Effects of meditation and mind-body exercise on brain-derived neurotrophic factor: A literature review of human experimental studies

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ABSTRACT

This paper provides a literature review of current studies investigating the effects of meditation and mind-body exercise on peripheral concentrations of brain-derived neurotrophic factor (BDNF), an important mediator of the neuroplasticity of the central nervous system and cognitive function. A literature search was conducted to collect currently published randomized controlled, non-randomized controlled and uncontrolled intervention studies. Fifteen studies were identified; and among these studies, seven were randomized controlled studies, three were non-randomized studies, and five were uncontrolled studies. Current limited evidence tends to support that mindfulness meditation and mind-body exercise (e.g. yoga and tai chi) increase circulating BDNF concentrations in healthy and diseased individuals. It is noteworthy that these findings are based on current studies with a relatively small sample size, or without a randomized controlled design. Further studies are needed to identify a definite effect of meditation or mind-body exercise on BDNF and its role in improving/maintaining brain functions in various populations.

Introduction

Brain-derived neurotrophic factor (BDNF) is an important mediator of the neuroplasticity of the central nervous system, and is involved in promoting and maintaining brain functions.1 Peripheral BDNF concentrations decline with several conditions and diseases related to changes in the central nervous system, such as aging, mild cognitive decline, depression, Parkinson's disease and Alzheimer's disease.2,3 In addition, BDNF appears to be an important biomarker of neuropsychiatric disorders characterized by neurodegenerative changes.5

The effects of physical exercise on BDNF have been well summarized by several published reviews.6–11 Current evidence supports that physical exercise may alter peripheral BDNF concentrations.6–11 In general, acute and chronic aerobic exercise increase peripheral BDNF concentrations, while strength exercise does not change BDNF concentrations.6,12 However, recent evidence indicates that both aerobic exercise and resistance exercise seem to increase BDNF concentrations in older adults.8,11

Mindfulness meditation and mind-body exercise (e.g. qigong, yoga, and tai chi) have been reported to benefit brain functions in healthy and diseased individuals.12,13 Considering the important role of BDNF in regulating brain functions, a number of recent studies have focused on the effects of meditation and mind-body exercise on peripheral BDNF concentrations. However, findings from these studies have not been well reviewed. The purpose of this review article is to summarize current evidence on potential effects of meditation and mind-body exercise on BDNF and to provide guidance for future research.

Methods

Electronic searches were conducted using PubMed/Medline, Web of Science, and the Cochrane Library from inception through August 2019. We used the following terms to conduct the searches as follows: “brain-derived neurotrophic factor” OR “BDNF” AND “meditation” OR “mindfulness” OR “qigong” OR “qi gong” OR “yoga” OR “tai chi” OR “tai ji”. Hand searches were also conducted to obtain additional references. Inclusion criteria for the studies were healthy or diseased individuals; meditation, mindfulness, or mind-body exercise protocols; randomized controlled studies, quasi-experimental studies, or uncontrolled studies; written in English; and measurement of peripheral BDNF concentrations. Exclusion criteria were animal studies; no meditation, mindfulness, or mind-body exercise protocols; randomized controlled studies, quasi-experimental studies, or uncontrolled studies; written in English; and measurement of peripheral BDNF concentrations. Exclusion criteria were animal studies; no meditation, mindfulness, or mind-body exercise intervention; and acute one-session studies. In the initial search, 115 articles were reviewed from the databases. After
increased or tended to increase peripheral BDNF concentrations in studies. Overall, the majority of the interventions included mindfulness meditation, yoga and tai chi. The studies met the inclusion criteria. This is the first review to summarize current evidence regarding the effects of meditation and mind-body exercise on peripheral BDNF concentrations.

Table 1
Effects of meditation and mind-body exercise on peripheral BDNF concentrations: Randomized controlled studies.

| Study     | Participants                                                                 | Study Design                                                                 | Effects on BDNF |
|-----------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------|-----------------|
| lkal et al. 2014 | 50 patients with schizophrenia or related psychotic disorders | Control group: daycare rehabilitation | Compared to the control group, the experimental group: ↑ BDNF | |
| Lee et al., 2014 | 25 premenopausal women with chronic low back pain | Experimental group: Hatha yoga, 8 weeks | Significant group × time interactions in serum BDNF. | |
| Tolahunase et al. 2018 | 58 patients with major depressive disorder | Control group: no intervention | Compared to the control group, ↑ BDNF (p < 0.01) | |
| Dada et al. 2018 | 90 patients with primary open-angle glaucoma | Experimental group: yoga and meditation-based lifestyle intervention (YMLI) | Compared to the waitlist control group, ↑ BDNF (p < 0.001) | |
| Gagrani et al. 2018 | 60 patients with primary open-angle glaucoma | Control group: standard medical treatment | Compared to standard medical treatment only, ↑ BDNF (p < 0.01) | |
| Sungkarat et al. 2018 | 66 older adults with amnestic mild cognitive impairment | Control group: cognitive education | Compared to control group, ↑ BDNF (p < 0.05) | |
| Nery et al. 2019 | 99 infertile women | Control group: no intervention | Compared to the control group, MBP: ↑ BDNF | |

= No change or no difference. ↑ Elevated or higher.

removing the duplicates, 35 articles were assessed for eligibility. Among these studies, 15 studies met the inclusion criteria. This is the first review to summarize current evidence regarding the effects of meditation and mind-body exercise on peripheral BDNF concentrations.

