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Mindfulness and Yogic Movement in Autoimmune Pathophysiology

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Abstract

Autoimmune diseases are complex disorders characterized by abnormal immune responses against the body's own tissues. Their development and progression involve genetic susceptibility, environmental influences, immune dysregulation, chronic inflammation, oxidative stress and neuroendocrine abnormalities. Increasing attention has been directed towards mind-body interventions, particularly mindfulness and yoga, as complementary approaches to improving psychological well-being and potentially influencing immune and inflammatory pathways.

Objective: To review scientific evidence regarding the potential effects of mindfulness practices and yogic movement on autoimmune pathophysiology, with emphasis on stress regulation, neuroendocrine mechanisms, inflammatory cytokines, immune responses and quality of life.

Methods: This narrative review discusses scientific literature on autoimmune pathophysiology, mindfulness-based interventions, yoga therapy, stress physiology and immune-inflammatory regulation. Evidence from systematic reviews, randomized controlled trials, clinical studies and mechanistic research is considered.

Results: Available research suggests that mindfulness and yoga may influence physiological pathways associated with stress and inflammation, including hypothalamic-pituitary-adrenal axis activity, autonomic nervous system regulation and inflammatory signalling. Studies have reported improvements in fatigue, psychological distress, depressive symptoms and quality of life among individuals with selected autoimmune conditions. Some investigations have also reported changes in inflammatory biomarkers such as interleukin-6 (IL-6), tumour necrosis factor-alpha (TNF-α) and C-reactive protein (CRP). However, findings are inconsistent, and evidence does not establish that these practices reverse autoimmunity or directly prevent autoimmune disease progression.

Conclusion: Mindfulness and yogic movement represent promising complementary approaches for supporting psychological well-being, physical functioning and stress management in individuals with autoimmune disorders. Further high-quality clinical research is necessary to establish their immunological effects and long-term therapeutic value.

Keywords

Autoimmune diseases; mindfulness; yoga therapy; yogic movement; inflammation; immune regulation; cytokines; oxidative stress; neuroendocrine system.

1. Introduction

The immune system protects the body against infectious organisms, foreign antigens and abnormal cells. Under normal physiological conditions, immune responses are regulated through interactions between innate and adaptive immunity, ensuring that protective responses do not damage healthy tissues.

Autoimmune diseases develop when immune tolerance is impaired, resulting in immune responses directed against self-antigens.

Autoimmune disorders include rheumatoid arthritis, systemic lupus erythematosus, multiple sclerosis, autoimmune thyroid disorders, type 1 diabetes mellitus and inflammatory bowel diseases. These conditions differ in their clinical manifestations and affected organs but share underlying mechanisms such as autoreactive lymphocytes, autoantibody production, inflammatory cytokines and tissue injury.

The development of autoimmunity is multifactorial. Genetic predisposition, environmental exposures, infections, hormonal influences, alterations in the intestinal microbiome and psychological stress may contribute to disease susceptibility and progression. Chronic stress can influence communication between the nervous, endocrine and immune systems, potentially modifying inflammatory responses.

Mindfulness is a psychological practice involving present-moment awareness, attention regulation and non-judgmental observation of thoughts and sensations. Yoga is a traditional mind-body discipline integrating physical postures, breathing techniques, relaxation and meditation. These practices have attracted scientific interest because they may influence stress-related physiological mechanisms and improve health-related quality of life.

Recent reviews have examined yoga interventions in autoimmune disorders. A 2025 systematic review by Baishya and colleagues included randomized controlled trials across several autoimmune-related conditions and reported potential improvements in selected outcomes, although the strength of evidence varied. This review examines plausible mechanisms and clinical findings while distinguishing supportive care outcomes from disease-modifying effects.

2. Overview of Autoimmune Pathophysiology

2.1 Loss of immune tolerance. Immune tolerance refers to mechanisms through which the immune system distinguishes self-antigens from foreign antigens. Central tolerance occurs during lymphocyte development in the thymus and bone marrow, while peripheral tolerance regulates potentially autoreactive cells outside these organs. Failure of these mechanisms may allow autoreactive T and B lymphocytes to survive and become activated.

