International Research Journal of Ayurveda & Yoga Vol. 8(3), pp. 71-76, March, 2025
Available online at http://irjay.com
ISSN: 2581-785X
DOI: 10.48165/IRJAY.2025.80312

REVIEW ARTICLE

Meditation and Mind-Body Practices: Effects on Brain-derived Neurotrophic Factor and Brain Health: A Narrative Review

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ARTICLE INFO

Article history:
Received on: 08-02-2025
Accepted on: 09-03-2025
Published on: 31-03-2025

Key words:
Brain-derived neurotrophic factor,
Cognitive function,
Meditation,
Mental health,
Mind-body exercises,
Neuroplasticity,
Yoga.

ABSTRACT

Background: Brain-derived neurotrophic factor (BDNF) plays a crucial role in neuroplasticity and cognition. Meditation and mind-body exercises such as yoga may increase BDNF levels, offering a non-pharmacological strategy to enhance brain health.

Methods: This narrative review synthesizes evidence from published studies, primarily randomized controlled trials, sourced from PubMed, Scopus, Cochrane Library, and Web of Science, between 2020 and 2025, in accordance with the PRISMA guidelines. Studies have focused on meditation and mind-body interventions and their effects on peripheral BDNF levels.

Results: Eight studies demonstrated that mindfulness-based interventions, including yoga and meditation, consistently elevated BDNF levels across diverse populations, including healthy adults and individuals with depression. These increases are linked to reduced stress and inflammation, suggesting the underlying mechanisms. Mental health benefits, such as reduced depression and anxiety, have been widely observed, although cognitive and functional outcomes vary, particularly in older adults, where some studies have noted BDNF attenuation.

Conclusion: Meditation and mind-body practices have the potential to enhance BDNF levels and improve mental health, with possible cognitive benefits. However, inconsistencies in older adults and chronic pain populations underscore the need for further research to refine interventions and elucidate their underlying mechanisms.

1. INTRODUCTION

Brain-derived neurotrophic factor (BDNF) is a crucial protein involved in neuroplasticity and plays a key role in the development, maintenance, and survival of neurones.[1,2] This protein is fundamental to cognitive functions, such as learning and memory, and serves as a cornerstone of brain health. Dysregulation of BDNF has been associated with various neurological and psychiatric disorders including depression, Alzheimer's disease, and Parkinson's disease.[3-9]

As the global population ages and neurodegenerative disorders become more prevalent, there is an urgent need to identify non-pharmacological strategies that enhance BDNF levels to support brain function and mitigate disease risks. Physical exercise, particularly aerobic activities such as running or cycling, significantly increases BDNF production.[10,11] Dietary choices also play a role; omega-3 fatty acids, antioxidant-rich foods, and probiotics may support BDNF synthesis.[12-15] In addition, adequate sleep and regular social engagement are associated with higher BDNF levels, underscoring the value of a holistic and accessible approach to brain health.[16]

Complementing these strategies, meditation and mindfulness practices elevate BDNF levels, likely by reducing stress and altering neural activity in brain regions associated with emotional regulation. These practices blend physical movement, controlled breathing, and mental focus, engaging unique neurobiological pathways such as BDNF upregulation, which is distinct from conventional exercise, which focuses on cardiovascular and muscular fitness.[17,18] Unlike pharmacological interventions, they offer a safe, accessible, and side-effect-free alternative that appeals to diverse individuals, including those with physical limitations or contraindications to drugs.

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Recent research has begun to elucidate the effects of these practices on BDNF, with studies indicating increased peripheral BDNF levels across diverse populations ranging from healthy adults to individuals with mental health challenges.[19] Nevertheless, the underlying mechanisms and broader implications for cognitive and emotional well-being remain the subject of ongoing research. The potential of these interventions as preventive or therapeutic tools is particularly compelling given the increasing prevalence of neurodegenerative and mood disorders.

