RESEARCH PAPER

Integrative Ayurvedic Management of Metabolic Syndrome: Bridging Classical Concepts and Contemporary Evidence

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ABSTRACT

Background: Metabolic syndrome (MetS) a cluster of central obesity, insulin resistance, dyslipidaemia and hypertension affects approximately 25% of the global adult population. Conventional management relies on lifestyle modification and polypharmacy, often with limited long-term adherence.

Objectives: To synthesise classical Ayurvedic principles with contemporary biomedical evidence for the management of MetS, and to propose an integrated, step-wise treatment algorithm.

Methods: A narrative review was conducted by searching classical Ayurvedic texts (*Charaka Samhita*, *Sushruta Samhita*, *Ashtanga Hridaya*, *Bhaishajya Ratnavali*) and modern databases (PubMed, Scopus, Google Scholar) up to December 2025. Only original research, systematic reviews and randomised controlled trials in English were included.

Results: Ayurveda views MetS through the lens of *Mandagni* (weak digestive fire), *Ama* (metabolic toxins), *Medovaha Srotas* (fat-carrying channels) and *Sthaulya* (obesity). This framework maps closely onto modern concepts of insulin resistance, metabolic endotoxaemia and chronic inflammation. Randomised controlled trials and clinical studies demonstrate that dietary modification, *Panchakarma* (especially *Virechana* and *Lekhana Basti*), and formulations such as Triphala, Guggulu, Tryushnadi Churna and Chandraprabha Vati significantly improve body weight, lipid profiles, glycaemic control and inflammatory markers. Mechanistic studies show prebiotic modulation of gut microbiota, upregulation of mitochondrial biogenesis markers (PGC-1α, TFAM) and downregulation of inflammasome pathways (NLRP3, caspase-1).

Conclusion: Ayurvedic interventions offer a rational, multi-targeted approach for MetS that addresses both root causes and clinical manifestations. An integrated step-wise algorithm is proposed. High-quality randomised controlled trials and multi-omic mechanistic studies are needed for full validation.

Keywords: Metabolic syndrome, Ayurveda, Sthaulya, Agni, Panchakarma, Guggulu

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1. INTRODUCTION

Metabolic syndrome (MetS) is a constellation of interrelated metabolic abnormalities that together substantially increase the risk of type 2 diabetes mellitus and cardiovascular disease. The harmonised definition from the International Diabetes Federation, American Heart Association and other major bodies requires the presence of any three of five criteria: increased waist circumference, elevated fasting glucose, raised triglycerides, reduced high-density lipoprotein cholesterol, and hypertension [1]. The condition is highly prevalent worldwide, affecting roughly one in four adults, with even higher rates in urbanised and rapidly developing regions [2].

The pathophysiology of MetS is complex and multifactorial. Insulin resistance is considered the central driver, leading to compensatory hyperinsulinaemia, dyslipidaemia and endothelial dysfunction [3]. Chronic low-grade inflammation,

driven by pro-inflammatory cytokines such as tumour necrosis factor-alpha and interleukin-6, both causes and exacerbates insulin resistance [4]. More recently, gut dysbiosis has emerged as a key contributor. Lipopolysaccharides from Gram-negative bacteria activate Toll-like receptor 4 and nuclear factor kappa-B signalling, triggering systemic metabolic inflammation – a state termed metabolic endotoxaemia [5].

Current clinical guidelines recommend lifestyle modification as first-line therapy, followed by pharmacological agents targeting individual components: statins for dyslipidaemia, antihypertensives, metformin for insulin resistance [6]. While these strategies reduce cardiovascular events, they often require lifelong treatment, may have side effects, and do not address the underlying systemic imbalance. Consequently, there is growing interest in integrative, patient-centred approaches that target the root causes of MetS [7].

Ayurveda, India's traditional system of medicine, offers a comprehensive framework for understanding and managing metabolic disorders. Central to this framework are the concepts of *Agni* (digestive-metabolic fire), *Ama* (undigested, toxic residue), *Medovaha Srotas* (channels carrying fat tissue) and *Sthaulya* (obesity) [8]. According to classical texts, excessive intake of heavy, unctuous, sweet foods combined with a sedentary lifestyle weakens *Agni*, leading to *Ama* formation, obstruction of channels and accumulation of *Meda Dhatu* (adipose tissue) [9]. This sequence closely parallels the modern understanding of insulin resistance, metabolic endotoxaemia and dyslipidaemia. This review aims to present the Ayurvedic perspective on MetS, summarise the evidence for key interventions, propose an integrated management algorithm, and identify gaps for future research.

