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A COMPREHENSIVE REVIEW OF NEUROBIOLOGICAL MECHANISMS DRIVING THE EFFECTS OF YOGA ON MENTAL HEALTH

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ABSTRACT

Yoga has been found to promote positive changes in brain function strengthening areas that help regulate emotions and decision-making while also improving the balance of chemicals that contribute to mood stability. The practice encourages relaxation and helps the body shift into a calmer state reducing stress and anxiety through mindful breathing and exercises. Additionally, yoga supports the body's natural ability to manage stress by lowering excessive levels of stress hormones and fostering a more balanced physiological response. It also plays a key role in sharpening mental focus and breaking cycles of negative thought patterns helping individuals develop greater clarity and emotional resilience. The benefits of yoga extend to various mental health conditions that include anxiety, depression, and trauma-related disorders providing an accessible and holistic approach to psychological well-being. Furthermore, yoga's influence on brain health contributes to long-term emotional stability, supporting mental clarity and helping maintain cognitive sharpness over time. This study explores the growing understanding of how yoga influences mental health and the underlying mechanisms that explain how yoga enhances emotional well-being, cognitive function, and is effective in overall stress management. The interconnected effects of yoga on multiple neurobiological systems suggest its utility in preventive mental health care, facilitating emotional stability, stress adaptability, and optimized cognitive performance.

Keywords: Contemplative Neuroscience, Emotional Resilience, Meditation, Mental Health, Yoga

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1. INTRODUCTION TO YOGA AND MENTAL HEALTH

Yoga has long been acknowledged as an effective practice that improves mental and physical health. Yoga has its roots in the ancient Indian tradition and uses a variety of methods, such as physical postures, breathing exercises, and meditation. The idea that yoga provides significant mental health benefits and is a useful adjunct to psychological and emotional well-being has gained more and more scientific backing over time (Hendriks et al., 2017). The ability of yoga to reduce stress is one of the main ways it affects mental health. Chronic stress has become a widespread problem that impacts millions of people worldwide in today's fast-paced world, resulting in anxiety, depression, and a variety of psychosomatic disorders. Yoga promotes relaxation by stimulating the parasympathetic nervous system which restricts the stress reaction of the body (Kumari et al., 2024). Breathing techniques in yoga such as Pranayama promote oxygen intake and have an impact on the autonomic nervous system which lowers cortisol levels which is the main stress

hormone (Udupa and Sathyaprabha, 2018). As a result, practitioners frequently report feeling more at ease and peaceful which helps to lessen the symptoms of anxiety and stress. Additionally, yoga is essential for enhancing emotional stability and resilience. Regular practitioners of yoga have noted improved emotional intelligence and mood regulation (Joseph et al., 2019). The meditative elements of yoga such as mindfulness and concentration exercises promote self-awareness and a better capacity to manage unpleasant emotions.

Studies have shown that individuals engaging in yoga experience reduced symptoms of depression owing to the role of yoga exercises in enhancing dopamine and serotonin levels which are neurotransmitters associated with pleasure and happiness (Padmavathi et al., 2023; Bhatt et al., 2024). Furthermore, yoga encourages cognitive flexibility allowing individuals to shift their perspectives and develop a positive outlook on life. Beyond mood regulation, yoga has been instrumental in addressing various mental health disorders. Yoga is often integrated into treatment plans for conditions such as post-traumatic stress disorder (PTSD), bipolar disorder and schizophrenia (Sathyanarayanan et al., 2019). Research has demonstrated that yoga-based interventions can reduce intrusive thoughts, enhance cognitive function, and improve sleep quality among individuals suffering from psychiatric conditions (Varambally et al., 2016). The physical postures in yoga, known as asanas, promote neuroplasticity and increase brain-derived neurotrophic factor (BDNF) which supports mental clarity and neural regeneration (Gangenahalli et al., 2024). Consequently, yoga aids in memory retention and enhances overall cognitive function. Additionally, yoga fosters a strong mind-body connection, which is essential for holistic mental health (Barua, 2025). Many psychological issues stem from a disconnection between physical sensations and emotional states. Through yoga, practitioners learn to attune themselves to bodily cues that helps in improved self-regulation. This heightened awareness leads to healthier responses to stressors and prevents emotional reactivity promoting mindfulness and active living.

The cultivation of bodily awareness through yoga has shown significant benefits in individuals suffering from various disorders, addiction, and obsessive-compulsive disorder (OCD), as it strengthens self-control and promotes self-acceptance. Besides, human connection has been demonstrated to be a critical factor in mental well-being and yoga facilitates opportunities for social engagement while encouraging compassion and empathy. Moreover, the philosophy embedded within yoga emphasizes self-compassion and non-judgmental acceptance which are essential in fostering healthy relationships with oneself and others. In conclusion, yoga offers a multifaceted approach to mental health by reducing stress, regulating mood, improving cognitive function, enhancing emotional resilience, and strengthening the mind-body connection. Its ability to integrate physical movement with mindfulness and meditation makes it a unique and effective method for psychological well-being.

2. HISTORICAL EVOLUTION OF YOGA AS A MIND-BODY PRACTICE

Yoga started in ancient India as a deep spiritual practice and over time it grew into a full system that includes both mental and physical health. The Vedas, a collection of sacred texts written between 1500 and 500 BCE, are some of the earliest texts that mention yoga. They mostly talk about rituals, hymns, and philosophical ideas. At this time, yoga wasn't yet a structured physical discipline. Instead, it was closely linked to meditation and spiritual growth, with the goal of bringing the mind and consciousness together with divine power (Pradhan, 2015). As Indian philosophy evolved, the Upanishads talked about the metaphysical parts of yoga in more depth. These texts emphasized introspection and the pursuit of self-knowledge laying the foundation for the meditative and contemplative dimensions of yoga. The Bhagavad Gita, written around the 5th to 2nd century BCE further refined these ideas, presenting yoga as a means of attaining liberation through disciplined action, devotion and knowledge (Muralikrishna, 2019). This text classified yoga into different paths, including Bhakti Yoga (devotion), Karma Yoga (selfless action), and Jnana Yoga (wisdom). The classical phase of yoga was significantly shaped by the seminal work of Patanjali whose Yoga Sutras composed around the 2nd century CE systematized yoga into an eight-limbed path known as Ashtanga Yoga (Rathore, 2023). This structure delineated ethical principles, physical postures (asanas), breath control (pranayama), concentration techniques, and meditative absorption, thereby establishing yoga as a comprehensive mind-body discipline. The emphasis of Patanjali on mental discipline and self-regulation positioned yoga as not merely a spiritual practice but also a psychological tool for achieving inner balance and emotional resilience. During the medieval period, yoga underwent further transformation with the emergence of Hatha Yoga, a system that integrated physical postures, breath control, and purification techniques to prepare the body for deeper states of meditation (Diamond and Aitken, 2013). Hatha Yoga, as described in texts like the Hatha Yoga Pradipika (15th century CE) and Gheranda Samhita (17th century CE) placed a stronger emphasis on bodily control, marking a significant departure from earlier philosophical traditions that were

primarily meditative in nature. This shift played a crucial role in popularizing yoga as a practical method for achieving holistic health, integrating both physiological and psychological dimensions. The modern era of yoga began in the late 19th and early 20th centuries, as Indian yogis such as Swami Vivekananda introduced yogic philosophy to the West (Pradhan, 2015). Vivekananda's efforts in disseminating Raja Yoga, which focused on mental discipline and meditation, helped bridge Eastern and Western thought, making yoga more accessible to global audiences. Subsequently, yoga masters like Tirumalai Krishnamacharya pioneered a revival of Hatha Yoga, blending traditional techniques with modern physical training methodologies. His students, including B.K.S. Iyengar, Pattabhi Jois, and Indra Devi, contributed to the international proliferation of yoga by emphasizing its therapeutic and health-related benefits (Singh et al., 2023).

