Open access Journal of
Neurology & Neurosurgery
ISSN: 2476-0501

Juniper Publishers
key to the Researchers

Mini Review
Volume 6 Issue 1 - september 2017
DOI: 10.19080/OAJNN.2017.06.555680

Open Access J Neurol Neurosurg

Yoga Induced Brain Plasticity- Role of Neurotrophic Factors

Trichur Raju* and HR Nagendra

S-VYASA Deemed University, India

Submission: August 19, 2017; **Published:** September 20, 2017

***Corresponding author:** Trichur Raju, S-VYASA Deemed University, India, Email: trraju.nimhans@gmail.com

Abstract

Yoga has become a proven therapy to treat depression, stress and pain. It has a therapeutic effect on neurological diseases as well. Therapeutically changes may be brought about by promoting brain plasticity. Brain plasticity can be influenced by several factors including neurotrophic factors, neurotransmitters, endocrines, cytoskeleton proteins and neuronal electrical activity to name a few. This review will focus on the effect of Yoga on neurotrophic factors.

Keywords: Yoga; Neurotrophic factors; BDNF; VEGF; IGF-1; GDNF; Depression

Abbreviations: 5-HT: 5-Hydroxytryptamine; BDNF: Brain-Derived Neurotrophic Factor; FGF2: Fibroblast Growth Factor; GDNF: Glial Cell Derived Neurotrophic Factor; HDRS: Hamilton Depression Rating Scale; IGF1: Insulin Like Growth factor 1; LTD: Long Term Depression; LTP: Long Term Potentiation; MAPK: Mitogen-Activated Protein Kinases; MBSR: Mindfulness-Based Stress Reduction; NGF: Nerve Growth Factor; PTSD: Post-Traumatic Stress Disorder; VEGF: Vascular Endothelial Growth Factor

Introduction

Neurotrophic Factors are key molecules which are involved in the development and differentiation of the nervous system and play a major role in neuronal plasticity. The practice of yoga produces brain plasticity leading to enhancement in cognitive performance and alleviation of symptoms like depression and Post Traumatic Stress Disorder (PTSD). It has great potentials in treating neurological diseases as well. Accordingly, it is critical to evaluate yoga induced changes in the expression of neurotrophic factors and their receptors. The neurotrophic factors which are thought to be important are: Brain Derived Neurotrophic Factor (BDNF), Vascular Endothelial Growth factor (VEGF), Insulin like Growth factor -1(IGF-1), Glial Cell Derived Neurotrophic Factor (GDNF), Nerve Growth Factor (NGF) and Fibroblast Growth Factor (FGF2). This review will focus on BDNF, VEGF, IGF and GDNF.

Brain-Derived Neurotrophic Factor (BDNF)

BDNF is a key member of the neurotrophin family which also includes nerve growth factor, neurotrophin 3, and neurotrophin 4 [1]. BDNF has a high expression levels in the brain and it plays an important role in the survival, differentiation and synaptic formation of several classes of neurons [2,3]. It also influences synaptic function by regulating the activity-dependent forms of synaptic plasticity such as long-term potentiation (LTP), which is the cellular basis of learning and memory [4]. The main receptor involved is TrkB [5]. The immature form of BDNF (proBDNF) activates p75NTR receptor, which has an opposing effect on the TrkB induced action. This may result in long term depression (LTD) [6]. BDNF in addition to its role in hippocampus also has a profound effect on spinal cord neurons [7].

BDNF is known to be an essential factor for preventing the motor neuron cell death and is an important skeletal muscle derived trophic factor for motor neurons [8-10]. BDNF knockout mice display a lack of coordination of movements and balance along with excessive loss of neurons in peripheral sensory ganglia [11]. Further, BDNF offers a significant neuroprotection against excitotoxicity and also mediates anti-apoptotic effect [12,13].

In a study aimed at the treatment of depression with Yoga, it was found that patients who undertook yoga therapy were better than drugs-only group with respect to reduction in Hamilton Depression Rating Scale (HDRS) scores. There was a statistically significant positive correlation between a fall in HDRS and rise in serum BDNF levels in yoga-only group, but not in those receiving yoga and antidepressants or antidepressants-alone over a three month time period. The authors suggest that

synaptic neuroplasticity induced by BDNF may be responsible for the therapeutic benefit of yoga in depression. Another study also showed a reduction in cortical level along with an increased BDNF content following treatment with Yoga in patients with depression [14-16].

With regards to Yoga in the modulation of pain, it has been shown that the decrease of low chronic back pain in women following practice of Yoga was associated with an increase in the level of BDNF. The authors propose that BDNF may be one of the key factors mediating beneficial effects of yoga on chronic low back pain [17].

Insulin and Insulin-Like Growth Factors

Insulin, the insulin-like growth factors (IGF1, IGF2) and their receptors also play an important role in the development and function of central nervous system. These factors can regulate neuronal survival, neurogenesis, angiogenesis, excitatory and inhibitory neurotransmission, food intake, and cognition [18]. There is a linkage between brain insulin/IGF1 and certain neuropathology's, such as Alzheimer's, Motor Neuron Disease [19]. IGF-1 is also an important skeletal muscle derived trophic factor for motor neurons that has a role during development as well as during recovery from injury [20].

A study was conducted to examine the effects of specific Mindfulness-Based Stress Reduction (MBSR) activities (yoga, sitting and informal meditation, body scan) on immune function, circulating IGF-1 concentrations, and positive affect among older adults. A committed practice of yoga was associated with higher IGF-1 levels and greater improvement in positive affect. The authors also found that sitting meditation was positively associated with post-treatment IGF-1 level [21].

