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Review Article

Toxicant-Induced Metabolic Dysfunction: Connecting Environmental Obesogens with *Agni Mandya* and *Medovaha Srotodushti*

Dr.Savita Arvind Rathod
Assistant Professor-Department of Agadtantra ,K.V.T.R Ayurved College,Boradi, Ta-Shirpur Dist-Dhule,Maharashtra
dr.savita.rathod1980@gmail.com

Dr.Nilesh Tatyarao Gore,
Associate Professor-Department of Agadtantra, VEWS's Ahinsa Institute of Ayurveda, Dondaicha
drnileshgore@gmail.com

Dr.Sangeeta B Bhosale,
Assistant Professor-Department of Agadtantra evam vidhivaidyak, Sai Ayurveda College, Hospital & Research Center,Sasure-Vairag,Dist Solapur,Maharashtra, India
drsangitadeshkukh@gmail.com

Abstract

Obesity and metabolic disease cannot be explained completely by energy intake and physical inactivity. Experimental and epidemiological research increasingly implicates endocrine-disrupting chemicals that alter adipocyte development, appetite regulation, insulin signalling, mitochondrial function, inflammation, and epigenetic programming. These compounds, often described as environmental obesogens or metabolism-disrupting chemicals, are encountered through food packaging, plastics, pesticides, industrial products, household dust, water, and occupational settings. Ayurveda interprets progressive metabolic impairment through disturbances of *Agni*, the formation of *Ama*, abnormal *Meda*, and *Medovaha Srotodushti*. This review examines the two knowledge systems without treating their terms as biological equivalents. The comparison is most useful as a clinical and preventive framework: exposure may add to metabolic vulnerability, while impaired digestion, tissue transformation, and channel function describe a broader pattern of declining metabolic resilience. Current evidence supports exposure reduction, healthy food, physical activity, sleep, and conventional risk management. Ayurvedic measures such as *Deepana*, *Pachana*, *Langhana*, *Shodhana*, and *Rasayana* remain promising areas for investigation, but specific protection against obesogens has not been established clinically. Future studies should combine validated exposure assessment, metabolic phenotyping, reproducible Ayurvedic evaluation, authenticated interventions, pharmacovigilance, and long-term outcomes.

Keywords

Environmental obesogens; metabolic dysfunction; Agni Mandya; Medovaha Srotodushti; endocrine disruption; obesity; Ayurveda

1. Introduction

The rapid growth of obesity, type 2 diabetes, fatty liver disease, and metabolic syndrome has occurred alongside major changes in food systems, physical activity, sleep, urban environments, and chemical exposure. Diet and inactivity remain central determinants, but they do not account for every difference in susceptibility. Researchers have therefore examined whether low-dose exposure to particular chemicals can modify metabolic regulation before overt disease appears.

The obesogen hypothesis proposes that some environmental chemicals promote weight gain or metabolic dysfunction by changing adipocyte number or function, appetite pathways, energy expenditure, insulin action, or developmental programming. The concept does not mean that a chemical exposure inevitably causes

obesity. It describes one component within a network that also includes genes, age, diet, activity, stress, medicines, socioeconomic conditions, and the built environment.

Ayurveda similarly regards metabolic disease as a process rather than an isolated laboratory abnormality. *Agni* governs digestion and transformation, while *Srotasa* support transport and communication among tissues. Persistent *Agni Mandya* may favour *Ama* formation, disturbed *Dhatu* metabolism, abnormal *Meda* accumulation, and *Medovaha Srotodushti*. These ideas provide a whole-system account of declining metabolic efficiency, although they cannot be substituted for toxicokinetic, endocrine, or molecular explanations.

2. Aim and Objectives

The review aims to evaluate toxicant-induced metabolic dysfunction and to explore a cautious conceptual relationship between environmental obesogens, *Agni Mandya*, and *Medovaha Srotodushti*. Its objectives are to summarize major exposure sources and mechanisms, describe the classical Ayurvedic account of metabolic impairment, identify defensible points of comparison, assess preventive and therapeutic implications, and define priorities for interdisciplinary research.

