

Meta-Analytical Review of MRI and fMRI Findings on Yoga's Impact on Brain Structure and Connectivity

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DESCRIPTION

Neuroplasticity—the brain's remarkable ability to reorganize and adapt itself structurally and functionally throughout life—has revolutionized our understanding of brain health and recovery. Once believed to be largely fixed after early development, the adult brain is now recognized as a dynamic organ capable of change in response to experience, learning, and environmental stimuli. Among the various lifestyle interventions explored for their neuroplastic potential, yoga has garnered increasing attention. Combining physical postures, controlled breathing, and mindfulness meditation, yoga offers a holistic approach that may stimulate brain plasticity. Recent advances in neuroimaging techniques, particularly Magnetic Resonance Imaging (MRI) and functional MRI (fMRI), have provided compelling evidence for the positive impact of yoga on brain structure and function.

MRI studies have revealed that consistent yoga practice is associated with structural changes in key brain regions involved in attention, emotion regulation, memory, and self-awareness. For example, several cross-sectional studies comparing experienced yoga practitioners with matched controls found increased gray matter volume in the hippocampus, prefrontal cortex, insula, and anterior cingulate cortex. These regions are critically involved in learning, executive function, and emotional processing. Given that these areas typically shrink with aging or stress, the finding that yoga practice may counteract such decline underscores its potential as a neuroprotective intervention.

Longitudinal MRI studies have further supported this notion by demonstrating that regular yoga practice leads to increases in cortical thickness and gray matter density over time. One notable study tracked participants engaged in an eight-week yoga and meditation program and reported significant increases in hippocampal volume, a brain region integral to memory consolidation and stress regulation. Such neuroplastic changes correlate with improvements in cognitive performance and psychological well-being, suggesting a direct link between yoga practice and enhanced brain health.

Functional MRI (fMRI), which measures brain activity by detecting changes in blood flow, has provided additional insights

into how yoga influences neural networks. Studies using fMRI have shown that yoga practitioners exhibit altered activity and connectivity in the Default Mode Network (DMN), a set of brain regions involved in self-referential thought, mind-wandering, and emotion regulation. Enhanced DMN connectivity in yoga practitioners is associated with improved mindfulness and reduced rumination, common contributors to anxiety and depression.

Moreover, fMRI investigations have revealed that yoga modulates activation patterns in the prefrontal cortex and amygdala, regions implicated in executive control and emotional reactivity. Increased prefrontal activation combined with decreased amygdala response suggests improved top-down regulation of emotions, which aligns with self-reported reductions in stress and anxiety among yoga practitioners. These findings highlight the potential of yoga to recalibrate neural circuits related to mood regulation and cognitive control.

The breath-focused practices inherent to yoga also play a significant role in promoting neuroplasticity. Breath regulation techniques have been shown to influence autonomic nervous system balance, favoring parasympathetic activation, which supports relaxation and recovery. Neuroimaging studies indicate that controlled breathing exercises enhance connectivity between the brainstem and cortical regions, fostering better autonomic regulation and stress resilience. This mind-body integration is thought to facilitate structural and functional brain changes conducive to emotional balance and cognitive flexibility.

In addition to adult populations, emerging research indicates that yoga can induce neuroplastic changes in diverse groups including children, older adults, and clinical populations. For instance, studies involving older adults practicing yoga have documented improvements in memory and executive function, paralleling structural brain changes observed *via* MRI. Similarly, patients with neurological or psychiatric conditions such as depression, PTSD, or mild cognitive impairment show promising brain responses to yoga-based interventions, reinforcing its therapeutic potential.

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Despite these encouraging findings, challenges remain in standardizing yoga protocols and controlling for confounding variables such as physical fitness, meditation experience, and lifestyle factors. Most studies to date involve small sample sizes and vary widely in yoga style, frequency, and duration, which limits generalizability. Future research with larger, randomized controlled trials and multimodal neuroimaging approaches will be essential to further clarify the mechanisms and optimize interventions.

CONCLUSION

MRI and fMRI studies provide compelling evidence that yoga induces neuroplastic changes in brain structure and function. By

enhancing gray matter volume, improving functional connectivity, and modulating activity in regions critical for cognition and emotion, yoga emerges as a powerful mind-body practice with potential to support brain health across the lifespan. As neuroscience continues to unveil the intricate ways lifestyle influences the brain, yoga stands out as a promising, accessible, and holistic tool for fostering neuroplasticity and mental well-being.