Results

Current randomized controlled studies regarding the effects of meditation and mind-body exercise on peripheral BDNF concentrations are summarized in Table 1. To date, 7 randomized controlled studies have been conducted in various populations, including patients with schizophrenia, women with chronic low back pain, older adults with mild cognitive impairment, individuals with major depressive disorder, and women with infertility. The interventions included mindfulness meditation, yoga, and tai chi. The term ranged from 3 weeks to 6 months. Overall, the majority of the studies reported that mindfulness meditation or mind-body exercise increased or tended to increase peripheral BDNF concentrations in various populations.

Current quasi-experimental studies and uncontrolled studies regarding the effects of meditation and mind-body exercise on peripheral BDNF concentrations are summarized in Table 2. To date, there are 3 non-randomized controlled studies (belong to the same parent study) and 5 uncontrolled studies reported in the literature. The subjects were apparently healthy adults, patients with major depressive disorder, and patients with chronic fatigue syndrome. The interventions were mainly yoga and/or meditation lasting 4 days to 3 months. Current non-randomized controlled studies and some uncontrolled studies reported significantly increased peripheral BDNF concentrations. Two uncontrolled studies did not report a significant change; however, it is noteworthy that the intervention term was very short (4 days) in one of the studies.

Discussion and conclusion

To date, several randomized controlled studies have reported the
effects of meditation and/or mind-body exercise on peripheral BDNF concentrations in diseased individuals. Limited findings indicate meditation and mind-body exercise (e.g. yoga and tai chi) tend to increase BDNF concentrations in women with chronic low back pain, older adults with mild cognitive impairment, individuals with major depressive disorder, and individuals with primary open-angle glaucoma. Similar findings have been shown by non-randomized controlled studies and uncontrolled studies. It is noteworthy that current randomized controlled studies have reported a relatively small sample size, or a relatively short intervention term. More studies are needed in the future to confirm these findings and to investigate if BDNF mediates the effects of meditation and mind-body exercise on cognition and other brain functions.

Current randomized controlled studies, non-randomized controlled studies and uncontrolled studies tend to support a positive effect of meditation and mind-body exercise on BDNF concentrations. However, the limited evidence is not sufficient to identify a potential difference between mindfulness meditation and mind-body exercise in their effects on BDNF. It is important to note that exercise itself has shown to increase BDNF concentrations, thus, effect observed from mind-body exercise such as yoga and tai chi may be due to its physical demand rather than the mindfulness of the program. Therefore, it is necessary for future well-designed mind-body exercise studies to consider the influence of physical exercise alone on BDNF and clarify if mind-body exercise has an additional effect in altering peripheral BDNF concentrations in healthy and diseased individuals.

Conflict of interest

The authors declare no conflicts of interest.

Submission statement

This manuscript has not been published and is not under consideration for publication elsewhere.

Authors’ contributions

TJY generated the idea, conducted literature search and drafted the paper. E.F.O., conducted literature search and revised the paper.

