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Effects of Meditation on brain's structural and Functional changes: A review

Dr. Namrata Chouhan Dhakad[1] & Dr. Neha Saini[2]

1. Assistant Professor, Shri Vaishnav Vidhyapeeth Vishwavidyalaya, Indore (M.P.)
2. Assistant Professor, Gurukul Kangadi, Deemed University, Haridwar

Abstract:
Yoga is Widely used therapy for Mind, Body & overall health, different disease prevention and as a possible treatment for neurological disorder. There is a lacuna of evidence base literature. Previous researches shown the Brain structural and functional changes associate with meditation. but effect of Meditation on the structural and functional changes in the brain remain a research area that lacks consensus. **Aim:** The purpose of the study was to examine the review existing literature on the effect of meditation on structural and functional changes. **Methodology:** For this research the researcher has performed a Comprehensive search for that reviewed 36 relevant studies and examining the effect of Meditation on brain structure & studies on brain function. **Relevance:** Collectively the studies demonstrate a positive effect of Meditation on structure and function of Brain. Major **Finding:** Studies have found that regular meditation can increase grey matter density in areas of the brain associated with learning, memory, and emotional regulation, such as the hippocampus. outcome have shown changes in Meditation has been extensively studied for its effects on brain function, revealing numerous changes in neural activity and connectivity.
Keywords: Meditation, Brain, Structure, Function, Neuron.

INTRODUCTION:

Background: Mediation is an ancient practice rooted in numerous cultural and spiritual traditions that has generated substantial scientific interest due to its potential to alter brain structure and function profoundly. Using modern neuroimaging techniques, researchers have been able to investigate how meditation influences the brain, revealing complex interactions between neuroplasticity, functional connectivity, and cognitive enhancement. The purpose of this review is to synthesize current findings on the structural and functional brain changes associated with meditation, drawing upon a wide range of published studies.

METHOD:

The terms "Meditation and Brain Structure, Meditation and Brain Function " were used to find the literature that was selected for this review. The database made use of Clinical.gov, PubMed, Google Scholar, and the Medline database. Qualitative and quantitative research were the two groups into which potential articles were categorised. **The studies that looked at meditation and used changes in brain structure and function as an outcome variable** were the only ones that met the inclusion criteria. The exclusion criteria included research done prior to year 2000, unpublished works, and articles that were based on the opinions of a single individual. The studies were examined after being screened for inclusion and exclusion criteria.

MEDITATION AND ITS EFFECT ON BRAIN STRUCTURE

Several review articles have demonstrated the profound anatomical alterations in the brain that occur because of meditation. Studies utilising neuroimaging methods, such as MRI and fMRI, have shown that meditation alters the brain's grey and white matter and influences neuronal plasticity.

Increased Gray Matter Density: Increases in grey matter volume have been linked to meditation in several different brain regions. These alterations are most frequently seen in the right anterior insula, which is important in emotional regulation and self-awareness, according to a systematic review and meta-analysis. Furthermore, there have been reports of increased grey matter in the prefrontal cortex, which is linked to higher order cognitive processes like attention and decision-making, and the hippocampus, which is essential for memory and learning. Yoga encompasses a wide range of disciplines, including physical postures, controlled breathing, meditation, and other associated activities. According to one study, long-term practitioners of hatha yoga and meditation had larger grey matter volumes than controls who did not practise yoga. The left hippocampal grey matter content increased, as validated by analyses in a priori regions of interest. Increases in the temporo-parietal junction, the cerebellum, and the posterior cingulate cortex were seen in whole brain studies between the Mindfulness based stress Reduction group and the controls. The findings imply that engagement in Mindfulness based stress Reduction is linked to modifications in the amount of grey matter present in areas of the brain related to perspective taking, emotion regulation, self-referential processing, and learning and memory.

White Matter Density: Additionally, research suggests that meditation may improve the white matter tracts' integrity. These modifications are hypothesised to increase connection across various brain regions, improving coordination and communication among the brain's networks. This may be the cause of the long-term improvements in cognitive abilities and emotional control.

According to longitudinal research, consistent meditation practice can lead to the development of these anatomical alterations. There may be a dose-response association between the magnitude of these alterations and the duration of meditation. This implies that a person's brain may undergo more noticeable structural alterations the longer and more regularly they meditate.

Research suggests that meditation could improve white matter tract integrity. It is believed that these modifications will increase the connectivity between various brain regions, improving coordination and communication among the brain's networks. This may be the reason behind the gains in long-term meditators' emotional control and cognitive abilities**.**

These anatomical alterations can emerge with consistent meditation practice, according to longitudinal research. A dose-response association appears to exist between the magnitude of these alterations and the duration of meditation. This suggests that the more prolonged and regular a person meditates, the more noticeable the anatomical alterations in their brain may be**.**

Thickening of the Prefrontal Cortex: There is evidence that meditation on its own has neuroprotective effects as well by thickening the cortex, and that older individuals are more likely to benefit from meditation. The prefrontal cortex, which governs executive processes including self-control, attention, and decision-making, has been linked to an increase in cortical thickness during meditation. Regular Meditation Practice is Linked to increased thickness in a Subset of the Cortical Region Associated with Interoceptive, Somatosensory, Auditory, and Visual Processing. Additionally, consistent meditation practice may lessen

the frontal cortex's age-related shrinkage. Working memory capacity was increased by the intervention's activation of the bilateral dorsolateral prefrontal cortex, and each person's rise in WMC was found to be correlated with this activation.

