



Association of Lipid Accumulation Product and Triglyceride-Glucose Index with Metabolic Syndrome in Young Adults: A Cross-sectional Study

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Abstract

Background: Metabolic syndrome is a cluster of elements linked with type 2 diabetes mellitus and cardiovascular disease (CVD). The early detection of individuals at the risk of developing metabolic syndrome can prevent the development of type 2 diabetes mellitus and CVD.

Objectives: This study aimed to evaluate the association of the lipid accumulation product (LAP) and triglyceride-glucose (TyG) index with metabolic syndrome among young adults.

Methods: This cross-sectional study included 300 young adults within the age range of 20 - 40 years. Metabolic syndrome was defined according to modified National Cholesterol Education Program Adult Treatment Panel III guidelines. The LAP and TyG index were calculated. Multivariate logistic regression and receiver operating characteristic curve analyses were performed to assess the association of the LAP and TyG index with metabolic syndrome.

Results: The LAP and TyG index were significantly associated with metabolic syndrome ($P < 0.05$). The LAP showed the highest area under the curve (0.882 and 0.905 in male and female subjects, respectively), followed by the TyG index (0.875 and 0.886 in male and female subjects, respectively, at $P < 0.0001$). The cut-off values for the LAP were 45.65 in males with a sensitivity and specificity of 80% and 46.91 in females with a sensitivity and specificity of 88%. The cut-off points for the TyG index were 8.63 in males with 80% sensitivity and 78.9% specificity and 8.54 in females with 83.3% sensitivity and 79.6% specificity.

Conclusions: The LAP and TyG index are significantly associated with metabolic syndrome in young adults. As simple and inexpensive markers, they can be used to identify individuals with metabolic syndrome with high sensitivity and specificity.

Keywords: Lipid Accumulation Product, Metabolic Syndrome, Triglyceride-Glucose Index

1. Background

Metabolic syndrome is a congregation of various factors associated with the development of type 2 diabetes mellitus and cardiovascular disease (CVD) (1). The risk factors include abdominal obesity, hypertension, glucose intolerance, and dyslipidemia. Metabolic syndrome is currently recognized as a clinical and public health problem. Therefore, the metabolic syndrome should be identified earlier to prevent cardiovascular complications (2).

The diagnosis of metabolic syndrome is made using National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) criteria, along with the modifica-

tion of waist circumference specifically applicable to South Asians (3). The commonly used indicators of metabolic syndrome are anthropometric parameters, such as body mass index (BMI), waist circumference, and waist-hip ratio (WHR) (2). However, these parameters cannot distinguish between visceral obesity and subcutaneous fat (3).

Recently, a new index called the lipid accumulation product (LAP) was proposed as a better indicator of metabolic syndrome, as it reflects the central lipid accumulation. The LAP is based on waist circumference and fasting triglyceride levels (4). As the LAP includes two of the five components of metabolic syndrome, it can be a reliable indicator of metabolic syndrome (5). Although the

LAP is an evolving tool for screening purposes, a limited number of studies have been conducted to assess its ability to identify metabolic syndrome (2).

Another marker proposed is the triglyceride-glucose (TyG) index which is based on fasting plasma glucose and triglyceride levels (6). This index requires only simple biochemical parameters which can be measured in a laboratory without much cost (7) and predicts insulin resistance better than the homeostatic model assessment of insulin resistance (HOMA-IR) (8-10). As insulin resistance is an important factor responsible for metabolic syndrome, TyG, a simple index that reflects insulin resistance, can be a better indicator of metabolic syndrome. However, a limited number of studies in India have investigated the relationship between the TyG index and metabolic syndrome to date (6).

2. Objectives

This study aimed to evaluate the association of the LAP and TyG index with metabolic syndrome in young adults.

3. Methods

3.1. Study Design and Population

This cross-sectional study was conducted in the Department of Biochemistry at Aarupadai Veedu Medical College & Hospital, Puducherry, India, after obtaining approval from the Institutional Scientific Research Committee and the Ethics Committee. A total of 300 young adults (150 male and 150 female subjects) within the age range of 20 - 40 years were recruited by the random sampling method from patients visiting for the general health check-up in the institute. The individuals with a known history of diabetes mellitus, hypertension, CVD, renal disease, liver disease, acute illness, autoimmune disease, cancer, thyroid disorder, and those on lipid-lowering drugs were excluded from the study.

