

Mechanistic Basis of Yoga-Based Lifestyle Intervention in the Management of Type 2 Diabetes Mellitus: A Narrative Review of Psycho-Neuro-Endocrine and Metabolic Pathways

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Abstract: *Background: Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder with rapidly escalating prevalence in India, where more than 101 million adults are currently estimated to live with diabetes and another 136 million with prediabetes. Pharmacological management addresses hyperglycaemia but does not modify the underlying lifestyle drivers, and is constrained by cost, adherence, and long-term side effects. Yoga-based lifestyle interventions have emerged as a complementary therapeutic strategy with reproducible glycaemic benefit, although the biological mechanisms linking practice to outcome remain incompletely integrated.*

Aim: To synthesise the current mechanistic evidence on how yoga-based interventions influence the pathophysiology of T2DM, focusing on psycho-neuro-endocrine, autonomic, inflammatory, and metabolic pathways.

Methods: A narrative review of peer-reviewed literature published between January 2000 and February 2026 was conducted using PubMed, Google Scholar, and the Cochrane Library. Search terms combined "yoga", "pranayama", "meditation", "type 2 diabetes", "insulin resistance", "HPA axis", "cortisol", "heart rate variability", "inflammation", and "oxidative stress". Studies were prioritised by methodological strength (randomised controlled trials, systematic reviews, meta-analyses) and biological mechanism specificity.

Results: Six interlinked mechanism families emerge from the literature: (i) recalibration of the hypothalamic-pituitary-adrenal (HPA) axis with reduction in circulating cortisol; (ii) shift in sympathovagal balance toward parasympathetic dominance, reflected in improved heart rate variability; (iii) attenuation of chronic low-grade inflammation, with reductions in C-reactive protein, interleukin-6, and tumour necrosis factor- α ; (iv) reduction of systemic oxidative stress; (v) improvement in peripheral insulin sensitivity and skeletal-muscle glucose uptake; and (vi) behavioural changes including mindful eating, treatment adherence, and stress-coping. These pathways are not independent: they converge on stress physiology and metabolic flexibility, providing a coherent mechanistic basis for the glycaemic effects observed in meta-analyses of yoga in T2DM.

Conclusion: Yoga acts on T2DM through several parallel and partially overlapping biological pathways rather than a single mechanism. Future research should prioritise integrated, multi-biomarker studies in well-defined cohorts, with attention to dose, intervention components, and the relative contribution of asana, pranayama, and meditation.

Keywords: type 2 diabetes mellitus; yoga; pranayama; HPA axis; heart rate variability; insulin resistance; inflammation; oxidative stress; mind-body intervention