The dorsal and medial prefrontal cortex, as well as the posterior cingulate cortex, are the primary components of this network. Since their differential involvement is determined by the dominating activity, these midline structures are antagonistic to self-specifying and self-relational processes. Changes in brain volume and function show that brain plasticity is mediated by long-term mental conditioning.

Neuroplasticity brought on by meditation alters the structure of the brain. Enhanced cortical thickness and grey matter density have been observed in areas related to learning, memory, and emotional control. A stronger sense of emotional and cognitive resilience is correlated with these structural alterations Positive changes in mood, anxiety, and other neuropsychologic indicators were linked to meditation programs in individuals with memory loss, and these changes were tied with improvements in Cerebral Blood Flow.

Amygdala Size Reduction: People who frequently meditate tend to have a smaller amygdala, which is involved in processing emotions like stress and fear. Reduced stress and anxiety are associated with this anatomical alteration. Increases in the subiculum brought on by mindfulness training and a reduction in hippocampal connection to lateral occipital areas during contextual retrieval of suppressed fear. In the right amygdala region of interest (ROI) analysis and both hippocampal regions, the MBI group showed higher GMD than the UC group. Increased GMD was found in the left thalamus, bilateral temporo-parietal junction, left occipital lobe at the lingual gyrus and cuneus, and the left and right caudate nuclei, according to whole brain analysis. On the other hand, GMD variations were discovered in the cerebellum's dentate nucleus and left anterior lobe of the UC group. MBS training reduced negative emotion experience, lowered amygdala activity, increased attentional activity in certain brain regions, and improved self-esteem, anxiety, and despair symptoms in SAD patients.

Enhanced Connectivity: Studies using functional MRI indicate that meditation reduces activity in the brain network known as the default mode network (DMN), which is linked to self-referential and mind-wandering thoughts. At the same time, brain areas like the insula and anterior cingulate cortex that are involved in emotional and cognitive regulation are more activated. This change in brain activity is thought to be a factor in the improved attention and emotional fortitude that practitioners of meditation frequently describe. Meditation can increase the connectivity between different regions of the brain, particularly the default mode network, which is involved in self-referential thoughts and mind-wandering.

MEDITATION AND ITS EFFECT ON BRAIN FUNCTION

Enhanced Emotional Regulation: Even one session of "group mantra-meditation" training has the potential to enhance emotional states and have a good impact on some immunological components. In addition to group therapy, this straightforward and inexpensive psych neurobehavioral intervention may improve mental health in assisted living facilities. The findings showed that short-term IBMT (Integrative Body-Mind Training), lasting 30 minutes a day for seven days, produced greater emotional control than Relaxation Training and enhanced creative performance on the divergent thinking challenge. Furthermore, a cross-lagged analysis revealed that the IBMT(Integrative Body-Mind Training) group's creativity may be influenced by both happy and negative affect. By

lowering amygdala activation and raising prefrontal cortex activity, meditation can enhance emotional regulation. People are able to handle pressures more composedly and resiliently as a result.

Enhanced Functional Connectivity:

Practices like mindfulness and meditation enhance the brain's functional connections. Enhanced connection among various brain regions and the prefrontal cortex, which is responsible for higher-order thinking, is one example of this. There has also been evidence of increased connection in the default mode network, which is linked to better self-referential processing and emotional control.

Compared to controls, Mindfulness based stress individuals showed enhanced functional connectivity between the bilateral medial prefrontal cortex, left hippocampus, and posterior cingulate cortex. Furthermore, compared to control participants, Mindfulness based stress reduction patients exhibited patterns of reduced bilateral hippocampus volume atrophy.

Alterations in Brain Activity

Patterns of brain activity can be changed by meditation. Studies using functional MRI (fMRI) reveal less activity in the Default mode Network which is frequently associated with better focus and less mind-wandering. The brain regions in charge of attention and sensory processing are busier at the same time.

Impact on Cognitive Functions

Consistent meditation practice has been linked to gains in executive function, memory, and attention. Changes in brain areas like the hippocampus and anterior cingulate cortex, which are essential to various cognitive functions, are partially responsible for these improvements.

In addition to the favourable effects of Preksha Meditation on transcriptome changes and cognitive abilities, recent research shows that 8 weeks after the intervention, the DNA methylation profile of naïve and healthy college students is also impacted by Preksha meditation.

At six months, there were no discernible differences in the improvement of episodic memory or executive function among older persons with subjective cognitive issues who had received mindfulness training, exercise, or both.