3.2. Sample Size Calculation

The sample size was calculated using PASS software (version 19.0.10) (11). The minimum required sample size was 266 to detect a difference of 0.100 between the area under the receiver operating characteristic (ROC) curve using a two-sided z-test at a 5% level of significance and 80% power. The sample size was further modified by increasing by 20% to gain confidence, and the final estimated sample size was 300.

3.3. Data Collection

After obtaining written informed consent from the participants, a brief clinical history was collected via questionnaires. Height was measured to the nearest 0.1 cm using a portable stadiometer (IndoSurgical height measuring scale, India), and weight was measured to the nearest 0.5 kg using Rossmax WB101 Weighing Scale. The BMI was calculated using the formula of weight in kg/height in m². Waist circumference was measured at the mid-point between the iliac crest and the last rib. Hip circumference was measured at the level of greater trochanters.

The WHR was calculated using the formula of waist circumference (cm)/hip circumference (cm). The waist-height ratio (WHtR) was calculated using the formula of waist circumference (cm)/body height (cm). Blood pressure was measured in the sitting posture after 5 minutes of rest using a standard mercury sphygmomanometer (Diamond Mercurial Blood Pressure Monitor, Elegant Enterprises, India). Blood pressure was measured twice in the right arm, and the mean blood pressure was recorded.

After overnight fasting of 10 hours, 3mL of venous blood sample was collected from the study subjects. Fasting blood glucose and serum lipid profile was measured using the Mindray BS-380 Biochemistry Autoanalyzer (Mindray Bio-Medical Electronics Co. Ltd., Shenzhen, P. R. China). The fasting plasma glucose levels by glucose oxidase method and total cholesterol levels by cholesterol oxidase method using the kits obtained from Jeev Diagnostics Pvt. Ltd., Chennai, India, were measured. Serum triglyceride levels by the glycerol kinase peroxidase method and high-density lipoprotein (HDL) cholesterol levels by the direct method using the kits from Mindray Bio-Medical Electronics Co. Ltd., Shenzhen, China, were measured. Very-low-density lipoprotein (VLDL) cholesterol levels were estimated using the formula (12) as follows:

$$\text{VLDL cholesterol (mg/dL)} = \text{Triglyceride (mg/dL)} / 5$$

Low-density lipoprotein (LDL) cholesterol was estimated using the Friedewald formula (12) as follows:

$$\text{LDL cholesterol (mg/dL)} = \text{Total cholesterol (mg/dL)} - \text{HDL cholesterol (mg/dL)} - \text{Triglyceride (mg/dL)} / 5$$

The LAP was calculated using the following formulas:

$$(\text{Waist circumference in cm} - 65) \times (\text{Triglyceride in mmol/L})$$

for male subjects

$$(\text{Waist circumference in cm} - 58) \times (\text{Triglyceride in mmol/L})$$

for female subjects (2).

The TyG index was calculated using the following formula (10):

$$\ln (\text{Fasting triglycerides [mg/dL]} \times \text{Fasting glucose [mg/dL]}/2)$$

3.4. Definition of Metabolic Syndrome

In keeping with modified NCEP ATP III criteria with the modification of waist circumference value applicable to South Asians, metabolic syndrome is present if three or more of the following five criteria are met (3):

(1) Waist circumference ≥ 90 and ≥ 80 cm in male and female subjects, respectively

(2) Blood pressure $\geq 130/85$ mmHg

(3) Fasting plasma glucose ≥ 100 mg/dL or on drug treatment for diabetes mellitus

(4) Fasting serum triglyceride ≥ 150 mg/dL

(5) Fasting serum HDL cholesterol ≤ 40 and ≤ 50 mg/dL in male and female subjects, respectively.

3.5. Statistical Analysis

All the results were statistically analyzed using SPSS software (version 16.0; SPSS Inc., USA). Normally distributed continuous variables were expressed as mean \pm standard deviation, and nonnormal data were expressed as median (interquartile range). The comparison of variables among subjects with and without metabolic syndrome was made by student's unpaired *t*-test or Mann-Whitney U test. Multivariate logistic regression analysis was carried out to determine the association of the LAP and TyG index with metabolic syndrome. The ROC curve analyses were performed to determine the cut-off points of the LAP and TyG index. A *p*-value of less than 0.05 was considered statistically significant.