2.2 Role of T lymphocytes and B lymphocytes. T lymphocytes participate in cellular immune responses and regulate inflammation. CD4-positive T-helper cells, particularly Th1 and Th17 subsets, contribute to inflammatory processes through cytokine production. Regulatory T cells (Tregs) help maintain immune tolerance and suppress excessive immune activation. B lymphocytes contribute through antibody production, antigen presentation and cytokine secretion. In certain autoimmune conditions, autoantibodies target cellular or tissue components and contribute to disease manifestations.

2.3 Inflammatory cytokines. Cytokines are signalling molecules that coordinate immune responses. Excessive or prolonged production contributes to chronic inflammation. Important mediators include IL-1β, IL-6, TNF-α, IL-17 and interferon-gamma. Regulatory mediators, including IL-10 and transforming growth factor-beta (TGF-β), help control immune activity. The balance between inflammatory and regulatory signalling is important for immune homeostasis.

2.4 Oxidative stress. Oxidative stress occurs when reactive oxygen species exceed the antioxidant defence capacity of the body. Excessive oxidative stress can damage cellular structures, modify proteins and lipids, and influence inflammatory signalling pathways. It has been implicated in several autoimmune conditions, including rheumatoid arthritis and systemic lupus erythematosus.

2.5 Neuroendocrine and immune interactions. The nervous, endocrine and immune systems communicate through hormonal and neural signalling pathways. The hypothalamic-pituitary-adrenal (HPA) axis and autonomic nervous system are particularly important in stress responses. Prolonged psychological stress may alter cortisol secretion, sympathetic activity and inflammatory regulation. These relationships vary across autoimmune conditions; stress should not be considered the sole cause of autoimmune disease.

3. Mindfulness and Its Physiological Mechanisms

Mindfulness involves consciously directing attention towards present experiences without excessive judgment or emotional reactivity. Common approaches include mindfulness-based stress reduction (MBSR), mindfulness-based cognitive therapy (MBCT) and mindful breathing practices.

3.1 Regulation of psychological stress. Individuals living with autoimmune disorders may experience persistent stress associated with pain, fatigue, functional limitations and uncertainty about disease progression. Mindfulness may improve emotional regulation and reduce perceived stress by encouraging awareness of thoughts, sensations and emotional responses. Reduced perceived stress may indirectly influence physiological stress responses, although the extent to which this produces measurable changes in autoimmune activity remains uncertain.

3.2 Hypothalamic-pituitary-adrenal axis. The HPA axis is an important neuroendocrine system involved in responses to psychological and physiological stress. During stress, the hypothalamus releases corticotropin-releasing hormone, stimulating the anterior pituitary to release adrenocorticotropic hormone. This subsequently stimulates cortisol secretion from the adrenal cortex. Cortisol influences glucose metabolism, immune-cell activity and inflammatory signalling. Mindfulness interventions have been investigated for possible effects on cortisol regulation and HPA-axis activity, but findings are variable.

3.3 Autonomic nervous system regulation. The autonomic nervous system consists of sympathetic and parasympathetic divisions. Sympathetic activation supports the stress response, whereas parasympathetic activity contributes to recovery and physiological regulation. Mindful breathing and meditation may influence autonomic activity through changes in breathing patterns, attention and relaxation. Heart-rate variability (HRV) is frequently investigated as a non-invasive indicator of cardiac autonomic regulation. Some studies suggest that mind-body practices may improve HRV, although the relationship between HRV changes and autoimmune disease activity requires further investigation.

3.4 Mindfulness and inflammatory signalling. Psychological stress and inflammatory processes interact through several molecular pathways. Nuclear factor kappa B (NF-κB) is an important transcription factor regulating genes associated with inflammation. Mindfulness interventions have been investigated for possible effects on inflammatory gene expression and circulating biomarkers. Results vary according to intervention duration, participant characteristics and measurement methods.

4. Yogic Movement and Immune System Regulation

Yoga combines physical movement, breathing, relaxation and meditation. Different forms include Hatha yoga, restorative yoga, Iyengar yoga and gentle therapeutic yoga. Yogic movement may support people with chronic autoimmune disorders through physical conditioning, improved mobility, relaxation and psychological support.

4.1 Asana and physical functioning. Asanas are physical postures performed with awareness of breathing and body alignment. Gentle, appropriately modified postures may support joint mobility,

flexibility, balance and muscular endurance. In rheumatoid arthritis, supervised and adapted movement may help maintain functional capacity. In multiple sclerosis, appropriately selected yoga practices have been investigated for balance, fatigue and mobility. Intensity should be adjusted according to symptoms, joint involvement and physical limitations.

4.2 Pranayama and respiratory regulation. Pranayama refers to the regulation of breathing through controlled respiratory techniques. Slow and comfortable breathing may influence autonomic activity, respiratory efficiency and perceived stress. Examples include Nadi Shodhana (alternate-nostril breathing), Bhramari (humming-bee breathing), gentle diaphragmatic breathing and relaxed awareness of natural respiration. These practices may support relaxation and emotional regulation; direct evidence that individual techniques modify autoimmune disease mechanisms remains limited.

4.3 Meditation and relaxation. Meditation and relaxation practices encourage focused attention and reduced psychological reactivity. Yoga Nidra and guided relaxation may support sleep quality, stress management and emotional well-being. These outcomes are relevant because disturbed sleep and psychological distress commonly accompany chronic inflammatory conditions.

4.4 Combined effects of yogic practices. The combined practice of asana, pranayama and meditation may influence multiple physiological systems simultaneously. Physical activity may improve functional capacity, while breathing and meditation may support stress regulation. It is difficult to determine which component produces a particular effect because many clinical studies use multicomponent yoga interventions.

5. Interaction Between Mindfulness, Yoga and Inflammatory Pathways

Mindfulness and yoga have been investigated for their potential influence on inflammatory pathways through neuroendocrine, autonomic and behavioural mechanisms.

5.1 Interleukin-6. IL-6 is a cytokine involved in immune regulation and inflammatory responses. Elevated IL-6 has been observed in several inflammatory and autoimmune conditions. Some yoga intervention studies have reported reductions in IL-6. A 2024 systematic review and meta-analysis by Mishra and colleagues evaluated studies investigating yoga and inflammatory biomarkers. Although individual studies reported favourable changes, pooled findings for important biomarkers were not consistently conclusive.

5.2 Tumour necrosis factor-alpha. TNF-α is a pro-inflammatory cytokine involved in inflammatory cell recruitment and tissue damage. It plays an important role in rheumatoid arthritis and other immune-mediated disorders. Yoga interventions have been examined for potential influence on TNF-α. Findings are inconsistent and do not establish yoga as a treatment for TNF-mediated autoimmune disease.

5.3 C-reactive protein. CRP is an acute-phase protein produced primarily by the liver in response to inflammatory signalling, particularly IL-6. It is frequently used as a systemic inflammatory marker. Some studies have reported reductions following yoga-based interventions, although differences in populations, protocols and study quality limit interpretation.

5.4 Regulatory immune responses. IL-10 and TGF-β are involved in immune regulation and maintenance of immune tolerance. Their roles are complex and depend on cellular and disease context. Research has investigated whether mind-body interventions influence regulatory immune responses; evidence regarding consistent improvements in Treg function or restoration of immune tolerance remains insufficient.

5.5 Oxidative stress and antioxidant defence. Physical activity and stress-management practices may influence oxidative stress through changes in metabolic and physiological processes. Yoga has been studied for potential effects on antioxidant enzymes and oxidative stress markers. Direct evidence demonstrating that yoga prevents autoimmune tissue damage through antioxidant mechanisms is limited.

6. Clinical Evidence in Autoimmune Disorders

6.1 Rheumatoid arthritis. Rheumatoid arthritis is a chronic autoimmune inflammatory disease primarily affecting synovial joints. It involves inflammatory cytokines, immune-cell activation and progressive joint damage. Yoga has been investigated as an adjunctive intervention for physical function, psychological health and inflammatory outcomes. Clinical studies have reported improvements in selected measures of disease activity, depressive symptoms and inflammatory markers. Yoga should be adapted to joint condition and disease activity and should not replace disease-modifying antirheumatic drugs or prescribed treatment.

6.2 Multiple sclerosis. Multiple sclerosis is an immune-mediated neurological disorder characterized by inflammation and damage involving myelin and the central nervous system. People with multiple sclerosis may experience fatigue, balance disturbances, mobility limitations and psychological distress. Yoga interventions have been studied for fatigue, balance, mood and quality of life. Existing evidence suggests potential improvements in selected functional and psychological outcomes.