References

1. Benarroch EE. Brain-derived neurotrophic factor: regulation, effects, and potential clinical relevance. Neurology. 2015;84:1704.
2. Brunoni AR, Lopes M, Fregni F. A systematic review and meta-analysis of studies on major depression and BDNF levels: implications for the role of neuroplasticity in depression. Int J Neuropsychopharmacol. 2008;11:1169–1180.
3. Diniz BS, Teixeira AL. Brain-derived neurotrophic factor and Alzheimer’s disease: physiopathology and beyond. NeuroMolecular Med. 2011;13:217–222.
4. Diniz BS, Reynolds 3rd CF, Begley A, et al. Brain-derived neurotrophic factor levels in late-life depression and comorbid mild cognitive impairment: a longitudinal study. J Psychiatr Res. 2016;74:96–101.
5. Teixeira AL, Barbosa IG, Diniz BS, et al. Circulating levels of brain-derived neurotrophic factor: correlation with mood, cognition and motor function. Biomarkers Med. 2010;4:871–887.
6. Kneepkens K, Goekint M, Heyman EM, et al. Neuroplasticity - exercise-induced response of peripheral brain-derived neurotrophic factor: a systematic review of experimental studies in human subjects. Sports Med. 2010;40:765–801.
7. Mang CS, Campbell KL, Ross CJ, et al. Promoting neuroplasticity for motor rehabilitation after stroke: considering the effects of aerobic exercise and genetic variation on brain-derived neurotrophic factor. Phys Ther. 2013;93:1707–1716.
8. Coelho FG, Gobbi S, Andreatto CA, et al. Physical exercise modulates peripheral levels of brain-derived neurotrophic factor (BDNF): a systematic review of experimental studies in the elderly. Arch Gerontol Geriatr. 2013;56:10–15.
9. Noguara B, Karst M, Engelí S, et al. Brain-derived neurotrophic factor and exercise in fibromyalgia syndrome patients: a mini review. Rheumatol Int. 2012;32:2593–2599.
10. Huang T, Larsen KT, Ried-Larsen M, et al. The effects of physical activity and exercise on brain-derived neurotrophic factor in healthy humans: a review. Scand J Med Sci Sports. 2014;24:1–10.
11. Marinus N, Hammen D, Feyes P, et al. The impact of different types of exercise training on peripheral blood brain-derived neurotrophic factor concentrations in older adults: a meta-analysis. Sports Med. 2019;49:1529–1546.
12. Simkin DR, Black NB. Meditation and mindfulness in clinical practice. Child Adolesc. Psychiatr. Clin North Am. 2014;23:487–534.
13. Chiesa A, Serretti A. A systematic review of neurobiological and clinical features of mindfulness meditations. Psychol Med. 2010;40:1239–1252.
14. Iai S, Suzuki T, Uchida H, et al. Effects of weekly one-hour Hatha yoga therapy on resilience and stress levels in patients with schizophrenia-spectrum disorders: an eight-week randomized controlled trial. J Alternative Compl Med. 2014;20:823–830.
15. Lee M, Moon W, Kim J. Effect of yoga on pain, brain-derived neurotrophic factor, and serotonin in premenopausal women with chronic low back pain. Evid base Compl. Alternat Med. 2014;2014, 203173.
16. Tolahunase MR, Sagar R, Faq M, et al. Yoga- and meditation-based lifestyle intervention increases neuroplasticity and reduces severity of major depressive disorder: a randomized controlled trial. Restor Neurol Neurosci. 2018;36:423–442.
17. Dada T, Mittal D, Mohanty K, et al. Mindfulness meditation reduces intraocular pressure, lowers stress biomarkers and modulates gene expression in glaucoma: a randomized controlled trial. J Glaucoma. 2018;27:1061–1067.
18. Gagrani M, Faq MA, Sidhu T, et al. Meditation enhances brain oxygenation, upregulates BDNF and improves quality of life in patients with primary open angle glaucoma: a randomized controlled trial. Restor Neurol Neurosci. 2018;36:741–753.
19. Sungkarat S, Boripuntakul S, Kumsu S, et al. Tai chi improves cognition and plasma BDNF in older adults with mild cognitive impairment: a randomized controlled trial. Neurorehabil Neural Repair. 2018;32:142–149.
20. Nery SF, Palva SPC, Vieira EI, et al. Mindfulness-based program for stress reduction in infertile women: randomized controlled trial. Stres Health. 2019;55:49–58.
21. Naveen GH, Thirthalli J, Rao MG, et al. Positive therapeutic and neurotropic effects of yoga in depression: a comparative study. Indian J Psychiatr. 2013;55:5400–5404.
22. Naveen GH, Varambally S, Thirthalli J, et al. Serum cortisol and BDNF in patients with major depression-effect of yoga. Int Rev Psychiatry. 2016;28:273–278.
23. Halappa NG, Thirthalli J, Varambally S, et al. Improvement in neurocognitive functions and serum brain-derived neurotrophic factor levels in patients with depression treated with antidepressants and yoga. Indian J Psychiatr. 2018;60:32–37.
24. Pal R, Singh SN, Chatterjee A, et al. Age-related changes in cardiovascular system, autonomic functions, and levels of BDNF of healthy active males: role of yogic practice. Age. 2014;36:9683.
25. Turakikutvanakan W, Mekseepralard C, Busaranumtragul P. The pilot study of the effect of meditation to the serum brain-derived neurotrophic factor (BDNF) of medical students, srinakharinwirot university. J Med Assoc Thail. 2015;98(10):S107–S111.
26. Cahn RR, Goodman MS, Peterson CT, et al. Yoga, meditation and mind-body health: increased BDNF, cortisol awakening response, and altered inflammatory marker expression after a 3-month yoga and meditation retreat. Front Hum Neurosci. 2017;11:315.
27. Tolahunase M, Sagar R, Dada R. Impact of yoga and meditation on cellular aging in apparently healthy individuals: a prospective, open-label single-arm exploratory study. Ovid Med Clin Longens. 2017;2017, 7928981.
28. Oka T, Tanahashi T, Sudo N, et al. Changes in fatigue, autonomic functions, and blood biomarkers due to sitting isometric yoga in patients with chronic fatigue syndrome. Biopsychos Soc. Med. 2016;12:3.