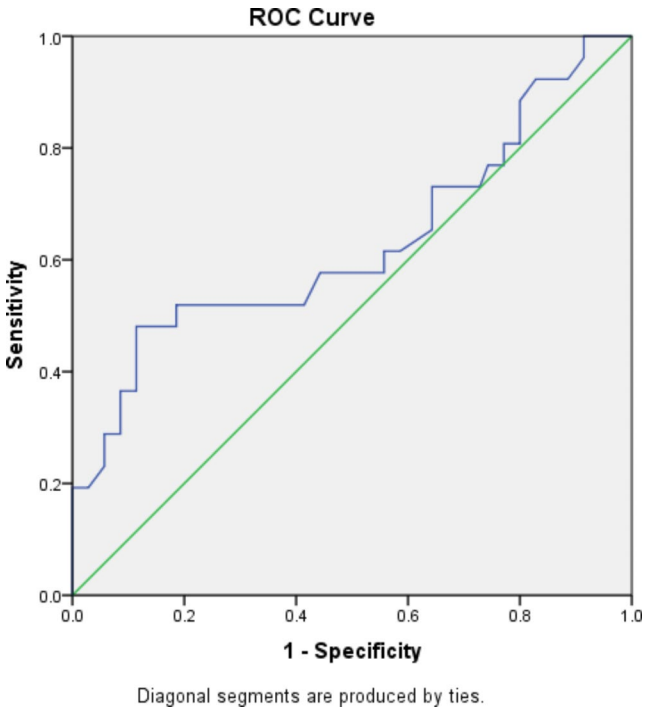

Fig. 2 ROC Curve for the Performance of TyG Index
AUC for TyG index = 0.628; cut-point for TyG index = 8.45

the prevalence of high TyG index in this study. A previous study had reported comparable findings between those with medium and high risk based on FINDRISC and high TyG index [29].

The activation of pathways for chronic low grade inflammation is linked with the pathogenesis of T2DM [34]. As such, previous authors have reported elevated white blood cell count in patients with impaired glucose tolerance [35], T2DM [34] and conditions of diabetic complications [36]. Interleukin-1 beta, produced by macrophages and/or stimulated by elevated glucose levels is known to drive pancreatic beta cell apoptosis and partly mediates the progressive decline in functional beta cell mass characteristic of the disease [37, 38]. Beyond that, it is worth mentioning that the low-grade inflammation in T2DM is associated with increased plasma levels of various biomarkers of inflammation including C-reactive protein [39]. In a recent Brazilian study, the FINDRISC score was found to be linked with both T2DM and inflammation due to its association with elevated high-sensitivity C-reactive protein, an inflammatory biomarker associated with diabetes. However, whereas the FINDRISC tool demonstrated a good discrimination for the prediction of T2DM, it had a low discrimination for low-grade inflammation [40].

TyG index is linked to the occurrence of diabetes and several cardiovascular outcomes, including patients with coronary artery disease [29, 41, 42]. This present study reported that 31.1% of the study participants were in the highest TyG index quartile (TyG index ≥ 8.82). This figure compares with a recent study that reported 35.4% of participants with TyG index ≥ 8.8 [29]. In a 9-years follow-up study involving adults without diabetes, it was observed that, over time, patients with high TyG index had a higher frequency of developing diabetes than those with low TyG index [43]. The pattern of higher frequency of occurrence in males relative to females observed in this study is at variance with the pattern observed in a recent study in Turkey. The differences in the gender distribution of triglyceride and fasting blood glucose may have accounted for the discrepancy. In this present study, triglyceride and fasting blood glucose levels were higher in males and females, respectively, while triglyceride levels were lower in female participants with no gender-based differences in fasting blood glucose levels in the Turkish study [29].

In addition to TyG index, there are other triglyceride and lipid indexes that play useful roles in the diagnosis of T2DM and these include but not limited to triglyceride to HDL-cholesterol ratio [44], uric acid to HDL-cholesterol ratio [45]. Their association with diabetes mellitus and complications of the disease have been recognized by previous authors. For instance, uric acid to HDL-cholesterol ratio is thought to be a promising predictor of diabetic control in T2DM due to its significant association with glycated haemoglobin and fasting plasma glucose levels [45]. Also, the significant association of poorly controlled hypertension with elevated uric acid to HDL-cholesterol ratio has recently

been reported [46]. Similarly, uric acid to HDL-cholesterol ratio has recently been reported to be positively associated with diabetes-related vascular complications in men and postmenopausal women although the relationship between uric acid to HDL-cholesterol ratio and diabetic retinopathy remains elusive [47].

