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Original Article

Biochemistry Section

Role of Triglyceride Glucose Index and Other Triglyceride Ratios in Predicting Metabolic Syndrome among Medical Students in Karnataka: A Cross-sectional Study

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ABSTRACT

Introduction: Metabolic Syndrome (MetS) has emerged as one of the public health problem. MetS is a group of disorders, which increase the risk of chronic diseases and it is associated with high mortality. Recently, Triglyceride Glucose (TyG) Index, a derivative of fasting serum triglycerides and serum glucose, along with other triglyceride ratios, have been suggested for predicting MetS.

Aim: To compare TyG index and other triglyceride ratios among MetS and non MetS medical students and also to assess their ability to predict MetS.

Materials and Methods: A cross-sectional study, was conducted for a period of three months from June 2015 to August 2015 at Mandya Institute of Medical Sciences (MIMS), Mandya, Karnataka, India. By applying convenient sampling method 325 consenting medical students of both male and female gender pursuing in 1st, 2nd, 3rd and 4th year at MIMS in the age group of 17 to 25 years were included for the study. Their anthropometric parameters were measured using appropriate measuring tools. TyG Index and other triglyceride ratios such as, TyG-Body Mass Index (BMI), TyG-Waist Circumference (WC), TyG-WHpR (WHpR: Waist to Hip ratio) and TyG-WHtR (WHtR: Waist to Height ratio) were calculated. Mean values of various parameters were compared using Student t-test. Pearson's linear correlation was used to correlate the various parameters with MetS.

Results: Out of 325 students, 159 (48.9%) were male students and 166 (51.1%) were female students. The mean value of TyG index was found to be significantly higher among students with MetS (9.18±0.20) as compared to students with non MetS (8.52±0.43). Other triglyceride ratios were also significantly higher among students with MetS as compared to non MetS students. The Receiver Operating Characteristic curve (ROC curve) revealed that, the Area Under the Curve (AUC) for TyG index was the highest (0.903), as compared to other triglyceride ratios.

Conclusion: The present study founds that the TyG index and other triglyceride ratios were higher among students with MetS as compared to non MetS students. On further analysis, TyG index found as a better predictor of MetS as compared to other triglyceride ratios.

Keywords: Bachelor of medicine and bachelor of surgery, Metabolic disorders, Serum glucose, Serum triglycerides

INTRODUCTION

Metabolic Syndrome (MetS) is a group of disorders characterised by obesity, hypertension, glucose intolerance and dyslipidemia [1]. The aetiology of MetS is multifactorial involving genetic, metabolic and environmental factors [2]. To diagnose MetS, minimum three out of five of the following components should be present-abdominal obesity, high Fasting Plasma Glucose (FPG), hypertriglyceridemia, low levels of high-density lipoprotein cholesterol and high blood pressure [3].

One of the major risk factor for MetS, Diabetes Mellitus (DM) and Cardiovascular Disease (CVD) is Insulin resistance (IR). Insulin Resistance is defined as either impaired tissue sensitivity or decreased responsiveness to circulating insulin [4,5]. The direct assessment of IR requires sophisticated methods like hyperinsulinemic-euglycemic clamp and is considered as "gold standard" procedure, but it is difficult to perform in large scale as well as in day-to-day practice because of its cost [6].

To overcome this, several surrogate markers have been proposed, such as Homeostatic Model Assessment of IR (HOMA-IR) and Quantitative Insulin Sensitivity Check Index (QUICKI). The HOMA-IR is calculated based on the measurement of FPG and insulin levels [6]. However, few characteristics of insulin such as it's high biological variability and the point that the measurement of insulin is yet to be standardised would have to considered before assessing IR using HOMA-IR [7,8].

Studies have shown that traditional lipid ratios have better role in predicting IR and CVD risk than with single standard lipid parameters [9,10]. Recently TyG index, a product of triglyceride and FPG and a novel tool has been found to correlate with surrogate and direct measures of IR [11,12].