Vascular Endothelial Growth Factor (VEGF)

VEGF promotes neurogenesis, neuronal patterning, neuroprotection and glial growth [22]. VEGF guides neuronal migration in the embryonic brain and supports axonal and arterial co-patterning in the developing skin [22]. VEGF can be considered to be a promising tool to promote neuronal health and nerve repair. VEGF has potent neurotrophic and mitogenic activity as it induces axonal out growth and increases the survival of neurons, satellite cells and proliferating Schwann cells [23].

VEGF appears to induce neurogenesis in-vitro as well as in-vivo [24] During CNS development, VEGF stimulates neuronal growth and maturation, mediated by the VEGFR2 receptor via the MAPK (Mitogen-activated protein kinases) pathway [24,25]. In addition, VEGF is shown to be unregulated in the skeletal muscle after exercise as well as after chronic motor neuron stimulation [26,27]. Recently it has been shown that VEGF promotes reinnervation by inducing axonal regeneration after ischemic injury by promoting the expression of NGF/ GDNF in the skeletal muscle [28] suggesting the influence of VEGF on other tropic factors. The role of VEGF in Yoga/Meditation still needs to be explored.

Glial Derived Neurotrophic Factor (GDNF)

GDNF is known to regulate the functioning of the brain's dopaminergic system. BDNF and GDNF interact with the 5-hydroxytryptamine (5-HT) system of the brain to regulate complex behaviours. GDNF, as well as BDNF, stimulates 5-HT neurons and in turn, 5-HT affects the expression of genes that control BDNF and GDNF in brain structure [29].

GDNF is the most potent neurotrophic factor for the motor neurons [30-32]. Yoga and exercise can increase the level of GDNF which can be beneficial in diseases like Parkinson's disease.

Conclusion

The study on the effect of Yoga on neurotrophic factors offers immense potentials for further investigation. A comprehensive understanding of this area will enable us to define the beneficial role of yoga in treating not only mental health disorders but also neurological disorders such as Parkinson's, Alzheimer's, Motor Neuron diseases, Multiple sclerosis and stroke since it is well known that neurotrophic factors confer potent neuroprotection.

Referances

1. Hallbook F (1999) Evolution of the vertebrate neurotrophin and Trk receptor gene families. Curr Opin Neurobiol 9(5): 616-621.
2. Oppenheim RW, Yin QW, Prevette D, Yan Q (1992) Brain-derived neurotrophic factor rescues developing avian motoneurons from cell death. Nature 360(6406): 755-757.
3. Pinzon-Duarte G, Pinzón-Duarte G, Arango-González B, Guenther E, Kohler K (2004) Effects of brain-derived neurotrophic factor on cell survival, differentiation and patterning of neuronal connections and Muller glia cells in the developing retina. Eur J Neurosci 19(6): 1475-1484.
4. Lu Y, Christian K, Lu B (2008) BDNF: a key regulator for protein synthesis-dependent LTP and long-term memory? Neurobiol Learn Mem 89(3): 312-323.
5. Kaplan DR, Miller FD (2000) Neurotrophin signal transduction in the nervous system. Curr Opin Neurobiol 10(3): 381-391.
6. Woo NH, Teng HK, Siao CJ, Chiaruttini C, Pang PT, et al. (2005) Activation of p75NTR by proBDNF facilitates hippocampal long-term depression. Nat Neurosci 8: 1069-1077.
7. Lu B, Nagappan G, Lu Y (2014) BDNF and synaptic plasticity, cognitive function, and dysfunction. Handb Exp Pharmacol 220: 223-250.
8. DiStefano PS, Friedman B, Radziejewski C, Alexander C, Boland P, et al. (1992) The neurotrophins BDNF, NT-3, and NGF display distinct patterns of retrograde axonal transport in peripheral and central neurons. Neuron 8(5): 983-993.
9. Griesbeck O, Parsadanian AS, Sendtner M, Thoenen H (1995) Expression of neurotrophins in skeletal muscle: quantitative comparison and significance for motoneuron survival and maintenance of function. J Neurosci Res 42(1): 21-33.
10. Mousavi K (2004) BDNF rescues myosin heavy chain IIB muscle fibers after neonatal nerve injury. Am J Physiol Cell Physiol 287(1): C22-C29.
11. Ernfors P, Kucera J, Lee KF, Loring J, Jaenisch R (1995) Studies on the physiological role of brain-derived neurotrophic factor and neurotrophin-3 in knockout mice. Int J Dev Biol 39(5): 799-807.
12. Almeida RD, Manadas BJ, Melo CV, Gomes JR, Mendes CS (2005) Neuroprotection by BDNF against glutamate-induced apoptotic cell

How to cite this article: T Raju , HR Nagendra . Yoga Induced Brain Plasticity- Role of Neurotrophic Factors. Open Access J Neurol Neurosurg. 2017; 6(1): 555680. DOI: 10.19080/OAJNN.2017.06.555680.

death is mediated by ERK and PI3-kinase pathways. Cell Death Differ 12(10): 1329-1343.

13. Bhave SV, Ghoda L, Hoffman PL (1999) Brain-derived neurotrophic factor mediates the anti-apoptotic effect of NMDA in cerebellar granule neurons: signal transduction cascades and site of ethanol action. J Neurosci 19(9): 3277-3286.

14. Cahn BR, Goodman MS, Peterson CT, Maturi R, Mills PJ (2017) 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 11: 315.

15. Naveen GH (2013) Positive therapeutic and neurotropic effects of yoga in depression: A comparative study. Indian J Psychiatry 55(Suppl 3): S400-S444.

16. Naveen GH, Varambally S, Thirthalli J, Rao M, