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Neuroimaging Evidence of Brain Changes Associated with Reflexology: A Narrative Review

Dr Havyashri Poojary[1], Dr Vineetha A N[2], Dr Jyothi K V[3], Dr Vanitha S Shetty[4]

[1]PG scholar, Clinical Naturopathy, Alva's College of Naturopathy and Yogic Sciences Moodbidri.
[2]Associate Professor, Department of Naturopathy, Alva's College of Naturopathy and Yogic Sciences Moodbidri.
[3]Assistant Professor, Department of Naturopathy, Alva's College of Naturopathy and Yogic Sciences Moodbidri.
[4]Principal & HOD, Department of Naturopathy, Alva's College of Naturopathy and Yogic Sciences Moodbidri.

ABSTRACT

Reflexology is a complementary therapy that has been shown to influence brain activity by affecting distant organs through specific reflex points. Neuroimaging techniques provide objective evidence of central mechanisms underlying these effects. This narrative review examines available neuroimaging evidence on brain responses to reflexology. A literature search was conducted using PubMed, Google Scholar, and Scopus. Four functional magnetic resonance imaging studies reported modulation of brain activity and functional connectivity within sensorimotor, limbic, and pain-related networks. Overall, the neuroimaging evidence indicates that reflexology produces measurable effects within the central nervous system, supporting a brain-mediated mechanism underlying its therapeutic effects.

Keywords: reflexology, neuroimaging, sensory cortex, functional magnetic resonance imaging

Abbreviations

fMRI- Functional Magnetic Resonance Imaging
PET- Positron Emission Tomography
SPECT- Single Photon Emission Computed Tomography
CAM- Complementary and Alternative Medicine
EEG- Electroencephalography
MEG- Magnetoencephalography
RCT- Randomised Controlled Trial

INTRODUCTION

Reflexology is a treatment method where pressure applied to the feet without oil or based on the theory that there are reflex points on the feet, hands and head linked to every part of the body [1]. It differs from traditional massage since it does not intend to manually manipulate muscles or soft tissues, but involves stimulation of reflex points and nerves through direct pressure to these reflex zones in order to achieve

systemic effects [2]. Reflexology is also described as a non-invasive manual therapy aimed at stimulating the body's self-healing potential, relaxing and normalising it´s functions by influencing specific effects on neuro-reflexive pathways instead of mechanical effects on tissues [3]. In the early 20th century, Eunice Ingham systematized reflexology by creating foot reflex maps that connected specific areas to body organs. This change turned reflexology from an empirical practice into a structured method with clear principles and techniques [4]. The practice later expanded to include hand and ear reflexology and spread globally as a complementary therapy. These changes allowed reflexology to move toward clinical use and scientific study [1]. Reflexology is based on the concept that specific points on the feet, hands, and ears correspond to different organs and body systems. Stimulation of these points is thought to influence distant organs through neural connections, autonomic regulation, and central nervous system processing [5]. The neural and reflex-arc hypotheses say that stimulating these reflex points activates peripheral nerves, which then influence spinal and brain pathways leading to central effects [2]. Reflexology is often used as a complementary therapy for pain relief, stress reduction, sleep issues, and managing symptoms in chronic and supportive care settings [5]. Reflexology is commonly used in integrative healthcare settings, including the management of musculoskeletal conditions, cancer-related symptoms, and in palliative care. Clinical studies have reported improvements in patient-reported outcomes, particularly quality of life, following reflexology interventions [6]. Its non-invasive nature, ease of application, and good tolerance contribute to high patient acceptance, making it suitable for regular clinical use across diverse populations. The favourable safety profile and minimal reported side effects further support its popularity and inclusion in routine and supportive care practices [7,8]. So, this positive shift has led to more studies on its physiological and neurobiological functions using objective measures [9].

Traditional reflex zone models show inconsistencies and lack of clarity, which highlights gaps in purely mechanistic peripheral explanations and the need for further investigation [10]. Standard explanations of effects of reflexology limited only to the peripheral processes or placebo effects and do not fully explain its systemic, organ-specific and non-local results found in clinical studies. This has led for more objective physiological research beyond just subjective outcomes [5]. The observed systemic outcomes like reductions in stress, pain, and anxiety often happen quickly after stimulation. This suggests the involvement of brain regulatory processes. These limitations strongly support the need to explore mechanisms mediated by the brain, where neuroimaging can provide an objective way to assess the involvement of the central nervous system in reflexology [11].

