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# Yogic Lifestyle and Epigenetic Reprogramming: A Promising Preventive Strategy for Lifestyle Disorders

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**Abstract**

Background

Lifestyle disorders—including diabetes, cardiovascular disease, obesity, depression, and autoimmune conditions—are rising rapidly worldwide. Noncommunicable diseases now account for nearly 74% of global deaths, and India alone has 101 million people with diabetes and 29% of adults with hypertension. These disorders are driven not only by genetics but also by epigenetic influences shaped by stress, environment, and lifestyle. Emerging evidence indicates that yoga, comprising asana, pranayama, meditation, and mindful living, influences health at the molecular level through epigenetic mechanisms such as DNA methylation, histone modification, and non-coding RNA regulation.

Objectives

To review and summarize scientific findings on how yoga modulates epigenetic markers and gene expression related to inflammation, oxidative stress, mitochondrial activity, neuroplasticity, telomere biology, and immune function, and to evaluate its potential role in the prevention and management of lifestyle disorders.

Methods

A narrative review of randomized controlled trials, molecular studies, and mechanistic research examining the epigenetic and gene-expression effects of yoga practices. Evidence related to DNA methylation, histone deacetylase (HDAC) activity, cytokine expression, mitochondrial gene regulation, telomerase activity, BDNF levels, and immune pathways was analyzed.

Results

Research shows that yoga:
Decreases HDAC activity and downregulates NF-κB and pro-inflammatory cytokines
Enhances antioxidant gene expression and reduces oxidative stress markers
Improves mitochondrial function and associated gene expression
Increases telomerase activity and brain-derived neurotrophic factor (BDNF) levels
Modulates immune pathways, including improved T-reg and Th17 balance
These findings indicate that yoga produces beneficial epigenetic modifications across multiple physiological systems.

Conclusion
Yoga acts as a multi-modal epigenetic intervention with significant preventive and therapeutic potential for lifestyle disorders. By modulating inflammation, oxidative stress, mitochondrial efficiency, neuroplasticity, telomere maintenance, and immune regulation, yoga emerges as an accessible, cost-effective, non-pharmacological strategy for health promotion and disease prevention.

**Key words**: Yoga, Epigenetics, Gene Expression, DNA Methylation, Histone Modification, Non-coding RNA, Lifestyle Disorders, Inflammation, Mitochondrial Function, BDNF, Telomerase, Immune Modulation.

## Introduction

Lifestyle disorders such as diabetes, heart disease, obesity, depression, and immune problems are increasing rapidly across the world. According to the World Health Organization, noncommunicable diseases (NCDs) now account for nearly 74% of global deaths, making them the leading public health challenge of this century1. Cardiovascular diseases alone cause 17.9 million deaths every year, remaining the top global killer2.

In India, the burden is equally alarming. The ICMR–INDIAB Study (2023) reports that 101 million Indians are living with diabetes, with another 136 million having prediabetes.3 Hypertension has also risen significantly, with about 29% of Indian adults affected, as reported by Gupta et al.4 According to the latest NFHS-5 survey (2021–23), overweight and obesity have doubled in many states, contributing to rising metabolic and cardiovascular risks.5 Mental health conditions are also increasing, with the Global Burden of Disease Study (2021) showing that depression is one of the top contributors to global disability.6 These alarming trends highlight the urgent need for sustainable, preventive health strategies such as yoga.

These conditions develop not only because of our genes, but also because of how our environment, habits, stress levels, and daily lifestyle influence the way our genes behave. This science is known as epigenetics, which means "changes in gene activity without changing the DNA sequence."

Modern research shows that yoga—a holistic system combining movement (asana), breathing (pranayama), meditation, and mindful living—can create positive changes in the body right down to the genetic level. Yoga works like a natural, multi-modal therapy that reduces stress, calms the mind, improves immunity, and brings the body toward balance. These effects are not just physical or psychological; they extend deep into the molecular level through measurable epigenetic modifications.

Studies have shown that regular yoga practice can lower harmful inflammation-related genes, increase protective antioxidant genes, improve mitochondrial function, enhance brain-supporting molecules like BDNF, increase telomerase activity linked to cellular longevity, and regulate immune pathways. In simple terms, yoga helps the body switch on "healing genes" and switch off "stress genes."

Because of these powerful biological effects, yoga is emerging not only as a mind-body practice but also as a promising preventive and therapeutic tool for lifestyle-related disorders. Understanding how yoga influences gene expression helps explain why it improves overall health, emotional balance, and long-term wellbeing.