2. METHODS

This is a narrative review based on a structured search of classical Ayurvedic texts and contemporary biomedical literature. The primary classical compendia consulted were *Charaka Samhita* (Chikitsa Sthana), *Sushruta Samhita* (Uttara Tantra), *Ashtanga Hridaya* (Chikitsa Sthana) and *Bhaishajya Ratnavali* (Sthaulya and Prameha chapters). For modern evidence, PubMed, Scopus and Google Scholar were searched up to December 2025 using combinations of the terms: "metabolic syndrome", "Ayurveda", "Sthaulya", "Medoroga", "Agni", "Ama", "Panchakarma", "Virechana", "Lekhana Basti", "Triphala", "Guggulu", "obesity", "dyslipidaemia", "insulin resistance", "gut microbiome". Only original research articles, systematic reviews and randomised controlled trials published in English were included. Data were extracted and synthesised narratively, and two summary tables were constructed. No ethical approval was required for this review.

3. RESULTS

3.1 Ayurvedic understanding of metabolic syndrome

In Ayurveda, the condition most closely resembling MetS is *Sthaulya* (or *Atisthaulya*). Acharya Charaka listed *Sthaulya* among the eight undesirable physical states (*Ashtaunindita*), describing it as excessive and abnormal accumulation of *Meda Dhatu* (adipose tissue) along with *Mamsa Dhatu* (muscle tissue), resulting in pendulous appearance of the buttocks, belly and breasts without a corresponding increase in energy [10,11]. *Medoroga* is a broader term encompassing disorders of lipid metabolism, often used interchangeably with obesity in Ayurvedic literature [12].

The pathogenesis begins with *Mandagni* (weak digestive fire) due to excessive intake of heavy, unctuous, sweet foods and lack of physical activity. This produces *Ama*, a toxic, proinflammatory waste product of improper digestion that blocks the *Medovaha Srotas*, causing accumulation of *Meda Dhatu* and vitiation of *Kapha Dosha* [13]. Chronic obstruction further weakens tissue-level metabolic fires, perpetuating the cycle. Modern research aligns *Ama* with metabolic endotoxaemia and chronic low-grade inflammation [14].

Prakriti (individual constitution) influences susceptibility to MetS. A statistically significant association between *Kapha Prakriti* and obesity has been demonstrated ($p < 0.01$), with alterations in the leptin receptor gene affecting protein stability [15]. In a North Indian cohort, *Kapha* combined with *Vata* or *Pitta* comprised 64% of MetS patients [16]. Genomic studies have revealed differential risk for metabolic disorders among *Prakriti* groups, with *Kapha* types showing higher predisposition to obesity, diabetes and atherosclerotic conditions [17].

3.2 Dietary and lifestyle interventions

The core dietary advice for MetS is a *Kapha*-pacifying diet: light, dry, warm and with pungent, bitter and astringent tastes. Foods to prioritise include barley, old rice, green gram, bitter vegetables and spices such as ginger, black pepper and long pepper. Honey, due to its scraping property, is specifically recommended. Heavy, oily, sweet foods, dairy products and fried items are restricted. Regular physical activity is prescribed to mobilise *Kapha* and enhance *Agni*. A systematic review and meta-analysis of randomised controlled trials confirmed that lifestyle interventions combining diet and physical activity significantly reduce waist circumference, body weight and blood pressure in patients with MetS [18].

3.3 Panchakarma (bio-purification therapies)

Shodhana (purification) is considered definitive for chronic metabolic disorders because it eliminates accumulated *Doshas* and *Ama* from the root [19].

Virechana (therapeutic purgation) is the principal *Shodhana* for *Medoroga*. A clinical evaluation of *Virechana* in MetS (n = 30) demonstrated maximum improvement in systolic blood pressure (87%) and diastolic blood pressure (82.3%), with reductions in blood sugar (23.9%), improvement in HDL cholesterol (37.7%) and triglycerides (37.6%), and reduction in waist circumference (78.8%) [20]. Another study found that *Virechana* is effective in obesity management by reducing colonisation of *Escherichia coli* and addressing gut flora dysbiosis [21].

