

# The Neuroimaging of Kundalini Yoga: A Focused Narrative Review on Brain Structure, Function, and Mechanisms

<sup>1</sup>Dr. Kanchan M, <sup>2</sup>Dr. Archana K, <sup>3</sup>Dr. Vanitha shetty

<sup>1</sup> PG Scholar, Department of Clinical Yoga Alva's College of Naturopathy & Yogic Sciences, Moodbidri, Karnataka

<sup>2</sup> Professor, HOD of Department of Yoga, Alva's College of Naturopathy & Yogic Sciences,

<sup>3</sup>Principal, HOD of clinical naturopathy, Alva's College of Naturopathy & Yogic Sciences, Moodbidri, Karnataka

<sup>1</sup> Department of Yoga,  
<sup>1</sup>India

## Abstract

### Background:

Kundalini Yoga (KY) is a multimodal mind–body practice combining mantra, breath regulation, movement, mudras, and meditation. Kirtan Kriya (KK), a brief KY technique, has been widely studied in ageing and dementia-risk populations. Neuroimaging offers objective insight into KY's effects on brain structure and function beyond behavioural outcomes.

### Objective:

To synthesise neuroimaging and physiological evidence on the effects of KY/KK on brain structure, function, and mechanisms underlying cognitive change.

### Methods:

A narrative review was conducted using PubMed and Google Scholar up to December 2024. Inclusion criteria were peer-reviewed human studies employing neuroimaging (MRI, fMRI, EEG, MEG, PET, SPECT) and KY/KK interventions. Twenty-one studies met eligibility.

### Results:

Across modalities, KY is associated with increased cerebral blood flow in prefrontal and temporal regions, modulation of electrophysiological rhythms (enhanced alpha and theta activity), improved functional connectivity in executive and memory networks, and preservation or increase of hippocampal grey matter. These neural changes correspond with improvements in memory, attention, executive function, mood, and stress regulation.

### Conclusion:

KY exerts cognitive benefits through acute neural activation, repeated network-level reorganization, and chronic physiological modulation, including reduced cortisol and improved autonomic balance. Although findings are promising, studies remain small and heterogeneous. Large, standardized, multimodal trials with long-term follow-up are needed. KY is a safe, accessible intervention with strong potential for cognitive health promotion and dementia prevention.

**Keywords:** Kundalini yoga, Kirtan Kriya, Neuroimaging.

## 1. Introduction

KY is a type of yoga that emphasises breathing exercises and mental visualisations more than other types of yoga. It also incorporates movement and meditation. Meditation practices can be silent or feature repetitive Sanskrit mantras intended to bring tranquility to the mind. These meditative activities can further involve mudras, continuous or shifting positions of the hands and fingers. (1)

Dynamic kriyas, pranayama (breathwork), mantra chanting (such as Sa Ta Na Ma), mudras, and concentrated meditation are all combined in Kundalini Yoga (KY), a multimodal mind-body practice. In cognitive ageing research, Kirtan Kriya (KK), a brief, systematic chant-mudra-visualization practice, has received the most attention among KY techniques. Neuroimaging provides objective measures to evaluate the brain underpinnings of KY's cognitive effects and to get beyond behavioural outcomes to processes of change. This review focusses on physiological imaging (CBF/HRV correlations) and neuroimaging results (structural MRI, fMRI, SPECT/PET, EEG/MEG) related to KY/KK and cognition (2)

One sort of meditation from a normal KY practice, Kirtan Kriya (KK), has been examined earlier in older individuals and carers. For hundreds of years, people have practiced yoga. KK was utilised as a homework practice and includes chanting the mantra sounds, Saa Taa Naa Maa combined with repetitive finger gestures, or mudras, and visualisations (mudras). KK is supposed to be balancing and uplifting. The sounds derive from the mantra "Sat Nam," which means "my true essence." It is possible to modify this secular practice for a variety of durations, such as 11 or 32 minutes. It has been demonstrated to be effective in boosting cognitive and emotional functioning (e.g. decreased depression, anxiety and stress, and increased mood, sleep, cognition, attention, memory, and resiliency) in dementia carers. (3,4)

Cognitive functions such as attention, working memory, long-term memory, executive function, processing speed, and emotional regulation are regulated by autonomic balance, stress hormones, and neuroplastic changes—domains strongly modulated by yogic and meditation practices. Meditation traditions broadly promote cognitive performance by boosting prefrontal activation, strengthening hippocampal integrity, regulating limbic activity, and promoting functional neural connection (5-7)

## 2. Methodology

This narrative review was conducted to summarise current scientific evidence on The Neuroimaging of Kundalini Yoga: A Focused Narrative Review on Brain Structure, Function, and Mechanisms. The methodological approach followed established standards for narrative (non-systematic) reviews.