In contemporary society, yoga has evolved into a mainstream mind-body practice recognized for its ability to enhance physical fitness, reduce stress, and improve mental health. Scientific research has validated many of the traditional claims of yoga demonstrating its efficacy in modulating neurochemical processes, enhancing cognitive function, and promoting emotional resilience. The integration of mindfulness-based approaches, such as Yoga Therapy and Trauma-Informed Yoga, has further broadened its scope making it an essential component of holistic healthcare. Yoga has remained a dynamic and adaptive discipline throughout its historical evolution continually reshaping itself to align with cultural and scientific advancements. From its origins as a spiritual pursuit to its contemporary role as a therapeutic practice, yoga exemplifies the intricate interplay between mind and body reaffirming its significance as a timeless method for achieving personal well-being and psychological harmony.

3. MENTAL HEALTH BENEFITS ASSOCIATED WITH YOGA

Yoga has gained widespread recognition as a holistic approach to mental well-being, supported by both ancient traditions and contemporary scientific research. The practice encompasses physical postures, breath regulation, and meditation, all of which contribute to psychological resilience and emotional stability. The impact of yoga on mental health is deeply rooted in its ability to regulate neurobiological mechanisms, reduce stress, and enhance cognitive functioning (Voss et al., 2023). One of the most significant mental health benefits associated with yoga is its ability to reduce stress and anxiety. Chronic stress leads to heightened levels of cortisol which can contribute to mood disorders and physical health issues. Yoga counteracts this process by activating the parasympathetic nervous system, promoting relaxation, and reducing physiological arousal (Gard et al., 2014). Techniques such as deep breathing, mindfulness meditation, and progressive muscle relaxation enhance autonomic regulation, leading to lower levels of anxiety and an increased sense of emotional balance. Studies have shown that individuals who practice yoga consistently experience decreased symptoms of generalized anxiety disorder and panic disorder, as yoga fosters a deep sense of calm and self-awareness.

Yoga also plays a crucial role in alleviating symptoms of depression. Depression is often characterized by imbalances in neurotransmitters such as serotonin and dopamine, which regulate mood and emotional responses. Regular yoga practice has been associated with increased production of these neurotransmitters, contributing to improved mood regulation and a heightened sense of well-being (Krishnakumar et al., 2015). Meditation and mindfulness components of yoga promote cognitive restructuring, encouraging individuals to shift their perspectives and cultivate positive thought patterns. Additionally, physical movement stimulates endorphin release, further enhancing feelings of happiness and contentment. Cognitive function is another key area where yoga demonstrates substantial benefits. The integration of breath control, movement, and meditation strengthens neural connections in the prefrontal cortex, which is responsible for decision-making, emotional regulation, and problem-solving (Yadav et al., 2022). Yoga has been linked to improved memory retention, attention span, and overall cognitive flexibility. Research has indicated that women and elderly individuals who engage in regular yoga sessions exhibit slower cognitive decline and a reduced risk of neurodegenerative disorders such as Alzheimer's disease (Krause-Sorio et al., 2022). Moreover, yoga enhances executive function, allowing individuals to approach challenges with greater clarity and focus.

Sleep quality is an additional domain in which yoga exerts positive effects. Sleep disturbances, often associated with anxiety and depression, can lead to a range of physical and mental health issues. Yoga promotes relaxation by reducing hyperarousal and regulating the body's natural circadian rhythm (Yashotha, 2025). Practices such as Yoga Nidra, a form of guided meditation, have been found to improve sleep onset, duration, and overall restfulness. By alleviating insomnia and promoting deep sleep cycles, yoga enhances emotional resilience and cognitive performance. Yoga also facilitates emotional intelligence and self-awareness, which are essential for maintaining psychological well-being (Surana et al., 2025). The practice encourages introspection, allowing individuals to identify and process their emotions more

effectively. Individuals develop a greater capacity for self-regulation through mindfulness techniques preventing impulsive reactions and fostering more thoughtful responses to stressors. This increased emotional awareness has been particularly beneficial for individuals with trauma-related disorders as yoga assists in managing intrusive thoughts and emotional distress. The philosophical principles embedded within yoga such as non-judgmental acceptance and self-compassion reinforce a positive self-image and promote interpersonal harmony. Yoga offers a comprehensive and validated approach to mental health addressing stress reduction, mood regulation, cognitive enhancement, sleep quality, and emotional intelligence. The dynamic effect of yoga on mental health makes it a powerful tool for individuals seeking holistic well-being bridging physical and psychological health.

4. SCIENTIFIC APPROACHES TO STUDYING NEUROBIOLOGICAL EFFECTS OF YOGA

Scientific research investigating the neurobiological effects of yoga employs a variety of approaches integrating neuroscience, psychology, and physiology to examine how the practice influences brain function and mental health (Campelo et al., 2025). Over the past few decades, advancements in neuroimaging techniques, biochemical analyses, and cognitive assessments have provided substantial empirical evidence supporting the therapeutic potential of yoga in regulating neural pathways and modulating brain activity (Gothe et al., 2019). One of the primary methods used to study the neurobiological effects of yoga is functional magnetic resonance imaging (fMRI). This technique measures changes in blood flow within the brain, offering insights into neural activity in real time. Studies utilizing fMRI have demonstrated that regular yoga practitioners exhibit enhanced activity in brain regions associated with emotional regulation, attention, and self-awareness, such as the prefrontal cortex, insula, and anterior cingulate cortex (Van Aalst et al., 2020). Additionally, fMRI studies reveal that yoga practice leads to structural changes in the brain, including increased gray matter density (Mishra et al., 2017) in areas responsible for executive function and emotional processing, suggesting neuroplasticity benefits.

Electroencephalography (EEG) is another valuable tool in understanding the neurophysiological impact of yoga. By measuring electrical activity in the brain, EEG studies have shown that yoga and meditation induce shifts in brain wave patterns (Kora et al., 2021). Specifically, yoga practitioners often exhibit increased alpha and theta wave activity, which are associated with relaxation, creativity, and reduced anxiety. These findings indicate that yoga facilitates heightened states of consciousness and attentional control, reinforcing its effectiveness in stress management and cognitive enhancement. Biochemical analyses have further elucidated the neurobiological mechanisms underlying mental health benefits of yoga (Tolahunase et al., 2021). Studies measuring hormonal changes have identified significant reductions in cortisol levels among individuals engaging in regular yoga practice. Since cortisol is a primary stress hormone linked to anxiety, depression, and cognitive impairment, its reduction through yoga underscores the practice's ability to mitigate stress-induced physiological damage. Additionally, yoga has been shown to enhance the production of neurotransmitters such as serotonin, dopamine, and gamma-aminobutyric acid (GABA) which contribute to mood stabilization, emotional resilience, and reduced symptoms of anxiety disorders (Padmavathi et al., 2023).

Studies conducted on the autonomic nervous system have further given insights into the neurobiological effects of yoga. Heart rate variability (HRV), a marker of autonomic regulation, is commonly measured in yoga studies to assess stress response and emotional balance (Tyagi, A., and Cohen, 2016). Research indicates that yoga practitioners exhibit increased HRV signifying improved adaptability of the nervous system and enhanced parasympathetic tone, which fosters relaxation and resilience against stressors (Pascoe et al., 2017). Furthermore, studies assessing vagal nerve activity highlight role of yoga in enhancing parasympathetic nervous system functions, promoting calmness and emotional well-being (Udupa and Sathyaprabha, 2018). Furthermore, cognitive and psychological assessments complement neurobiological research by examining yoga's impact on cognitive flexibility, memory, and emotional regulation (Gard et al., 2014). Behavioral studies utilizing standardized neuropsychological tests have shown that yoga practitioners consistently demonstrate improved attentional control, working memory, and decision-making abilities (Jayantilal and Kashyap, 2024). These improvements are believed to result from the integrated effects of breath control, movement coordination, and mindfulness training inherent in yoga practice.

