VER
Vascular & Endovascular Review

Effectiveness of Adjuvant Yoga Therapy on Atherogenic Dyslipidemia and Insulin Resistance Markers: TG/HDL Ratio and TyG Index Compared with Standard Medical Management

Dr. Rajasekaran Balaji[1], Dr. Munuswamy Arunkumar[2], Prof. Meena Ramanathan[3], Prof. Ananda Balayogi Bhavanani[4], Prof. Lakshmi Jatiya[5], Dr. Shanmugam Lokesh[6], Dr. Lokeshmaran Anandraj[7], Dr. Senkadhirdasan Dakshinamurthy[8], Prof. AR Srinivasan[9]

[1]MD (A.M), PhD, Assistant Professor, School of Yoga Therapy, Institute of Salutogenesis & Complementary Medicine, Sri Balaji Vidyapeeth (Deemed to be University), drbalajirajasekaran@gmail.com, orcid id- 0000-0003-4372-0895
[2]MBBS, MD, DM, Founder & Chairman AKR Super Specialty Clinic, Chennai, akvegita87@gmail.com
[3]PhD, C- IAYT, Principal, School of Yoga Therapy, Institute of Salutogenesis & Complementary Medicine, Sri Balaji Vidyapeeth (Deemed to be University), saineema@gmail.com, orcid id- 0000-0002-7253-6504
[4]DSc, C- IAYT, Director- Institute of Salutogenesis & Complementary Medicine, Sri Balaji Vidyapeeth (Deemed to be University), iscm@sbvu.ac.in, orcid id- 000-0003-0077-5394
[5]MD, Professor, Dept. of Physiology, Aarupadai Veedu Medical College & Hospital (AVMCH), Vinayaka Mission Research Foundation, jatiyalakshmi@yahoo.co.in, Orcid id- 0000-0003-0668-0724
[6]Scientist-E, MD, ICMR-National Institute of Epidemiology, India, lokeshsdr@gmail.com, Orcid id: 0000-0003-4348-1572
[7]PhD, Associate Professor of Bio- Statistics, Dept. of Community Medicine, MGMCRI, Sri Balaji Vidyapeeth (Deemed to be University), lokeshmaran.slams@gmail.com, orcid id- 000-0002-5772-8831
[8]MD, Assistant Professor, Dept. of Community Medicine, MGMCRI, Sri Balaji Vidyapeeth (Deemed to be University), senkadhirdasan85@gmail.com, orchid id- 0000-0001-6689-0016
[9]Professor, PhD, Dept. of Biochemistry, MGMCRI, Adjunct Faculty, ISCM, Sri Balaji Vidyapeeth (Deemed to be University), ar@sbvu.ac.in, Orcid id- 0000-0001-5775-272X

ABSTRACT

Atherogenic dyslipidemia, defined by elevated triglycerides (TG), reduced high-density lipoprotein cholesterol (HDL-C), and a high TG/HDL ratio, is a recognized surrogate for cardio metabolic risk and insulin resistance. The triglyceride–glucose (TyG) index is a validated, inexpensive marker of insulin resistance. To evaluate the impact of Adjuvant Yoga Therapy (AYT) added to Standard Medical Management (SMM) on TG/HDL ratio and TyG index in adults with metabolic syndrome. In this randomized controlled trial, 116 participants with metabolic syndrome were allocated to SMM (n=58) and SMM+AYT (n=58). AYT consisted of a structured yoga program combining asanas, pranayama, and relaxation techniques delivered over six months. Primary outcomes were TG/HDL ratio and TyG index, assessed at baseline, mid-intervention, and post-intervention AYT participants showed marked improvements in TG/HDL ratio compared with SMM. TyG index improved in AYT, while remaining high in SMM. Risk-category mitigation revealed that 77.3% of AYT participants shifted to intermediate/ low TG/HDL strata, compared with none in SMM. AYT, as an adjunct to SMM, significantly improved surrogate markers of atherogenic dyslipidemia and insulin resistance. TG/HDL ratio and TyG index emerged as responsive biomarkers for monitoring non-pharmacological cardio metabolic interventions.

KEYWORDS: Adjuvant Yoga Therapy; Metabolic Syndrome; TG/HDL ratio; TyG index; Insulin resistance

How to Cite: Rajasekaran Balaji, Munuswamy Arunkumar, Meena Ramanathan, Ananda Balayogi Bhavanani, Lakshmi Jatiya, Shanmugam Lokesh, Lokeshmaran Anandraj, Senkadhirdasan Dakshinamurthy, AR Srinivasan., (2025) Effectiveness of Adjuvant Yoga Therapy on Atherogenic Dyslipidemia and Insulin Resistance Markers: TG/HDL Ratio and TyG Index Compared with Standard Medical Management, Vascular and Endovascular Review, Vol.8, No.9s, 262--266.

