Indian Journal of Health Care, Medical & Pharmacy Practice (Vol 7, Issue 3-4, Oct-Dec 2026)
Home page of the journal: https://ijhmp.com/Home

Research Article

EVALUATION & VALIDATION OF NEW INSULIN RESISTANCE INDEXES TG/HDL-C, VAI, LAP, TYG & METS-IR IN NON-DIABETIC POPULATION

Dr. Ram Niwas[1]*, Dr. Sanjeev Maheshwari[2], Dr. Payal Tailor[3], Dr. Sunil Bainda[4]

[1]Sr. Resident, MD Gen Medicine, Department of Medicine, J.L.N. Medical College and Hospital, Ajmer, Rajasthan, India.
[2]Sr. Professor, Gen Medicine, Department of Medicine, J.L.N. Medical College and Hospital, Ajmer, Rajasthan, India.
[3]Resident, MD Microbiology, Department of Medicine, J.L.N. Medical College and Hospital, Ajmer, Rajasthan, India.
[4]MBBS, Department of Medicine, J.L.N. Medical College and Hospital, Ajmer, Rajasthan, India.

Corresponding Author*: Dr. Ram Niwas, Sr. Resident, MD Gen Medicine, Department of Medicine, J.L.N. Medical College and Hospital, Ajmer, Rajasthan, India.

Email ID: drrnbainda@gmail.com

DOI: https://doi.org/10.59551/IJHMP/25832069/2026.7.3/4.121

How to cite this article: Niwas R, Maheshwari S, Tailor P et al. Evaluation & Validation of New Insulin Resistance Indexes TG/HDL-C, VAI, LAP, TYG & METS-IR in Non-Diabetic Population. *Indian J. Health Care, Med. Pharm. Pract.* 2026;7(3-4):169-172.

COPYRIGHT@ 2026, IJHMP | This work is licensed under a Creative Commons Attribution 4.0 International Licence

Received: 09 Oct, 2026, Decision for Acceptance: 11 Nov, 2026

ABSTRACT

Background: Insulin resistance is an important metabolic abnormality associated with cardiovascular and metabolic disorders. Simple surrogate indices based on anthropometric and biochemical parameters may help identify insulin resistance in non-diabetic individuals.

Aim: To evaluate insulin resistance using HOMA-IR and assess its relationship with lipid-based and anthropometric indices, including the lipid accumulation product (LAP), visceral adiposity index (VAI), and triglyceride-glucose (TG) index.

Materials and Methods: This cross-sectional study included 100 non-diabetic participants attending JLN Medical College and Hospital, Ajmer, from January to December 2023. Anthropometric measurements and biochemical parameters were assessed, and HOMA-IR, LAP, VAI, and TG index were calculated. Participants were classified into insulin-resistant and non-insulin-resistant groups according to the study-defined HOMA-IR cut-off. Statistical comparisons were performed between the groups.

Results: Of the 100 participants, 88 (88%) were female and 12 (12%) were male. The mean HOMA-IR was 2.56, with insulin resistance identified in 37 (37%) participants. The mean LAP, VAI, and TG index were 63.01, 2.99, and 1.40, respectively. Compared with participants without insulin resistance, those with insulin resistance had significantly higher systolic and diastolic blood pressure, triglycerides, fasting insulin, fasting blood glucose, LAP, and TG index, and lower HDL-C (all $p<0.0001$). VAI did not differ significantly between the groups ($p=0.6215$).

Conclusion: LAP and the TG index were significantly associated with the metabolic profile of insulin-resistant participants, whereas VAI showed no significant difference. Further studies with larger populations and diagnostic accuracy analyses are needed to establish the clinical utility of these indices.

KEYWORDS: Insulin Resistance, HOMA-IR, Lipid Accumulation Product, Visceral Adiposity Index, Triglyceride-glucose Index.

Introduction

Insulin resistance (IR) is associated with metabolic abnormalities, abdominal obesity and cardiovascular disorders. Insulin regulates glucose absorption and lipid metabolism, while circulating fatty acids and adipocytokines have been described in obesity-associated IR[1]. Homeostasis model assessment of insulin resistance (HOMA-IR), calculated from fasting glucose and insulin, is widely used for assessment of IR[2,3]. Anthropometric measures such as waist circumference, waist-to-hip ratio and waist-to-height ratio do not fully reflect fat distribution or lipid accumulation[4].

The lipid accumulation product (LAP), based on triglyceride levels and waist circumference, was introduced as an indicator of metabolic risk[5] and has been studied in relation to metabolic disorders including polycystic ovary syndrome[6,7]. Other indices, including the triglyceride-glucose (TyG) index and visceral adiposity index (VAI), have also been associated with metabolic syndrome and cardiovascular risk[8,9]. This study estimated insulin resistance indices in non-diabetic individuals and assessed their relationship with HOMA-IR.

Aim and Objectives

To estimate TG/HDL-C ratio, VAI, LAP, TyG index and MetS-IR in a non-diabetic population; measure fasting serum insulin and fasting blood glucose; calculate HOMA-IR; and estimate the correlation of insulin resistance indices with HOMA-IR.

Materials and Methods

This cross-sectional study was conducted in the Department of Medicine, JLN Medical College & Hospital, Ajmer, from January to December 2023. Informed consent was obtained, and permission was obtained from the institutional ethical committee. The study included non-diabetic subjects aged 20–60 years attending the OPD or admitted to medical wards, including individuals with obesity who wished to lose weight. Exclusion criteria included diabetic-range fasting or 2-hour post-load glucose, diabetes, cancer, inflammatory, renal or autoimmune disorders, steroid use, insufficient information, pregnancy or lactation, thyroid dysfunction, heavy smoking or alcohol addiction, and surgery within the previous six months.

Age, sex, height, weight, waist and hip circumferences, and blood pressure were recorded. BMI was calculated as weight (kg)/height² (m²). After 12 hours of fasting, blood was analysed for glucose, insulin, total cholesterol, LDL-C, HDL-C, triglycerides and TSH. Plasma glucose was measured by the GOD-POD endpoint method; fasting serum insulin by ELISA; and lipids by enzymatic methods. LDL-C was calculated using the Friedewald equation and non-HDL-C by subtracting HDL-C from total cholesterol. HOMA-IR was calculated as fasting glucose × fasting insulin/405.28; values above 2.5 were considered indicative of IR. TyG was calculated as Ln [fasting triglycerides (mg/dL) × fasting plasma glucose (mg/dL)/2]. Statistical analysis was performed using SPSS version 20. Normally distributed data were expressed as mean ± SD; Pearson correlation was specified for relationships with HOMA-IR. Ethical letter no. & Date of approval of plan in College: 3012/Acad-III/MCA/2023/10-11-2023.

Results

The study included 100 non-diabetic participants: 88 females and 12 males. Overall mean age was 36.92 years. Mean BMI was 34.27 kg/m², fasting blood sugar was 95.1 mg/dL, serum insulin was 10.71 mIU/L and HOMA-IR was 2.56. The mean values of LAP, TG Index and VAI were 63.01, 1.40 and 2.99, respectively.

Among participants grouped by MetS status (MetS yes, n=40; no, n=60), significant differences were reported in systolic and diastolic blood pressure, HDL-C, triglycerides, insulin, fasting blood sugar, LAP, HOMA-IR, VAI and TG Index. In the HOMA-IR grouping (IR, n=37; no IR, n=63), significant differences were reported in systolic and diastolic blood pressure, HDL-C, triglycerides, insulin, fasting blood sugar, LAP and TG Index.

Table 1: Demographic and anthropometric characteristics

Parameter	Total (N=100)	Female (N=88)	Male (N=12)	p value
Age (years), mean ± SD	36.92 ± 5.27	36.96 ± 5.50	36.58 ± 3.26	0.8161
Height (cm), mean ± SD	159.05 ± 9.69	157.58 ± 9.34	169.83 ± 3.35	<0.0001
Weight (kg), mean ± SD	85.94 ± 11.70	85.36 ± 11.83	90.17 ± 10.21	0.1831
BMI (kg/m²), mean ± SD	34.27 ± 6.01	34.68 ± 6.17	31.27 ± 3.52	0.0647
Waist circumference (cm)	101.89 ± 9.21	101.58 ± 8.93	104.77 ± 11.26	0.2630
Hip circumference (cm)	115.66 ± 12.94	116.64 ± 13.20	108.50 ± 8.13	0.0404
Waist-hip ratio	0.88 ± 0.13	0.87 ± 0.13	0.96 ± 0.15	0.0295

Table 2: Biochemical parameters

Parameter	Total (N=100)	Female (N=88)	Male (N=12)	p value
Systolic BP (mmHg)	117.36 ± 14.01	117.42 ± 14.08	117.00 ± 14.08	0.9230
Diastolic BP (mmHg)	76.48 ± 9.55	75.86 ± 9.94	81.00 ± 3.86	0.0804
Total cholesterol (mg/dL)	192.83 ± 28.22	194.83 ± 29.49	178.17 ± 5.08	0.0547
LDL-C (mg/dL)	118.06 ± 8.63	118.75 ± 9.94	113.00 ± 6.69	0.0522
Triglycerides (mg/dL)	129.63 ± 31.74	129.42 ± 29.28	131.17 ± 47.84	0.8589
HDL-C (mg/dL)	44.50 ± 11.80	45.50 ± 11.92	37.70 ± 7.90	0.0304
Fasting blood sugar (mg/dL)	95.10 ± 9.87	94.92 ± 8.81	96.42 ± 16.17	0.6240
Serum insulin (mIU/L)	10.71 ± 8.40	9.84 ± 7.69	14.94 ± 9.73	0.0396

Table 3: Insulin resistance indices

Index	Total (N=100)	Female (N=88)	Male (N=12)	p value
LAP	63.01 ± 20.45	63.38 ± 18.39	60.26 ± 32.86	0.6225
HOMA-IR	2.56 ± 2.07	2.39 ± 2.02	3.82 ± 2.06	0.0238
TG Index	1.40 ± 0.61	1.35 ± 0.52	1.73 ± 1.02	0.0413
VAI	2.99 ± 0.87	3.14 ± 0.79	1.87 ± 0.52	<0.0001

Table 4: Selected parameters by MetS status

Parameter	MetS yes (n=40), mean ± SD	MetS no (n=60), mean ± SD	p value
Systolic BP (mmHg)	131.3 ± 2.49	110.4 ± 9.92	<0.0001
Diastolic BP (mmHg)	84.7 ± 7.92	71.0 ± 5.94	<0.0001
HDL-C (mg/dL)	35.65 ± 4.16	50.4 ± 11.56	<0.0001
Triglycerides (mg/dL)	160.8 ± 19.51	108.85 ± 18.48	<0.0001
Insulin (µIU/L)	15.5 ± 8.49	7.53 ± 6.72	<0.0001
LAP	78.37 ± 16.17	51.36 ± 18.36	<0.0001
HOMA-IR	3.97 ± 2.14	1.63 ± 1.38	<0.0001
VAI	3.19 ± 0.75	2.84 ± 0.92	0.0480
TG Index	2.01 ± 0.44	0.99 ± 0.14	<0.0001

Table 5: Selected parameters by HOMA-IR status

Parameter	IR (n=37), mean ± SD	No IR (n=63), mean ± SD	p value
Systolic BP (mmHg)	127.16 ± 10.14	111.06 ± 12.76	<0.0001
Diastolic BP (mmHg)	83.68 ± 7.17	72.25 ± 8.17	<0.0001
HDL-C (mg/dL)	37.17 ± 4.19	48.81 ± 12.69	<0.0001
Triglycerides (mg/dL)	148.59 ± 30.71	118.49 ± 26.85	<0.0001
Insulin (µIU/L)	19.12 ± 8.69	5.78 ± 1.50	<0.0001
Fasting blood sugar (mg/dL)	100.89 ± 8.54	91.70 ± 9.02	<0.0001
LAP	73.99 ± 23.42	56.55 ± 15.33	<0.0001
VAI	3.04 ± 0.89	2.95 ± 0.87	0.6215
TG Index	1.79 ± 0.52	1.16 ± 0.53	<0.0001

Discussion

In the present cross-sectional study of 100 non-diabetic participants, the mean HOMA-IR was 2.56, and 37 participants (37%) were classified as insulin resistant using the study cut-off. The mean LAP, VAI and TG index were 63.01, 2.99 and 1.40, respectively. The insulin-resistant group had higher systolic and diastolic blood pressure, triglycerides, fasting insulin, fasting blood glucose, LAP and TG index, while HDL-C was lower than in participants without insulin resistance (all p<0.0001). VAI did not differ significantly between the groups (3.04 vs 2.95; p=0.6215). These findings suggest that several lipid-based and anthropometric indices reflect the adverse metabolic profile accompanying higher HOMA-IR, although not all indices performed similarly in this sample.

ISSN 2583-2069

The results are partly consistent with Bermúdez et al.[10], who assessed 1,818 adults in Maracaibo, Venezuela, and found that LAP was more strongly associated with insulin resistance than VAI. Their area under the ROC curve was 0.689 for LAP compared with 0.645 for VAI, and only LAP tertiles remained significantly associated with insulin resistance in adjusted analyses[10]. In the present study, LAP was significantly higher among insulin-resistant participants (73.99 ± 23.42 vs 56.55 ± 15.33; $p<0.0001$), whereas VAI showed no significant difference. This supports the comparative pattern reported by Bermúdez et al.[10]; however, the present study did not perform ROC analysis, so diagnostic accuracy cannot be directly compared.