5. NEUROBIOLOGICAL FOUNDATIONS OF THE EFFECT OF YOGA ON MENTAL HEALTH

The neurobiological effects of yoga on mental health are driven by a complex interaction of structural, biochemical and functional mechanisms that influence cognitive and emotional regulation drives. Neuroscientific studies conducted

in the last few decades have shown that yoga has a major impact on a variety of brain areas linked to stress resilience, emotional control, and cognitive function (Veerakannan, 2025). Practices in yoga such as breath control, meditation, and physical movement help to alter neural activity and biochemical pathways. Yoga has been shown to enhance the functioning of the prefrontal cortex, the brain region responsible for executive function, decision-making, and emotional regulation. Regular yoga practice facilitates increased connectivity between the prefrontal cortex and the limbic system, particularly the amygdala, which is involved in processing emotions such as fear and stress (Gerbarg and Brown, 2015). By strengthening these neural connections, yoga improves emotional resilience, allowing individuals to manage negative emotions more effectively. Studies utilizing functional magnetic resonance imaging (fMRI) have revealed that yoga practitioners exhibit reduced amygdala reactivity, signifying a decreased stress response and enhanced emotional stability (Khajuria et al., 2023). Another critical aspect of the neurobiological impact of yoga is its influence on neurotransmitter systems. Yoga has been shown to elevate levels of gamma-aminobutyric acid (GABA), a neurotransmitter that inhibits excessive neural activity and promotes relaxation (Streeter et al., 2012). Low GABA levels are associated with anxiety disorders, depression, and heightened stress sensitivity. By increasing GABAergic transmission, yoga helps regulate mood and reduces symptoms of anxiety-related conditions. Additionally, yoga enhances the release of serotonin and dopamine, neurotransmitters crucial for mood stabilization, motivation, and overall emotional well-being. These biochemical effects contribute to the antidepressant properties of yoga, making it an effective adjunct therapy for individuals experiencing mood disorders.

The autonomic nervous system plays a pivotal role in stress regulation, and yoga has been demonstrated to enhance parasympathetic nervous system activity, promoting relaxation and recovery (Udupa et al., 2022). Heart rate variability (HRV), an indicator of autonomic flexibility and stress resilience, is significantly improved in individuals who engage in regular yoga practice. Increased HRV is associated with better emotional regulation, reduced stress sensitivity, and enhanced cardiovascular health. Breath control techniques such as pranayama activate the vagus nerve, which is involved in parasympathetic regulation, further reinforcing yoga's ability to counteract the physiological effects of chronic stress.

Yoga also exhibits neuroplastic effects, fostering structural and functional changes within the brain. Long-term yoga practitioners demonstrate increased gray matter density in brain regions such as the hippocampus, which is essential for memory formation and emotional regulation (Gothe et al., 2019). The neurogenic effects of yoga are attributed to the elevation of brain-derived neurotrophic factor (BDNF), a protein that supports neural growth, synaptic plasticity, and cognitive resilience (Tolahunase et al., 2018). BDNF is critical in protecting against neurodegenerative disorders and cognitive decline, suggesting that yoga may serve as a preventive strategy for maintaining brain health. Beyond structural changes, yoga has been implicated in improving cognitive function, including attention, memory, and problem-solving abilities. The integration of movement and mindfulness strengthens attentional networks within the brain, enhancing sustained focus and mental clarity. Research utilizing electroencephalography (EEG) has indicated that yoga induces shifts in brain wave activity, increasing alpha and theta waves which are associated with relaxation, creativity, and enhanced cognitive processing (Gaur et al., 2020).

The implications of yoga for mental health are substantial with numerous studies advocating its integration into psychotherapy and psychiatric treatment protocols (O'Shea et al., 2022). Yoga serves as an adjunct to conventional therapeutic approaches providing a non-invasive, self-directed healing method that minimizes dependency on pharmacological interventions. Empirical evidence supports its efficacy in reducing symptoms of anxiety, depression, and post-traumatic stress disorder (PTSD), underscoring its value as a complementary therapeutic modality (Sciarrino et al., 2017). Taken together, the neurobiological foundations of effect of yoga on mental health are deeply rooted in neuroplasticity, neurotransmitter regulation, autonomic modulation, hypothalamic-pituitary-adrenal (HPA) axis, and cognitive processing. These neurobiological mechanisms collectively contribute to improved emotional resilience, psychological stability, and stress adaptation.

5.1. NEUROPLASTICITY AND STRUCTURAL BRAIN CHANGES

Neuroplasticity refers to the capacity of the brain to reorganize and adapt by forming new neural connections, serves as a fundamental mechanism underlying the cognitive and emotional benefits of yoga for mental health. The practice of yoga integrates physical movement, breath control, and meditative focus, all of which contribute to structural and functional brain changes that enhance psychological resilience. Through sustained engagement, yoga fosters synaptic remodeling, cortical reorganization, and improved neural efficiency, reinforcing its therapeutic potential for alleviating

anxiety, depression, and stress-related disorders (Tolahunase et al., 2018). The structural brain changes induced by yoga are particularly evident in regions responsible for emotional regulation, self-awareness, and executive function. Neuroimaging studies indicate that individuals who engage in regular yoga practice exhibit increased gray matter volume and cortical thickness in the prefrontal cortex, hippocampus, and anterior cingulate cortex (Froeliger et al., 2012). The prefrontal cortex plays a critical role in decision-making and impulse control, and its enhanced connectivity supports emotional stability and cognitive flexibility. The hippocampus, essential for memory formation and stress regulation, undergoes neurogenesis in response to mindfulness-based interventions embedded within yoga (Veerakannan, 2025). This neuroplastic adaptation aids in mitigating the effects of chronic stress and prevents cognitive decline. The anterior cingulate cortex, a region involved in attentional control and emotional processing, exhibits strengthened functional integration, leading to improved self-regulation and resilience to psychological stressors.

At the synaptic level, yoga promotes long-term potentiation (LTP), a process that enhances synaptic efficacy and facilitates learning and memory (Sharma et al., 2024). LTP-driven synaptic reinforcement is modulated by brain-derived neurotrophic factor (BDNF), a neurotrophic factor that supports neuronal survival and synaptic growth. Elevated BDNF levels have been observed in individuals practicing yoga and meditation, suggesting that yoga-induced neuroplasticity is mediated by the upregulation of growth factors that optimize neural connectivity (Naveen et al., 2016). This molecular adaptation contributes to improved cognitive processing, heightened emotional awareness, and enhanced capacity for stress adaptation. Furthermore, the regulation of glutamatergic and GABAergic neurotransmission in response to yoga practice reinforces excitatory-inhibitory balance, reducing neural hyperactivity associated with anxiety disorders (Arora et al., 2024). Yoga-induced neuroplasticity is particularly relevant for mental health interventions, as structural brain changes associated with the practice provide a biological basis for its therapeutic efficacy. The convergence of cortical reorganization, synaptic remodeling, neurotransmitter modulation, and autonomic regulation underscores the role of yoga in optimizing brain function.