A hyperglycaemic clamp validated study conducted by Vasques AC et al., in a Brazilian population to compare and determine the predictive ability of TyG index and HOMA-IR in identifying IR showed that the TyG index outperformed the HOMA-IR in predicting IR in the study subjects [13].

Raimi TH et al., conducted a study on Nigerians population using TyG index and related parameters as a predictor of MetS [14]. Another study by Unger G et al., used triglycerides and glucose index as an indicator of IR [15].

Medical students belonging to the age group of 17-25 years are important segment of the population and students in this age group may not follow healthy diet. Their diet is high in fat, sodium and sugar because of frequent snacking and consumption of fast food. This along with physical inactivity in turn leads to overweight and obesity and is considered as one of the risk factor for developing MetS [16].

None of the studies have used TyG index and other triglyceride ratios in predicting MetS among medical students. Hence, this study was carried out to calculate the various triglyceride ratios and

to compare the use of TyG index in predicting MetS to help in its early identification among medical students.

Study Objectives

- To compare TyG index and other triglyceride ratios among MetS and non MetS medical students of Mandya Institute of Medical Sciences (MIMS), Mandya.
- To assess the ability of TyG index and other triglyceride ratios to predict MetS among medical students.

MATERIALS AND METHODS

This was a cross-sectional study carried out for a period of three months from June 2015 to August 2015. The study was conducted on the consenting medical students pursuing MBBS degree in Mandya Institute of Medical Sciences (MIMS), Mandya, Karnataka, India, after obtaining ethical clearance from the Institutional Ethics Committee of MIMS, Mandya: No-MIMS/IEC/2015/61 dated 12/02/2015.

After explaining about the need for the study to the students, anthropometric measurements such as Height (H), Weight (W), Waist Circumference (WC) and Hip Circumference (HC) were measured using appropriate tools and biochemical investigations such as FPG, Serum Triglyceride (TG) and High-Density Lipoprotein-Cholesterol (HDL-C) and Low-Density Lipoprotein-Cholesterol (LDL-C) were estimated. By applying convenient sampling method, out of 396 MBBS students studying in 1st, 2nd, 3rd and 4th year at MIMS, 325 consenting students were included and 71 students were excluded from the study, which included students who remained absent and had incomplete proforma.

Inclusion criteria: All consenting MBBS students studying in 1st, 2nd, 3rd and 4th year at MIMS Mandya aged above 17 years, were included.

Exclusion criteria: Students with known history of

- Diabetes mellitus.
- Cardiovascular disease
- Students who were not willing to be part of the study.
- Students who remained absent after two follow-ups.

Study Procedure

Anthropometric measurements: Height (in cm) was measured using stadiometer, weight (in kg) by analogue weighing scale, Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) was measured at sitting position using mercury sphygmomanometer. The WC and HC were measured using non stretchable measuring tape and BMI was calculated as weight in kg/(height in metre)^2. After anthropometric measurements the students were instructed regarding overnight fasting for 10-12 hours.

Collection of blood sample: The following day morning, fasting venous blood sample of each study participant was collected under aseptic precautions into non-vacuum plain tubes with clot activator and they were allowed to stand for about 25-30 minutes. Later the blood samples were centrifuged at 3500 rpm for 15-20 minutes to separate the serum. Before analysing the student's samples for various analytes, a two-level internal quality check was done and subsequently the samples were analysed for FPG and lipid profile using various enzymatic methods in the clinical biochemistry section of Central Diagnostic Laboratory utilising the fully automated analyser XL-300 (Erba Diagnostics Mannheim GmBH).

The reference range of FPG and lipid profile analytes were applied from American Diabetes Association (ADA) and National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III) Criteria respectively [17,18].

Diagnosis of MetS: MetS was diagnosed based on NCEP ATP III criteria. Students presenting with any of the following three out of the five criteria were considered to be having MetS [18].