Park et al.[11] studied Korean adults and reported that the triglyceride-glucose (TyG) index predicted prevalent and incident type 2 diabetes better than HOMA-IR. The AUC for incident diabetes was 0.640 for TyG versus 0.531 for HOMA-IR [11]. This supports the wider relevance of lipid-glucose indices, but the present study's reported group comparisons do not establish that TyG outperformed HOMA-IR. Therefore, superiority should not be inferred from the current data.

Jog et al.[12] compared novel insulin-resistance biomarkers with HOMA-IR in a South Indian population and emphasised the need for population-specific cut-offs[12]. This is pertinent because the present study involved only 100 participants from a single centre, with a marked female predominance (88 females and 12 males). Its cut-offs and group differences should therefore be interpreted cautiously and should not be generalised to all non-diabetic populations. The study also did not provide a correlation-coefficient table in the results available for this article; hence, no correlation between individual indices and HOMA-IR can be claimed. Larger, more balanced studies incorporating ROC analysis and correlation testing are required to assess the diagnostic utility of these indices.

Conclusion

Significant differences were observed in systolic and diastolic blood pressure, HDL-C, triglycerides, insulin, fasting blood sugar, LAP, HOMA-IR, VAI and TG Index between MetS groups. In comparisons based on HOMA-IR, significant differences were observed in systolic and diastolic blood pressure, HDL-C, triglycerides, insulin, fasting blood sugar, LAP and TG Index. Lipid-based indices including TyG, TG:HDL ratio and LAP require fasting glucose and lipid measurements and anthropometric assessment, which can be performed in primary care settings. Larger studies are required to establish applicable cut-off values.

Conflicts of Interest

None

References

1. Aedh AI, Alshahrani MS, Huneif MA, Pryme IF, Oruch R. A Glimpse into Milestones of Insulin Resistance and an Updated Review of Its Management. Nutrients. 2023;15(4):921.
2. Gutch M, Kumar S, Razi SM, Gupta KK, Gupta A. Assessment of insulin sensitivity/resistance. Indian J Endocrinol Metab. 2015;19(1):160-164.
3. Park SY, Gautier JF, Chon S. Assessment of Insulin Secretion and Insulin Resistance in Human. Diabetes Metab J. 2021;45(5):641-654.
4. Zhang FL, Ren JX, Zhang P, Jin H, Qu Y, Yu Y, et al. Strong Association of Waist Circumference, Body Mass Index, Waist-to-Height Ratio, and Waist-to-Hip Ratio with Diabetes: A Population-Based Cross-Sectional Study in Jilin Province, China. J Diabetes Res. 2021;2021:8812431.
5. Kahn HS. The "lipid accumulation product" performs better than the body mass index for recognizing cardiovascular risk: a population-based comparison. BMC Cardiovasc Disord. 2005;5:26.
6. Palomba S, Santagni S, Falbo A, La Sala GB. Complications and challenges associated with polycystic ovary syndrome: current perspectives. Int J Womens Health. 2015;7:745-763.
7. Xiang S, Hua F, Chen L, Tang Y, Jiang X, Liu Z. Lipid accumulation product is related to metabolic syndrome in women with polycystic ovary syndrome. Exp Clin Endocrinol Diabetes. 2013;121(2):115-118.
8. Ciofani JL, Han D, Allahwala UK, Woolf B, Gill D, Bhindi R. Lipids, Blood Pressure, and Diabetes Mellitus on Risk of Cardiovascular Diseases in East Asians: A Mendelian Randomization Study. Am J Cardiol. 2023;205:329-337.
9. Du MF, Zhang X, Hu GL, Mu JJ, Chu C, Liao YY, et al. Associations of lipid accumulation product, visceral adiposity index, and triglyceride-glucose index with subclinical organ damage in healthy Chinese adults. Front Endocrinol (Lausanne). 2023;14:1164592.
10. Bermúdez V, Salazar J, Fuenmayor J, Nava M, Ortega Á, Duran P, et al. Lipid accumulation product is more related to insulin resistance than the visceral adiposity index in the Maracaibo City population, Venezuela. J Obes. 2021;2021:5514901. doi:10.1155/2021/5514901.
11. Park HM, Lee HS, Lee YJ, Lee JH. The triglyceride-glucose index is a more powerful surrogate marker for predicting the prevalence and incidence of type 2 diabetes mellitus than the homeostatic model assessment of insulin resistance. Diabetes Res Clin Pract. 2021;180:109042. doi:10.1016/j.diabres.2021.109042.
12. Jog KS, Eagappan S, Santharam RK, Subbiah S. Comparison of novel biomarkers of insulin resistance with homeostasis model assessment of insulin resistance, its correlation to metabolic syndrome in South Indian population and proposition of population specific cutoffs for these indices. Cureus. 2023;15(1):e33653. doi:10.7759/cureus.33653.