5.2. NEUROTRANSMITTER MODULATION AND MOOD REGULATION

Neurotransmitter modulation plays a pivotal role in the regulation of mood and emotional well-being, influencing neural circuits that govern cognition, affective processing, and stress adaptation. Yoga has been found to exert profound effects on neurotransmitter activity contributing to enhanced emotional stability and reduced susceptibility to mood disorders such as depression and anxiety (Padmavathi et al., 2023). Through its integration of breath control, meditative practices, and physical movement, yoga facilitates neurochemical adaptations that optimize synaptic transmission and neuromodulation. One of the key neurotransmitters implicated in yoga-induced mood regulation is gamma-aminobutyric acid (GABA), an inhibitory neurotransmitter responsible for reducing neuronal excitability and promoting relaxation (Arora et al., 2024). Low GABA levels are associated with heightened stress responses, excessive neural activity, and symptoms of anxiety disorders. Empirical studies using magnetic resonance spectroscopy have demonstrated that yoga practitioners exhibit increased GABA concentrations, reinforcing its anxiolytic effects (Streeter et al., 2010). Enhanced GABAergic transmission facilitates neural inhibition, diminishing hyperactivity in stress-responsive regions such as the amygdala and hypothalamus. This modulation contributes to reduced physiological arousal, fostering a sense of calmness and emotional equilibrium.

Serotonin, another critical neurotransmitter involved in mood regulation, is significantly influenced by yoga (Kinser et al., 2012). This neurotransmitter plays an essential role in emotional processing, impulse control, and stress resilience. Reduced serotonin availability is commonly observed in individuals with major depressive disorder denoting its efficacy in affective regulation. Yoga has been found to elevate serotonin synthesis and release promoting positive affect and reducing depressive symptoms (Pascoe and Bauer, 2015). This effect is partially mediated by the activation of the raphe nuclei in the brainstem which govern serotonergic transmission throughout the central nervous system. Increased serotonergic activity enhances neural communication between the prefrontal cortex and limbic system, improving emotional regulation and cognitive flexibility. The impact of yoga on serotonin levels suggests potential therapeutic applications for mood disorders offering a non-pharmacological approach to depression management.

Dopamine, a neurotransmitter associated with reward processing and motivation, is also modulated through yoga practice. Dopaminergic pathways, particularly those originating in the ventral tegmental area and substantia nigra, contribute to feelings of pleasure, motivation, and engagement. Yoga-induced dopamine release fosters enhanced motivation, reducing symptoms of anhedonia commonly observed in depressive states (Virk et al., 2020). This modulation is particularly relevant in mindfulness-based yoga practices, where sustained attentional focus and sensory

integration reinforce dopaminergic activity. Improved dopamine signaling enhances reward sensitivity, supporting long-term adherence to yoga practice and reinforcing positive behavioral adaptations. In addition to its effects on individual neurotransmitters, yoga promotes the release of endogenous opioids, including endorphins, which contribute to pain reduction and emotional well-being (Suri et al., 2017). Endorphin release is associated with increased tolerance to stress and enhanced feelings of relaxation. The ability of yoga practices to stimulate endorphin production suggests its efficacy in stress management and psychological resilience. Moreover, yoga-mediated endorphin release interacts with other neurochemical pathways, potentiating the effects of serotonin and dopamine, thereby amplifying overall mood regulation.

The neurochemical effects of yoga are not solely restricted to individual neurotransmitters but also extend to systemic neuromodulatory networks that regulate emotional processing and cognitive function. The interaction between GABAergic, serotonergic, and dopaminergic systems shows the complex synergy of neurobiological mechanisms underlying the therapeutic effects of yoga. Additionally, yoga influences neuropeptide signaling, including oxytocin, a hormone implicated in social bonding and emotional connection. Increased oxytocin levels in yoga practitioners suggest improved interpersonal engagement and emotional support reinforcing its psychosocial benefits.

5.3. AUTONOMIC NERVOUS SYSTEM AND STRESS REGULATION

The autonomic nervous system (ANS) plays a crucial role in the regulation of stress responses, serving as a critical interface between the brain and physiological adaptations to environmental stimuli. The ANS is composed of two primary subdivisions: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS), which work in opposition to maintain homeostasis. The SNS is responsible for activating the body's fight-or-flight response, characterized by increased heart rate, elevated cortisol levels, and heightened vigilance, whereas the PNS facilitates relaxation, recovery, and physiological restoration through its rest-and-digest functions. Dysregulation of the ANS, often observed in individuals experiencing chronic stress, anxiety, and mood disorders, can lead to persistent sympathetic activation, impaired parasympathetic function, and systemic physiological imbalances. Yoga has been found to exert significant regulatory effects on the ANS, promoting autonomic balance and enhancing stress resilience through neurobiological mechanisms.

One of the primary ways yoga influences autonomic regulation is through controlled breathing techniques, known as pranayama. Breathing patterns have a direct impact on autonomic function, with slow and deep respiration stimulating parasympathetic dominance. Empirical research has demonstrated that yoga-based breath regulation enhances vagal tone, which is a key marker of parasympathetic activity associated with emotional resilience and adaptive stress responses (Smaniotto-Holmes, 2024). The vagus nerve, a central component of the parasympathetic nervous system, governs heart rate variability, digestion, and inflammatory responses. By strengthening vagal tone, yoga fosters improved autonomic equilibrium, reducing sympathetic overactivity and mitigating the physiological manifestations of chronic stress.

The practice of yoga also induces neuroplastic adaptations within brain regions implicated in autonomic control (Schmalzl et al., 2015). The prefrontal cortex which is responsible for executive function and emotional regulation exhibits enhanced connectivity in yoga practitioners contributing to improved autonomic regulation. The amygdala, a structure central to stress processing and fear responses demonstrates reduced activity in response to yoga-induced relaxation. This downregulation of amygdala hyperactivity correlates with diminished sympathetic arousal reinforcing the anxiolytic effects of yoga (Gerbarg and Brown, 2015). Furthermore, yoga has been shown to optimize functional integration between the anterior cingulate cortex and insular cortex, areas involved in interoceptive awareness and autonomic modulation (Weng et al., 2021). This neural reorganization supports improved stress adaptation, fostering a greater sense of self-regulation and physiological balance.

The regulatory effects of yoga practices on autonomic function extend to cardiovascular and inflammatory processes (Akella et al., 2020). Chronic stress and autonomic dysregulation are associated with increased pro-inflammatory cytokine production and heightened cardiovascular risk factors. Yoga-mediated autonomic balance contributes to reductions in blood pressure, improved endothelial function, and decreased inflammatory markers offering protective benefits against stress-induced systemic disorders (Patil et al., 2024). The integration of mind-body practices within yoga facilitates bidirectional communication between neural, cardiovascular, and immune systems further reinforcing its holistic impact on stress regulation. The therapeutic potential of yoga as an autonomic regulatory intervention

highlights its applicability in clinical and preventive mental health care. As a non-pharmacological approach, yoga provides a sustainable method for enhancing autonomic resilience, mitigating stress-related physiological disruptions, and promoting emotional well-being.

5.4. HYPOTHALAMIC-PITUITARY-ADRENAL AXIS AND CORTISOL REGULATION

The hypothalamic-pituitary-adrenal (HPA) axis serves as the central regulatory system for stress responses, coordinating neuroendocrine interactions that influence both physiological and psychological adaptation to environmental challenges. The activation of this axis follows a sequential pathway, beginning with stress-induced stimulation of the hypothalamus which releases corticotropin-releasing hormone (CRH). CRH subsequently stimulates the anterior pituitary gland to secrete adrenocorticotropic hormone (ACTH), which then acts on the adrenal cortex to trigger the synthesis and release of cortisol, the primary stress hormone. While acute cortisol release is necessary for adaptive responses, chronic HPA axis dysregulation characterized by sustained cortisol elevation has been implicated in various psychiatric disorders, including anxiety, depression, and post-traumatic stress disorder. Yoga has emerged as a potent intervention for regulating HPA axis activity and restoring endocrine balance, thereby mitigating stress-related neurobiological dysfunction (Bakshi and Srivastava, 2024). One of the primary mechanisms through which yoga influences HPA axis function is the modulation of hypothalamic activity. The hypothalamus integrates sensory, cognitive and emotional inputs orchestrating neuroendocrine responses to stressors. Yoga, particularly through mindfulness and breath regulation, alters hypothalamic excitability by promoting inhibitory neurotransmission and reducing hyperactivation of stress-responsive circuits (Clemente-Suárez et al., 2025). Functional neuroimaging studies have demonstrated that regular yoga practitioners exhibit reduced hypothalamic activity during exposure to stress, correlating with diminished CRH release and attenuated HPA axis activation (Aggarwal, 2020). This suppression of hypothalamic overactivity contributes to reduced cortisol secretion and prevents maladaptive physiological consequences associated with chronic stress exposure.