1. Abdominal obesity as measured by WC (males >102 cm and females >88 cm),
2. Serum TG>150 mg/dL,
3. Serum HDL-C in males <40 mg/dL and females <50 mg/dL,
4. Blood Pressure (BP) ≥130/85 mmHg,
5. FPG ≥110 mg/dL.

Formula to calculate TyG index and other triglyceride ratios are shown in [Table/Fig-1]. The TyG index was calculated using TG and FPG, whereas other triglyceride ratios were calculated using TG, BMI, WC, WHpR and WHtR [14,19,20].

Calculated parameters	Formula
TyG Index [19]	=Ln [TG (mg/dL) × FPG (mg/dL)/2]
TyG-BMI [20]	=TyG Index × BMI
TyG-WC [20]	=TyG Index × WC
TyG- Waist to hip ratio (WHpR) [14]	=TyG Index × WHpR
TyG- Waist to height ratio (WHtR) [14]	=TyG Index × WHtR

[Table/Fig-1]: Formula to calculate TyG index and other triglyceride ratios [14,19,20].

STATISTICAL ANALYSIS

The collected data was entered in excel sheet and results were analysed using Epi-info software. Descriptive statistics was applied and the results were expressed in terms of mean±Standard Deviation (SD) and p-value of less than 0.05 was considered as statistically significant. Student's t-test was used to find out the statistical significance of the difference between male and female students. Pearson's correlation was used to assess the correlation between components of MetS with TyG index and other triglyceride ratios and ROC analysis was done to predict the utility of triglyceride-glucose index and other triglyceride ratios in identifying MetS.

RESULTS

In the present study, a total of 325 consenting MBBS students studying in 1st, 2nd, 3rd and 4th year, between the ages of 17-24 years participated, out of which 159 were male students (48.9%) and 166 (51.1%) were female students.

The distribution of study subjects based on year of studying is depicted in [Table/Fig-2] using descriptive statistics. The mean age of the study subjects was 20±1.4 years.

Year of study	n (%)	Mean Age±SD (in years)
1st Year	96 (29.54)	18.44±0.71
2nd Year	82 (25.23)	19.83±0.81
3rd Year	76 (23.38)	20.62±0.63
4th Year	71 (21.85)	21.73±0.74
Total	325 (100)	20±1.4

[Table/Fig-2]: Distribution of MBBS students according to the year of study.

The baseline characteristics of the study subjects are depicted in [Table/Fig-3] using descriptive statistics. Mean values of WC, HC SBP, DBP and FPG, TG were found be higher among male students as compared to female students. Except for HC, mean value of WC, SBP, DBP and FPG, TG showed statistically significant difference between male and female students. Whereas, mean value of HDL-C was lower among male students. The TyG index and other triglyceride ratios also showed higher mean values among male students as compared to female students. Except for mean values of TyG-BMI and TyG-WHtR, rest of the parameters showed statistically significant difference between male and female students.

About 108 (33.23%) students had atleast one component of the metabolic syndrome. Among 159 male students, 31 (19.50%) and among 166 female students, 18 (10.84%) were positive for two components of MetS. Whereas, out of 325 MBBS students,

08 (2.46%) and 03 (0.92%) students had three and four components respectively as shown in [Table/Fig-4].