4. Results

The present study included 300 young adults within the age range of 20 - 40 years. Table 1 shows the comparison of anthropometric and biochemical variables between male and female subjects. Table 2 shows the comparison of anthropometric and biochemical variables between subjects with and without metabolic syndrome. Both male and female subjects with metabolic syndrome were significantly older, with increased weight, BMI, waist circumference, hip circumference, WHR, WHtR, systolic blood pressure, diastolic blood pressure, fasting blood glucose, triglyceride levels, LDL cholesterol, VLDL cholesterol,

and the LAP and TyG index. The HDL cholesterol levels were significantly lower in subjects with metabolic syndrome than in those without metabolic syndrome. The total cholesterol levels were significantly higher in males with metabolic syndrome than in those without metabolic syndrome. However, in females, the difference in total cholesterol levels between subjects with metabolic syndrome and without metabolic syndrome was not significant. Then, multivariate logistic regression analysis was carried out for the LAP and TyG index, separately along with other parameters, such as BMI, waist circumference, WHR, WHtR, systolic and diastolic blood pressure, total serum cholesterol, serum triglyceride, and serum HDL cholesterol. Among the analyzed parameters, the LAP and TyG index were significantly associated with metabolic syndrome (Tables 3 and 4).

In ROC curve analysis, the LAP showed the highest area under the curve (0.882 in males and 0.905 in females), followed by the TyG index (0.875 in males and 0.886 in females), compared to the anthropometric parameters (Table 5; Figures 1 and 2). The cut-off values for the LAP were 45.65 in males with a sensitivity and specificity of 80% and 46.91 in females with a sensitivity and specificity of 88%. The cut-off points for the TyG index were 8.63 in males with sensitivity of 80% and specificity of 78.9%, and 8.54 in females with a sensitivity of 83.3% and specificity of 79.6% (Table 5; Figures 1 and 2).

5. Discussion

In this study, the LAP and TyG index were significantly high in young adults with metabolic syndrome, suggesting high visceral adiposity in them (3). Although total serum cholesterol was higher in females with metabolic syndrome than in females without metabolic syndrome, the difference was not statistically significant. Nevertheless, other lipid parameters, such as serum triglyceride, LDL cholesterol, and VLDL cholesterol, were significantly high in females with metabolic syndrome. Moreover, total cholesterol is not a component of metabolic syndrome. Therefore, it is to be noted that patients with normal or even low total cholesterol can still have metabolic syndrome.

The LAP and TyG index were observed to be significantly associated with metabolic syndrome. Furthermore, in ROC curve analysis, the LAP showed the highest area under the curve (0.882 in male and 0.905 in female subjects), fol-

Table 1. Comparison of Anthropometric and Biochemical Variables Between Male and Female Subjects^a

Variables	Male (n = 150)	Female (n = 150)	P-Value
Age (y)	29.9 ± 6.2	30.2 ± 6.3	0.790
Height (cm)	169.3 ± 6.9	156.4 ± 5.8	< 0.0001
Weight (kg)	72.2 ± 11.5	62.5 ± 9.9	< 0.0001
BMI (kg/m ²)	25.2 ± 3.7	25.5 ± 4.2	0.524
Waist circumference (cm)	93.1 ± 8.8	86.8 ± 11.2	< 0.0001
Hip circumference (cm)	98.3 ± 6.2	99.1 ± 8.9	0.351
Waist-hip ratio	0.94 ± 0.05	0.87 ± 0.06	< 0.0001
Waist-height ratio	0.55 ± 0.06	0.56 ± 0.08	0.525
Systolic blood pressure (mmHg)	119.9 ± 14.8	117.1 ± 15.5	0.116
Diastolic blood pressure (mmHg)	77.7 ± 9.7	77.9 ± 9.3	0.809
Fasting blood glucose (mg/dL)	87.7 ± 21.2	83.2 ± 17.1	0.039
Serum total cholesterol (mg/dL)	174.3 ± 35.3	170.5 ± 33.6	0.344
Serum triglyceride (mg/dL)	129 (72)	105.5 (55)	0.016
Serum HDL cholesterol (mg/dL)	40.5 ± 7.4	48.6 ± 8.5	< 0.0001
Serum LDL cholesterol (mg/dL)	107.1 ± 32	98.3 ± 36.6	0.028
Serum VLDL cholesterol (mg/dL)	26.8 ± 11.7	23.7 ± 10.1	0.016
Lipid accumulation product	44.1 ± 26.5	39.2 ± 22.6	0.083
Triglyceride-glucose index	8.6 ± 0.5	8.4 ± 0.4	0.003

Abbreviations: HDL, high-density lipoprotein; LDL, low-density lipoprotein; VLDL, very-low-density lipoprotein.