This narrative review synthesizes evidence from clinical trials to assess the impact of meditation and mind-body exercises on BDNF levels. By elucidating this relationship, this review aims to provide a foundation for future research and inform clinical applications, particularly for the prevention and management of neurological and psychiatric disorders. Understanding the interplay between these accessible interventions and BDNF could pave the way for innovative, non-invasive approaches to enhance brain health across the lifespan.

2. METHODS

A systematic literature search, following PRISMA guidelines, was conducted across PubMed, Scopus, Cochrane Library, and Web of Science using keywords like "meditation," "yoga," "mind-body exercise," and "BDNF," combined with Boolean operators, studies published between 2020 and 2025 were considered.[20]

Studies were included if they involved human participants of any age, sex, or health status and examined the effects of meditation or mind-body exercises, without restrictions on duration or intensity. Eligible studies included a control group, with no intervention, waitlist, or active controls, or employed pre-post designs with baseline comparisons. The primary or secondary outcome of interest was the measurement of peripheral serum or plasma BDNF levels. Studies were considered to have a preference for randomized controlled trials (RCTs), but non-randomized and quasi-experimental designs were also included. Only studies published in English were reviewed. Two reviewers independently screened titles and abstracts, reviewed the full texts to resolve discrepancies, and extracted key data, including study design, participant details, intervention specifics, BDNF measurement methods, and outcomes, using a standardized approach.

3. RESULTS

A comprehensive search of the PubMed, Scopus, Cochrane Library, and Web of Science databases yielded 287 records, as illustrated in Figure 1. After removing 57 duplicate entries, 230 articles were screened based on their titles and abstracts. Of these, 205 articles were excluded for failing to meet the inclusion criteria, such as relevance and study design, resulting in 25 articles being selected for full-text review. Following a detailed evaluation, eight studies were included in the final review.[21-28] The characteristics of these studies are summarized in Table 1.

Here, we discuss the findings from eight studies examining the effects of yoga and mindfulness-based interventions (MBIs), such as mindfulness-based cognitive therapy (MBCT) and contemplative training, on BDNF levels and related clinical outcomes. These studies spanned diverse populations, including healthy young adults, older adults, individuals with depression, and expedition members living in extreme environments. The intervention type and duration varied, ranging from single sessions to 9-month programs.

3.1. Effects on BDNF levels

The reviewed studies collectively demonstrated that MBIs, such as yoga and meditation, consistently enhance peripheral BDNF levels across a variety of populations. Among healthy individuals, diverse intervention approaches have yielded significant increases in neurotrophic factor levels. For instance, a single session of brain yoga markedly elevated serum BDNF in young men, outperforming traditional yoga and control conditions,[21] while an intensive weekend mindfulness program produced similar elevations in healthy females compared to a relaxation control.[22] Long-term contemplative training over 9 months also resulted in cumulative BDNF increases, although variability in the control group tempered the significance of the final comparison.[23]

In clinical contexts, MBCT spanning 8 weeks significantly boosted BDNF levels in college students with major depressive disorder (MDD), with greater practice time amplifying this effect.[24] Similarly, patients with depression receiving augmented MBCT exhibited notable BDNF elevation relative to those receiving standard pharmacotherapy alone.[25] A brief, yet intensive, 4-day yoga retreat further underscored the potency of short-term interventions, achieving a substantial increase in BDNF levels.[26] Even under extreme stress, such as during an Antarctic expedition, yoga practice helped mitigate BDNF decline compared to controls, highlighting its protective potential.[27]

In contrast, a distinct pattern emerged in older adults, where a 10-week yoga intervention diverged from the predominant trend of BDNF elevation.[28] While the intervention improved functional outcomes such as balance and motor learning, it was associated with an attenuation of BDNF levels, suggesting a possible decrease or stabilization rather than an increase. This finding, unique among the reviewed studies, implies that the BDNF response to mindfulness interventions may not be universally positive and may depend on factors such as age or the specific nature of the intervention. Additional insights suggest that mindfulness practice may influence neurobiological changes, including increased BDNF levels, further supporting their therapeutic potential.[29] Collectively, these results affirm the broadly beneficial effect of yoga and mindfulness on BDNF levels, particularly in younger and clinical populations, while indicating potential variability in older adults, which warrants further exploration.