3. Review Method

A narrative review was prepared from classical Ayurvedic texts and contemporary biomedical literature. The Ayurvedic material included discussions of digestion, tissue metabolism, *Srotasa*, Sthaulya, and therapeutic principles. Biomedical sources included reviews, mechanistic studies, epidemiological literature, and public-health reports concerning endocrine disruption, obesogens, obesity, insulin resistance, inflammation, mitochondria, and the gut microbiome.

The review was not preregistered and did not use a formal risk-of-bias instrument. It should therefore be read as a critical synthesis rather than a systematic estimate of exposure effect. Particular attention was given to separating demonstrated associations, experimental mechanisms, and conceptual interpretation.

4. Ayurvedic Foundations of Metabolic Regulation

The *Charaka Samhita* places diet, digestion, and appropriate transformation at the centre of tissue nourishment [1]. Its discussion of Sthaulya describes obesity as a complex disturbance involving appetite, *Meda*, movement, and systemic function rather than excess body size alone [2]. The account of *Srotasa* further emphasizes that impairment of channels can alter the delivery and processing of nutritive material [3].

The *Sushruta Samhita* describes reciprocal changes among *Dosha*, *Dhatu*, and Mala and provides a framework for understanding progressive tissue imbalance [4]. The *Ashtanga Hridaya* likewise treats *Dosha* and *Dhatu* change as dynamic and interdependent [5]. Dravyaguna literature supplies the pharmacological basis for selecting substances according to action and patient context [6]. The *Bhavaprakasha* extends this clinical tradition through dietetic, medicinal, and *Rasayana* applications [7].

Within this framework, *Jatharagni* initiates digestion, while *Dhatvagni* represents tissue-level transformation. *Agni Mandya* may lead to incompletely processed material, described as *Ama*, and subsequent *Dosha-Dushya Sammurchana*. When *Meda* formation, transport, or utilization becomes disturbed, *Medovaha Srotodushti* can manifest through excess adiposity, lethargy, altered appetite, and related metabolic features.

5. Environmental Obesogens

The World Health Organization identifies obesity as a major global health problem linked to diabetes, cardiovascular disease, musculoskeletal disability, and several cancers [8]. The obesogen concept adds environmental chemical exposure to established behavioural, biological, and social determinants [9].

Endocrine-disrupting chemicals can interfere with hormone synthesis, transport, receptor binding, metabolism, or elimination [10]. Early research on organotin compounds showed that activation of nuclear receptors involved in adipocyte differentiation could favour fat-cell development [11]. This finding helped shift attention from simple toxicity at high doses to metabolic programming at lower or developmentally sensitive exposures.

The Endocrine Society has summarized evidence that endocrine disruptors may influence reproductive, neurological, immune, and metabolic health [12]. A later consensus described characteristic mechanisms by which such chemicals alter hormone action [13]. These frameworks support biological plausibility, but the strength of evidence differs substantially among compounds and outcomes.

6. Sources and Windows of Susceptibility

Commonly studied exposures include bisphenols, phthalates, per- and polyfluoroalkyl substances, organochlorine pesticides, organotins, flame retardants, and selected metals. Contact may occur through packaged food, plastic materials, personal-care products, indoor dust, contaminated water, industrial emissions, or work. European burden estimates suggest potentially substantial health and economic consequences, although such calculations depend on assumptions about causality and exposure-response relationships [14].

Developmental exposure is of special concern because fetal life, infancy, puberty, pregnancy, and ageing involve rapid endocrine and metabolic change. Obesogen research indicates that exposure during these windows may alter adipocyte lineage, appetite regulation, or later metabolic response [15]. Broader endocrine reviews also describe potential disruption of pancreatic, hepatic, adipose, and

neuroendocrine regulation [16]. The same dose may therefore have different effects depending on timing, mixture, nutrition, sex, and genetic background.

The obesogen hypothesis continues to evolve as evidence accumulates [17]. It should not be used to assign personal blame or to imply that avoiding a few consumer products will eliminate risk. Meaningful prevention also requires regulation, safer manufacturing, occupational safeguards, and environmental monitoring.