Emotional and Stress Regulation

The amygdala and the prefrontal cortex, two brain areas implicated in stress and emotion control, have been demonstrated to be modulated by meditation techniques. This modulation improves emotional stability and lowers stress reactions, both are beneficial to mental health in general.

Notable improvement trends were observed in mood, anxiety, tension, and fatigue in individuals with memory loss, who participated in the meditation training program; several indicators even reached statistical significance. Changes in Cerebral Blood Flow were linked with all main trends. Compared to health training, meditation training dramatically increases mindfulness and decreases stress-eating tendencies and food cravings. Changes in the default mode network, reward regions, hypothalamus, insula, and somatosensory areas are the cause of this. These alterations show how stress eating affects the brain.

Participants in mindfulness retreats reported significantly lower levels of subjective stress and anxiety as well as better balances of some important inflammatory state mediators.

Transcendental Meditation individuals showed a substantial rise in the POMS vigour subscale and a significant decrease in the POMS Total Mood Disturbance and the subscales measuring anxiety, anger, melancholy, weariness, and confusion. The BIS scores of Transcendental Meditation in individuals in the EEG-subgroup also increased significantly.

Activations of the Anterior Insula: The study found that long-term meditation practitioners showed higher activations of the anterior insula, ACC, medial prefrontal

cortex, and temporal pole when sharing social pain. However, left anterior insula activation was lower in long-term practitioners, and the strength of anterior insula activation was negatively correlated with trait compassion.[i] According to the study, long-term mindfulness meditation practitioners diminish left AI activity but increase activation in the anterior insula, medial prefrontal cortex, and temporal pole when sharing social sadness. According to the study, mindfulness meditation can be a helpful coping strategy for those who are distressed and promote acts of kindness.

Modified Brain Wave Patterns: A notable increase was observed when the theta power for the meditation condition was averaged across all brain areas. The frontal and temporal-central regions had much greater theta values than the posterior region upon closer examination. There was also a significant increase in alpha power during the meditation condition compared to the rest condition, when averaged across all brain areas. Additionally, it was demonstrated that the posterior than the frontal regions of the brain had a substantially higher abundance of alpha than the former. The findings of this study suggest that theta and alpha EEG patterns are significantly altered by nondirective meditation techniques, which may resemble mindfulness or concentration-based practices.

Various meditation techniques can cause particular brain wave patterns. For instance, enhanced theta wave activity, which is connected to deep relaxation and contemplative states, is frequently observed during mindfulness meditation.

The brain can undergo profound structural and functional changes because of meditation. These modifications support enhanced mental health generally, emotional control, and cognitive performance. Thus, consistent meditation practice can be an effective means of improving mental health and brain function.

Other Changes:

A brief meditation course was linked to a considerable increase in QOL (quality of life) and brain oxygenation, as well as a decrease in stress indicators. Meditation can help students to adapt to life stressors. The brain's affective and motivational dimension of the pain response is longitudinally reduced by the Transcendental Meditation approach. Studies on mindfulness meditation training in HIV-1-positive people offer preliminary evidence that it helps slow the loss of CD4+ T cells. Effect on verbal fluency and interference control; good ideas promote performance while bad suggestions inhibit it.

Better Concentration and Attention: Meditating improves one's capacity to sustain concentration and maintaining focus on tasks. Studies using functional magnetic resonance imaging (fMRI) reveal that Meditation enhanced activity in brain areas linked to attention and cognitive control.

Diminished Default Mode Network Activity: Mind-wandering and self-referential thoughts decreases which are related with a decrease in the activity of the default mode network which is frequently lower among seasoned meditators.

Enhanced Gamma Wave Activity: The brain activity of long-term meditators is frequently observed, and it has enhanced. The Higher mental functions including perception, consciousness, and problem-solving capabilities are linked to gamma waves.

DISCUSSION: Research has demonstrated that meditation alters the brain's structure and function in several ways. These modifications may result in greater emotional and mental well-being, sharper cognitive function, and general

wellbeing. The following are some important conclusions from research on how meditation affects the brain. Meditation leads to structural and functional changes in the brain, particularly in areas involved emotional regulation, memory, and cognitive control. These changes are thought to support the various psychological benefits of meditation, such as improved focus, emotional stability, and overall mental well-being.

CONCLUSION: The convergence of structural and functional changes in the brain due to meditation underscores its potential as a powerful tool for enhancing cognitive and emotional health. By fostering neuroplasticity and improving neural connectivity, meditation not only bolsters cognitive functions but also promotes emotional resilience and overall well-being. This review encapsulates the growing body of evidence supporting the transformative effects of meditation on the brain, paving the way for future research and practical applications in mental health and cognitive enhancement. In summary, meditation not only enhances functional connectivity and brain activity patterns but also leads to structural changes that support improved cognitive and emotional functions. These findings underscore the potential of meditation as a tool for enhancing mental health and cognitive performance.

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