Lekhana Basti (medicated enema with scraping formulations) is specifically designed for obesity and dyslipidaemia. A single-centre, open-labelled, randomised, comparative pilot study (64 obese participants) evaluated Navak Guggul and *Lekhana Basti*, individually and in combination. All groups showed significant reduction in body mass index (BMI) and significant improvement in Ayurvedic symptom scores. Transcriptional profiling revealed increased expression of UCP2, ADIPOR1 and PPARγ genes and decreased expression of FTO, ghrelin and leptin genes immediately post-treatment [22]. A urine exosome study demonstrated that six protein markers overexpressed during obesity were downregulated after *Lekhana Basti* treatment, while two markers increased in abundance [23].

Udvartana (external powder massage) is used daily to mobilise subcutaneous fat. Studies have reported that *Udvartana* causes a considerable drop in body weight, BMI, waist circumference, hip circumference and skin fold thickness, and exhibits adequate viability in terms of lipid levels [24].

3.4 Important Ayurvedic formulations

Table 1 summarises key single herbs and compound formulations with their classical indications and evidence base.

Table 1. Key Ayurvedic formulations and herbs for metabolic syndrome

Formulation / Herb	Classical indication	Key mechanisms / clinical evidence
Triphala Churna	*Medoroga*, *Sthaulya*	Meta-analysis of 12 clinical studies: reduction in body weight, waist circumference, body fat [25]; prebiotic effects: increases SCFA production, modulates gut microbiota, reduces LPS from gut microbiota [25,26]; protective role in impaired glucose tolerance [27]
Guggulu (Commiphora mukul)	*Medoroga*, dyslipidaemia	Clinical trial (n = 36): body weight decreased by 4.3 kg; improvements in metabolic parameters, inflammation and arthritis-related outcomes [28]; lowers LDL cholesterol and triglycerides
Tryushnadi Churna	MetS with obesity	Randomised double-blind controlled trial (n = 48): significant improvements in BMI, weight, waist circumference, body fat, HbA1c, triglycerides, HDL, LDL and total cholesterol [29]; large effect size
Chandraprabha Vati	*Medoroga*, *Prameha*	Animal study in high-fat diet/fructose-induced MetS rats: CPV 100 mg/kg reduced body weight, improved glucose tolerance, lipid profiles and insulin sensitivity; decreased TNF-α and IL-6; upregulated mitochondrial biogenesis markers TFAM and PGC-1α; downregulated inflammasomes caspase-1 and NLRP3 [30]
Vyoshadi Guggulu	*Medoroga*, dyslipidaemia	Prospective open-label multicenter study (n = 165): effective and safe in obesity management; combination with Haritaki Churna improved weight, lipid profile and subjective symptoms [31,32]; superior to Triphala in reducing lipid levels [32]
Guduchi (Tinospora cordifolia)	*Prameha*, *Rasayana*	Mechanistic review: beneficial effects on hyperlipidaemia, obesity, atherosclerosis, hypertension and diabetes mellitus [33]
Haridra (Curcuma longa)	*Medohara*, anti-inflammatory	Curcumin improves glucose metabolism and has documented anti-obesity and anti-hyperlipidemic activity [34]

3.5 Integrated management algorithm

Based on classical principles and modern evidence, an integrative step-wise algorithm is proposed in Table 2.

Table 2. Proposed integrated Ayurvedic management algorithm for metabolic syndrome

Severity	Ayurvedic intervention	Conventional adjunct (if needed)
Subclinical (risk factors only)	*Kapha*-pacifying diet, Udvartana, daily walking, *Agni*-kindling spices	Lifestyle advice
Mild MetS (1-2 components)	Above + Triphala Churna 5 g twice daily with honey; yoga	Monitor

Moderate MetS (3 components, no organ damage)	Guggulu 500 mg twice daily or Vyoshadi Guggulu; annual *Virechana*	Consider statin / metformin if high risk
Severe MetS (all components + target organ damage)	Intensive *Shodhana*: *Virechana* followed by *Lekhana Basti* (15 sessions); then *Rasayana* (Guduchi / Amalaki)	Full conventional therapy