^a Values are expressed as mean ± standard deviation.

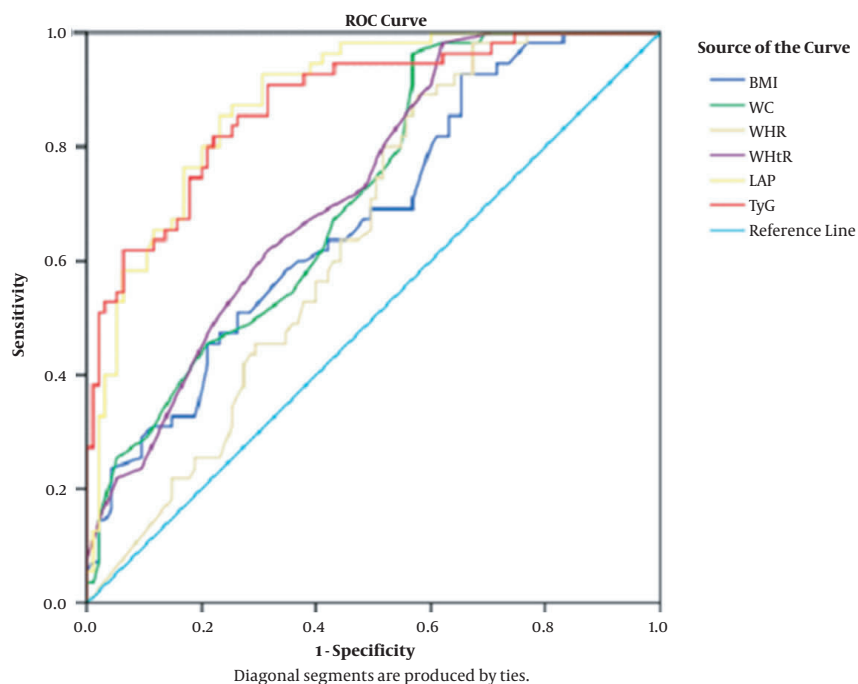
**Figure 1.** Receiver operating characteristic curve analysis of lipid accumulation product and triglyceride-glucose in male subjects

Table 2. Comparison of Anthropometric and Biochemical Variables Between Male and Female Young Adults with and without Metabolic Syndrome^a

Variables	Male			Female		
	With Metabolic Syndrome (n = 55)	Without Metabolic Syndrome (n = 95)	P-Value	With Metabolic Syndrome (n = 42)	Without Metabolic Syndrome (n = 108)	P-Value
Age (year)	32.6 ± 5.1	28.4 ± 6.3	< 0.0001	33.8 ± 4.4	28.7 ± 6.4	< 0.0001
Height (cm)	168.1 ± 7.2	169.9 ± 6.8	0.131	153.9 ± 4.5	154.3 ± 5.5	0.126
Weight (kg)	76.0 ± 11.3	69.9 ± 11.1	0.002	67.6 ± 8.7	60.4 ± 9.8	< 0.0001
BMI (kg/m ²)	26.7 ± 3.6	24.3 ± 3.5	< 0.0001	28.5 ± 3.8	24.2 ± 3.7	< 0.0001
Waist circumference (cm)	97.5 ± 4.9	90.5 ± 9.5	< 0.0001	94.7 ± 8.5	83.7 ± 10.6	< 0.0001
Hip circumference (cm)	100.7 ± 4.8	96.9 ± 6.5	< 0.0001	103.6 ± 6.7	97.3 ± 8.9	< 0.0001
Waist-hip ratio	0.96 ± 0.03	0.93 ± 0.06	< 0.0001	0.91 ± 0.05	0.85 ± 0.07	< 0.0001
Waist-height ratio	0.58 ± 0.04	0.53 ± 0.06	< 0.0001	0.62 ± 0.06	0.53 ± 0.07	< 0.0001
Systolic blood pressure (mmHg)	127.5 ± 15.9	115.4 ± 12	< 0.0001	127.3 ± 15.5	113.1 ± 13.6	< 0.0001
Diastolic blood pressure (mmHg)	81.9 ± 9.9	75.2 ± 8.7	< 0.0001	84.4 ± 8.8	75.4 ± 8.3	< 0.0001
Fasting blood glucose (mg/dL)	97.8 ± 29.9	81.9 ± 10.1	< 0.0001	92.1 ± 26.4	79.6 ± 9.7	< 0.0001
Total cholesterol (mg/dL)	186 ± 32.5	167.4 ± 35.4	0.002	178.2 ± 37.2	159.2 ± 21.5	0.211
Triglyceride (mg/dL)	167 (51)	105 (55)	< 0.0001	154.5 (69)	97 (41)	< 0.0001
HDL cholesterol (mg/dL)	35.9 ± 6.2	43.1 ± 6.6	< 0.0001	44.7 ± 6.7	50.1 ± 8.7	< 0.0001
LDL cholesterol (mg/dL)	114.7 ± 31.1	102.5 ± 31.9	0.024	101.9 ± 40.6	88.6 ± 21.1	0.045
VLDL cholesterol (mg/dL)	35.3 ± 12.5	21.8 ± 7.7	< 0.0001	31.5 ± 11.9	20.7 ± 7.4	< 0.0001
Lipid accumulation product	65.1 ± 24.7	31.9 ± 18.8	< 0.0001	63.3 ± 19.7	29.8 ± 15.6	< 0.0001
Triglyceride-glucose index	8.9 ± 0.4	8.3 ± 0.3	< 0.0001	8.8 ± 0.3	8.3 ± 0.3	< 0.0001