Variables	All participants N=325	Male (mean±SD) n=159	Female (mean±SD) n=166	Student's t-test p-value
Age (years)	20.00±1.407	19.99±1.410	20.02±1.408	0.845
Weight (kg)	59.51±11.622	64.94±11.404	54.31±9.224	0.0001*
Height (m)	164.89±10.113	171.98±7.840	158.10±6.862	0.0001*
WC (cm)	74.56±9.947	77.84±9.851	71.42±9.003	0.0001*
HC (cm)	90.13±10.017	91.08±9.808	89.22±10.159	0.095
BMI (kg/m^2)	21.82±3.37	21.92±3.30	21.72±3.43	0.592
SBP (mmHg)	115.41±11.53	120.19±10.57	110.83±10.53	0.0001*
DBP (mmHg)	74.28±9.59	78.59±8.32	70.16±8.89	0.0001*
FPG (mg/dL)	85.51±9.14	86.69±8.57	84.38±9.55	0.022*
TG (mg/dL)	131.62±59.66	139.02±55.68	123.90±62.80	0.022*
HDL-C (mg/dL)	52.57±11.04	50.95±12.32	54.26±9.25	0.007*
TyG-Index	8.54±0.44	8.59±0.43	8.49±0.46	0.031*
TyG-BMI	186.63±32.42	186.54±33.08	186.71±31.88	0.963
TyG-WC	637.48±97.56	661.86±101.86	614.13±87.36	0.0001*
TyG-WHpR	7.09±0.86	7.28±0.86	6.91±0.83	0.0001*
TyG-WHtR	3.87±0.56	3.89±0.56	3.85±0.56	0.508

[Table/Fig-3]: Distribution of clinical characteristics of the study participants.
*p<0.05

Metabolic syndrome components	Males n=159, n (%)	Females n=166, n (%)	Total N=325, N (%)
0	68 (42.77)	89 (53.61)	157 (48.31)
1	52 (32.70)	56 (33.74)	108 (33.23)
2	31 (19.50)	18 (10.84)	49 (15.078)
3	06 (3.77)	02 (1.21)	08 (2.46)
4	02 (1.26)	01 (0.6)	03 (0.92)

[Table/Fig-4]: Distribution of number components of MetS among study subjects.

The mean value of TyG index and other triglyceride ratios were higher among students with MetS as compared to non MetS students and it showed statistically significant difference between students with MetS and non MetS students as shown in [Table/Fig-5].

Triglyceride-Glucose index and other triglyceride ratios	MetS (n=11) (mean±SD)	Non MetS (n=314) (mean±SD)	p-value
TyG index	9.18±0.20	8.52±0.43	0.0001*
TyG-BMI	233.41±53.47	184.99±30.28	0.0001*
TyG-WC	744.55±106.10	633.73±95.26	0.0001*
TyG-WHpR	7.75±0.68	7.06±0.86	0.008*
TyG-WHtR	4.62±0.66	3.84±0.54	0.0001*

[Table/Fig-5]: Association of Triglyceride-Glucose index and other triglyceride ratios among students with MetS and non MetS using Student's t-test.
*p<0.05

The strength of association between TyG index and other triglyceride ratios and components of MetS were analysed by using Pearson's correlation. The [Table/Fig-6] shows significant positive correlation between TyG index vs WC, SBP, FPG and TG. (r=0.170; p=0.002, r=0.337; p=<0.001, r=0.337; p=<0.001 and r=0.941; p=<0.001) respectively. However TyG index correlated negatively with HDL-C (r=0.200; p=<0.001). Similarly all other triglyceride ratios showed positive correlation with WC, SBP and TG and it was found to be statistically significant.

The ROC curve analysis was done to analyse the ability of using Triglyceride-Glucose Index and other triglyceride ratios to predict MetS. As seen in [Table/Fig-7], it was found that, the area under the curve for TyG Index was 0.903, as compared to TyG-WHtR: 0.814, TyG-WC: 0.798, TyG-WHpR: 0.772 and TyG-BMI: 0.766 with MetS. AUC for TyG index was more among students with MetS and hence, in the present study, TyG index emerged as a better index as compared to other triglyceride ratios in predicting MetS among medical students.

DISCUSSION

The present study compared TyG Index and the other triglyceride ratios among medical students with MetS and non MetS and also compared as well as assessed their ability in predicting MetS. Detecting MetS at the earliest is important because it identifies the patients who are at high risk of developing type-2 diabetes mellitus and CVD [1].

The IR assessment requires sophisticated methodology that is difficult and costly to perform [6]. Therefore, different alternatives have been suggested as surrogate markers to measure IR. In the present study, the authors have used TyG Index and the other triglyceride ratios among medical students to predict Mets.