INTRODUCTION

Atherogenic dyslipidemia (AD), elevated triglycerides (TG), reduced high-density lipoprotein cholesterol (HDL-C), and a higher TG/HDL ratio, is a robust marker of adverse cardiometabolic risk.[1,2] In addition to these core components, AD also involves other pro-atherogenic changes, including a perceptible elevation in the levels of small, dense LDL particles (sdLDL). This acquires great relevance in the light of the fact that it is not LDL levels that matter in silo, but in relation to the percentage of LDL that exists as sdLDL, a fact frequently disregarded in routine practice.[3,4] The TG/HDL ratio correlates with metabolic syndrome, incident type 2 diabetes, and coronary outcomes.[5–7] In parallel, the triglyceride–glucose (TyG) index—computed from fasting TG and glucose—has emerged as a practical, low-cost surrogate of insulin resistance with strong agreement to HOMA-IR.[8,9]

Lifestyle modification remains foundational in addressing dyslipidemia and insulin resistance. Mind–body practices such as yoga integrate physical postures, breathwork, and meditative elements and are associated with improvements in lipid profile, glycemic control, autonomic balance, oxidative stress, and inflammation..[10–12] Community-scale investigations further suggest favorable effects on lipid metabolism with yoga-based lifestyles.[13] However, the responsiveness of composite indices (TG/HDL and TyG)—which embed physiologic information beyond single analytes—has been underexplored.[13] We conducted a randomized

trial to evaluate whether Adjuvant Yoga Therapy (AYT), when added to standard medical management (SMM), improves TG/HDL ratio and TyG index over six months in adults with metabolic syndrome (MetS). We additionally examined risk-category migration based on TG/HDL thresholds to contextualize clinical relevance. By focusing on intervention-responsive composite biomarkers, this Short Communication addresses a salient evidence gap and informs scalable non-pharmacological strategies for cardiometabolic risk attenuation.

METHODS

Design and setting

The present work constitutes a part of a larger research project undertaken as a component of the doctoral dissertation. Prospective, randomized controlled, parallel-group trial conducted over six months at a tertiary teaching hospital in Puducherry (Department of General Medicine, AVMC; School of Yoga Therapy, Institute of Salutogenesis & Complementary Medicine [ISCM], SBV). Ethics approval: AVMC/IEC2019/015; CTRI registration: CTRI/2018/08/015514. Written informed consent was obtained; conduct adhered to the Declaration of Helsinki (2013).

Participants

Adults aged 30–60 years with MetS (IDF criteria for South Asians: central obesity—waist ≥90 cm men/≥80 cm women—plus ≥2 of: TG ≥150 mg/dL, HDL <40 mg/dL men/<50 mg/dL women, BP ≥130/85 mmHg or treatment, fasting glucose ≥100 mg/dL or diabetes). Exclusions: recent major cardiovascular events, chronic kidney/liver disease, psychiatric illness, pregnancy, significant musculoskeletal limitations, or current yoga practice.

Sample size and allocation

For two-sample comparisons (α=0.05, power 80%), an estimated 48 per arm was required; inflated to 58/arm (20% attrition). Of 116 enrolled, 3 control and 5 intervention participants were lost to follow-up.[14] Randomization was 1:1 to SMM or SMM+AYT.

Interventions

SMM included guideline-based pharmacological management of hypertension, diabetes, and dyslipidemia, as well as dietary counselling and advice on ≥150 minutes/week of moderate physical activity. AYT participants additionally undertook a structured yoga program validated by yoga therapists, integrative medicine experts comprising **"techniques to enhance experience of the life force**" ***pranayama*** and ***asana*** **"mindful static postures to cultivate body awareness"** which are listed in table **1**. Sessions were supervised thrice-weekly supervision with emphasis on daily home practice. Compliance was monitored with logbooks and weekly phone reinforcement.