7. Molecular Pathways of Toxicant-Induced Dysfunction

Endocrine-disrupting chemicals may affect estrogen, androgen, thyroid, glucocorticoid, or metabolic nuclear-receptor pathways. Reviews now use the broader term metabolism-disrupting chemicals to include agents that alter pancreatic, hepatic, adipose, muscle, or neuroendocrine function [18].

Experimental and human studies describe effects on adipogenesis, insulin signalling, glucose transport, lipid handling, oxidative stress, and inflammatory pathways [19]. Tissue distribution and persistence influence which organs receive an effective dose and for how long [20]. Lipophilic compounds may accumulate in adipose tissue, whereas other agents are cleared more rapidly but encountered repeatedly.

Mitochondrial dysfunction is another plausible route. Disturbed oxidative phosphorylation, reactive oxygen species, and impaired fatty-acid oxidation can lower metabolic flexibility. However, a mechanistic effect in cells or animals does not by itself establish clinically meaningful disease in humans at typical exposure levels.

8. Gut Microbiome and Intestinal Barrier

The gut microbiome participates in energy harvest, bile-acid metabolism, immune signalling, and intestinal barrier integrity [21]. Chemical exposure may alter microbial composition or function, while diet and metabolic disease also reshape the microbiome. This bidirectionality makes cause and effect difficult to separate.

From an Ayurvedic perspective, impaired *Ahara Paka* and *Ama* formation provide a clinical language for disordered digestion and systemic consequences. A conceptual comparison with microbial dysbiosis or barrier dysfunction may generate hypotheses, but *Ama* is not a microbiome marker and should not be defined by a single metabolite or inflammatory test.

9. Inflammation, Adipose Tissue, and Insulin Resistance

Chronic low-grade inflammation is central to many metabolic disorders [22]. Enlarged or dysfunctional adipocytes, immune-cell infiltration, altered adipokines, and ectopic fat contribute to insulin resistance. Inflammatory pathways linking obesity with glucose and lipid disturbance have been described extensively [23].

Ayurveda would interpret a comparable clinical progression through persistent *Agni Mandya*, *Ama*-associated *Dosha* aggravation, *Meda Vriddhi*, and obstruction of *Medovaha Srotas*. The parallel lies in the recognition of a self-reinforcing process. It does not mean that *Ama* equals cytokines or that Srotorodha equals one histological lesion.

10. Obesity as a Multifactorial Condition

Long-term weight management is shaped by adaptive appetite, energy expenditure, food environment, sleep, medicines, and psychosocial factors [24]. Contemporary obesity science therefore rejects the idea that body weight is governed by willpower alone. Global epidemiological reviews also emphasize genetic, developmental, environmental, and societal influences [25].

The worldwide scale of obesity reinforces the need for population-level prevention rather than exclusively individual treatment [26]. Environmental chemical control may become one component of that response, but it must accompany access to nutritious food, opportunities for safe activity, adequate sleep, and non-stigmatizing medical care. Gut-host metabolic interactions add further complexity to metabolic syndrome and its prevention [27].

11. *Medovaha Srotodushti*: A Cautious Correlation

Adipose tissue is an active endocrine organ that stores energy, releases signalling molecules, and responds to nutritional and hormonal cues [28]. When adipose expandability is exceeded or distribution becomes unfavourable, lipids may accumulate in the liver, muscle, or pancreas.

The Ayurvedic account of *Medovaha Srotodushti* similarly extends beyond visible fat accumulation. It includes disturbed formation, transport, and utilization of *Meda*. Excessive nourishment, inactivity, sleep patterns, and impaired *Agni* are described as contributors. This wider view can help clinicians consider appetite, digestion, activity, strength, distribution of adiposity, and comorbidity together.

Adipocytokines connect adipose tissue with inflammation and immune function [29]. This modern evidence offers a plausible reason to study systemic effects of abnormal *Meda*, but it does not validate a direct terminological equivalence.