In current study, it was found that, the mean values of WC, SBP, DBP, FPG and TG were significantly higher among male students as compared to female students. The HDL-C was significantly lower among male students as compared to the female students. Further, the mean values of HC and BMI were higher among male students as compared to female students but, however, did not show significant difference between them.

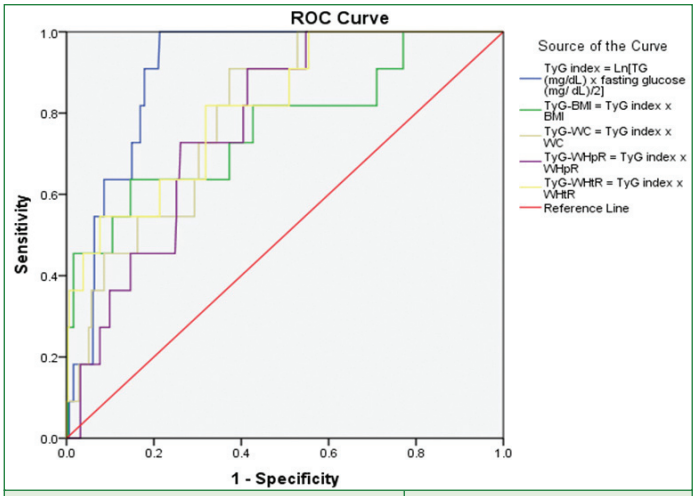
In the present study, 8 (5.03%) male students and 3 (1.81%) female students had MetS. This was in concurrence with the study conducted by Kandula SGNSV et al., on medical students in Andhra Pradesh. It was found that prevalence of MetS as per the International Diabetes Federation criteria was 6% (n=24) and further the male students had a higher prevalence 12.19% (n=20) as compared to female students 1.69% (n=4) [21].

In the present study, the mean value of TyG Index and other triglyceride ratios were significantly higher among students with MetS as compared to non MetS students. Similar findings were observed in a study conducted by Unger G et al, who concluded that, the mean value of TyG index (9.1±0.6) was markedly higher in subjects with MetS as compared to non MetS students [15].

In the present study it was noticed that the TyG index and other triglyceride ratios showed significant correlation with WC, SBP and TG which also aligned with the findings of the study conducted by Manjareeka M et al., [22]. The results of the present study, showed that the AUC for TyG index was the maximum as compared to other triglyceride ratios in predicting MetS and hence TyG index is emerged as a better marker in predicting MetS.

	WC		SBP		DBP		FPG		TG		HDL-C	
Variables	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
TyG Index	0.170	0.002	0.337	<0.001	0.039	0.480	0.337	<0.001	0.941	<0.001	-0.200	<0.001
TyG BMI	0.515	<0.001	0.248	<0.001	0.149	0.007	0.142	0.010	0.455	<0.001	-0.051	0.352
TyG-WC	0.940	<0.001	0.281	<0.001	0.192	<0.001	0.086	0.122	0.504	<0.001	0.012	0.835
TyG-WHpR	0.515	<0.001	0.194	<0.001	0.127	0.022	0.212	<0.001	0.541	<0.001	-0.049	0.374
TyG-WHtR	0.822	<0.001	0.158	0.004	0.059	0.286	0.055	0.327	0.557	<0.001	-0.024	0.662

[Table/Fig-6]: Pearson's correlation between components of MetS and Triglyceride-Glucose Index and other triglyceride ratios among study subjects.



Test result variables	Area under the curve (AUC)
TyG Index=Ln [TG (mg/dL) × FPG (mg/dL)/2]	0.903
TyG-BMI=TyG Index × BMI	0.766
TyG-WC=TyG Index × WC	0.798
TyG-WHpR=TyG Index × WHpR	0.772
TyG-WHtR=TyG Index × WHtR	0.814

[Table/Fig-7]: Receiver Operating Characteristic (ROC) curve to compare Triglyceride-Glucose index and other triglyceride ratios with MetS.

