



REVIEW ARTICLE

Insulin resistance in Ageing: An Ayurvedic Approach

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Abstract

Ageing is a progressive, inevitable biological process associated with functional decline and increased susceptibility to metabolic disorders, notably insulin resistance. Modern science attributes insulin resistance in ageing to changes in body composition, hormonal alterations, oxidative stress, and reduced physical activity. *Ayurveda* explains ageing (*Jara*) as a natural process governed by *Sahaja hetu* and *Vata dosha* aggravation, leading to disturbances in *Agni*, *Dhatu*, and *Ojas*. Ageing is accompanied by gradual metabolic changes, with insulin resistance emerging as a key factor in the pathogenesis of type 2 diabetes mellitus and metabolic syndrome. Contemporary biomedical research links insulin resistance in ageing to increased adiposity, chronic inflammation, mitochondrial dysfunction, and hormonal imbalance. *Ayurveda* provides a comprehensive framework for understanding ageing (*Jara*) and metabolic imbalance through the principles of *Dosha*, *Dhatu*, *Agni*, and *Srotas*. Ageing is marked by the predominance of *Vata*, accompanied by *Dhatukshaya* and *Agnimandya*, resulting in compromised tissue metabolism. Insulin resistance may be understood in Ayurvedic terms as a manifestation of *Medo dhatu dushti*, *Dhatvagni mandya*, and *Medovaha srotodushti*, corresponding to the early stages of *Prameha*. The accumulation of *Ama* resulting from impaired *Agni* further aggravates metabolic dysfunction. The Ayurvedic approach emphasizes both prevention and treatment through *Ahara*, *Vihara*, *Rasayana* therapy, and purification measures aimed at re-establishing *Agni* and metabolic balance. This article explores insulin resistance in ageing through an integrative Ayurvedic perspective, correlating classical concepts with contemporary biomedical theories.

Introduction

Insulin resistance is defined as a reduced biological response of target tissues—primarily the liver, skeletal muscle, and adipose tissue—to insulin¹. It is a central feature of metabolic disorders such as type 2 diabetes mellitus and metabolic syndrome. Ageing is associated with a progressive increase in insulin resistance due to mitochondrial dysfunction, sarcopenia, chronic inflammation, oxidative stress, and age-related hormonal changes.² According to the World Health Organization, ageing is a biological process that begins at conception and ends with death³. *Ayurveda* conceptualizes ageing as *Jara* or *Vardhakya*, a natural and

inevitable condition classified under *Swabhavabalapravritta vyadhi*⁴ The ageing process is predominantly influenced by Vata dosha aggravation, impaired *Agni*, *Dhatu kshaya*, and *Ojakshaya*. Understanding Insulin resistance through Ayurvedic principles such as *Agni*, *Ama*, *Medo dhatu*, and *Tridosha* imbalance provides a holistic framework for addressing metabolic dysfunction in the elderly. Insulin resistance refers to a diminished responsiveness of peripheral tissues to physiological concentrations of insulin, leading to reduced glucose uptake and utilization⁵ The occurrence of insulin resistance rises with increasing age, even among individuals without evident obesity or diabetes.⁶ Conventional medical literature explains age-related insulin resistance as a multifactorial condition resulting from increased adiposity, chronic low-grade inflammation, mitochondrial dysfunction, oxidative stress, and age-associated hormonal alterations, which together lead to disturbances in glucose and lipid metabolism in the elderly. Despite advances in modern medicine, the multifactorial nature of insulin resistance in ageing continues to pose significant management challenges. While both modern science and *Ayurveda* offer distinct frameworks, a comprehensive, integrative understanding that systematically correlates their respective concepts to inform novel approaches remains underexplored⁷ *Ayurveda*, the classical system of Indian medicine, offers a holistic approach to understanding ageing (*Jara*) and metabolic dysfunction through the core concepts of *Dosha*, *Dhatu*, *Agni*, and *Srotas*.⁸ In *Ayurveda*, ageing is considered a naturally occurring (*Swabhava bala pravritta*) process, primarily marked by the predominance of *Vata dosha*. The dominance of Vata in ageing causes *Dhatukshaya* and *Agnimandya*, leading to compromised metabolism and tissue dysfunction.⁹ *Agni* is central to digestion, metabolism, and tissue nourishment, and its dysfunction is regarded as a key contributor to the development of disease.¹⁰ During ageing, diminished *Agni* results in incomplete nutrient metabolism and the accumulation of *Ama*, a toxic by-product of impaired digestion.¹¹ *Ama* accumulation leads to obstruction of *Srotas*, worsening metabolic dysfunction and disease risk.¹²