3.6 Mechanistic convergence

Modern mechanistic studies have validated many Ayurvedic concepts. *Ama* correlates with metabolic endotoxaemia and chronic low-grade inflammation driven by gut-derived lipopolysaccharides [5]. *Mandagni* mirrors cellular insulin resistance [35]. Ayurvedic herbs act as prebiotics, enriching SCFA-producing bacteria, which alter the relative abundance of taxa encoding butyrate and propionate pathways, reduce inflammation and improve colonic barrier function [26]. Triphala modulates gut microbiota, mucosal permeability and SCFA secretion, reducing liver fat and inflammatory responses [25,26]. Guggulu modulates PPAR-gamma and TNF-alpha pathways [28]. *Lekhana Basti* upregulates mitochondrial biogenesis genes and downregulates adipogenic and inflammatory genes [22,23]. Chandraprabha Vati targets mitochondrial biogenesis and suppresses inflammasome activation [30].

4. DISCUSSION

The alignment between classical Ayurveda and contemporary biomedicine in understanding metabolic syndrome is striking. *Mandagni* (diminished digestive-metabolic fire) can be directly mapped onto insulin resistance at the cellular level – a reduced ability to utilise nutrients effectively. *Ama*, described as a sticky, foul-smelling substance that obstructs microchannels, corresponds closely to metabolic endotoxaemia driven by gut-derived lipopolysaccharides and the resultant chronic low-grade inflammation that characterises obesity and insulin resistance [5,14]. *Medovaha Srotodushti* (dysfunction of the fat-carrying channels) is the functional equivalent of central obesity and atherogenic dyslipidaemia.

The *Prakriti* concept provides a rational basis for personalised medicine. The demonstrated association between *Kapha Prakriti* and obesity ($p < 0.01$), coupled with genetic evidence linking *Kapha* types to leptin receptor polymorphisms, supports the classical assertion that constitution-based stratification improves therapeutic outcomes [15,17]. Genomic studies have shown differential risk for metabolic disorders among *Prakriti* groups, enabling predictive, preventive and personalised approaches [17].

The multi-targeted nature of Ayurvedic interventions is particularly advantageous for a complex condition like MetS. Unlike single-target pharmacological agents, Ayurvedic formulations act simultaneously on multiple pathways: they improve insulin sensitivity, reduce inflammation, modulate the gut microbiome, promote lipolysis and enhance basal metabolic rate. For example, Triphala has prebiotic effects and reduces LPS from gut microbiota [25,26]. Guggulu improves weight, metabolic parameters and inflammation [28]. *Virechana* addresses gut flora dysbiosis by reducing *E. coli* colonisation [21].

The inclusion of *Panchakarma* procedures, especially *Virechana* and *Lekhana Basti*, offers a depot-cleansing function with no direct analogue in conventional medicine. *Lekhana Basti* has been shown to modulate gene expression (upregulating UCP2, ADIPOR1 and PPARγ) and alter urinary exosome protein profiles, suggesting systemic metabolic effects [22,23]. These findings provide a molecular basis for the classical claim that *Shodhana* eliminates *Ama* and restores *Agni*.

Several limitations must be acknowledged. Most clinical studies are small, open-label, or lack rigorous blinding. Standardisation of formulations varies across manufacturers. Direct comparative effectiveness studies among different *Panchakarma* regimens are lacking. Long-term safety data, especially for herbo-mineral formulations, need further generation. Nevertheless, the existing evidence base supports the integration of Ayurveda into the clinical pathway for MetS, at least as an adjunct to conventional care. An integrative approach following the step-wise model in Table 2 reserves intensive *Shodhana* for resistant or severe cases.

Future research priorities include: (i) large, multi-centre randomised controlled trials of standardised formulations (e.g., Tryushnadi Churna, Chandraprabha Vati) with hard cardiovascular endpoints; (ii) mechanistic studies using metagenomics and metabolomics to map pathways modulated by *Panchakarma*; (iii) cost-effectiveness analyses of integrated Ayurveda-conventional care; and (iv) long-term safety studies on *Lekhana Basti* and herbo-mineral preparations.

5. CONCLUSION

Metabolic syndrome is a major global health challenge that calls for integrated, patient-centred strategies. Ayurveda provides a coherent conceptual framework – rooted in *Agni*, *Ama*, *Medovaha Srotas* and *Prakriti* – that maps closely onto contemporary understanding of insulin resistance, chronic inflammation and dyslipidaemia. Dietary and lifestyle modifications, *Panchakarma* (especially *Virechana* and *Lekhana Basti*), and specific formulations such

as Triphala, Guggulu, Tryushnadi Churna and Chandraprabha Vati have demonstrated beneficial effects on the key components of MetS. An integrated step-wise algorithm is proposed to guide clinical practice. High-quality randomised trials, formulation standardisation and multi-omic mechanistic studies are needed to fully validate and integrate Ayurveda into mainstream guidelines for metabolic syndrome.