Furthermore, yoga exerts direct effects on pituitary function by modulating ACTH release. The anterior pituitary plays a crucial role in propagating stress signals through ACTH-dependent stimulation of adrenal cortisol synthesis. Yoga-mediated autonomic regulation, facilitated by controlled breathing and meditative focus, has been shown to downregulate pituitary excitability, leading to decreased ACTH levels (Najafi and Moghadasi, 2017). This endocrine adjustment results in lower cortisol output, reinforcing yoga's capacity to mitigate hypercortisolemia-associated psychiatric symptoms such as heightened anxiety and impaired emotional regulation. Additionally, the bidirectional communication between the pituitary and hypothalamus suggests that yoga-induced reductions in CRH release indirectly influence pituitary responsiveness (Arora and Bhattacharjee, 2008), further contributing to HPA axis stability.

At the adrenal level, yoga influences cortisol biosynthesis and systemic hormonal balance by optimizing adrenal gland responsiveness (Lamba et al., 2023). Chronic stress leads to excessive adrenal activation, perpetuating sustained cortisol release and impairing feedback inhibition mechanisms. Yoga enhances adrenal sensitivity to negative feedback regulation ensuring that cortisol production remains within optimal physiological limits. This regulatory effect is mediated through enhanced glucocorticoid receptor expression in limbic structures, particularly the hippocampus and prefrontal cortex. These brain regions exert inhibitory control over the HPA axis via feedback loops that suppress hypothalamic CRH release upon detecting elevated cortisol concentrations. Yoga-induced neuroplasticity strengthens hippocampal and prefrontal regulatory pathways, reinforcing adaptive HPA axis modulation and promoting emotional resilience.

Beyond its direct neuroendocrine effects, yoga influences systemic metabolic and immunological processes linked to HPA axis function. Chronic cortisol elevation is associated with heightened inflammatory marker expression, including increased pro-inflammatory cytokines such as interleukin-6 and tumor necrosis factor-alpha (Pascoe and Bauer, 2015). Yoga has been found to lower circulating inflammatory markers by reducing cortisol-driven immune activation, thereby protecting against stress-induced inflammatory dysregulation. This immunomodulatory effect contributes to improved psychological well-being, given the established role of neuroinflammation in mood disorders. Additionally, yoga's impact on metabolic function includes the regulation of cortisol-mediated glucose metabolism, preventing insulin resistance and metabolic disruptions commonly observed in chronic stress conditions.

5.5. DEFAULT MODE NETWORK AND COGNITIVE FUNCTION

The default mode network (DMN) is a set of interconnected brain regions primarily active during periods of rest and introspection, governing self-referential thinking, memory consolidation, and spontaneous cognition. The DMN comprises structures such as the medial prefrontal cortex, posterior cingulate cortex, precuneus, and inferior parietal lobule, which collectively facilitate internal mental processing. While the DMN plays a critical role in cognitive function, excessive activity within this network has been implicated in maladaptive thought patterns, including rumination, anxiety, and depressive symptoms. Overactivation of the DMN is associated with a heightened focus on negative self-referential thoughts, contributing to emotional dysregulation and cognitive rigidity. Yoga has been shown to modulate DMN activity, promoting cognitive flexibility and psychological resilience through sustained neurobiological adaptations (Santaella et al., 2019). Neuroimaging studies indicate that yoga and meditation practices reduce hyperactivity within the DMN, shifting cognitive processing away from self-referential ruminative cycles towards present-moment awareness (Chand and Sazima, 2024). This attenuation of DMN overactivity is facilitated by enhanced functional connectivity between task-positive networks, such as the central executive network (CEN) and salience network (SN), which govern attentional control and sensory integration. By strengthening communication between these networks, yoga fosters improved cognitive regulation, diminishing excessive engagement with maladaptive thought patterns. The reduction in DMN activity observed in long-term yoga practitioners is correlated with enhanced emotional balance and a decreased vulnerability to stress-induced cognitive distortions (Lavretsky et al., 2015). One of the primary mechanisms through which yoga influences DMN function is through mindfulness-based practices that cultivate attentional focus and interoceptive awareness (Fialoke et al., 2024). Mindfulness meditation, a core component of yoga, engages executive control processes within the prefrontal cortex, leading to greater regulation over internally directed thoughts. This shift from spontaneous cognitive activity towards intentional cognitive regulation enhances cognitive clarity and emotional stability. Additionally, yoga-induced neuroplasticity within the anterior cingulate cortex supports improved cognitive flexibility, allowing individuals to disengage from repetitive negative thought patterns and adopt adaptive cognitive strategies.

The impact of yoga on DMN function extends to memory processing and emotional recall. The posterior cingulate cortex, a central hub within the DMN, is implicated in autobiographical memory retrieval and emotional valuation. Dysregulated activity in this region is linked to overgeneralized memory recall, a phenomenon observed in individuals with depression and PTSD. Yoga has been found to recalibrate posterior cingulate function, facilitating more precise and adaptive emotional memory processing (Wadden et al., 2018). This modulation enhances emotional regulation, reducing susceptibility to intrusive thoughts and stress-related cognitive distortions. Beyond cognitive regulation, yoga-mediated DMN modulation has profound implications for stress resilience and autonomic balance. Excessive DMN activity is associated with heightened physiological stress responses, including increased cortisol secretion and sympathetic nervous system activation. The effect of yoga practices on DMN function contribute to parasympathetic predominance, lowering physiological arousal and fostering a state of relaxation (Gerbarg and Brown, 2015). This autonomic recalibration strengthens the mind-body connection, reinforcing the role of yoga in holistic mental health interventions.

The neurobiological mechanisms driving the effect of yoga on mental health demonstrate its profound ability to enhance emotional resilience, cognitive function, and physiological stability through multiple interconnected mechanisms. Yoga induces structural brain changes, fostering neuroplasticity and strengthening regions responsible for emotional regulation, memory, and executive function. Through neurotransmitter modulation, yoga balances neurochemical activity, increasing GABA, serotonin, and dopamine levels to support mood regulation and reduce anxiety and depression. The autonomic nervous system is recalibrated via yoga, shifting physiological responses toward parasympathetic dominance, enhancing vagal tone, and improving stress resilience. The influence of yoga practices on the hypothalamic-pituitary-adrenal axis ensures balanced cortisol regulation, mitigating the harmful effects of chronic stress and preventing neuroendocrine dysregulation. Additionally, the modulation of the default mode network reduces maladaptive thought patterns, fostering cognitive flexibility and psychological clarity. Collectively, these neurobiological processes establish yoga as a key intervention for mental health offering a holistic, non-invasive, and scientifically supported approach to emotional and cognitive well-being. The integration of yoga into mental health care frameworks holds significant promise paving the way for innovative therapies that harness its neurobiological benefits to promote overall psychological stability and stress adaptation.