Abbreviations: BMI, body mass index; HDL, high-density lipoprotein; LDL, low-density lipoprotein; VLDL, very-low-density lipoprotein.

^a Values are expressed as mean ± standard deviation.

lowed by the TyG index (0.875 in male and 0.886 in female subjects), compared to other anthropometric parameters. The cut-off points for the LAP were 45.65 in males with a sensitivity and specificity of 80% and 46.91 in females with a sensitivity and specificity of 88%. The optimal cut-off points for the TyG index were 8.63 in males with 80% sensitivity and 78.9% specificity and 8.54 in females with 83.3% sensitivity and 79.6% specificity.

The LAP is a simple parameter calculated according to two measurements, waist circumference and triglycerides (2). It is associated with dysfunctional and lipolytic adipose tissue, a key factor in the development of the metabolic syndrome. Waist circumference, a parameter of the LAP, represents abdominal subcutaneous adipose tissue and

visceral adipose tissue (13). The TyG index is more linked with insulin resistance than HOMA-IR (14), and insulin resistance is the underlying mechanism of metabolic syndrome (9).

In a study conducted on Indian adults by Ray et al., the LAP was significantly higher in subjects with metabolic syndrome than in controls (3). Other studies also demonstrated significantly high LAP in polycystic ovary syndrome patients with metabolic syndrome (15) and in premenopausal and postmenopausal female subjects with metabolic syndrome (16).

A study conducted on middle-aged and elderly Chinese individuals by Li et al. (6) also showed a significant association between the LAP and TyG index with metabolic syn-

Table 3. Multivariate Logistic Regression Analysis of Association of Lipid Accumulation Product with metabolic Syndrome

Variables	Adjusted Odds Ratio	P-Value	95% Confidence Interval	
			Lower	Upper
Male Subjects				
BMI (kg/m ²)	1.109	0.469	0.838	1.467
Waist circumference (cm)	1.228	0.455	0.717	2.104
Waist-hip ratio	1.142	0.244	0.966	1.346
Waist-height ratio	1.047	0.493	0.801	1.112
Systolic blood pressure (mmHg)	1.072	0.069	0.995	1.154
Diastolic blood pressure (mmHg)	1.076	0.156	0.973	1.190
Fasting blood glucose (mg/dL)	0.845	0.205	0.652	1.096
Serum total cholesterol (mg/dL)	0.999	0.906	0.978	1.020
Serum triglyceride (mg/dL)	1.108	0.063	0.999	1.228
Serum HDL cholesterol (mg/dL)	0.785	0.060	0.892	1.890
Lipid accumulation product	1.078	0.004	1.024	1.136
Female Subjects				
BMI (kg/m ²)	1.033	0.704	0.875	1.219
Waist circumference (cm)	0.807	0.061	0.651	1.001
Waist-hip ratio	1.003	0.286	0.954	1.120
Waist-height ratio	1.261	0.202	0.845	1.010
Systolic blood pressure (mmHg)	1.024	0.327	0.977	1.073
Diastolic blood pressure (mmHg)	1.020	0.630	0.940	1.108
Fasting blood glucose (mg/dL)	1.066	0.201	1.025	1.109
Serum total cholesterol (mg/dL)	0.982	0.062	0.964	1.001
Serum triglyceride (mg/dL)	0.982	0.341	0.945	1.020
Serum HDL cholesterol (mg/dL)	0.944	0.082	0.884	1.007
Lipid accumulation product	1.149	0.027	1.016	1.299