In recent years, neuroimaging has become a crucial tool in neuroscience research. It allows for the visualization and analysis of brain structure, function, and metabolism. Techniques such as functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and single photon emission computed tomography (SPECT) give detailed insights into neural activity, blood flow in the brain, and metabolic states that were previously hard to measure with traditional psychophysiological methods [12,13]. The use of neuroimaging in complementary and alternative medicine (CAM) research has provided a valuable way to objectively study the underlying mechanisms of therapeutic effects, which are otherwise often assessed only through subjective reports or peripheral outcomes. Many CAM interventions, including acupuncture, manual therapies, yoga and diet involve complex sensory, motor, and emotional components, making the assessment of central nervous system responses essential for understanding how these therapies work [12,14]. By assessing brain activation, network connectivity, and regional metabolic changes, neuroimaging connects clinical outcomes with central nervous system processes. This finding provides deeper insights into how these interventions might produce therapeutic

effects beyond placebo responses. Functional neuroimaging methods, especially fMRI, have become key tools in CAM research due to their ability to map brain responses during both task-related and resting-state conditions. Resting-state fMRI allows for the examination of intrinsic brain networks which are important for pain perception, emotional regulation, and cognitive processing, all of which are often targeted by CAM therapies [15]. Other techniques like PET and SPECT also offer insights into metabolic and perfusion changes. This allows researchers to explore deeper processes, like neurotransmitter activity, cerebral blood flow, and energy use [4]. Neuroimaging now goes beyond simple activation mapping by assessing functional connectivity and brain network dynamics, allowing advanced analyses to link CAM-related changes in neural organisation with clinical and behavioural outcomes [16].

Still the growing neuroimaging evidence highlights the importance of central nervous system measures in understanding how reflexology interventions work. It shows patterns of brain activation, connectivity, and changes that relate to important areas like pain, emotion, and autonomic regulation.

In reflexology, a CAM practice suggesting that stimulation of certain points on the body affects distant regions and systems, neuroimaging provides an important way to explore if these effects show up in central processing networks. By reviewing current neuroimaging evidence, this study aims to clarify how much reflexology engages specific brain pathways and network dynamics that may explain its therapeutic effects. Using objective imaging results instead of just subjective reports, the neurobiological foundations of reflexology can be defined more accurately within the wider field of CAM research.

This narrative review aims to gather and critically evaluate neuroimaging findings on the brain effects of reflexology. By focusing only on studies that use established neuroimaging techniques, the review hopes to shed light on central nervous system links, clarify the underlying brain mechanisms, and identify gaps to help direct future research.

METHOD

A comprehensive search of the literature was carried out using major electronic databases, namely PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar. We used keyword combinations such as reflexology, foot reflexology, neuroimaging, functional MRI, fMRI, PET, SPECT, and brain activation. We included original research studies involving human subjects available in full text. This encompassed randomized controlled trials, clinical studies, pilot studies, case reports, and case series. Only studies that directly examined brain structure, function, perfusion, or metabolism using recognized neuroimaging techniques were considered. We excluded electrophysiological studies like EEG and MEG, as well as autonomic or peripheral physiological measures, only available as abstracts. Eligible articles were screened based on their title, abstract, and full text. We extracted key information on study design, study population, reflexology intervention, and neuroimaging method. Then, we narratively summarized the reported brain outcomes to provide a clear overview of the current evidence.

DISCUSSIONS

Table 1: Characteristics of review papers.

Year & Author	Study design	Sample size	Reflexology intervention (type & procedure)	Imaging modality	Result	Key findings
2024 Lee et al. [17]	Case report	1 infant with sensorineural hearing loss	Foot reflexology (30 min/day in week days for 24 weeks)	Resting-state fMRI	Increased regional homogeneity in frontal and temporal language related regions	Brain network changes accompanied recovery of hearing thresholds
2023 Descamps et al. [18]	Randomised controlled trial	30 healthy adults	Foot reflexology vs sham foot massage during scanning	Resting-state fMRI	Altered connectivity in default mode, sensorimotor, executive, and pain-related networks	Both reflexology and sham altered resting-state network
2022 Wattanaruangkowit et al. [19]	Pilot clinical study	20 smokers	Foot reflexology for 10 minutes on smoking related points	Task-based fMRI	Activation of precentral and postcentral gyri (sensorimotor cortex)	Reflexology consistently activated somatosensory brain areas; feasibility of neuroimaging demonstrated
2013 Miura et al. [20]	Double blinded experimental study	32 healthy adults	Eye Reflex area stimulation with correct vs incorrect information	Task-based fMRI	Activation of primary somatosensory cortex regardless of information given	Brain responses were independent of expectation, supporting a physiological rather than

						placebo-driven effect

Activates Primary Sensory Brain Regions

Across neuroimaging studies, a consistent finding is that reflexology activates primary sensory brain regions, especially the primary somatosensory cortex. The functional magnetic resonance imaging study provides the clearest experimental evidence for this effect [20]. When specific reflex areas on the foot were stimulated, researchers observed activation in somatosensory cortical regions traditionally associated with the face and eyes. Importantly, this activation happened whether participants received accurate or intentionally incorrect information about the reflex point being stimulated. This difference between cognitive expectation and brain response strongly suggests that reflexological stimulation is experienced as real sensory input, rather than as a reaction to belief or suggestion.