**Aims and Objectives**

Aim

To evaluate and summarize the epigenetic effects of yoga and its potential role as a preventive strategy for lifestyle-related disorders.

Objectives

1. To explain the key epigenetic mechanisms influenced by yoga.
2. To review scientific evidence showing how yoga modulates DNA methylation, histone modification, and non-coding RNA activity.
3. To identify yoga-induced molecular changes associated with inflammation, oxidative stress, neuroplasticity, mitochondrial function, and immune regulation.
4. To analyze how these epigenetic changes relate to the prevention or improvement of lifestyle disorders such as diabetes, CVD, obesity, depression, and autoimmune diseases.
5. To present a structured summary of relevant clinical trials and molecular studies.

Methodology and Search strategy

This review follows a narrative review methodology with structured steps for identification, screening, eligibility, and inclusion of literature related to yoga and epigenetics.

Databases Searched

Pubmed, Google scholar, Scopus, Web of science

Search Approach

1. Identification of peer-reviewed articles related to yoga interventions and epigenetic outcomes.
2. Screening titles and abstracts for relevance to genetic, molecular, or biochemical effects of yoga.
3. Selection of randomized controlled trials (RCTs), controlled studies, comparative studies, and meta-analyses.
4. Extraction of data on epigenetic endpoints such as DNA methylation, histone modification, cytokine gene expression, telomerase activity, BDNF levels, mitochondrial gene expression, and immune markers.

**Inclusion criteria**

1. Peer-reviewed publications.
2. Interventions exclusively involving yoga, pranayama, meditation, or relaxation response based on yogic practices.
3. Studies reporting molecular or epigenetic outcomes, such as DNA methylation, Histone modifications, MicroRNA changes, Cytokine gene expression, Telomerase activity, BDNF levels, Mitochondrial gene expression, Immune gene regulation

**Exclusion criteria**

1. Studies involving non-yogic interventions
2. Animal or in-vitro studies.
3. Articles without molecular or genetic outcomes.

**Epigenetic mechanisms**

Epigenetics is the study of changes in gene expression or cellular function that occur without altering the DNA sequence itself. These changes are influenced by environment, lifestyle, and experiences, and may be inherited across generations. The primary mechanisms include DNA methylation, histone modifications, and non-coding RNAs.7

DNA methylation: Addition of a methyl group to the cytosine base within CpG dinucleotides forms 5-methylcytosine. This modification is typically associated with gene suppression, whereas removal of methyl groups (demethylation) is linked with gene activation.7

Histone modification: Histones, proteins around which DNA is wrapped, undergo post-translational modifications (PTMs) such as acetylation, methylation, phosphorylation, ubiquitination, and sumoylation. These modifications alter chromatin structure and regulate the accessibility of transcriptional

machinery, thereby influencing gene expression.8

Non-coding RNAs: MicroRNAs and long non-coding RNAs regulate gene expression at transcriptional and post-transcriptional levels. They can modulate chromatin structure, recruit epigenetic modifiers, and affect mRNA stability and translation.9

Yoga as a multi modal epigenetic intervention

Yoga functions as a complex lifestyle-based biological intervention composed of coordinated physical, respiratory, cognitive, and behavioral elements. Unlike single-target pharmacological treatments, yoga produces multi-system, multi-gene regulatory effects. Scientific studies consistently show that even short-term practice can produce measurable molecular changes.

Epigenetic evidence

1. Reduction in HDAC Levels and Pro-Inflammatory Genes

Evidence:

Kaliman et al. (2013), in an experimental study involving 19 experienced meditators who practiced mindfulness meditation for eight hours, reported a significant decrease in HDAC levels accompanied by a reduction in major pro-inflammatory genes, specifically IL-6 and TNF-α ($p < 0.05$).10

Implication:

These findings suggest that even short-term meditation can induce rapid epigenetic changes that suppress inflammation and promote a protective molecular profile.

2. Increase in Telomerase Activity and Reduction in Depressive Symptoms

Evidence:

Lavretsky et al. (2013), in a randomized controlled trial on 39 high-stress dementia caregivers practicing Kirtan Kriya meditation for 12 minutes daily over eight weeks, demonstrated a 43% increase in telomerase activity ($p = 0.038$) along with a reduction in depressive symptoms.11

Implication:

This shows that yogic meditation enhances cellular longevity mechanisms while simultaneously improving psychological health.