Abbreviations: BMI, body mass index; HDL, high-density lipoprotein.

drome. In other studies that compared the LAP with BMI and waist circumference, the LAP was observed to be a better marker among Spanish adults (13), Iranian adults (17), male subjects in Argentina (18), and male subjects in Nigeria (19). However, in a cohort study carried out on Chinese adults, waist circumference was accurate in predicting metabolic syndrome (1). In another study performed on the Xinjiang population (20), the WHtR was a better marker than the LAP and BMI. In the two aforementioned studies, metabolic syndrome was defined using International Diabetes Federation criteria which could be a reason for their contradictory findings.

Therefore, the accurate and reliable parameter for metabolic syndrome differs by age, gender, ethnicity, region, and criteria used to define metabolic syndrome. In

Brazilian adults (2), the cut-off points of the LAP were 64.1 and 38 in male and female patients; nevertheless, it was reported as 53.63 in Argentinians (18). In a study conducted on the pediatric age group, the cut-off value of the TyG index was 8.33 (14). In another study, the cut-off points of the TyG index were 8.65 and 8.35 in Mexican American adults and non-Hispanic blacks, respectively (9). These differences in the cut-off points could be due to the differences in populations assessed in various regions and ethnicities.

The major limitation of the current study is a lack of a population-based study design and the non-representative sample. Other limitations include a small sample size and a cross-sectional design, and causal inferences could not be made.

Table 4. Multivariate Logistic Regression Analysis of Association of Triglyceride-Glucose with Metabolic Syndrome

Variables	Adjusted Odds Ratio	P-Value	95% Confidence Interval	
			Lower	Upper
Male Subjects				
BMI (kg/m ²)	1.116	0.429	0.850	1.467
Waist circumference (cm)	0.853	0.130	0.694	1.048
Waist-hip ratio	1.717	0.217	0.900	1.380
Waist-height ratio	1.557	0.207	0.816	1.054
Systolic blood pressure (mmHg)	1.076	0.206	1.015	1.484
Diastolic blood pressure (mmHg)	1.064	0.210	0.966	1.172
Fasting blood glucose (mg/dL)	1.189	0.140	1.008	1.402
Serum total cholesterol (mg/dL)	0.999	0.915	0.978	1.020
Serum triglyceride (mg/dL)	1.104	0.062	0.999	1.220
Serum HDL cholesterol (mg/dL)	0.766	0.230	0.870	1.676
Triglyceride-glucose index	1.096	0.020	1.015	1.184
Female Subjects				
BMI (kg/m ²)	1.041	0.630	0.883	1.228
Waist circumference (cm)	0.924	0.377	0.775	1.101
Waist-hip ratio	1.002	0.252	0.936	1.165
Waist-height ratio	1.998	0.097	0.821	1.035
Systolic blood pressure (mmHg)	1.025	0.297	0.979	1.073
Diastolic blood pressure (mmHg)	1.024	0.568	0.944	1.110
Fasting blood glucose (mg/dL)	1.005	0.893	0.937	1.078
Serum total cholesterol (mg/dL)	0.980	0.065	0.961	0.999
Serum triglyceride (mg/dL)	0.986	0.450	0.951	1.022
Serum HDL cholesterol (mg/dL)	0.947	0.084	0.890	1.007
Triglyceride-glucose index	1.035	0.044	0.905	1.241

Abbreviations: BMI, body mass index; HDL, high-density lipoprotein.

5.1. Conclusions

The LAP and TyG index are significantly associated with metabolic syndrome in young adults. As simple and inexpensive markers, they can be used to identify individuals with metabolic syndrome with high sensitivity and specificity. By the early identification of metabolic syndrome, lifestyle modifications, such as dietary changes and regular physical activity, can be introduced at an early age to avoid the development of type 2 diabetes mellitus and CVD in the future. Further prospective studies are required with a larger sample size to confirm the obtained findings.