### 1. Search Strategy

A comprehensive literature search was conducted across major scholarly databases, including:

- PubMed
- Google Scholar

The search covered all years up to December 2024.

### 2. Search Terms

- Kundalini Yoga
- Kirtan Kriya
- MRI, fMRI, EEG, MEG
- SPECT, PET, cerebral blood flow
- hippocampus, connectivity

### 3. Study Selection

Titles and abstracts were screened, followed by full-text review.

Grey literature (conference papers, theses, blogs, preprints, dissertations) was excluded.

#### Inclusion Criteria

- Peer-reviewed primary research
- Human participants
- Used neuroimaging or cognitive measures
- Intervention included Kundalini Yoga, Kirtan Kriya, or related meditative practices

#### Exclusion Criteria

- Animal studies
- Non-peer-reviewed or grey literature
- Pure philosophical/qualitative discussions
- Papers not reporting brain or cognitive outcomes

### 4. Number of Studies Identified

The search initially identified 312 records.

After removing duplicates ( $n = 89$ ), screening titles/abstracts ( $n = 223$ ), and applying full-text criteria, 21 studies met inclusion criteria.

#### Breakdown:

- Neuroimaging studies: *9 papers*
  - fMRI = 4
  - EEG = 3
  - PET/SPECT = 2
- Cognitive/behavioural studies: *12 papers*
  - Memory = 7
  - Stress/affect regulation = 5

### 5. Data Extraction

Data from each study were extracted manually and summarised for:

- Sample size & demographics
- Study design and duration
- Neuroimaging modality
- Cognitive outcomes
- Key findings
- Proposed mechanisms

### 6. Synthesis Approach

Because narrative reviews do not statistically pool data, findings were synthesised qualitatively. Themes were organised into:

1. Structural brain changes
2. Functional brain activation patterns
3. Perfusion Imaging (SPECT/PET) and Cerebral Blood Flow
4. Electrophysiology: EEG and Oscillatory Dynamics

## 7. A Mechanistic Model

How Kundalini Yoga may influence brain structure, function, and cognition is presented and illustrated.

### 1 Structural Brain Changes

#### 1.1 Evidence for hippocampal structural effects

KY structural-imaging data originate from studies evaluating hippocampus volume. After a KY intervention, older people' right hippocampus grey matter volume increased compared to an education control, according to a pilot randomised controlled experiment. The hypothesis that relatively short KY treatments can result in volumetric effects in memory-related structures is supported by this experiment.

Potential mechanisms for hippocampal volume change include reduced cortisol-mediated hippocampal atrophy, increased BDNF-mediated neurogenesis, improved cerebral perfusion, and activity-dependent plasticity through repeated mnemonic/semantic activation associated with mantra practice. However, existing MRI studies are small and sometimes exploratory; larger, longer-duration randomized trials with standardized acquisition and processing pipelines are needed to confirm hippocampal neuroplasticity attributable specifically to KY. (2)

### 2. Functional brain activation patterns

#### 2.1 Acute functional changes during chanting/meditation

A study on Cerebral blood flow differences between long-term meditators and non-meditators shows the CBF of long-term meditators was significantly higher ( $p < .05$ ) compared to non-meditators in the prefrontal cortex, parietal cortex, thalamus, putamen, caudate, and midbrain. There was also a significant difference in the thalamic laterality with long-term meditators having greater asymmetry. The observed changes associated with long-term meditation appear in structures that underlie the attention network and also those that relate to emotion and autonomic function. (8)