These findings are further supported by a pilot neuroimaging study in the context of smoking cessation, which demonstrated consistent activation of the contralateral primary motor and primary somatosensory cortices following reflexological stimulation of the foot [19]. Such opposite-side activation matches established principles of somatosensory neuroanatomy and indicates that reflexology engages ascending peripheral pathways. Notably, the brain's response went beyond what would be expected from simple foot touch. This suggests that reflexological stimulation may involve greater area summation or deeper engagement of mechanoreceptors.

From a mechanistic viewpoint, sustained pressure applied during reflexology likely activates skin and deeper mechanoreceptors, including Merkel cells, Ruffini endings, and deeper proprioceptive afferents. These signals travel through the dorsal column and medial lemniscus system to the primary somatosensory cortex, where the brain integrates and interprets them. Similar sensory brain activations have been reported in neuroimaging studies of acupuncture and therapeutic massage. This supports the idea that reflexology works within known sensory processing pathways, not just through non-specific touch [17,18].

Modulates Large-Scale Brain Networks

Reflexology has been shown to affect large-scale brain networks, indicating its impact at a systems neuroscience level. The randomised controlled trial by Descamps and colleagues revealed notable changes in resting-state functional connectivity after foot reflexology. Specifically, reduced connectivity was found in the posterior areas of the default mode network, including the posterior cingulate cortex. These areas are linked to self-referential thought, internal thinking, and mind-wandering [18].

Reduced connectivity in the default mode network usually indicates a shift towards attention focused on the outside world and sensory engagement. This pattern is also seen during meditation, mindfulness practices, and other body-focused non-drug treatments. In the case of reflexology, this suggests that stimulating the feet may temporarily change baseline brain activity to a state with less internal cognitive noise and greater awareness of the present [21]. At the same time, increased connectivity was observed in the sensorimotor network, which includes the primary motor cortex, primary somatosensory cortex, supplementary motor area, and thalamus. The thalamus acts as a key sensory relay and integrative center. The improved thalamocortical connectivity suggests better sensory integration and processing. These findings support a model where reflexology improves communication between peripheral sensory input and central processing networks [22].

While the study did not show reflexology-specific effects in comparison to sham massage after a single short session, the fact that foot-based tactile stimulation alone can reorganize intrinsic connectivity is

clinically important. It implies that reflexology, especially when done repeatedly or in clinical settings, may have stronger and more distinct network-level effects.

Influences Emotional, Pain-Related, and Behavioural Circuits

Neuroimaging evidence shows that reflexology affects emotional, pain-related, and behavioral regulation circuits. In a randomized controlled trial, researchers found connectivity changes within a widespread pain-related network. This network includes the thalamus, anterior insula, anterior cingulate cortex, amygdala, hippocampus, and basal ganglia [18]. These areas work together to process different aspects of pain: sensory discrimination, emotional response, and cognitive interpretation. Increased connectivity in limbic structures like the amygdala and hippocampus shows improved emotional processing and memory-related influence on sensory input. Changes in the anterior cingulate cortex and insula align with shifts in how we attribute significance to stimuli and our awareness of internal body states. These mechanisms fit with modern pain neuroscience models that highlight central modulation over peripheral nociceptive input as a main factor in pain perception [23,24]. The smoking cessation study offers additional evidence that reflexology may affect behavioral circuits [19]. In smokers, reflexology stimulated frontal and subcortical regions involved in executive control, motivation, and habit management. While still exploratory, these results indicate that reflexology could indirectly influence cravings and behavioral impulses by affecting interactions between the limbic system and prefrontal areas. Researchers have observed similar patterns in neuroimaging studies of mindfulness-based interventions and vagal nerve stimulation, where changes in interoceptive and autonomic networks lead to behavioral shifts [25,26].

Overall, these findings support the idea that reflexology works not only through sensory pathways but also through limbic-autonomic connections. This could help explain its reported benefits for pain, stress-related disorders, and behavioral issues.

Support Neuroplasticity with Repeated Application

Evidence for long-term neuroplastic effects of reflexology is limited but suggestive. A clinical case report of an infant with sensorineural hearing loss showed that six months of regular foot reflexology was linked to measurable changes in resting-state brain connectivity in frontal and temporal language-related areas [17]. These neuroimaging changes occurred alongside objective clinical improvements in hearing thresholds and age-appropriate speech development. From a mechanistic viewpoint, the developing brain shows increased plasticity. This allows sensory input to shape cortical organization and functional connectivity. Repeated sensory stimulation through reflexology may strengthen underactive neural pathways and encourage functional reorganization, especially when used during sensitive developmental periods. The reduced activity in visual compensatory regions seen in the case report suggests a possible normalization of cross-modal reorganization, a phenomenon well-documented in cases of sensory deprivation [27].