6.3 Systemic lupus erythematosus. Systemic lupus erythematosus is a multisystem autoimmune disease characterized by autoantibody production, immune-complex formation and inflammatory tissue injury. Mindfulness may help patients manage stress, emotional distress and illness-related challenges. However, evidence demonstrating direct improvement in lupus disease activity through mindfulness or yoga remains limited.

6.4 Inflammatory bowel disease. Inflammatory bowel disease includes Crohn's disease and ulcerative colitis. These conditions involve dysregulated intestinal immune responses and chronic inflammation. Yoga and mindfulness have been investigated for potential improvements in stress, anxiety, sleep and quality of life. Their role in controlling intestinal inflammation or inducing clinical remission remains uncertain.

6.5 Ankylosing spondylitis. Ankylosing spondylitis is a chronic inflammatory rheumatic disease that primarily affects the axial skeleton and sacroiliac joints. Appropriately modified yoga-based movement may support spinal mobility, flexibility, posture and physical functioning. Clinical research has reported promising findings for selected outcomes, although larger controlled trials are required.

7. Potential Mechanistic Framework

The possible relationship between mindfulness, yoga and immune regulation can be understood through interconnected physiological pathways:

Mindfulness and yoga-based stress management → possible modulation of HPA-axis activity and autonomic regulation → changes in stress-related hormonal and neural signalling → potential influence on inflammatory signalling pathways → possible changes in selected inflammatory biomarkers → improvement in psychological well-being, fatigue and physical functioning.

This framework represents a proposed mechanism rather than a proven sequence of events. Changes in biomarkers do not necessarily indicate improved immune tolerance or reduced autoimmune tissue damage.

8. Discussion

Available literature indicates that mindfulness and yogic movement may offer complementary benefits for individuals with autoimmune disorders. Their potential value is related to interactions between psychological stress, neuroendocrine activity, autonomic regulation and immune-inflammatory pathways. The strongest clinical evidence currently concerns improvements in psychological well-being, fatigue, balance and quality of life rather than reversal of autoimmune pathology.

A 2025 systematic review by Baishya and colleagues examined randomized controlled trials across multiple autoimmune-related conditions and identified positive findings for selected outcomes. A 2024 systematic review and meta-analysis by Mishra and colleagues examined yoga and inflammatory biomarkers. Although many individual studies reported favourable results, the overall evidence was limited by heterogeneity and risk of bias.

Mindfulness may contribute to improved emotional regulation and coping. This is important because chronic illness can affect sleep, social participation, daily functioning and psychological health. Nevertheless, studies frequently involve small samples, short intervention periods, different yoga protocols and inconsistent biomarker measurements. The effects of physical activity, breathing, meditation and social interaction are also difficult to separate.

Future studies should include larger randomized controlled trials, standardized intervention protocols, validated autoimmune disease activity measures and longer follow-up periods.

9. Limitations and Future Research

Current research has several limitations: (1) many clinical trials involve small participant groups; (2) yoga interventions differ in duration, frequency and technique; (3) biomarker measurements are inconsistent; (4) long-term effects on autoimmune disease progression are not well established; (5) mindfulness and yogic movement are frequently combined, making their independent effects difficult to determine; and (6) disease-specific differences limit generalization.

Future investigations should examine the relationship between mindfulness, yoga and immune regulation using standardized measures of IL-6, TNF-α, CRP, IL-10, cortisol, HRV and disease-specific clinical outcomes. Research should also investigate whether improvements in stress, sleep and physical functioning are associated with meaningful changes in disease activity.

10. Conclusion

Mindfulness and yogic movement are promising complementary approaches for supporting individuals living with autoimmune disorders. Their potential benefits include improved psychological well-being, stress management, physical functioning, fatigue and quality of life. Emerging research suggests that these practices may influence neuroendocrine regulation and selected inflammatory pathways. However, evidence regarding direct immune modulation and long-term changes in autoimmune disease activity remains inconclusive.

Mindfulness and yoga may be incorporated into individualized supportive-care programmes under appropriate professional guidance. They should be used alongside, rather than instead of, conventional medical treatment. Further well-designed clinical studies are required to establish their specific immunological mechanisms and therapeutic effectiveness.

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