12. Metabolomics and Phenotyping

Metabolomics can identify patterns of amino acids, lipids, bile acids, and intermediary metabolites associated with insulin resistance or toxicant exposure [30]. Such profiles may clarify whether particular exposures produce reproducible metabolic signatures.

Ayurvedic phenotyping could be included in this work if assessment methods are standardized, blinded where possible, and tested for inter-rater reliability. *Agni*, *Ama*, *Prakriti*, and *Medovaha Srotodushti* should be defined by transparent clinical criteria before correlation with laboratory data. Otherwise, retrospective classification risks circular reasoning.

A review of Ayurvedic metabolism concepts has highlighted possible areas for scientific dialogue while cautioning against oversimplification [31]. Integrative health research is strongest when each knowledge system retains its own definitions and the proposed relationship is tested rather than assumed [32].

13. Prevention: Exposure and Lifestyle

Prevention begins with reducing avoidable exposure without creating fear. Practical measures may include using food-safe containers as intended, avoiding heating food in unsuitable plastics, reducing indoor dust, following pesticide-safety instructions, ensuring ventilation, and using occupational protective measures. Product substitutions should be guided by evidence because replacing one chemical with a poorly studied analogue may not reduce risk.

Lifestyle measures remain essential. A minimally processed dietary pattern, regular physical activity, adequate sleep, tobacco avoidance, limited harmful alcohol exposure, and management of blood pressure, glucose, and lipids reduce metabolic risk regardless of chemical exposure. These measures should not be portrayed as detoxification.

14. Ayurvedic Therapeutic Principles

Deepana and *Pachana* are traditionally selected to support appetite, digestion, and processing when *Agni Mandya* and *Ama* are present. *Langhana* reduces metabolic burden through appropriately chosen lightening measures. *Shodhana* is a distinct physician-supervised intervention, not a generic synonym for removal of industrial chemicals. *Rasayana* aims to support resilience, tissue quality, and healthy ageing.

Treatment selection should consider strength, age, comorbidity, medicines, digestive state, and *Prakriti*. Severe obesity, diabetes, fatty liver disease, dyslipidaemia, or endocrine illness requires laboratory evaluation and evidence-based medical management. Ayurvedic care may be integrated only with attention to herb-drug interactions, product quality, contraindications, and adverse-event reporting.

15. Evidence for Ayurvedic Interventions

Several medicinal plants and formulations show antioxidant, anti-inflammatory, hepatoprotective, or insulin-sensitizing activity in experimental models. These properties justify further study but do not demonstrate removal of stored toxicants or prevention of obesogen-related disease in humans.

The central limitation is specificity. Many trials enrol people with obesity or diabetes without measuring chemical exposure. Consequently, an improvement in glucose or lipids cannot be attributed to protection from environmental obesogens. Future trials need verified exposure biomarkers, standardized interventions, clinically relevant outcomes, and sufficiently long follow-up.

16. Critical Appraisal

Metabolism-disrupting chemicals have become an important public-health research area [33]. The field is nevertheless challenged by mixtures, non-linear dose-response relationships, changing exposure over time, residual confounding, and differences between experimental doses and ordinary human exposure. Reverse causation is also possible because body fat can affect chemical storage and measured concentrations.

Metabolic syndrome is closely related to gut microbial and host metabolic interactions [27], adding another layer of complexity. No single biomarker can separate the contributions of exposure, diet, adiposity, medicines, and disease stage.

A recent public-health perspective argues that metabolism-disrupting chemicals deserve greater preventive attention [33]. The most defensible integrative position is therefore balanced: environmental exposure may modify metabolic susceptibility; Ayurvedic concepts may organize clinical patterns and preventive thinking; neither proposition justifies unsupported causal claims or unvalidated detoxification therapies.

17. Research Priorities

Prospective cohorts should measure exposure repeatedly from early life and examine incident obesity, insulin resistance, fatty liver disease, and metabolic syndrome. Mixture modelling, social determinants, diet, activity, sleep, and medication use need careful control.