3. Downregulation of NF-κB and Upregulation of Mitochondrial Genes

Evidence:

Bhasin et al. (2013), in a comparative study with 26 healthy adults practicing the Relaxation Response for 20 minutes daily over eight weeks, observed downregulation of NF-κB-related inflammatory genes and upregulation of mitochondrial genes ($p < 0.05$).12

Implication:

This indicates that yoga-based relaxation practices can simultaneously reduce inflammation and strengthen mitochondrial function.

4. Reduction in Pro-Inflammatory Genes and Increase in Antioxidant Genes

Evidence:

Bhaskar et al. (2023), in a randomized controlled trial involving 97 healthy participants practicing Sudarshan Kriya Yoga and an Advanced Meditation Program over four days, reported significant reductions in pro-inflammatory gene expression and increases in antioxidant genes ($p < 0.001$).13

Implication:

These results highlight the rapid epigenetic benefits of yogic breathing in enhancing antioxidant defense and reducing inflammatory load.

5. Large-Scale Gene Expression Changes and Reduced Stress Pathway Activation

Evidence:

Dusek et al. (2008), in a gene-expression profiling study of 35 participants practicing the Relaxation Response for eight or more weeks, documented altered expression in

2,209 genes with clear reductions in stress-related pathway activation ($p < 0.01$).14
Implication:
This demonstrates that long-term yoga-based relaxation practices produce extensive genome-wide epigenetic changes favoring stress resilience.

6. Increase in BDNF Levels
Evidence:
Gomutbutra et al. (2020), through a meta-analysis of 11 randomized controlled trials involving 479 participants practicing mindfulness-based therapy, observed a significant increase in BDNF levels ($p < 0.001$).15
Implication:
This indicates that yoga-related meditative practices enhance neuroplasticity and cognitive-emotional regulation at the molecular level.

7. Reduction in IL-6, TNF-α and DNA Methylation Changes
Evidence:
Harkess et al. (2016), in a pre-post feasibility study on approximately 30–40 stressed women undergoing four weeks of brief yoga combining asana, breathing, and meditation, reported reductions in IL-6 and TNF-α along with DNA methylation changes in stress-related genes such as NR3C1 and FKBP5 ($p < 0.05$).16
Implication:
These findings support the role of yoga in regulating inflammatory cytokines and modulating stress-related gene methylation.

8. Increase in Treg Cells and Reduction in Immune Aging Markers
Evidence:
Gautam et al. (2023), in a randomized controlled trial involving 66 rheumatoid arthritis patients who participated in eight weeks of yoga therapy, found increases in Treg cells, reductions in Th17 levels, decrease in T-cell aging markers, and suppression of HDAC1 ($p < 0.05$).17
Implication:
This shows that yoga modulates immune pathways and can reverse molecular markers associated with immune aging.

Table: Showing epigenetic effects of yoga and meditation: Summary of Clinical and Experimental Studies

| Study (Author) | Sample size & Study design | Intervention | Outcomes (Main epigenetic effect) | P Value | Significant? |
|---|---|---|---|---|---|
| Kaliman et al., 2013 | 19 experienced meditators, experimental study | Mindfulness meditation (8 hours) | ↓ HDAC levels ↓ pro-inflammatory genes (IL-6, TNF-α) | <0.05 | Yes |
| Lavretsky et al., 2013 | 39 high stress dementia caregivers, RCT | Kirtan Kriya meditation (12 min/day, 8 weeks) | ↑ Telomerase activity (43%), ↓ depressive symptoms | 0.038 | Yes |
| Bhasin et al., 2013 | 26 healthy adults, | Relaxation response (20 | ↓ NF-κB inflammatory genes; | <0.05 | Yes |

| | | | | | |
|---|---|---|---|---|---|
| | comparative study | min/day, 8 weeks) | ↑ mitochondrial genes | | |
| Bhaskar et al., 2023 | 97 healthy participants, RCT | Sudarshan Kriya Yoga & Advanced Meditation Program (4 days) | ↓Pro-inflammatory genes; ↑ antioxidant genes | <0.001 | Yes |
| Dusek et al., 2008 | 35 participants (16 RR, 19 controls); gene expression profiling study | Long-term Relaxation Response (≥8 weeks) | Altered expression in 2,209 genes; ↓ stress pathway activation | <0.01 | Yes |
| Gomutbutra et al., 2020 | Meta-analysis (11 RCTs), 479 participants | Mindfulness-Based Therapy | ↑ BDNF levels | <0.001 | Yes |
| Harkess et al., 2016 | ~30–40 stressed women; pre-post feasibility study | Brief yoga (asana + breathing + meditation, ~4 weeks) | ↓ IL-6, TNF-α; DNA methylation changes in NR3C1, FKBP5 | <0.05 | Yes |
| Gautam et al., 2023 | 66 RA (Rheumatoid arthritis) patients; RCT | Yoga therapy (8 weeks) | ↓ Th17, ↑ Treg cells; ↓ T cell aging; HDAC1 suppression | <0.05 | Yes |

**Epigenetic Impact of Yoga on Specific Lifestyle Disorders**

Yoga's epigenetic effects—including downregulation of inflammatory cytokines, improved antioxidant and mitochondrial gene expression, enhanced neurotrophic signaling, beneficial DNA methylation changes, and improved immune regulation—relate directly to the pathophysiology of multiple lifestyle disorders. The following subsections provide disease-specific interpretations.

3.1 Diabetes and Metabolic Syndrome

Yoga influences genes to behave in a positive way, helping the body work more efficiently. It reduces the activity of genes that promote inflammation, increases the action of genes that produce protective antioxidants, decreases harmful HDAC activity, and improves the function of mitochondria—the cell's energy centers. Because of these changes, the body experiences less long-term inflammation and oxidative stress, and its cells produce and use energy better. Clinical trials also show that yoga improves blood sugar levels and other metabolic markers in people with type 2 diabetes.18 Altogether, this creates a healthier internal environment

that improves insulin sensitivity, protects the insulin-producing β-cells in the pancreas, and supports better overall metabolic health.

3.2 Cardiovascular diseases (CVD)
Yoga helps calm down NF-κB and other genes that normally increase inflammation. At the same time, it improves the activity of genes that support healthy mitochondria and balances the autonomic nervous system. These changes reduce stress on blood vessels, lower oxidative damage, and decrease the overactive "fight-or-flight" response — all of which are major causes of atherosclerosis, high blood pressure, and heart problems. Clinical evidence confirms yoga lowers blood pressure and cardiovascular risk.19 Together, these epigenetic and physical improvements lead to better heart health, lower cardiovascular risk, and overall better functional capacity.

3.3 Obesity
Obesity involves long-term, low-grade inflammation, more oxidative stress, and difficulty switching between different energy sources. Yoga helps change gene activity in a way that reduces inflammation, boosts the body's natural antioxidant defenses, and improves how mitochondria (the cell's energy centers) work. These changes lower overall inflammation and help cells use energy more efficiently. As a result, fat cells function more normally, metabolic stress decreases, and yoga can support healthier weight management.

3.4 Depression, Neurodegenerative and Psychological Disorders
Yoga increases helpful brain-supporting molecules like BDNF, boosts telomerase activity (which protects cells from aging), and positively influences stress-related gene activity. These changes make brain cells stronger, improve how well nerve connections form, and help the body regulate its stress system (the HPA axis) more smoothly. Together, these brain-protective and gene-level effects explain why yoga often helps reduce symptoms of depression and anxiety and these neuro-epigenetic changes underlie many of yoga's clinically observed antidepressant and anxiolytic benefits.20

3.5 Immune and Autoimmune Disorders
Yoga helps rebalance the immune system by increasing T-reg cells (which calm the immune response) and reducing Th17 cells (which promote inflammation). It also lowers the activity of inflammatory genes, decreases HDAC1 activity, and slows age-related decline in immune function. These changes help the immune system stay more stable, restore healthy immune tolerance, and reduce the overactive immune responses seen in autoimmune conditions. Clinical RCTs also confirm that yoga improves important immune markers in autoimmune diseases, supporting these benefits.17

**Conclusion**
Yoga is much more than physical exercise. Modern research shows that it can influence the body at a deep biological level by changing how our genes behave. Through mechanisms such as DNA methylation, histone modification, and regulation of non-coding RNAs, yoga helps reduce inflammation, improve antioxidant activity, strengthen mitochondrial function, support brain health, and balance the immune system. These epigenetic changes explain why regular practice of asana, pranayama, and meditation is linked with better physical, mental, and emotional wellbeing.
The scientific evidence reviewed in this article shows that yoga acts as a powerful, multi-dimensional tool for preventing and managing lifestyle disorders such as diabetes, heart disease, obesity, depression, and autoimmune conditions. Because yoga is safe, accessible, low-cost, and adaptable for all age groups, it offers a practical solution for improving long-term health. Understanding yoga's epigenetic effects

highlights its value not only as a wellness practice but also as an important preventive strategy in modern healthcare.

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Conflicts of interest
There are no conflicts of interest.

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