Although we cannot draw causal conclusions from a single case, the findings align with broader neuroplasticity research. It shows that repeated peripheral stimulation can drive central reorganization over time [28]. This raises the possibility that reflexology, when applied over a longer period, may support lasting brain changes rather than just temporary adjustments

Interpretation of Neuroimaging Findings

While the brain changes seen in reflexology are similar to those seen in foot/massages and general tactile stimulation, there is evidence to show that reflexologists process sensory input differently than non-specific touching. Activation of the right somatosensory cortex and the engagement of pain networks suggests that reflexological stimulation is processed by the body as structured sensory input [18, 20].

Repeated or structured reflexology treatments may lead to increased stimulation of brain regions related to reflexology. Integration of sensory information with cognition and emotional feelings will be modulated through networks that reside in the insula, anterior cingulate cortex, and limbic regions of the brain. These areas play a significant role in the regulation of emotional and physical stress responses. Therefore, the brain's ability to modulate the body is likely responsible for the benefits of reflexology in the treatment of stress-related disorders and psychogenic illnesses documented in research [23, 25]. Neuroimaging studies provide evidence for an association between reflexology and altered brain functioning. Studies reporting variations in reflexology technique, intensity or length of treatment, and the type of patient could explain differences in how patients respond to reflexology across studies [11, 18]. While variability in neural responses between studies will result from variability in techniques used to perform reflexology, intensity of each stimulation or treatment, enhancing treatment with reflexology is reliant upon reflexology as a whole; all studies should focus on long-term effects and neuroplastic changes that result from repeated application of reflexology techniques over a period of time (27,28). Overall, it is generally accepted that periodic stimulation of the peripheral nerves will lead to functional reorganisation of the brain over the course of time; this is supported by previous studies within the neuroscience field.

Clinical implication

Neuroimaging findings indicate that reflexology produces measurable changes in brain function, supporting its use as a complementary therapy for selected clinical conditions. The observation that reflexological stimulation activates the primary somatosensory cortex regardless of expectation or suggestion suggests that its effects are mediated through genuine sensory pathways. This supports the potential use of reflexology in conditions such as pain disorders, sensory integration problems, and psychosomatic illnesses, where modulation of sensory processing plays a key role.

Changes observed in brain networks related to pain and emotional regulation, including the thalamus, insula, anterior cingulate cortex, and limbic regions, provide a neurobiological explanation for the reported benefits of reflexology in chronic pain, stress-related conditions, and anxiety-associated physical symptoms. In addition, activation of brain regions involved in motivation and behavioural control among smokers indicates that reflexology may serve as a supportive intervention in addiction-related conditions, particularly smoking cessation, where regulation of craving and executive function is important.

Evidence of altered activity in auditory and language-related brain networks following repeated reflexology in an infant with sensorineural hearing loss further suggests possible applications in neurodevelopmental and rehabilitation settings. This may be especially relevant in contexts where non-invasive, sensory-based therapies are preferred.

Limitations of Current Evidence

The existing neuroimaging literature is limited by small sample sizes, variability in study design, and an emphasis on short-term brain responses. Most studies examined immediate neural effects, with only one report addressing longer-term changes suggestive of neuroplasticity. Moreover, in healthy participants, the neural effects of reflexology could not be clearly distinguished from those of general foot massage following a single session, highlighting the importance of considering treatment duration and cumulative exposure.

Future Directions

Future studies should focus on long-term randomised controlled trials using standardised reflexology protocols and clearly defined neuroimaging outcomes. Research involving clinical populations, particularly individuals with chronic pain, psychosomatic conditions, addiction, and neurodevelopmental

disorders, is needed to establish clinical relevance. The use of multiple neuroimaging approaches may further clarify underlying mechanisms and help identify neural markers associated with therapeutic response.

CONCLUSION

Current neuroimaging evidence suggests that reflexology produces measurable effects within the central nervous system. Studies consistently demonstrate activation of the primary somatosensory cortex and modulation of brain networks involved in sensory processing, pain, emotion, and autonomic regulation. These findings indicate that reflexology engages genuine neural pathways rather than acting solely through expectancy or placebo effects. Although the available evidence is limited and largely short term, it supports a central nervous system mechanism underlying the therapeutic effects of reflexology. Further well-designed, long-term neuroimaging studies are required to confirm these findings and establish their clinical significance.

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