3.2. Effects on Other Physiological Markers

Five studies explored the impact of mindfulness and yoga interventions on a range of physiological markers, often linking these changes to BDNF alterations or broader health outcomes, thereby providing insight into the multifaceted mechanisms underlying the observed neurotrophic benefits. Stress reduction has emerged as a central pathway, and in a longitudinal contemplative training program, increases in BDNF were associated with reduced long-term cortisol secretion and increased dentate gyrus volume, suggesting a stress-mediated neuroplasticity mechanism.[23]

Similarly, in a high-stress environment, yoga practice for over 10 months led to decreased cortisol levels and reduced oxidative stress, as evidenced by lower 8-hydroxy-2'-deoxyguanosine (biomarker of oxidative DNA damage) levels, along with a slight increase in serotonin, underscoring the intervention's capacity to mitigate stress-related physiological burdens.[27] Inflammation modulation is another key mechanism: An 8-week MBCT intervention significantly reduced proinflammatory cytokines concurrent with BDNF elevation, highlighting an anti-inflammatory effect that may support neurotrophic activity.[24]

An intensive weekend mindfulness program decreased mitochondrial oxidative phosphorylation complex-1, which was interpreted as a reduction in oxidative stress, although no significant changes were observed in cortisol or heart rate variability.[22] In addition to stress and inflammation, a 4-day yoga retreat substantially increased endocannabinoid levels, such as anandamide and 2-arachidonoylglycerol, by ≥70%, with weak correlations with improved happiness and well-being, suggesting that mindfulness practices may also influence neurotransmitter systems involved in emotional regulation.[26] Collectively, these findings illustrate the diverse physiological pathways, including stress reduction, inflammation control, and neurotransmitter modulation, through which mindfulness and yoga interventions may enhance neuroplasticity and mental health, often in concert with BDNF up-regulation.

3.3. Mental Health Outcomes

Six studies reported consistent improvements in mental health. MBCT reduces depression, anxiety, and sleep problems in students with MDD,[24] and improves self-esteem and stigma in patients with depression.[25] Short-term yoga lowered anxiety and enhanced well-being,[26] whereas long-term interventions bolstered resilience.[23,27]

3.4. Cognitive and Functional Outcomes

Three studies reported variable results. Yoga improved short-term memory in young men and balance in older adults,[21,28] but a weekend mindfulness program had no cognitive impact in healthy females suggesting context-specific effects.[22]

3.5. Summary of Findings

Mindfulness and yoga reliably enhance BDNF and mental health, with less consistent cognitive and functional benefits, particularly in older adults or short-term settings. The outcomes may depend on age, health status, and intervention design. This highlights the need for further research to refine these strategies and clarify the conditions for optimal clinical outcomes. In summary, these practices hold promise as therapeutic tools, with BDNF potentially acting as a key biological link between practice and benefits.

4. DISCUSSION

The reviewed clinical studies offer insights into the effects of non-pharmacological interventions such as meditation and mind-body exercises on BDNF levels and their broader implications for brain health.

A predominant finding across the reviewed studies was that MBIs tend to elevate peripheral BDNF levels, supporting their potential as non-pharmacological interventions to enhance neuroplasticity. Gomutbutra *et al.* conducted a meta-analysis of eight RCTs and reported a significant pooled effect size, indicating a moderate-to-large increase in BDNF following MBIs compared to controls.[18] This effect was consistent across both exercise-based and mediation-based MBIs, with no significant differences between the subgroups. Similarly, You *et al.* reviewed RCTs showing that BDNF levels increase in populations with conditions such as depression, mild cognitive impairment, and chronic pain following yoga and tai chi interventions.[19] Specific examples from the thinking trace reinforce this trend: Yang *et al.* observed significant increases in BDNF levels after a single brain yoga session in young men;[21] Sadhasivam *et al.* reported a more than 70% BDNF increase after a 4-day Isha Yoga retreat;[26] and Puhlmann *et al.* found that cumulative BDNF increases over a 9-month contemplative training program.[23]