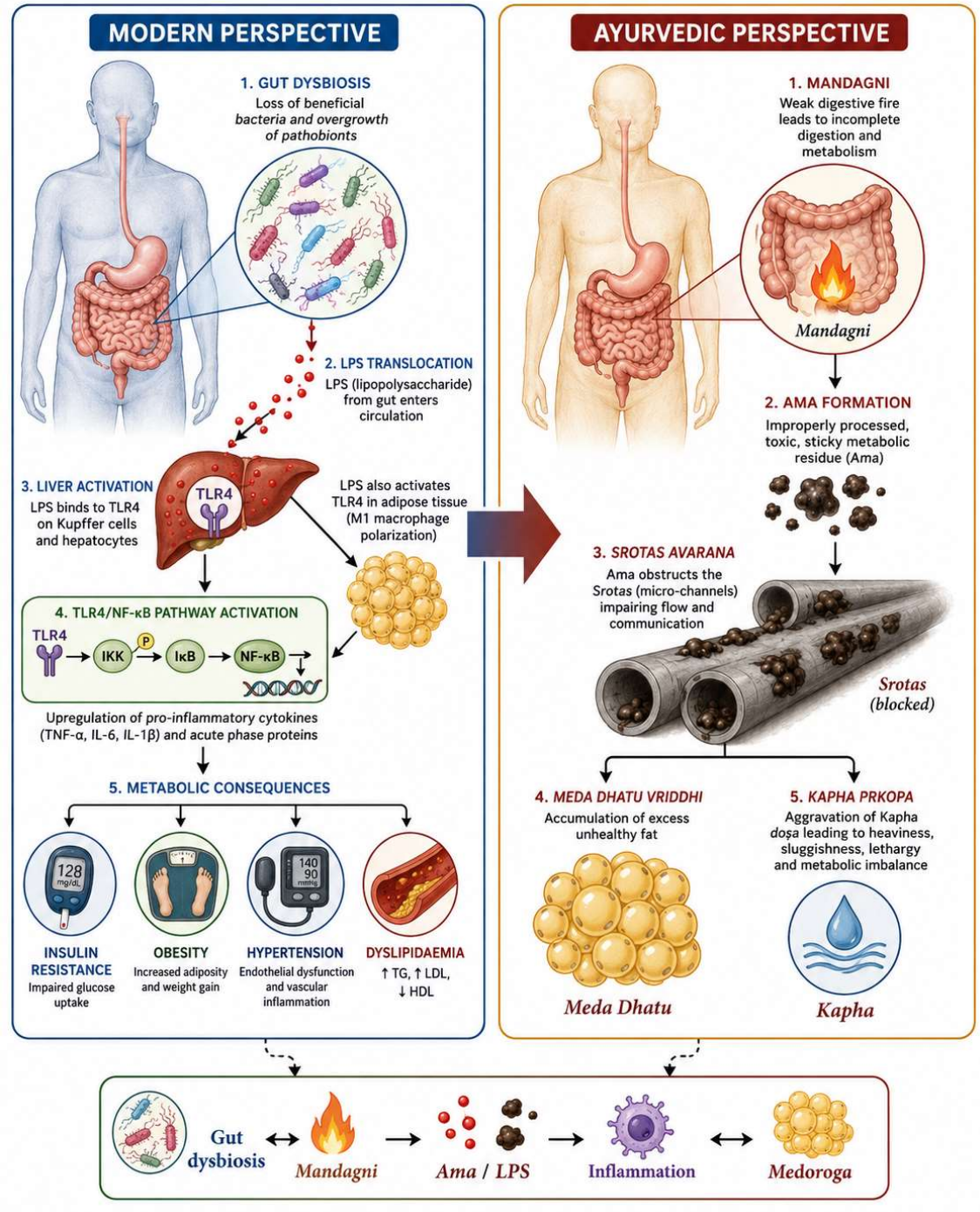

Figure 1: The alignment between classical Ayurveda and contemporary biomedicine in understanding metabolic syndrome is striking."

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