#### 2.2 Default Mode Network (DMN) and task-positive networks

Meditation studies more broadly suggest modulation of the DMN (reduced maladaptive mind-wandering) and increased recruitment of task-positive networks (dorsal attention network, frontoparietal control network). KY's combination of mantra, focused attention, and motor components likely engages both bottom-up sensory–motor and top-down executive networks, facilitating functional rebalancing between DMN and attentional systems — albeit direct KY-specific fMRI studies remain limited.(9)

### 3. Perfusion Imaging (SPECT/PET) and Cerebral Blood Flow

Early neuroimaging of chanting/meditation documented acute CBF changes that map to cognitive control and memory regions. SPECT and PET studies of chanting meditations report increased perfusion in prefrontal cortex, anterior cingulate, and temporal lobes during practice—consistent with improved attentional and mnemonic processing. Newberg's group and subsequent studies using perfusion techniques provided foundational evidence that KY-like vocal-motor meditations modulate regional blood flow

Perfusion increases can support metabolic needs of activated networks and may, over time, enable structural support (angiogenesis, synaptic strengthening) that underlies volumetric and connectivity changes seen in MRI studies. However, many CBF studies are acute-state studies with limited follow-up, so the translation to long-term plasticity requires further longitudinal perfusion imaging. (8)

## 4. Electrophysiology: EEG and Oscillatory Dynamics

### 4.1 Characteristic EEG signatures

EEG investigations of KY or experienced KY meditators reveal increases in alpha and theta power, markers typically associated with relaxation and focused internal attention, respectively. Advanced meditators may also show localized increases in gamma-band synchrony reflecting integrative cognitive processes. Early work on KY masters and small-sample EEG studies demonstrated distinct occipital–parietal and frontal rhythms during practice. (10)

### 4.2 Kirtan Kriya EEG findings

KK's combined chanting, finger movements, and visualization elicit robust and reproducible EEG changes even after short practice durations (e.g., 12 minutes daily). Studies of KK show enhanced frontal theta and alpha coherence that correlate with improvements in attention and working memory. These oscillatory signatures provide a real-time electrophysiological mechanism by which KK may entrain frontal–hippocampal circuits involved in mnemonic processing. (11)

## 7. Mechanistic Model Linking KY Neuroimaging Findings to Cognitive Change

Based on the imaging and physiological data, a plausible mechanistic chain includes:

1. **Acute activation during practice** (increased CBF to PFC/temporal areas; changes in EEG alpha/theta/gamma) → immediate cognitive-state benefits (attention, encoding). (8)
2. **Repeated practice** → enhanced network-level functional connectivity (hippocampus–PFC coupling), improved efficiency of task-positive networks and reduced maladaptive DMN activity. (12)
3. **Chronic physiological changes** (reduced cortisol, improved HRV, reduced inflammation) → create a neuroprotective milieu that supports structural plasticity (e.g., hippocampal volume preservation/increase). (2)
4. **Behavioural cognitive gains** (memory, executive function) emerge as network efficiency and structural integrity improve. Combined imaging–behavior correlations in trials support steps 2–4 but need larger, confirmatory datasets. (12)

## 8. Mechanism of Action

### KUNDALINI YOGA (KY) / KIRTAN KRIYA (KK)

#### 1. ACUTE NEURAL ACTIVATION

- ↑ Cerebral blood flow (PFC, ACC, temporal lobe)
- ↑ Alpha/theta oscillations
- ↑ Sensory–motor engagement (mantra + mudra)

#### 2. NETWORK-LEVEL FUNCTIONAL CHANGES

- ↓ Default Mode Network hyperactivity
- ↑ Executive / frontoparietal control
- ↑ Hippocampus–PFC connectivity

### 3. PHYSIOLOGICAL & MOLECULAR EFFECTS

- ↓ Cortisol and HPA-axis reactivity
- ↑ HRV (parasympathetic tone)
- ↓ Inflammatory markers (NF-kB)
- ↑ Telomerase activity

### 4. STRUCTURAL PLASTICITY

- ↑ Hippocampal grey matter volume
- ↑ Regional perfusion support
- Enhanced synaptic efficiency

### 5. COGNITIVE & EMOTIONAL OUTCOMES

- Improved memory & attention
- Better executive function
- Reduced stress, anxiety, depression
- Improved resilience

## 9. Critical Appraisal of the Evidence

### Strengths

- Multimodal convergence (MRI, EEG, PET/SPECT, biomarkers)
- RCTs linking imaging changes with cognitive improvements
- KY is safe, accessible, and low cost for older adults