From an Ayurvedic perspective, insulin resistance may be conceptualized as a manifestation of *Medo dhatu dushti*, *Dhatvagni mandya*, and *Medovaha srotodushti*.¹³ These pathological alterations resemble the initial stages of *Prameha samprapti*, in which disrupted fat metabolism and impaired tissue nourishment are central features.¹⁴ *Ayurveda* describes *Prameha* as a metabolic disorder due to *Kapha* and *Meda* predominance, impaired *Agni*, and *Srotas* obstruction, which aligns with the modern understanding of insulin resistance.¹⁵ *Ayurveda* emphasizes preventive and therapeutic

interventions—including *Ahara*, *Vihara*, *Rasayana* therapy, and *Shodhana*—to restore *Agni* and maintain metabolic equilibrium. Such approaches are particularly relevant in ageing, where prevention and maintenance of metabolic health are of paramount importance. Therefore, this review addresses the gap in systematically correlating classical Ayurvedic principles with contemporary biomedical understanding of insulin resistance in ageing, aiming to establish an integrative framework for its prevention and management.¹⁶

Methods

Study Design

This study was conducted as a narrative and conceptual review to explore insulin resistance in ageing through an Ayurvedic perspective and to correlate classical Ayurvedic principles with contemporary biomedical understanding.

Data Sources and Search Strategy

Classical Ayurvedic literature including *Charaka Samhita*, *Sushruta Samhita*, and *Ashtanga Hridaya*, along with their relevant commentaries, were reviewed to identify concepts related to *Jara*, *Tridosha*, *Agni*, *Ama*, *Medo Dhatu*, *Ojas*, *Prameha*, *Srotas*, and *Dhatvagni*. Modern scientific literature was searched using electronic databases such as PubMed and Google Scholar. The search was conducted between January 2020 and December 2025.

Inclusion Criteria

- Original research articles
- Review articles
- Clinical and observational studies related to insulin resistance and ageing
- Articles published in English language
- Relevant classical Ayurvedic references related to metabolic disorders

Exclusion Criteria

- Duplicate publications
- Abstract-only articles
- Non-English publications
- Studies not related to ageing or insulin resistance
- Articles lacking sufficient methodological relevance

Article Selection Process

A total of approximately 132 records were identified through electronic databases and manual searches of classical Ayurvedic texts and reference lists.

After removal of duplicates and screening based on titles and abstracts, 81 articles were found relevant for full-text assessment.

Finally, 40 articles along with relevant classical Ayurvedic references were included in this narrative review.

Data Analysis

A thematic and conceptual analysis was performed. Key Ayurvedic concepts such as *Agni*, *Ama*, *Dhatvagni mandya*, *Medo dhatu dushti*, *Srotorodha*, *Avarana*, and *Ojakshaya* were systematically correlated with modern biomedical mechanisms of insulin resistance in ageing, including impaired insulin signaling, chronic inflammation, oxidative stress, mitochondrial dysfunction, and altered glucose metabolism.

Result and Discussion

Tridosha, Metabolism, and Ageing

In ageing, *Vata dosha* naturally predominates. The *ruksha*, *laghu*, *chala*, and *khara* *gunas* of aggravated *Vata* lead to progressive *Dhatukshaya* and functional impairment of insulin-responsive tissues such as skeletal muscle and adipose tissue. Sarcopenia and loss of muscle mass in ageing, which are major determinants of peripheral glucose disposal, may be correlated with *Vata*-induced *mamsa dhatu kshaya*. Furthermore, the *chala guna* of *Vata* produces instability in metabolic and neuroendocrine regulation, resulting in impaired coordination between insulin secretion and peripheral insulin action. Classical descriptions of *Prameha* mention that aggravated *Vata* causes *shoshana* of *Dhatu*s and *srotodushti*, leading to defective utilization of nutrients by tissues. This can be correlated with post-receptor defects and impaired glucose uptake seen in insulin resistance. Thus, *Vata* aggravation in ageing contributes to insulin insensitivity by promoting tissue degeneration, impaired nutrient transport, and dysregulation of metabolic signaling pathways.