6. CLINICAL APPLICATIONS AND THERAPEUTIC POTENTIAL OF YOGA

Yoga has emerged as a valuable therapeutic modality with potential for clinical applications for mental health disorders. Its integration into healthcare and wellness practices is supported by extensive research demonstrating its efficacy in alleviating anxiety, depression, post-traumatic stress disorder (PTSD), and chronic stress. Unlike conventional pharmacological treatments, yoga offers a holistic approach that targets both physiological and psychological mechanisms underlying mental health conditions. By fostering neuroplasticity, modulating neurotransmitter activity, regulating the autonomic nervous system, and balancing endocrine responses, yoga establishes itself as a scientifically grounded intervention for mental health care. One of the primary clinical applications of yoga is its role in managing anxiety disorders. Yoga practice has been shown to reduce excessive neural activity in the amygdala, the brain region responsible for fear and threat perception. This downregulation of amygdala hyperactivity leads to decreased physiological arousal, diminished stress sensitivity, and improved emotional regulation. Additionally, yoga enhances gamma-aminobutyric acid (GABA) neurotransmission, which inhibits excessive neuronal excitability and fosters a state of relaxation. Clinical trials have demonstrated that individuals diagnosed with generalized anxiety disorder (GAD) who engage in regular yoga practice exhibit significant reductions in anxiety symptoms compared to control groups receiving standard care. The regulation of the autonomic nervous system through controlled breathing techniques further reinforces yoga's anxiolytic effects by enhancing parasympathetic tone and suppressing sympathetic overactivity.

Depression is another major area where yoga has demonstrated therapeutic potential. The neurobiological effects of yoga on mood regulation are largely mediated by the upregulation of serotonin and dopamine levels, which are essential for emotional balance, motivation, and reward processing. Depressive disorders are often associated with dysfunctions in these neurotransmitter systems, leading to persistent negative affect and anhedonia. Yoga facilitates serotonergic and dopaminergic modulation through mindfulness-based practices that engage executive control networks and limbic structures. Additionally, yoga-mediated reductions in hypothalamic-pituitary-adrenal (HPA) axis hyperactivity contribute to cortisol regulation, alleviating the physiological burden of chronic stress that exacerbates depressive symptoms. Clinical studies indicate that yoga-based interventions produce comparable antidepressant effects to pharmacological treatments, highlighting their potential as adjunct or standalone therapies.

Yoga has also been widely utilized in the treatment of PTSD, particularly among individuals exposed to trauma. PTSD is characterized by hyperactivation of the amygdala, impaired hippocampal function, and dysregulated autonomic responses. Yoga-based trauma-sensitive interventions have been developed to address these neurobiological disturbances through breath-centered practices and body-awareness exercises. These techniques mitigate hyperarousal symptoms, enhance cognitive flexibility, and promote emotional resilience, enabling individuals to process trauma more effectively. Neuroimaging studies have demonstrated that PTSD patients who engage in yoga therapy exhibit improved functional connectivity between the prefrontal cortex and limbic system, facilitating greater self-regulation and adaptive coping strategies.

Beyond psychiatric disorders, yoga has demonstrated efficacy in managing stress-related conditions that impact both mental and physical health. Chronic stress is associated with heightened cortisol levels, increased inflammation, and autonomic dysregulation, all of which contribute to systemic health complications. Yoga's ability to modulate the HPA axis and restore autonomic equilibrium makes it an effective intervention for reducing stress-related physiological dysregulation. Additionally, yoga has been incorporated into integrative healthcare models for managing chronic pain, sleep disorders, and neurodegenerative conditions, further expanding its therapeutic scope. The clinical applications of yoga extend to preventive mental health care, where regular practice fosters psychological resilience and cognitive longevity. Emerging research suggests that yoga may serve as a neuroprotective intervention, preserving cortical integrity and mitigating age-related cognitive decline. The enhancement of brain-derived neurotrophic factor (BDNF) levels in response to yoga practice supports synaptic plasticity and neural regeneration, underscoring its long-term benefits for mental health maintenance.

7. CHALLENGES AND IMPLICATIONS FOR FUTURE RESEARCH

Despite the growing body of evidence supporting the neurobiological effects of yoga on mental health, several challenges remain in establishing standardized methodologies for research and clinical application. One of the primary obstacles is the variability in yoga practices including differences in postures, breathing techniques, and meditation

styles across traditions and individual practitioners. This heterogeneity complicates the ability to conduct controlled trials with consistent intervention protocols, leading to difficulties in replicability and generalizability of findings. Additionally, while neuroimaging and biochemical assays provide valuable insights into yoga-induced neural and physiological adaptations, the precise mechanisms underlying these effects remain complex and require further exploration. A more integrative approach incorporating advanced neuroscientific tools such as functional connectivity analyses, computational modeling, and genetic profiling would enhance our understanding of yoga's role in cognitive and emotional regulation. Future research should also examine the clinical efficacy of yoga as a complementary or primary intervention across different psychiatric disorders, integrating findings from neurobiological, psychological and behavioral studies. While existing evidence suggests positive effects on anxiety, depression, PTSD and stress-related conditions, more rigorous randomized controlled trials are needed to compare therapeutic potential of yoga practices with conventional treatments such as pharmacotherapy and psychotherapy. Investigating personalized yoga protocols tailored to individual neurophysiological profiles and mental health needs could optimize therapeutic outcomes and broaden accessibility. Additionally, exploring the sociocultural and psychological factors that influence engagement with yoga-based interventions could improve adherence rates and long-term effectiveness. The convergence of contemplative neuroscience, psychiatry, and clinical psychology will provide valuable insights into how yoga can be integrated into mainstream mental health care, advancing its role as a scientifically validated modality for emotional resilience and cognitive enhancement.

8. CONCLUSION

The neurobiological foundations of the effect of yoga on mental health underscore its transformative potential as a therapeutic intervention that integrates physiological, psychological, and cognitive mechanisms. The practice of yoga induces structural brain changes that facilitate neuroplasticity, enhancing emotional regulation, executive function, and cognitive resilience. Through neurotransmitter modulation, yoga balances neurochemical systems, promoting increased levels of gamma-aminobutyric acid (GABA), serotonin, and dopamine, which collectively contribute to mood stabilization and reduced stress sensitivity. The influence of yoga practices on autonomic nervous system regulation establishes equilibrium between sympathetic and parasympathetic responses, strengthening vagal tone and fostering relaxation. Additionally, its impact on the hypothalamic-pituitary-adrenal (HPA) axis mitigates excessive cortisol release, ensuring adaptive endocrine regulation and reducing the detrimental effects of chronic stress. The modulation of the default mode network further enhances cognitive flexibility, reducing ruminative thought cycles and fostering mental clarity. The therapeutic implications of yoga extend beyond individual neurobiological effects to holistic mental health intervention strategies. The clinical applications demonstrate the efficacy of yoga in managing anxiety, depression, post-traumatic stress disorder, and stress-induced physiological disturbances, making it a valuable adjunct to conventional psychiatric treatments. The non-pharmacological approach of yoga offers sustainable, accessible and integrative solutions for individuals seeking comprehensive mental health care. Despite the substantial evidence supporting yoga's role in mental health, challenges remain in standardizing methodologies and refining personalized interventions. Therefore, future research is required to focus on developing advanced neuroscientific approaches to further explain the molecular pathways and neural mechanisms underlying psychological benefits of yoga. The growing intersection of contemplative neuroscience, clinical psychology, and psychiatric research highlights the potential of yoga as a scientifically validated modality for emotional resilience and cognitive enhancement, paving the way for its broader implementation in mental health care frameworks.

CONFLICT OF INTERESTS

None.

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REFERENCES

Aggarwal, A. (2020). Hypothalamo-pituitary-adrenal axis and brain during stress, yoga and meditation. *International Journal of Health and Clinical Research*, 3(9), 96-103.

Akella, K., Kanuri, S. H., Murtaza, G., Della Rocca, D. G., Kodwani, N., Turagam, M. K., & Lakkireddy, D. (2020). Impact of yoga on cardiac autonomic function and arrhythmias. *Journal of atrial fibrillation*, 13(1), 2408.