Calderone *et al.* further corroborated these findings by linking mindfulness practices, particularly Mindfulness-Based Stress Reduction (MBSR), to neurobiological changes, including increased BDNF production, which supports neuroplasticity and emotional regulation.[29] Studies such as Liu *et al.* and Guo *et al.* also demonstrated BDNF elevations in college students with depression and patients with augmented MBCT, respectively, along with psychological improvements.[24,25] This consistency across healthy and clinical populations, ranging from young adults to older adults and those in extreme environments such as Antarctica, suggests that MBIs have broad applicability in enhancing BDNF and associated brain health outcomes.[27]

4.1. Discrepancies and Population-Specific Effects

Despite the general trend of increased BDNF levels, some studies have reported divergent findings, particularly in specific populations. Čekanauskaitė *et al.* observed that a 10-week yoga intervention in older adults resulted in attenuated BDNF levels, contrasting with the increases noted in other studies.[28] However, they identified significant relationships between changes in BDNF and functional improvements, such as balance and motor learning, suggesting that BDNF dynamics may differ in older adults due to age-related neuroplasticity changes or factors specific to the intervention, such as yoga type and intensity. Similarly, Montero-Marin *et al.* identified that a mindfulness-based program for fibromyalgia patients reduced BDNF levels and improved pain symptoms, indicating a potential maladaptive role of BDNF in chronic pain states.[30] These discrepancies suggest that BDNF responses may be context-dependent and may be influenced by factors such as age, health status, and the nature of the intervention.

4.2. Duration and Dose-Response Effects

The duration of MBI interventions varies widely, from single sessions to nine months,[21,23] yet both short- and long-term practices appear to be effective in increasing BDNF levels. Gomutbutra *et al.* found no significant correlation between cumulative practice hours and BDNF effect sizes, in contrast to prior exercise literature suggesting a dose-response relationship.[22,31] However, Liu *et al.* (2024) reported a dose-dependent effect in college students with depression, where more MBCT sessions yielded greater BDNF increase and symptom relief. This discrepancy may reflect differences between exercise- and meditation-based MBIs, or insufficient statistical power in smaller samples. Calderone *et al.* noted that even abbreviated 4-week MBSR courses enhance BDNF-related outcomes, suggesting that brief interventions can initiate neurobiological changes, although sustained practice may amplify the benefits.[29]

4.3. Mechanisms of BDNF Upregulation

Several mechanisms may underlie the MBI-induced BDNF upregulation. Stress reduction is a prominent pathway, and Puhlmann *et al.* found that increased BDNF levels were mediated by reduced cortisol,[23] whereas Nirwan *et al.* observed yoga's role in maintaining BDNF under stress via lower cortisol and oxidative stress markers.[27] Calderone *et al.* emphasized that mindfulness reduces amygdala reactivity and enhances prefrontal cortex connectivity, potentially alleviating stress-related BDNF suppression.[29] Inflammation modulation is another mechanism; Liu *et al.* and Sadhasivam *et al.* linked BDNF increases to reduced proinflammatory cytokines and elevated endocannabinoids, respectively, aligning with findings that MBIs decrease inflammatory markers.[24,26] In

addition, Gomutbutra *et al.* proposed that meditation may enhance BDNF efflux from the brain or reduce its peripheral degradation, although the short half-life of BDNF complicates this hypothesis.[22]

4.4. Implications for Mental Health and Neuroplasticity

The reviewed studies consistently associated BDNF increases with improved mental health and cognitive outcomes. You *et al.* report enhanced mood and cognition in clinical populations,[19] mirrored by Guo *et al.* and Liu *et al.* who found reduced depression and anxiety alongside BDNF rises.[24,25] Yang *et al.* linked BDNF increase to better short-term memory,[21] whereas Puhlmann *et al.* observed structural brain changes (e.g. increased dentate gyrus volume), suggesting BDNF-mediated neuroplasticity.[23] Calderone *et al.* highlighted MBSR's role of MBSR in thickening cortical areas such as the insula, supporting emotional regulation, and sensory processing, which are key for neurorehabilitation.[29] These findings underscore the role of BDNF as a mediator of MBI benefits, potentially reducing the risks of mood disorders and neurodegeneration.