The Tridoshas—*Vata*, *Pitta*, and *Kapha*—govern all physiological processes. Their dominance varies across the lifespan: *Kapha* in childhood, *Pitta* in adulthood, and *Vata* in old age.

- *Vata* dominance in ageing, characterized by dryness, lightness, and instability, leads to tissue degeneration, loss of strength, and impaired nutrient transport, contributing to insulin resistance.
- *Pitta* imbalance disrupts digestion and metabolic transformation, promoting inflammation and defective glucose metabolism.
- *Kapha* imbalance, particularly *Kapha Medo Dushti*, results in visceral adiposity, metabolic sluggishness, hyperinsulinemia, and insulin resistance.

Vata Imbalance and Metabolism:

Excess *Vata* can disrupt metabolic functions, leading to irregular digestion and impaired nutrient absorption. Elevated *Vata* may also affect insulin sensitivity, contributing to glucose dysregulation, a characteristic feature of diabetes. Ayurvedic management of *Vata* imbalance focuses on calming therapies, nourishing dietary practices, and appropriate herbal formulations to restore metabolic balance and harmony.¹⁷ *Vata dosha*, defined by the qualities of *laghu* (lightness), *ruksha* (dryness), *chala* (mobility), and *khara* (roughness), plays a central role in regulating movement, neural activity, and the transport of nutrients and hormonal signals throughout the body.¹⁸ When *Vata* is aggravated, its heightened mobility and dryness disrupt the coordinated regulation of metabolic processes, resulting in impaired signaling between peripheral tissues and endocrine organs, including the pancreas. According to classical descriptions of *Prameha*, aggravated *Vata* causes disruption of *srotas* and depletion of bodily tissues, resulting in defective glucose utilization by peripheral tissue.¹⁹ This description parallels the modern understanding of insulin resistance, wherein defective insulin signaling leads to diminished glucose uptake by peripheral tissues.²⁰ Clinical studies substantiate this association, demonstrating that individuals with *Vata-Kapha* predominant prakriti exhibit significantly elevated insulin resistance indices (HOMA-IR) along with increased inflammatory markers.²¹

Pitta Imbalance and Nutrient Metabolism:

Imbalance of *Pitta* can interfere with normal digestive and metabolic processes. Excess *Pitta* may result in hyperacidity and inflammatory changes, which can impair insulin activity and glucose metabolism. Ayurvedic management of *Pitta* imbalance emphasizes cooling dietary measures, stress reduction, and the use of specific herbal formulations aimed at supporting digestion and reducing inflammation. *Pitta dosha*, characterized by *ushna*, *tikshna*, and *drava* *gunas*, regulates *Agni* and the body's biochemical transformations. When *Pitta* is deranged, *Agni dushti* occurs, causing improper carbohydrate metabolism and accumulation of *ama*. *Ama* further obstructs insulin-responsive pathways and promotes low-grade inflammation, a well-recognized contributor to the development of insulin resistance.²² Persistent oxidative stress and inflammation associated with *Pitta* imbalance can impair β -cell function and insulin action.²³ Therefore, whereas *Kapha* primarily initiates insulin resistance through accumulation and channel obstruction, *Pitta* and *Vata* collectively exacerbate and sustain the condition by disrupting metabolism, tissue responsiveness, and neuro-endocrine regulation.²⁴

Kapha Imbalance and Metabolic Sluggishness:

Aggravated *Kapha* is linked to slowed metabolic activity, which may lead to weight gain and insulin resistance. Ayurvedic interventions for *Kapha* imbalance focus on dietary regulation, increased physical activity, and detoxification therapies to enhance metabolic efficiency and restore balance²⁵ *Kapha* dosha, characterized by *guru* , *manda* , *snigdha* , and *sthira gunas*, plays a central role in initiating metabolic disorders such as *Prameha*²⁶ Elevated *Kapha* results in increased *meda dhatu* and *kleda*, causing blockage of metabolic channels and impaired glucose utilization.²⁷ The resulting *srotorodha* impairs insulin sensitivity in muscle and fat tissues, which is a hallmark of insulin resistance Modern research aligns with this explanation, indicating that inflammation associated with adiposity and disrupted adipokine signaling amplify insulin resistance. With disease progression, *Kapha*-induced heaviness and stagnation promote *Vata* aggravation, which intensifies metabolic imbalance.²⁸