The present study results were in concurrence with the findings of the study conducted by Raimi TH et al., in Nigerian Population. They showed that, TyG-WHtR had the largest AUC for MetS detection (0.863) followed by TyG-WC (0.858), TyG-BMI (0.838), TyG index (0.796,), WHtR (0.791) and TyG-WHpR (0.771). They concluded that the product of TyG index and anthropometric indices improved identification and prediction of MetS [14].

The pathogenic disorder underlying MetS is IR and it is characterised by either impaired tissue sensitivity or decreased responsiveness to circulating insulin [4,5]. Measurement of IR using hyperinsulinemic-euglycemic clamp is difficult and expensive to perform in large scale as well as in day to day practice [6]. To overcome this issue, other surrogate markers which include the calculated parameters like TyG Index and other triglyceride ratios have been developed to assess IR.

Few studies have suggested that direct measurement of IR and surrogate markers of IR are found to correlate with TyG index and hence TyG index is a novel tool that can be used to measure IR. Du T et al., concluded that TyG presented the greatest value of AUC in correlating IR (0.709 in men and 0.711 in women) [11,12].

In contrast to insulin measurement, the testing of TG by enzymatic methods is standardised and it is routinely analysed in most of the clinical laboratories. Calculation of TyG index is cost effective and it is inexpensive as compared to direct measurement of serum insulin [23]. Therefore, Triglyceride-Glucose index has an advantage over direct insulin measurement to assess Insulin resistance.

Limitation(s)

The main limitation of the present study was relatively small sample size and it was not possible to compare TyG index and other triglyceride ratios with the gold standard method using hyperinsulinemic-euglycemic clamp. The other limitation was age group restriction, since the present study was conducted on medical students of the age group between 17-25 years.

CONCLUSION(S)

To conclude, medical education is well known for its stress throughout the course of training and stress leads to development of overweight, obesity and other biochemical alteration. Increased abdominal circumference and altered biochemical parameters like increased FPG, TG, LDL-C and deceased HDL-C are the components of MetS. Early identification and prompt management of MetS at the earliest are important to prevent future development of type-2 Diabetes Mellitus and CVD. The IR is considered as one of the risk factors for MetS but direct measurement of IR is difficult in large scale population using the gold standard hyperinsulinemic-euglycemic clamp method. Hence the newer calculated parameters such as TyG Index and other triglyceride ratios could be used as surrogate marker as it is more cost effective to predict MetS among medical students using these markers. The present cross-sectional study finds that the mean value of TyG Index and other triglyceride ratios were higher among students with MetS and on comparison; the TyG index is a better predictor of MetS as compared to other triglyceride ratios. Further prospective large-scale studies are required to warrant the use of TyG index as an alternative marker of IR in predicting MetS.