In this present study, parameters such as body mass index, waist circumference, waist to hip ratio and diastolic blood pressure increased progressively with increasing FINDRISC group. Triglyceride levels increased progressively with increasing TyG index quartile. Additionally, FINDRISC correlated positively with body mass index, fasting blood sugar, waist circumference and waist to hip ratio. Body mass index had the strongest positive correlation with FINDRISC while triglycerides had the strongest positive correlation with TyG index. Similar findings have also been reported [29].

TyG index had an AUC value of 0.628 with a cut-point of 8.50 for diabetes risk prediction. This figure compares with the AUC values of 0.64 [43] and 0.651 [48] but lower than 0.75 [49] reported in previous studies that compared the performance of TyG index with fasting plasma glucose in the prediction of type-2 diabetes. Whereas Navarro-González et al. suggests that TyG index was a better predictor of type-2 diabetes than fasting plasma glucose, Chamroonkiadtikun et al., and Janghorbani et al., disagrees. FINDRISC had an AUC value of 0.826 with a cut-point of 8.45 for the prediction of diabetes risk in this study. The performance of FINDRISC in this study compares with the AUC values of 0.85 and 0.87 and a cut-point of 9 obtained from original Finnish population cohorts of 1987 and 1992 where the tool was developed [10] but higher than the AUC value of 0.621 in a Lebanese population [50]. The FINDRISC tool performs well in the prediction of undiagnosed type-2 diabetes mellitus [50–52]. As such, the AUC values from this study clearly shows that FINDRISC performed better than TyG-index in the prediction of diabetes risk.

In clinical settings, the use of the FINDRISC tool; a cheap, simple and non-invasive diagnostic tool that obviates the need for laboratory tests for T2DM screening will be invaluable especially in resource-limited regions such as low and middle income countries with a high burden of T2DM cases. This tool will help to timeously identify individuals in need of further attention and attenuate the burden of undiagnosed diabetes. As such, this study further supports well established reports of good discriminatory abilities of FINDRISC [10, 51, 52] and also suggests its routine clinical utilization in resource-scarce regions of the world.

The sampling of a specific age group rather than the entire population may limit the generalizability of the study findings. Thus, the findings should be confirmed in entire populations. The relatively small study population is due to a cultural challenge as most Nigerian populations attach a sense of sacredness to blood which makes them unwilling to participate in research studies involving blood sample collection. Fasting blood glucose measurements were taken only once rather than twice, as recommended by the guidelines of the American Diabetes Association [53]. However, the apathy exhibited by some young Nigerian adults towards health research makes this modest attempt good enough. Despite the limitations, this current study validates previous reports from developed nations on the diagnostic ability of the FINDRISC tool [10, 51, 52] in a young adult population study from a developing nation in Africa. Additionally, the recruitment of a previously unstudied population of apparently healthy young adults without any chronic health complications or underlying ailments is a novelty.

Conclusion

The diabetes risk status of this population demand public health attention. The performance of the FINDRISC tool in this study lends further credence to its use in diabetes risk assessment studies in Nigerian populations. Apart from the TyG index, the use of other triglyceride-derived parameters for diabetes risk prediction is recommended in future studies.

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Author contributions ACN and ANN were responsible for acquisition, analysis and interpretation of data. NEJO and III contributed to the conception, design and supervision of the study. ACN and ANN wrote the manuscript. ACN, NEJO and III did critical revision of the manuscript. All authors read and approved the final version of the revised manuscript.

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Data availability The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

Ethical approval and consent to participate This study was approved by the Delta State Ministry of Health Research Ethics Committee (MOHREC), Asaba, Nigeria (HM/596/T/55). This study was conducted in accordance with the guidelines of the 1964 Declaration of Helsinki and later versions. All participants in the study read, understood and signed the informed consent form prior to participating in the study. For participants under 18 years of age, a parent or legal guardian provided informed consent with the participants informed assent.

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