Role of Dhatvagni and Ama in Insulin resistance

Although *Jatharagni* is the primary digestive and metabolic force, insulin resistance is better explained through the concept of *Dhatvagni mandya*, particularly *Medodhatvagni*

mandya. Ayurveda describes *Dhatvagni* as the metabolic principle responsible for the transformation and nourishment of individual tissues. Impairment of *Medodhatvagni* leads to abnormal *Meda* accumulation, defective tissue metabolism, and the generation of *Ama*. These changes contribute to *Medovaha srotodushti* and metabolic dysfunction. Since insulin resistance primarily represents impaired glucose utilization and altered cellular metabolism rather than defective gastrointestinal digestion alone, *Medodhatvagni mandya* offers a more appropriate Ayurvedic explanation. The resulting *Meda vriddhi*, *Ama* accumulation, and *Srotorodha* further aggravate metabolic disturbances and may correspond to adipose tissue dysfunction and impaired insulin responsiveness observed in ageing.²⁹

Cellular senescence and Ageing

At the cellular level, ageing is characterized by cellular senescence, marked by irreversible growth arrest, telomere shortening, mitochondrial dysfunction, oxidative stress, and chronic low-grade inflammation (inflammageing). Senescent cells exhibit impaired insulin signaling and reduced metabolic efficiency, contributing significantly to age-related insulin resistance.³⁰In *Ayurveda*, *Ojas* is described as the sara of all