Table- 1: Yoga therapy schedule for metabolic syndrome

SookshamVyayama- Mainly for the abdomen, chest and hip
Aruna suryanamaskar variation I– 3 rounds
Ardhakati & Katichakrasana
Trikonasana
Vakrasana
Bharatwaja asana
Paschimottanasana
Nava asana
Pavanamukta Series (As eka & dwi padakriya and asana)
Jatara Paravrithi
Sarvanga asana & Viparitakarani
Chandra Nadi Pranayama
Nadi Shuddhi Pranayama

Brahma Mudra
Kavi (Sadanta) Pranayama
Kaya kriya: dynamic body relaxation with movements of lower, upper limbs and head and neck with breathing
Spandha Nishpandha Kriya: self-directed complete tensing of whole body followed by its instant relaxation
Shavasana with Savithri pranayama Breathing In for 4 secs, hold in 2 secs, breathing out for 2 secs, hold out for 2 secs
Shavasana with Pranava pranayama: Breathing in and then breathing out with the sounds of aaa... uuu… and mmm…
Shavasana with deep inhalation & exhalation
Total duration = 1 hour 35 minutes Techniques were delivered through a structured, progressive loading approach, whereby practices were incrementally introduced and reinforced in successive sessions
Weeks 1–11- During this phase, all yogic techniques were gradually introduced to participants enrolled in the AYT
Weeks 11–36- Following the introduction, all practices were systematically reinforced and administered throughout this period to ensure familiarity and consistency of practice
Week 37- At the end of 36 weeks, participant feedback was obtained to evaluate the intervention and gather insights on adherence, feasibility, and perceived benefits.
Weeks 38–72- all previously taught practices were continued, to enhance long-term applicability and sustainability of the practices.

Outcomes and measurements

Primary outcomes: TG/HDL ratio; TyG index calculated as TyG = ln [TG (mg/dL) × Fasting Glucose (mg/dL) / 2]. Assessments at baseline, mid-intervention, and six months. Secondary outcomes: TG/HDL risk categories (low <2.0, intermediate 2.0–3.5, high >3.5); anthropometry and blood pressure. Fasting blood samples were assayed using validated enzymatic methods; anthropometry and BP were recorded with calibrated devices per standardized protocols.

Statistical analysis

SPSS v21. Descriptive statistics summarized baseline characteristics. Between-group comparisons used independent t-tests/chi-square. Within-group trajectories used repeated-measures ANOVA. Two-sided $p<0.05$ denoted statistical significance.

RESULTS

Table- 2. Comparison of TG/HDL Ratio between MetS Groups

TG/HDL ratio declined substantially in AYT (9.98 ± 4.64 → 5.60 ± 1.63 → 2.98 ± 0.83) compared with SMM (8.32 ± 2.64 → 6.73 ± 2.39 → 6.94 ± 2.06). Between-group differences were significant at mid-intervention (p=0.005) and post-intervention (p<0.001). Within-group effects were significant for AYT (RM-ANOVA p<0.001) and SMM (p=0.003). TyG index was similar at baseline (AYT 10.17 ± 0.25; SMM 10.13 ± 0.26) but by six months improved in AYT (9.25 ± 0.27) while remaining high in SMM (9.97 ± 0.19; p<0.001).

Table- 3. Comparison of Triglyceride–Glucose (TyG) Index between MetS Groups

Time Point	AYT Mean ± SD	SMM Mean ± SD	p-value
Baseline TG/HDL Ratio	9.98 ± 4.64	8.32 ± 2.64	0.023
Mid-intervention TG/HDL Ratio	5.60 ± 1.63	6.73 ± 2.39	**0.005**
Post-intervention TG/HDL Ratio	2.98 ± 0.83	6.94 ± 2.06	**<0.001**
RMANOVA (within-group effect)	**p < 0.001**	**p = 0.003**	—
Time Point	**AYT Mean ± SD**	**SMM Mean ± SD**	**p-value**
Baseline TyG Index	10.17 ± 0.25	10.13 ± 0.26	0.350
Mid-intervention TyG Index	9.87 ± 0.29	9.92 ± 0.22	0.322
Post-intervention TyG Index	9.25 ± 0.27	9.97 ± 0.19	**<0.001**
RMANOVA (within-group effect)	**p < 0.001**	**p < 0.001**	—

Risk-category migration corroborated numerical improvements: by six months, 77.3% of AYT participants moved to low/ intermediate TG/HDL strata (low 7.5%, intermediate 69.8%), while all SMM participants remained high risk.