Integrative studies should validate assessment of *Agni*, *Ama*, and *Medovaha Srotodushti* before linking these constructs with exposure biomarkers, metabolomics, the microbiome, or inflammatory measures. Assessors should be trained, agreement reported, and hypotheses preregistered.

Trials of *Deepana*, *Pachana*, *Langhana*, *Shodhana*, or *Rasayana* approaches require authenticated ingredients, standardized manufacturing, dose justification, safety monitoring, and clear adjunctive use. The outcome should be meaningful metabolic health—not merely movement of an exploratory biomarker.

18. Conclusion

Environmental obesogens have broadened the understanding of obesity by showing that metabolic vulnerability can be shaped by chemical exposure as well as food, activity, genes, development, and social context. Plausible pathways include endocrine disruption, altered adipogenesis, mitochondrial stress, inflammation, microbiome change, and epigenetic programming. The evidence is compelling for continued research and exposure prevention, but it is not equally strong for every chemical or clinical outcome.

Ayurveda describes metabolic decline through *Agni Mandya*, *Ama*, disturbed tissue transformation, abnormal *Meda*, and *Medovaha Srotodushti*. These concepts offer a coherent preventive and clinical narrative, but they are not molecular substitutes for endocrine receptors, cytokines,

or toxicokinetics. Responsible integration should combine exposure reduction, comprehensive lifestyle and medical care, validated Ayurvedic assessment, and rigorously tested interventions.

19.Conceptual Comparison

Modern observation	Ayurvedic concept	Interpretive boundary
Reduced metabolic efficiency	*Agni Mandya*	Clinical analogy, not a molecular equivalence
Abnormal adipose formation or function	*Meda Vriddhi* and *Medovaha Srotodushti*	Requires independent anatomical and biochemical measurement
Inflammatory metabolic disturbance	*Ama*-associated pathology	*Ama* is not interchangeable with cytokines
Impaired tissue fuel handling	Disturbed *Dhatvagni*	A hypothesis-generating comparison
Multisystem metabolic disease	*Dosha-Dushya Sammurchana*	Different explanatory frameworks

20. References

[1] Charaka. *Charaka Samhita*. Sutra Sthana, Chapter 28 (*Annapana Vidhi Adhyaya*). In: Shastri K, Chaturvedi GN, editors. Vidyotini Hindi Commentary. Reprint ed. Varanasi: Chaukhambha Bharati Academy; 2023. p. 561-596.

[2] Charaka. *Charaka Samhita*. Chikitsa Sthana, Chapter 15 (*Sthaulya Chikitsa*). In: Shastri K, Chaturvedi GN, editors. Vidyotini Hindi Commentary. Reprint ed. Varanasi: Chaukhambha Bharati Academy; 2023. p. 431-448.

[3] Charaka. *Charaka Samhita*. Vimana Sthana, Chapter 5 (*Srotovimana*). In: Shastri K, Chaturvedi GN, editors. Vidyotini Hindi Commentary. Reprint ed. Varanasi: Chaukhambha Bharati Academy; 2023. p. 709-726.

[4] Sushruta. *Sushruta Samhita*. Sutra Sthana, Chapter 15 (*Doshadhatumalakshaya Vriddhi Vijnaniya*). In: Shastri AD, editor. Ayurveda Tatva Sandipika. Reprint ed. Varanasi: Chaukhambha Sanskrit Sansthan; 2023. p. 63-79.

[5] Vagbhata. *Ashtanga Hridaya*. Sutra Sthana, Chapter 11 (*Dosha*di Vijnaniya). In: Gupta A, editor. Vidyotini Hindi Commentary. Reprint ed. Varanasi: Chaukhambha Prakashan; 2022. p. 112-129.

[6] Sharma PV. *Dravyaguna Vijnana*. Vol. II. Reprint ed. Varanasi: Chaukhambha Bharati Academy; 2022.

[7] Mishra BS, editor. *Bhavaprakasha*. Purva Khanda. Reprint ed. Varanasi: Chaukhambha Sanskrit Bhavan; 2022.