Arora, R., Verma, H., Banumathy, N., & Sharma, M. (2024). The Regulation of Neuro-immune System by Pi (Parasympathetic) and SiGMA (Sympathetic Induction Governed by Meditation and Asana) Rhythmicity. *In Neuroscience of Yoga: Theory and Practice: Part 1, Singapore: Springer Nature Singapore,* 17-36.

Arora, S., & Bhattacharjee, J. (2008). Modulation of immune responses in stress by Yoga. *International journal of yoga*, 1(2), 45-55.

Bakshi, K., & Srivastava, V. (2024). Neurobiology of Yoga and Mindfulness and Its Impact on Neuronal Function, Wellbeing Addiction, and Palliative Care. *In Neuroscience of Yoga: Theory and Practice: Part 1, Singapore: Springer Nature Singapore,* 37-60.

Barua, R. (2025). Harmonizing Body and Mind: Investigating the Combined Impact of Yoga and Mindfulness Meditation on Depression, Anxiety, Stress. *In Global Innovations in Physical Education and Health, IGI Global,* 203-232.

Bhatt, D., Kashyap, K., Chandravanshi, J., & Kumar, A. (2024). Exercise, Yoga and Meditation Positive Impact on those Suffering from Depression and Anxiety Disorders. *European Journal of Cardiovascular Medicine*, 14(2).

Campelo, G., de Araújo, J. R., Aristizabal, J. P., de Souza, W., & de Castilho, G. M. (2025). Long-term effects of yoga-based practices on neural, cognitive, psychological, and physiological outcomes in adults: a scoping review and evidence map. *BMC complementary medicine and therapies*, 25(1), 92.

Chand, R., & Sazima, G. (2024). The Science of Mindfulness: Research and Benefits. *In Mindfulness in Medicine: A Comprehensive Guide for Healthcare Professionals, Springer Nature Switzerland,* 27-58.

Clemente-Suárez, V. J., Martín-Rodríguez, A., Curiel-Regueros, A., Rubio-Zarapuz, A., & Tornero-Aguilera, J. F. (2025). Neuro-Nutrition and Exercise Synergy: Exploring the Bioengineering of Cognitive Enhancement and Mental Health Optimization. *Bioengineering*, 12(2), 208.

Diamond, D., & Aitken, M. E. (2013). Yoga: The art of transformation. Smithsonian Books.

Fialoke, S., Tripathi, V., Thakral, S., Dhawan, A., Majahan, V., & Garg, R. (2024). Functional connectivity changes in meditators and novices during yoga nidra practice. *Scientific Reports*, 14(1), 12957.

Froeliger, B., Garland, E. L., & McClernon, F. J. (2012). Yoga Meditation Practitioners Exhibit Greater Gray Matter Volume and Fewer Reported Cognitive Failures: Results of a Preliminary Voxel-Based Morphometric Analysis. Evidence-Based Complementary and *Alternative Medicine*, 2012(1), 821307.

Gangenahalli, G., Chander, V., Verma, Y. K., & Singh, S. (2024). The Impact of Yoga, Pranayama, and Mindfulness Training on Neurocognitive, Neurophysiological, and Neuropsychological Changes in High Altitude. *In Neuroscience of Yoga: Theory and Practice*, *Springer,* (1)157-184.

Gard, T., Noggle, J. J., Park, C. L., Vago, D. R., & Wilson, A. (2014). Potential self-regulatory mechanisms of yoga for psychological health. *Frontiers in human neuroscience*, 8, 770.

Gaur, S., Panjwani, U., & Kumar, B. (2020). EEG Brain Wave Dynamics: A Systematic Review and Meta Analysis on Eff ect of Yoga on Mind Relaxation. *Journal of Biomedical Research & Environmental Sciences*, 1(7), 353-362.

Gerbarg, P. L., & Brown, R. P. (2015). Yoga and neuronal pathways to enhance stress response, emotion regulation, bonding, and spirituality. *In Yoga Therapy, Routledge*, 49-64.

Gothe, N. P., Khan, I., Hayes, J., Erlenbach, E., & Damoiseaux, J. S. (2019). Yoga effects on brain health: a systematic review of the current literature. *Brain Plasticity*, 5(1), 105-122.

Hendriks, T., De Jong, J., & Cramer, H. (2017). The effects of yoga on positive mental health among healthy adults: a systematic review and meta-analysis. *The Journal of Alternative and Complementary Medicine*, 23(7), 505-517.

Jayantilal, P. K., & Kashyap, A. (2024). The Role of Yoga in Enhancing Decision Making: A Research Perspective. *Journal of Ayurveda and Integrated Medical Sciences*, 9(8), 177-183.

Joseph, M. C., Kammath, S. P., & Fincy, M. P. (2019). Yoga and emotional intelligence. *IAHRW International Journal of Social Sciences Review*, 7(6).

Khajuria, A., Kumar, A., Joshi, D., & Kumaran, S. S. (2023). Reducing stress with yoga: A systematic review based on multimodal biosignals. *International journal of yoga*, 16(3), 156-170.

Kinser, P. A., Goehler, L. E., & Taylor, A. G. (2012). How might yoga help depression? A neurobiological perspective. *Explore*, 8(2), 118-126.

Kora, P., Meenakshi, K., Swaraja, K., Rajani, A., & Raju, M. S. (2021). EEG based interpretation of human brain activity during yoga and meditation using machine learning: A systematic review. *Complementary therapies in clinical practice*, 43, 101329.

Krause-Sorio, B., Siddarth, P., Kilpatrick, L., Milillo, M. M., Aguilar-Faustino, Y., Ercoli, L., & Lavretsky, H. (2022). Yoga prevents gray matter atrophy in women at risk for Alzheimer's disease: A randomized controlled trial. *Journal of Alzheimer's Disease*, 87(2), 569-581.

Krishnakumar, D., Hamblin, M. R., & Lakshmanan, S. (2015). Meditation and yoga can modulate brain mechanisms that affect behavior and anxiety-A modern scientific perspective. *Ancient science*, 2(1), 13.

Kumari, S., Nadholta, P., Dahiya, N., Sharma, A., Singh, H., Kumar, S., & Singh, G. (2024). Link between Yoga and Heart Rate Variability: Can Yoga Enhance the Cardiac Resonance. *International Journal of Yoga*, 17(2), 67-75.

Lamba, P., Deepti D., Navpreet M., Harminder K., Sunil K. C., Pragyasgaa C., and Nimapreet K. (2023). "Effect of Surya Namaskar on Autonomic Status and Serum Cortisol Levels in Male Medical Students: A Longitudinal Study." *Journal of Clinical & Diagnostic Research,* 17 (11).

Lavretsky, H., Yang, H., Eyre, H., Leaver, A., Narr, K., & Khalsa, D. (2015). M1. Changes in the Functional Brain Connectivity and Verbal Memory Performance Following Yoga or Memory Training in Older Adults with Subjective Memory Complaints. *Neuropsychopharmacology*, 40, S106-271.

Mishra, S. K., Khosa, S., Singh, S., Moheb, N., & Trikamji, B. (2017). Changes in functional magnetic resonance imaging with Yogic meditation: a pilot study. *AYU (An International Quarterly Journal of Research in Ayurveda),* 38(3-4), 108-112.

Muralikrishna, D. (2019). Bhagavad Gita" and "Yoga". *International Journal of Yoga and Allied Sciences*, 8(2), 148-151.

Najafi, P., & Moghadasi, M. (2017). The effect of yoga training on enhancement of Adrenocorticotropic hormone (ACTH) and cortisol levels in female patients with multiple sclerosis. *Complementary therapies in clinical practice*, 26, 21-25.

Naveen, G. H., Varambally, S., Thirthalli, J., Rao, M., Christopher, R., & Gangadhar, B. N. (2016). Serum cortisol and BDNF in patients with major depression—effect of yoga. *International review of psychiatry*, 28(3), 273-278.