DISCUSSION

Adding a structured yoga program to standard care resulted in significant, clinically relevant improvements in the TG/HDL ratio and TyG index over six months. While modest within-group changes occurred in SMM, AYT produced markedly greater reductions, achieving categorical risk mitigation advantages. These results align with evidence that positions TG/HDL as a practical biochemical indicator of atherogenic dyslipidemia and insulin resistance, and TyG as a reproducible and straightforward surrogate of insulin resistance.[2,15]

Studies consistently reveal a pronounced correlation between the TyG index and the euglycemic clamp (generally considered as the Gold Standard), as exemplified by the fact that TyG index demonstrates high sensitivity and specificity in reflecting IR in different populations..[16,17] Furthermore, the ease of utility and low cost render TyG as a valuable and reliable diagnostic tool for identifying IR. This acquires immediate relevance, particularly in primary care establishments and resource-limited settings, where the administration of the clamp is certainly not feasible. Hence, we advocate that the TyG index must invariably find a place in the diagnostic armamentarium with reference to insulin resistance-based studies, as applied to the frontiers of adjuvant yoga therapy. This would also ensure greater objectivity in monitoring the magnitude of insulin resistance, a favoured outcome measure in the realms of contemporary integrative medicine.

Large-scale and clinic-based evidence underscores their diagnostic and prognostic value; Paublini et al. reported strong associations between TG/HDL (and the lipid triad) and insulin resistance with high discriminatory performance, and Khan et al. showed TyG often emerges as a superior single predictor for metabolic clustering.[18,19] Our data extend these observations by demonstrating dynamic responsiveness of both indices to a mind–body intervention, with AYT outperforming SMM. Mechanistically, yoga may act via improved autonomic balance and vagal tone, attenuation of HPA-axis over-activation, endothelial benefits, and anti-inflammatory/antioxidant effects, plausibly explaining pronounced TG/HDL and TyG shifts. Prior trials and syntheses report beneficial effects of yoga on glycemia, insulin resistance, and lipids across populations and program intensities.[7,8,10] Strengths include randomized design, repeated measures, and dual-index assessment with risk-category analysis. Limitations include single-center conduct, moderate sample size, reliance on surrogate endpoints, and potential variability in home-practice adherence. Nonetheless, the magnitude and consistency of effects suggest a meaningful adjunctive role for yoga in MetS management, with TG/HDL and TyG **serving as practical monitoring tools in routine care.**

CONCLUSION

In adults with metabolic syndrome, Adjuvant Yoga Therapy added to standard care produced substantial six-month improvements in the TG/HDL ratio and TyG index, coupled with a favorable exit from high-risk TG/HDL categories. These results support AYT as a practical adjunct to standard medical management and highlight TG/HDL and TyG as responsive, implementable

biomarkers for monitoring lifestyle-based cardiometabolic interventions.

Conflict of interest
Nil.