REFERENCES

[1] Huang PL. A comprehensive definition for metabolic syndrome. Dis Model Mech. 2009;2(5-6):231-37.
[2] Cuevas A, Alvarez V, Carrasco F. Epidemic of metabolic syndrome in Latin America. Curr Opin Endocrinol Diabetes Obes. 2011;18(2):134-38.
[3] Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: A joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International atherosclerosis Society; and International Association for the Study of Obesity. Circulation. 2009;120(16):40-45.
[4] Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: Diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. Diabet Med. 1998;15(7):539-53.
[5] Gallagher EJ, Leroith D, Karnieli E. Insulin resistance in obesity as the underlying cause for the metabolic syndrome. Mt Sinai J Med. 2010;77(5):511-23.
[6] Dahan MH, Abbasi F, Reaven G. Relationship between surrogate estimates and direct measurement of insulin resistance in women with polycystic ovary syndrome. J Endocrinol Invest. 2019;42(8):987-93.
[7] Staten MA, Stern MP, Miller WG, Steffes MW, Campbell SE. Insulin standardization workgroup. Insulin assay standardization: Leading to measures of insulin sensitivity and secretion for practical clinical care. Diabetes Care. 2010;33(1):205-06.
[8] Chen Z, Caulfield MP, McPhaul MJ, Reitz RE, Taylor SW, Clarke NJ. Quantitative insulin analysis using liquid chromatography-tandem mass spectrometry in a highthroughput clinical laboratory. Clin Chem. 2013;59 Suppl.9:1349-56.
[9] Kimm H, Lee SW, Lee HS, Shim KW, Cho CY, Yun JE, et al. Associations between lipid measures and metabolic syndrome, insulin resistance and adiponectin. Usefulness of lipid ratios in Korean men and women. Circ J. 2010;74(5):931-37.
[10] Walldius G, Jungner I, Holme I, Aastveit AH, Kolar W, Steiner E. High apolipoprotein B, low apolipoprotein A-I, and improvement in the prediction of fatal myocardial infarction (AMORIS study): A prospective study. Lancet. 2001;358(9298):2026-33.
[11] Abbasi F, Reaven GM. Comparison of two methods using plasma triglyceride concentration as a surrogate estimate of insulin action in nondiabetic subjects: triglycerides×glucose versus triglyceride/high-density lipoprotein cholesterol. Metabolism. 201160(12):1673-76.
[12] Du T, Yuan G, Zhang M, Zhou X, Sun X, Yu X. Clinical usefulness of lipid ratios, visceral adiposity indicators, and the triglycerides and glucose index as risk markers of insulin resistance. Cardiovasc Diabetol. 2014;13:146.
[13] Vasques AC, Novaes FS, de Oliveira Mda S, Souza JR, Yamanaka A, Pareja JC, et al. TyG index performs better than HOMA in a Brazilian population: A hyperglycemic clamp validated study. Diabetes Res Clin Pract. 2011;93(3):e98-e100.
[14] Raimi TH, Dele-Ojo BF, Dada SA, Fadare JO, Ajayi DD, Ajayi EA, et al. Triglyceride-glucose index and related parameters predicted metabolic syndrome in Nigerians. Metab Syndr Relat Disord. 2021;19(2):76-82.
[15] Unger G, Benozzi SF, Perruzza F, Pennacchiotti GL. Triglycerides and glucose index: A useful indicator of insulin resistance. Endocrinol Nutr. 2014;61(10):533-40.
[16] Brunt A, Rhee Y, Zhong L. Differences in dietary patterns among college students according to body mass index. J Am Coll Health. 2008;56(6):629-34.
[17] American Diabetes Association Recommendations. Available from: https://www.amc.edu/pathology_labservices/addenda/addenda_documents/American diabetesas sociation recommendatio ns2.pdf.
[18] Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. Circulation. 2002;106(25):3143-421.
[19] Guerrero-Romero F, Simental-Mendia LE, Gonzalez-Ortiz M, et al. The product of triglycerides and glucose, a simple measure of insulin sensitivity. Comparison with the euglycemic-hyperinsulinemic clamp. J Clin Endocrinol Metab. 2010;95:3347-51.
[20] Zheng S, Shi S, Ren X, Han T, Li Y, Chen Y, et al. Triglyceride glucose-waist circumference, a novel and effective predictor of diabetes in first-degree relatives of type 2 diabetes patients: Cross-sectional and prospective cohort study. J Transl Med. 2016;14: 260.

[21] Kandula SGNSV, Sasi STVD, Shruti K, Santhosh KA. A study on the prevalence of obesity and metabolic syndrome among students of a medical college. International Journal of Research in Medical Sciences. 2017;5(6):2331-37.
[22] Manjareeka M, Nanda S, Mishra J, Mishra S. Correlation between anthropometry and lipid profile in healthy subjects of Eastern India. J Mid-life Health. 2015;6(4):164-68.
[23] Hong S, Han K, Park CY. The triglyceride glucose index is a simple and low-cost marker associated with atherosclerotic cardiovascular disease: A population-based study. BMC Med. 2020;18(1):361.

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