[8] World Health Organization. Obesity and overweight. Geneva: World Health Organization; 2024.

[9] Heindel JJ, Blumberg B. Environmental obesogens: mechanisms and controversies. Annu Rev Pharmacol Toxicol. 2019;59:89-106.

[10] Heindel JJ, Newbold R, Schug TT. Endocrine disruptors and obesity. Nat Rev Endocrinol. 2015;11:653-661.

[11] Grün F, Blumberg B. Environmental obesogens: organotins and endocrine disruption via nuclear receptor signaling. Endocrinology. 2006;147:S50-S55.

[12] Gore AC, Chappell VA, Fenton SE, et al. EDC-2: The endocrine society's scientific statement on endocrine-disrupting chemicals. Endocr Rev. 2015;36:E1-E150.

[13] La Merrill MA, Vandenberg LN, Smith MT, et al. Consensus on the key characteristics of endocrine-disrupting chemicals. Nat Rev Endocrinol. 2020;16:45-57.

[14] Legler J, Fletcher T, Govarts E, et al. Obesity, diabetes and associated costs of exposure to endocrine-disrupting chemicals in Europe. J Clin Endocrinol Metab. 2015;100:1278-1288.

[15] Janesick A, Blumberg B. Obesogens and metabolic disease. Annu Rev Pharmacol Toxicol. 2016;56:391-415.

[16] Nadal A, Quesada I, Tuduri E, et al. Endocrine-disrupting chemicals and metabolic disorders. Nat Rev Endocrinol. 2017;13:536-546.

[17] Heindel JJ, Schug TT. The obesogen hypothesis. Front Endocrinol. 2022;13:820930.

[18] Kassotis CD, Vandenberg LN, Demeneix BA, et al. Endocrine-disrupting chemicals and metabolic health. Endocr Rev. 2020;41:bnz042.

[19] Hou L, Zhang X, Wang D, et al. Environmental chemicals and obesity: mechanisms and evidence. Environ Res. 2022;204:112138.

[20] Renaud HJ, Cui JY, Khan M, Klaassen CD. Tissue distribution and mechanisms of environmental toxicants in metabolic disease. Toxicol Sci. 2021;181:1-16.

[21] Cani PD. Human gut microbiome and metabolic disease. Nat Rev Gastroenterol Hepatol. 2019;16:261-276.

[22] Hotamisligil GS. Inflammation, metaflammation and immunometabolic disorders. Nature. 2017;542:177-185.

[23] Saltiel AR, Olefsky JM. Inflammatory mechanisms linking obesity and metabolic disease. J Clin Invest. 2017;127:1-4.

[24] Hall KD, Kahan S. Maintenance of lost weight and long-term management of obesity. Med Clin North Am. 2018;102:183-197.

[25] Bluher M. Obesity: global epidemiology and pathogenesis. Nat Rev Endocrinol. 2019;15:288-298.

[26] World Obesity Federation. World Obesity Atlas 2024. London: World Obesity Federation; 2024.

[27] Tang WHW, Kitai T, Hazen SL. Gut microbiota and metabolic syndrome. Circ Res. 2017;120:1183-1196.

[28] Rosen ED, Spiegelman BM. What we talk about when we talk about fat. Cell. 2014;156:20-44.

[29] Tilg H, Moschen AR. Adipocytokines: mediators linking adipose tissue, inflammation and immunity. Nat Rev Immunol. 2006;6:772-783.

[30] Newgard CB. Metabolomics and metabolic disease. Cell Metab. 2017;25:43-56.

[31] Agrawal R, Sharma PK, Rao CV. Scientific basis of Ayurvedic concepts related to metabolism: a review. J Ayurveda Integr Med. 2021;12:623-631.

[32] Patwardhan B, Mutalik G, Tillu G. Integrative Approaches for Health: Biomedical Research, Ayurveda and Yoga. London: Academic Press; 2015.

[33] Heindel JJ, Blumberg B, Cave M, et al. Metabolism-disrupting chemicals and public health. Lancet Diabetes Endocrinol. 2022;10:145-146.