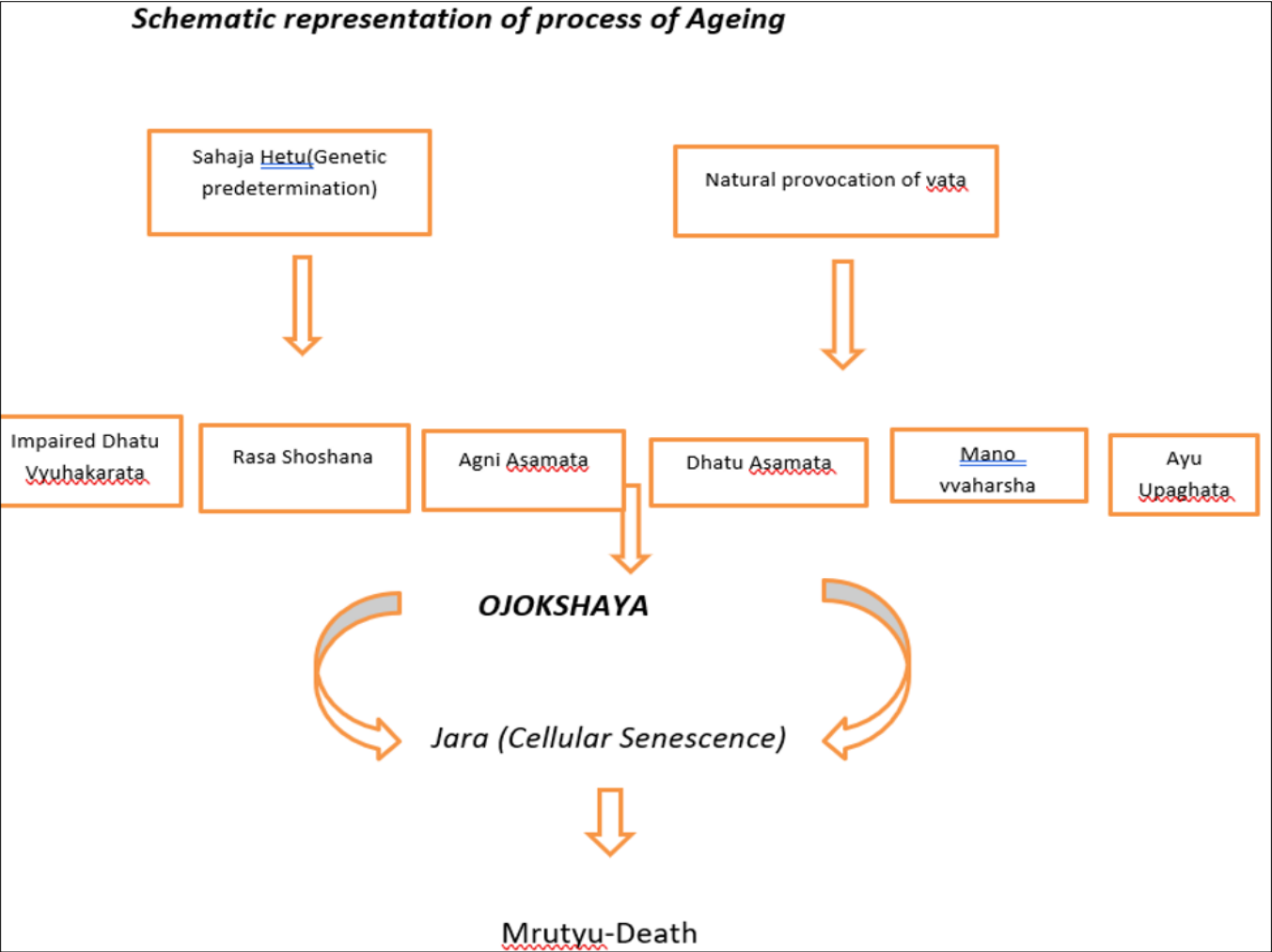


Figure 1

Dhatus and is responsible for maintaining vitality, immunity, tissue integrity, and cellular resilience. Classical texts describe *Ojakshaya* as presenting with *daurbalya*, *alpateja* (reduced vitality), *kshaya* (tissue depletion), and increased susceptibility to disease. The biological features of cellular senescence closely parallel the concept of *Ojakshaya*, as both represent a decline in cellular regenerative capacity and resistance to stress. Impaired Agni and the accumulation of Ama during ageing promote oxidative stress and inflammatory mediators, which accelerate cellular senescence. Thus, the modern concept of cellular senescence can be understood in Ayurvedic terms as a manifestation of *Ojakshaya* associated with *Agnimandya* and *Dhatukshaya*, forming the cellular basis of *Jara* and contributing to the development of insulin resistance in the elderly.³¹

Pathophysiology of Insulin Resistance

Insulin resistance arises due to impaired insulin receptor signaling and post-receptor defects in skeletal muscle, liver, and adipose tissue, resulting in reduced glucose uptake and persistent hepatic gluconeogenesis. Visceral adiposity contributes to increased free fatty acid flux and secretion of pro-inflammatory adipokines, which interfere with insulin signaling. Age-related mitochondrial dysfunction, oxidative stress, and chronic low-grade inflammation further aggravate insulin insensitivity, while sarcopenia reduces the primary site of peripheral glucose disposal in the elderly.³²

From an Ayurvedic standpoint, this pathological process can be understood as *Kapha*-mediated *Medo dhatu dushti* and *srotorodha* initiating metabolic obstruction, *Agnidushti* leading to Ama formation and impaired cellular metabolism, *Pitta*-induced inflammatory and oxidative injury to metabolic pathways, and *Vata*-driven *Dhatukshaya* and regulatory instability perpetuating metabolic dysfunction. This integrative framework provides a comprehensive understanding of insulin resistance in ageing.³³

Insulin Resistance and Ageing

Ageing is associated with increased insulin resistance, impaired glucose tolerance, and higher prevalence of hypertension, type 2 diabetes mellitus, and cardiovascular disease. Peripheral insulin resistance due to post-receptor defects reduces glucose uptake and shifts the insulin dose-response curve. Hyperinsulinemia develops as a compensatory response and is linked to reduced healthspan. Environmental factors such as increased adiposity, unfavorable fat distribution, and physical inactivity significantly exacerbate insulin resistance in older adults.³⁴

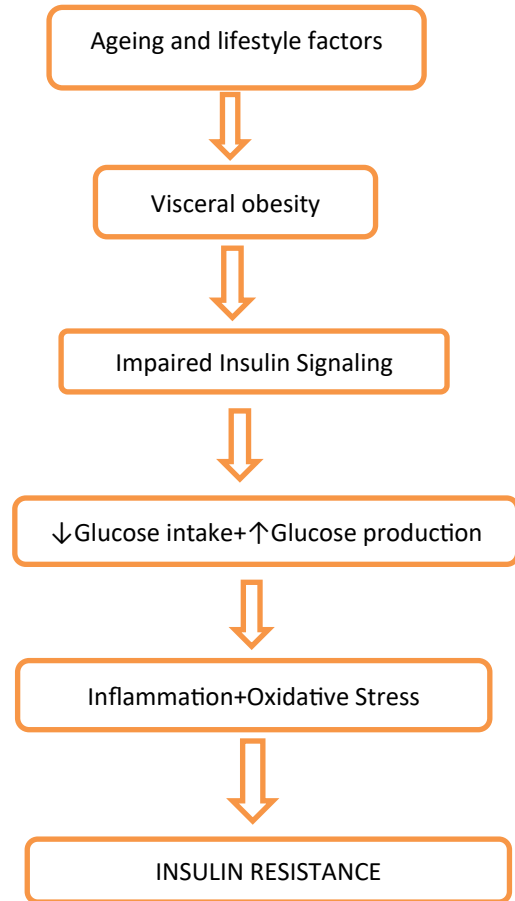


Figure 2

Dosha-Guna Based Pathogenesis of Insulin Resistance in Ageing

The establishment of insulin resistance in ageing can be understood as a *Tridoshaja* process involving the derangement of Doshas and their respective *gunas*, leading to *Agnidushti*, Ama formation, *Medo dhatu dushti*, and *Srotorodha*. *Kapha dosha*, characterized by *guru*, *snigdha*, *manda*, and *sthira* *gunas*, plays a primary role in initiating insulin resistance. The *guru* and *snigdha* *gunas* promote *Medo dhatu vridhhi* and *kleda*, leading to visceral adiposity and metabolic stagnation. The *manda guna* results in *Agnimandya*, causing incomplete metabolism and Ama formation, while *sthira guna* contributes to chronicity of metabolic obstruction. This *Kapha*-mediated *Medo dushti* and *srotorodha* of *Medovaha srotas* correlates with adipose tissue inflammation, adipokine dysregulation, and impaired insulin signaling in peripheral tissues. *Pitta dosha*, with *ushna*, *tikshna*, and *drava* *gunas*, contributes to oxidative stress and inflammatory changes at the cellular level. Prolonged *Pitta* imbalance leads to *Dhatvagni dushti*, mitochondrial dysfunction, and inflammatory injury to insulin receptors and pancreatic β -cells, thereby impairing glucose metabolism and insulin action. *Vata dosha*, predominant in old age, maintains insulin resistance through its *ruksha*, *laghu*, and *chala* *gunas*. *Ruksha* and *laghu* *gunas* cause *Dhatukshaya*, particularly *mamsa* and *meda kshaya*, reducing the functional

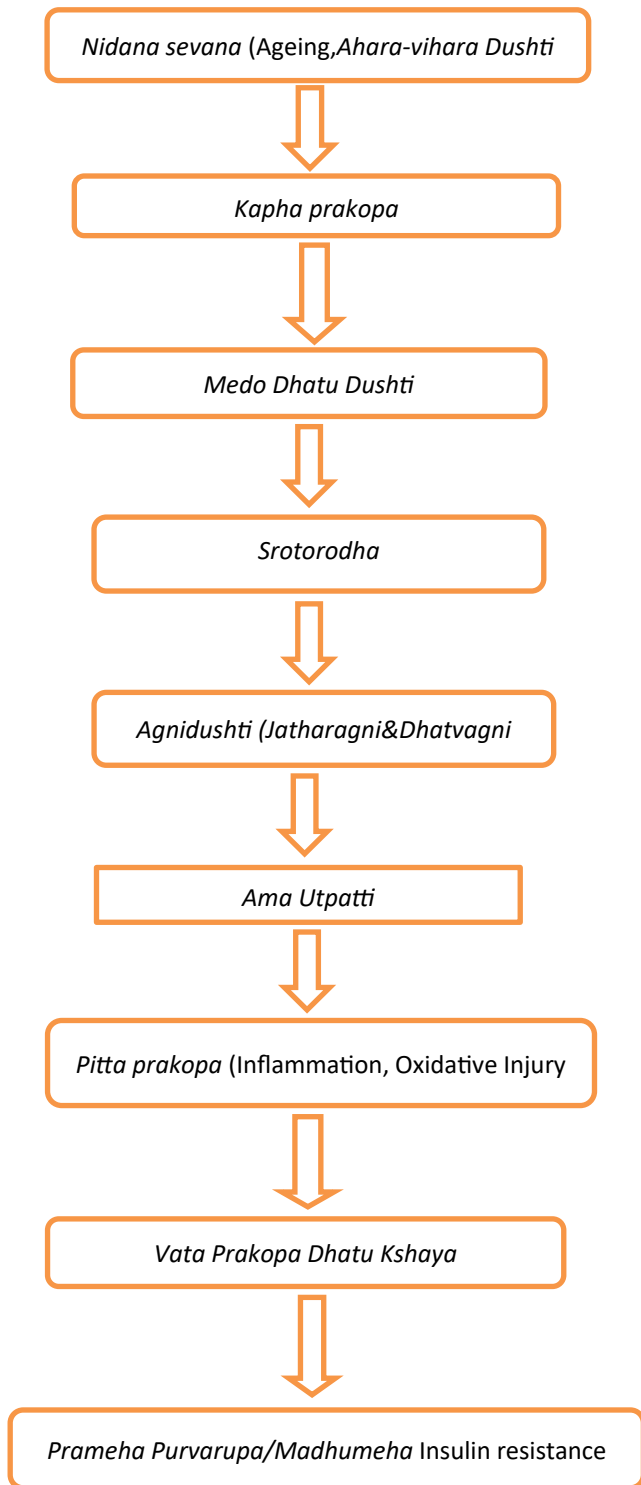


Figure 3

capacity of insulin-responsive tissues. The chala guna leads to instability of metabolic regulation and neuroendocrine signaling, thereby aggravating insulin resistance. Thus, insulin resistance in ageing may be understood as *Kapha*-initiated, *Pitta*-mediated, and *Vata*-perpetuated metabolic dysfunction.³⁵

Role of *Avarana* and *Srotorodha* in the Pathogenesis of Insulin Resistance

From an Ayurvedic perspective, insulin resistance in ageing may also be interpreted through the concepts of *Srotorodha* and *Avarana*. Excessive accumulation of *Kapha* and *Meda*

resulting from *Agnimandya* and *Dhatvagni mandya* leads to obstruction of *Medovaha srotas*. This *Srotorodha* impairs the normal movement and physiological functions of *Vata*, particularly *Vyana Vata*, resulting in *Avarana*.

Vyana Vata is responsible for the circulation and distribution of nutrients throughout the body. When its normal function is obstructed by *Kapha* and *Meda*, tissue nourishment and metabolic regulation become impaired. This condition can be correlated with defective insulin signaling and reduced glucose uptake at the cellular level. The resulting metabolic dysfunction promotes further *Meda* accumulation, *Ama* formation, and progression towards *Prameha*. Thus, the sequence of *Agnimandya* → *Dhatvagni mandya* → *Meda vriddhi* → *Srotorodha* → *Avarana* of *Vyana Vata* provides a plausible Ayurvedic explanation for the development of insulin resistance in ageing.³⁶

Role of *Rasayana* in Ageing and *Prameha*

Rasayana therapy is one of the most important therapeutic modalities described in classical *Ayurveda* for promoting longevity, enhancing immunity, improving tissue quality, and delaying ageing. *Rasayana* is defined as a therapeutic approach that promotes the optimal nourishment of *Dhatu*s, enhances *Ojas*, improves *Agni*, and maintains *Srotas* patency, thereby preventing degenerative and metabolic disorders³⁷

Rasayana in Ageing (*Jara*)

Rasayana is the principal line of management for *Jara*.