Funding
Nil

REFERENCES

1. Kazibwe R, Jehopio J, Schaich CL, Rikhi R, Mirzai S, Chevli PA, et al. Atherogenic dyslipidemia and incident cardiovascular events in high-risk hypertension. Progress in Cardiovascular Diseases [Internet]. 2025 May 18 [cited 2025 Sep 25]; Available from: https://www.sciencedirect.com/science/article/pii/S0033062025000696
2. Kosmas CE, Rodriguez Polanco S, Bousvarou MD, Papakonstantinou EJ, Peña Genao E, Guzman E, et al. The Triglyceride/High-Density Lipoprotein Cholesterol (TG/HDL-C) Ratio as a Risk Marker for Metabolic Syndrome and Cardiovascular Disease. Diagnostics (Basel). 2023 Mar 1;13(5):929.
3. Ivanova EA, Myasoedova VA, Melnichenko AA, Grechko AV, Orekhov AN. Small Dense Low-Density Lipoprotein as Biomarker for Atherosclerotic Diseases. Oxid Med Cell Longev. 2017;2017:1273042.
4. Wang J, Zhao X, Zhao Y, Jin R, Li Y, Wang J, et al. Discordance of Small Dense LDL Cholesterol Beyond LDL Cholesterol or Non–HDL Cholesterol and Carotid Plaque. JACC: Asia. 2025 Aug 1;5(8):1012–28.
5. Krishnamoorthy Y, Rajaa S, Murali S, Sahoo J, Kar S. Association Between Anthropometric Risk Factors and Metabolic Syndrome Among Adults in India: A Systematic Review and Meta-Analysis of Observational Studies. Preventing Chronic Disease [Internet]. 2022 May 5;19. Available from: https://consensus.app/papers/association-between-anthropometric-risk-factors-and-murali-rajaa/133c46fb15345065a0fda28b254aecb7/
6. Basu S, Thirunavukarasu A, Maheshwari V, Zode M, Hassan R. Burden, determinants and treatment status of metabolic syndrome among older adults in India: a nationally representative, community-based cross-sectional survey. BMJ Public Health [Internet]. 2023 Nov 1;1. Available from: https://consensus.app/papers/burden-determinants-and-treatment-status-of-metabolic-basu-maheshwari/1e248babc651531b8f8bccee415dd9d1/
7. Fabiani R, Naldini G, Chiavarini M. Dietary Patterns and Metabolic Syndrome in Adult Subjects: A Systematic Review and Meta-Analysis. Nutrients [Internet]. 2019 Sep 1;11. Available from: https://consensus.app/papers/dietary-patterns-and-metabolic-syndrome-in-adult-subjects-naldini-fabiani/26604c25002e59a285bd7a8c787be649/
8. Chu P, Gotink R, Yeh G, Goldie S, Hunink M. The effectiveness of yoga in modifying risk factors for cardiovascular disease and metabolic syndrome: A systematic review and meta-analysis of randomized controlled trials. European Journal of Preventive Cardiology. 2016 Feb 1;23:291–307.
9. Patil S, Aithala M, Naregal G, Shanmukhe A, Chopade S. Effect of yoga on cardiac autonomic dysfunction and insulin resistance in non-diabetic offspring of type-2-diabetes parents: A randomized controlled study. Complementary therapies in clinical practice. 2019 Feb 1;34:288–93.
10. Dhali B, Chatterjee S, Das S, Cruz M. Effect of Yoga on Insulin Resistance in Type 2 Diabetes: A Systematic Review and Meta-Analysis. Clinical Diabetology [Internet]. 2023 Jun 30; Available from: https://consensus.app/papers/effect-of-yoga-on-insulin-resistance-in-type-2-diabetes-a-chatterjee-cruz/8c702eb2db955cfb8e80a63f202578e8/
11. Kauric-Klein Z. Effect of yoga on physical and psychological outcomes in patients on chronic hemodialysis. Complementary therapies in clinical practice. 2019 Feb 1;34:41–5.
12. Pandey R, Arya T, Kumar A, Yadav A. Effects of 6 months yoga program on renal functions and quality of life in patients suffering from chronic kidney disease. International Journal of Yoga. 2017 Jan 1;10:3–8.
13. Nagarathna R, Kumar S, Anand A, Acharya IN, Singh AK, Patil SS, et al. Effectiveness of Yoga Lifestyle on Lipid Metabolism in a Vulnerable Population—A Community Based Multicenter Randomized Controlled Trial. Medicines (Basel). 2021 Jul 13;8(7):37.
14. Das T, Roy DS. Effect of Yoga on Metabolic Syndrome. 2015;5(9).
15. G. Schwartz, M. Abt, W. Bao, D. Demicco, D. Kallend, Michael Miller, et al. Fasting triglycerides predict recurrent ischemic events in patients with acute coronary syndrome treated with statins. Journal of the American College of Cardiology. 2015 Jun 2;65 21:2267–75.
16. Lee DH, Park JE, Kim SY, Jeon HJ, Park JH. Association between the triglyceride-glucose (TyG) index and increased blood pressure in normotensive subjects: a population-based study. Diabetol Metab Syndr. 2022 Oct 29;14:161.
17. Kurniawan LB. Triglyceride-Glucose Index As A Biomarker Of Insulin Resistance, Diabetes Mellitus, Metabolic Syndrome, And Cardiovascular Disease: A Review. EJIFCC. 2024 Apr 11;35(1):44–51.
18. Paublini H, González ÁAL, Busquets-Cortés C, Tomás-Gil P, Riutord-Sbert P, Ramírez-Manent J. Relationship between Atherogenic Dyslipidaemia and Lipid Triad and Scales That Assess Insulin Resistance. Nutrients [Internet]. 2023 Apr 27;15. Available from: https://consensus.app/papers/relationship-between-atherogenic-dyslipidaemia-and-riutord-sbert-ram%C3%ADrez-manent/49d95135d46a5d43b8669852a3cafaf5/
19. Khan S, Sobia F, Niazi N, Manzoor S, Fazal N, Ahmad F. Metabolic clustering of risk factors: evaluation of Triglyceride-glucose index (TyG index) for evaluation of insulin resistance. Diabetology & Metabolic Syndrome [Internet]. 2018 Oct 5;10. Available from: https://consensus.app/papers/metabolic-clustering-of-risk-factors-evaluation-of-sobia-khan/9a31032c7c7354e8af07beecde011b8b/