### Limitations

- Many studies are small, pilot trials
- Heterogeneity in KY protocols
- Variable imaging methods
- Short follow-up durations
- Lack of standardized analytic pipelines

## 10. Recommendations for Future Research

1. Multicentre RCTs with standardized KY manuals
2. Combined MRI–EEG–PET designs
3. ≥12-month follow-ups to test durability
4. Integration of BDNF, cortisol, telomerase, cytokines
5. Uniform EEG source-localization protocols
6. Dose–response mapping to identify core effective KY components

## 11. Conclusion

Neuroimaging evidence indicates that Kundalini Yoga—especially Kirtan Kriya—modulates key cognitive networks, enhances hippocampal structure and connectivity, improves cerebral perfusion, and regulates electrophysiological rhythms. These effects align with observed improvements in memory, attention, executive function, emotional regulation, and resilience.

## Reference

1. Krause-Sorio B, Siddarth P, Kilpatrick L, et al. Yoga Prevents Gray Matter Atrophy in Women at Risk for Alzheimer's Disease: A Randomized Controlled Trial. *J Alzheimers Dis.* 2022;87(2):569-581. doi:10.3233/JAD-215563
2. Ibrahim M, Therriault J, Nair VP, Dikaios E, Rosa-Neto P, Walpola IC, Rej S, Lifshitz M. Kundalini Yoga Intervention Increases Hippocampal Volume in Older Adults: A Pilot Randomized Controlled Trial. *Int J Yoga.* 2022 May-Aug;15(2):158-162. doi: 10.4103/ijoy.ijoy\_25\_22. Epub 2022 Sep 5. PMID: 36329774; PMCID: PMC9623893.
3. Black D.S. Yogic meditation reverses NF-kappaB and IRF-related transcriptome dynamics in leukocytes of family dementia caregivers in a randomized controlled trial *Psychoneuroendocrinology*, 38 (2013), pp. 348-355
4. Lavretsky H. A pilot study of yogic meditation for family dementia caregivers with depressive symptoms: effects on mental health, cognition, and telomerase activity *International Journal of Geriatric Psychiatry*, 28 (2013), pp. 57-65
5. Tang YY, Hölzel BK, Posner MI. The neuroscience of mindfulness meditation. *Nat Rev Neurosci.* 2015;16(4):213–25.
6. Fox KC, et al. Is meditation associated with altered brain structure? *Neurosci Biobehav Rev.* 2014;43:48–73.
7. Goyal M, et al. Meditation programs for psychological stress and well-being. *JAMA Intern Med.* 2014;174(3):357–68.
8. Newberg AB, Wintering N, Waldman MR, Amen D, Khalsa DS, Alavi A. Cerebral blood flow differences between long-term meditators and non-meditators. *Conscious Cogn.* 2010;19(4):899-905. doi:10.1016/j.concog.2010.05.003
9. van Aalst J, Ceccarini J, Demyttenaere K, Sunaert S, Van Laere K. What Has Neuroimaging Taught Us on the Neurobiology of Yoga? A Review. *Front Integr Neurosci.* 2020;14:34. Published 2020 Jul 8. doi:10.3389/fnint.2020.00034
10. Arambula P, Peper E, Kawakami M, Gibney KH. The physiological correlates of Kundalini Yoga meditation: a study of a yoga master. *Appl Psychophysiol Biofeedback.* 2001;26(2):147-153. doi:10.1023/a:1011343307783
11. Khalsa, D.S., & Newberg, A.B. (2011). Kirtan Kriya Meditation: A Promising Technique for Enhancing Cognition in Memory-Impaired Older Adults.
12. Kilpatrick, Lisa & Siddarth, Prabha & Krause-Sorio, Beatrix & Milillo, Michaela & Aguilar-Faustino, Yesenia & Ercoli, Linda & Narr, Katherine & Khalsa, dharma singh & Lavretsky, Helen. (2023). Impact of Yoga Versus Memory Enhancement Training on Hippocampal Connectivity in Older Women at Risk for Alzheimer's Disease. *Journal of Alzheimer's Disease.* 95. 149-159. 10.3233/JAD-221159.