Footnotes

Authors' Contribution: Suryapriya Rajendran researched the literature, conceived the study, analyzed and interpreted the data, and drafted the manuscript. Anand Kumar Kizhakkayil Padikkal was involved in patient recruitment and sample collection. Sasmita

Mishra and Manju Madhavanpillai were involved in estimating biochemical parameters and critical review of the manuscript. All the authors reviewed and edited the manuscript and approved the final version of the manuscript.

Conflict of Interests: The authors declare that they have no conflict of interest.

Data Reproducibility: It was not declared by the authors.

Ethical Approval: The present study was approved by the Institutional ethics committee (Human Studies) of Aarupadai Veedu Medical College (IEC no.: AVMC/IEC2019/36).

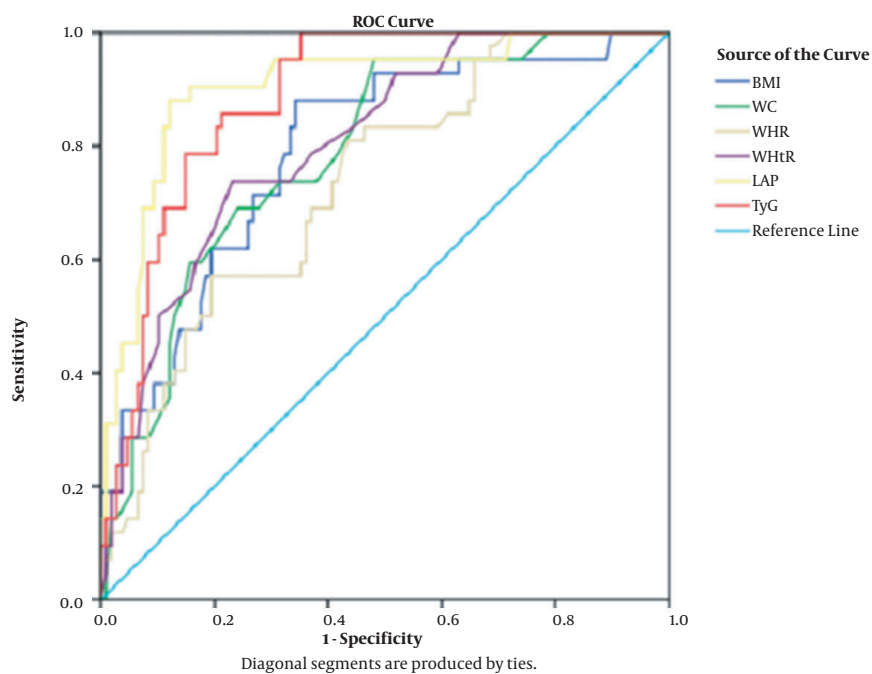
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Informed Consent: Informed consent was obtained from the participants.

Table 5. Receiver Operating Characteristic Curve Analysis, Cut-off Points, and Sensitivity and Specificity of Anthropometric and Biochemical Variables

Variables	Area Under Curve	P-Value	Cut-Off Point	Sensitivity (%)	Specificity (%)
Male Subjects					
BMI (kg/m ²)	0.675	< 0.0001	25.45	61.8	58.9
Waist circumference (cm)	0.710	< 0.0001	95.5	61.8	58.9
Waist-hip ratio	0.643	0.004	0.96	60	56.8
Waist-height ratio	0.725	< 0.0001	0.56	69.1	60
Lipid accumulation product	0.882	< 0.0001	45.65	80	80
Triglyceride-glucose index	0.875	< 0.0001	8.63	80	78.9
Female Subjects					
BMI (kg/m ²)	0.792	< 0.0001	26.62	71.4	73.1
Waist circumference (cm)	0.787	< 0.0001	88.5	73.8	68.5
Waist-hip ratio	0.733	< 0.0001	0.88	66.7	63
Waist-height ratio	0.802	< 0.0001	0.58	73.8	76.9
Lipid accumulation product	0.905	< 0.0001	46.91	88	88
Triglyceride-glucose index	0.886	< 0.0001	8.54	83.3	79.6

Abbreviation: BMI, body mass index.

**Figure 2.** Receiver operating characteristic curve analysis of lipid accumulation product and triglyceride-glucose in female subjects

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