O'Shea, M., Capon, H., Evans, S., Agrawal, J., Melvin, G., O'Brien, J., & McIver, S. (2022). Integration of hatha yoga and evidence-based psychological treatments for common mental disorders: An evidence map. *Journal of Clinical Psychology*, 78(9), 1671-1711.

Padmavathi, R., Kumar, A. P., Dhamodhini, K. S., Venugopal, V., Silambanan, S., Maheshkumar, K., & Shah, P. (2023). Role of yoga in stress management and implications in major depression disorder. *Journal of Ayurveda and Integrative Medicine*, 14(5), 100767.

Pascoe, M. C., & Bauer, I. E. (2015). A systematic review of randomised control trials on the effects of yoga on stress measures and mood. *Journal of psychiatric research*, 68, 270-282.

Pascoe, M. C., Thompson, D. R., & Ski, C. F. (2017). Yoga, mindfulness-based stress reduction and stress-related physiological measures: A meta-analysis. *Psychoneuroendocrinology*, 86, 152-168.

Patil, S. G., Sobitharaj, E. C., Chandrasekaran, A. M., Patil, S. S., Singh, K., Gupta, R., ... & Prabhakaran, D. (2024). Effect of yoga-based cardiac rehabilitation program on endothelial function, oxidative stress, and inflammatory markers in acute myocardial infarction: a randomized controlled trial. *International Journal of Yoga*, 17(1), 20-28.

Pradhan, B. (2015). Yoga: Original concepts and history. *Yoga and Mindfulness Based Cognitive Therapy: A Clinical Guide*, 3-36.

Rathore, V. (2023). A scientific exploration of stress management techniques in Patanjali Yog Sutra. *Yoga Mimamsa*, 55(2), 114-118.

Santaella, D. F., Balardin, J. B., Afonso, R. F., Giorjiani, G. M., Sato, J. R., Lacerda, S. S., & Kozasa, E. H. (2019). Greater anteroposterior default mode network functional connectivity in long-term elderly yoga practitioners. *Frontiers in Aging Neuroscience*, 11, 158.

Sathyanarayanan, G., Vengadavaradan, A., & Bharadwaj, B. (2019). Role of yoga and mindfulness in severe mental illnesses: A narrative review. *International journal of yoga*, 12(1), 3-28.

Schmalzl, L., Powers, C., & Henje Blom, E. (2015). Neurophysiological and neurocognitive mechanisms underlying the effects of yoga-based practices: towards a comprehensive theoretical framework. *Frontiers in human neuroscience*, 9, 235.

Sciarrino, N. A., DeLucia, C., O'Brien, K., & McAdams, K. (2017). Assessing the effectiveness of yoga as a complementary and alternative treatment for post-traumatic stress disorder: A review and synthesis. *The Journal of Alternative and Complementary Medicine*, 23(10), 747-755.

Sharma, K., Arya, K., Kumar, S., & Sharma, S. (2024). Neuro-molecular Effects of Yoga and Endurance Exercises: Similarities and Dissimilarities. *In Neuroscience of Yoga: Theory and Practice: Part 1, Singapore: Springer Nature Singapore,* 139-156.

Singh, S., Rai, M. S. K., Pandya, B. V., & Kumar, R. (2023). Yoga and meditation. Academic Guru Publishing House.

Smaniotto-Holmes, K. (2024). Learning, Breathing, and Well-Being: Resiliency and Yoga—Contemplations on the Neuroscientific Connection to Curriculum, Teaching, and Learning. *Interchange*, 55(3), 331-348.

Streeter, C. C., Gerbarg, P. L., Saper, R. B., Ciraulo, D. A., & Brown, R. P. (2012). Effects of yoga on the autonomic nervous system, gamma-aminobutyric-acid, and allostasis in epilepsy, depression, and post-traumatic stress disorder. *Medical hypotheses*, 78(5), 571-579.

Streeter, C. C., Whitfield, T. H., Owen, L., Rein, T., Karri, S. K., Yakhkind, A., & Jensen, J. E. (2010). Effects of yoga versus walking on mood, anxiety, and brain GABA levels: a randomized controlled MRS study. *The journal of alternative and complementary medicine*, 16(11), 1145-1152.

Surana, S., Singh, L., Jain, P. K., & Tharwan, A. (2025). The Synergy of Emotional Intelligence, Mental Health, and Physical Fitness: The Impact of Yoga on Daily Life. *In Emotional Intelligence in the Digital Era, Auerbach Publications*, 311-324.

Suri, M., Sharma, R., & Saini, N. (2017). Neuro-physiological correlation between yoga, pain and endorphins. *International Journal of Adapted Physical Education and Yoga*, 2(9), 18-32.

Tolahunase, M. R., Gautam, S., Sagar, R., Kumar, M., & Dada, R. (2021). Yoga in major depressive disorder: molecular mechanisms and clinical utility. *Frontiers in Bioscience-Scholar*, 13(1), 56-81.

Tolahunase, M. R., Sagar, R., Faiq, M., & Dada, R. (2018). Yoga-and meditation-based lifestyle intervention increases neuroplasticity and reduces severity of major depressive disorder: A randomized controlled trial. *Restorative neurology and neuroscience*, 36(3), 423-442.

Tyagi, A., & Cohen, M. (2016). Yoga and heart rate variability: A comprehensive review of the literature. *International journal of yoga*, 9(2), 97-113.

Udupa, K., & Sathyaprabha, T. N. (2018). Influence of yoga on the autonomic nervous system. *In Research-based perspectives on the psychophysiology of yoga, IGI Global,* 67-85.

Udupa, K., Bhavanani, A. B., & Ramanathan, M. (2022). Stress and the Autonomic Nervous System: Implication of Yoga. *In The principles and practice of Yoga in cardiovascular medicine, Springer,* 105-115.

Van Aalst, J., Ceccarini, J., Demyttenaere, K., Sunaert, S., & Van Laere, K. (2020). What has neuroimaging taught us on the neurobiology of yoga? A review. *Frontiers in integrative neuroscience*, 14, 34.

Varambally, S., Gangadhar, B. N., Lam, L., & Riba, M. (2016). Yoga-based interventions for the management of psychiatric disorders. *Physical Exercise Interventions for Mental Health*, 124-146.

Veerakannan, S. (2025). Yoga Effects on Brain Health: A Systematic Review of the Current Literature. *Aathiyoga Indian Journal of Ancient Medicine and Yoga*, 1(05), 171-192.

Virk, H., Seth, S., Rabac, J. K., & Jain, D. (2020). Spirituality, yoga practice & natural dopamine effects. *JS International Journal of Multidisciplinary Research*, 2(1).

Voss, S., Cerna, J., & Gothe, N. P. (2023). Yoga impacts cognitive health: neurophysiological changes and stress regulation mechanisms. *Exercise and sport sciences reviews*, 51(2), 73-81.

Wadden, K. P., Snow, N. J., Sande, P., Slawson, S., Waller, T., & Boyd, L. A. (2018). Yoga practitioners uniquely activate the superior parietal lobule and supramarginal gyrus during emotion regulation. *Frontiers in integrative neuroscience*, 12, 60.

Weng, H. Y., Feldman, J. L., Leggio, L., Napadow, V., Park, J., & Price, C. J. (2021). Interventions and manipulations of interoception. *Trends in neurosciences*, 44(1), 52-62.

Yadav, A., Verma, S., Panwar, M., & Yadav, N. K. (2022). Role of Yoga practices on cognitive functions: A review. *International Journal of Health Sciences*, (III), 3288-3304.

Yashotha, D. (2025). The Power of Yoga and Meditation in Combating Sleep Disorders. *Aathiyoga Indian Journal of Ancient Medicine and Yoga*, 2(02), 208-214