4.5. Exercise versus Meditation: Differential Contributions

Gomutbutra *et al.* found no significant difference in BDNF effect sizes between exercise- and meditation-MBIs, suggesting that both components contribute to BDNF upregulation. However, Yang *et al.* noted that brain yoga, but not traditional yoga, increased BDNF, hinting at specific mindfulness elements (e.g. cognitive engagement) that enhance effects beyond physical activity.[21] You *et al.* cautioned that exercise alone may drive BDNF increases in mind-body practices, necessitating studies that isolate mindfulness components.[19] Calderone *et al.* suggested that meditation's unique neural mechanisms (e.g. altered default mode network activity) complement exercise-induced BDNF increases, offering a synergistic effect in MBIs.[29]

4.6. Limitations and Future Directions

Current evidence is limited by small sample sizes, high study heterogeneity, and inconsistent designs, which limit generalizability. Future research needs larger, standardized RCTs to directly compare exercise- and meditation-based interventions and clarify BDNF responses in diverse groups, such as older adults and patients with chronic pain, where findings conflict. Advanced neuroimaging and biomarker studies are critical for pinpointing the underlying mechanisms.

5. CONCLUSION

MBI, including meditation and mind-body exercises, consistently increase peripheral BDNF levels across diverse populations, supporting their role in enhancing neuroplasticity, mental health, and cognitive function. While discrepancies in older adults and chronic pain states suggest context-specific effects, stress reduction and inflammation modulation have emerged as key mechanisms. These findings suggest that MBIs are promising tools for brain health, particularly for those with physical limitations, although further research is needed to optimize interventions and to clarify BDNF's role of BDNF across conditions.

6. ACKNOWLEDGMENTS

Nil.

7. AUTHORS' CONTRIBUTIONS

All the authors contributed equally in the design and execution of the article.

8. FUNDING

Nil.

9. ETHICAL APPROVALS

This study does not require ethical clearance as it is a review study.

10. CONFLICTS OF INTEREST

Nil.

11. DATA AVAILABILITY

The data analyzed in this review were obtained from publicly available sources, including peer-reviewed articles, observational studies, and surveys, accessible via databases, such as PubMed, Scopus, and Web of Science.

12. PUBLISHERS NOTE

This journal remains neutral with regard to jurisdictional claims in published institutional affiliation.

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How to cite this article:
Giridharan S, Pandiyan B. Meditation and Mind-Body Practices: Effects on Brain-derived Neurotrophic Factor and Brain Health: A Narrative Review. IRJAY. [online] 2025;8(3);71-76.
Available from: https://irjay.com
DOI link- https://doi.org/10.48165/IRJAY.2025.80312

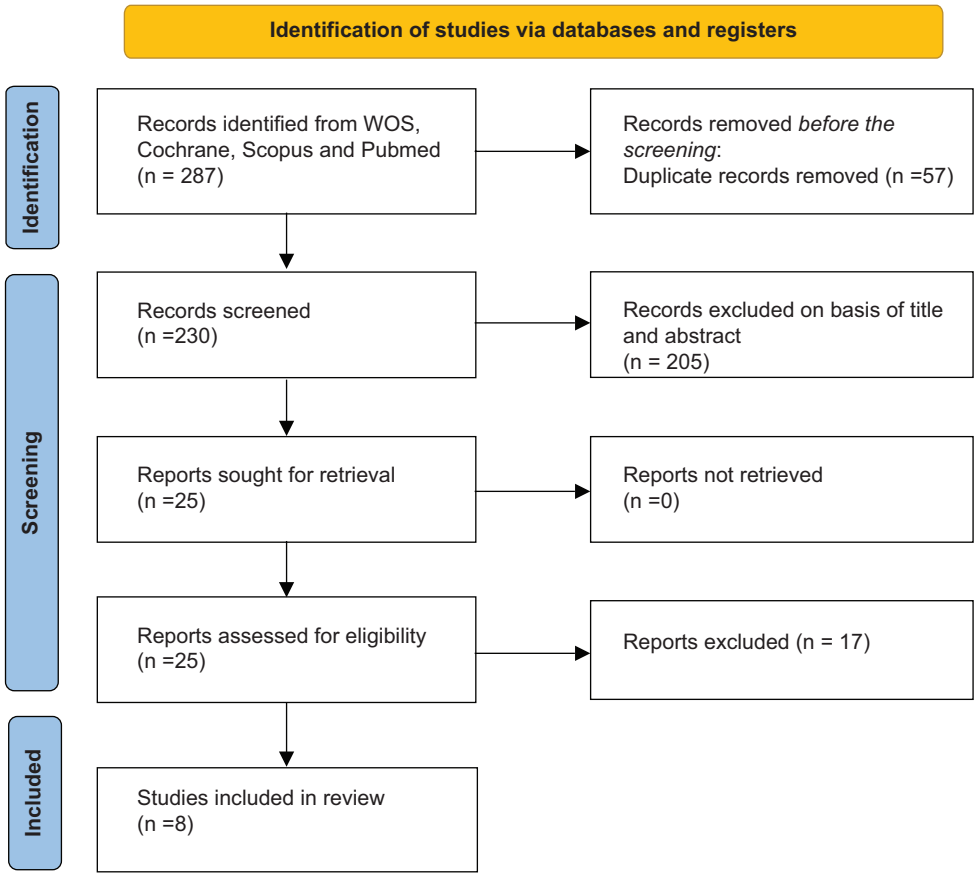

Figure 1: Summarized search strategy (Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram)

Table 1: Characteristics of included studies

Study	Study design	Population	Intervention	Duration	BDNF measurement	Primary outcomes
Yang *et al*. (2021)	RCT	30 healthy men, aged 20–29 years	Brain yoga (single session)	50 min	Serum	Increased BDNF and improved short-term memory in brain yoga group
Gomutbutra *et al*. (2022)	Randomized crossover	40 healthy female students	Intensive mindfulness	8 h (weekend)	Serum	Elevated BDNF, reduced anxiety, decreased mitochondrial OXPHOS complex-1
Puhlmann *et al*. (2025)	RCT	332 healthy adults	Contemplative training	9 months	Serum	Cumulative BDNF increase, reduced cortisol, increased dentate gyrus volume
Liu *et al*. (2024)	RCT	College students with MDD	MBCT	8 weeks	Serum	Higher BDNF, lower depression/anxiety/sleep issues, reduced inflammatory markers
Guo *et al*. (2022)	RCT	160 patients with depression	Augmented MBCT	8 weeks	Serum	Increased BDNF, improved psychological state (depression, self-esteem, stigma)
Sadhasivam *et al*. (2020)	Observational	Adults attending yoga retreat	Isha Yoga retreat	4 days	Serum	>70% increase in BDNF and endocannabinoids, improved mental health (sustained 1 month)
Nirwan *et al*. (2020)	Controlled trial	14 Antarctica expedition members	Yoga	10 months	Serum	Mitigated BDNF decline, enhanced resilience, reduced cortisol/oxidative stress
Čekanauskaitė *et al*. (2020)	RCT	33 older adults, aged 60–79 years	Yoga	10 weeks	Serum	Attenuated BDNF, improved balance/motor learning, no cognitive change

BDNF: Brain-derived neurotrophic factor, RCT: Randomized controlled trials, MDD: Major depressive disorder