- *Deerghayu* (longevity)
- *Smriti* and *Medha* (cognitive enhancement)
- *Bala* (strength)
- *Varna* (complexion)
- *Oja vardhana* (enhancement of vitality and immunity)

Ageing is characterized by *Vata* predominance, *Dhatukshaya*, *Agnimandya*, and *Ojakshaya*. *Rasayana* therapy counteracts these changes by:

- Strengthening *Agni*
- Nourishing *Dhatu*s
- Enhancing *Ojas*
- Reducing oxidative stress and cellular degeneration

Modern research suggests that many *Rasayana* drugs exhibit antioxidant, anti-inflammatory, adaptogenic, and immunomodulatory properties, which may help attenuate cellular senescence and mitochondrial dysfunction—major contributors to insulin resistance in ageing³⁸.

Herbs classified under *Rasayana* such as:

- *Ashwagandha Withania somnifera*
- *Amalaki Emblica officinalis*
- *Guduchi Tinospora cordifolia*

have demonstrated antioxidant and metabolic regulatory effects in experimental and clinical studies, suggesting potential benefits in age-associated metabolic decline³⁹

Rasayana in *Prameha* and Insulin Resistance

Prameha, described as a *Kapha–Medo* predominant metabolic disorder, shares pathophysiological similarities with insulin resistance. *Rasayana* therapy plays both preventive and adjunctive therapeutic roles in *Prameha* by:

- Correcting *Agnimandya*
- Reducing *Ama* accumulation
- Improving *Medo dhatu* metabolism
- Restoring *Srotas* integrity
- Enhancing insulin sensitivity

Charaka Samhita describes specific *Rasayana* preparations for *Prameha* that improve tissue metabolism and prevent progression to *Madhumeha*⁴⁰

From an integrative perspective, *Rasayana* therapy may influence insulin resistance in ageing through:

- Reduction of oxidative stress (*Ama*–oxidative stress correlation)
- Improvement of mitochondrial function (*Agni* at cellular level)
- Enhancement of muscle mass and tissue regeneration (*Mamsa dhatu poshana*)
- Modulation of inflammatory pathways (*Pitta shamana*)
- Prevention of *Dhatukshaya* and *Ojakshaya*

Thus, *Rasayana* serves as a bridge between preventive geriatrics and metabolic regulation, offering a promising adjunct in the management of age-related insulin resistance.

Limitations

This narrative and conceptual review provides an integrative perspective on insulin resistance in ageing; however, it is subject to several limitations. Firstly, the correlation between classical Ayurvedic concepts and modern biomedical mechanisms, while systematically attempted, involves a degree of conceptual interpretation due to the distinct epistemologies of these systems. Direct empirical validation for many of these proposed correlations is still nascent and

beyond the scope of this review. Secondly, as a narrative review, this article does not involve a systematic quantitative synthesis of evidence, which may introduce selection bias in the literature presented. Finally, while potential Ayurvedic interventions are highlighted, their clinical efficacy and safety in the context of age-related insulin resistance require rigorous, controlled clinical trials, which were not part of this conceptual exploration. Future research should focus on empirical validation of the integrative framework proposed herein

Conclusion

Ageing is a natural, irreversible, and progressive process associated with structural and functional decline. From both modern and Ayurvedic perspectives, insulin resistance emerges as a key metabolic disturbance in ageing. *Ayurveda* attributes this to *Vata* aggravation, *Agnimandya*, *Dhatu kshaya*, and *Ojakshaya*, while modern science emphasizes changes in body composition, hormonal decline, and oxidative stress. Lifestyle interventions such as dietary regulation, weight management, aerobic and resistance exercise have been shown to improve insulin sensitivity and glucose metabolism in the elderly. *Rasayana* therapy offers a unique preventive and rejuvenative strategy in ageing by enhancing *Agni*, preserving *Ojas*, and preventing *Dhatukshaya*. Its antioxidant, anti-inflammatory, and metabolic regulatory properties may provide a promising adjunctive approach in preventing and managing insulin resistance and *Prameha* in the elderly. Future controlled clinical studies are warranted to validate its role in geriatric metabolic care. Ayurvedic principles further emphasize balancing Tridoshas, strengthening *Agni*, reducing *Ama*, and preserving *Ojas*. An integrative approach combining Ayurvedic wisdom with modern lifestyle and clinical interventions holds promise for preventing insulin resistance, improving metabolic health, and enhancing quality of life in ageing populations. Further clinical research is required to validate Ayurvedic interventions in geriatric metabolic care.

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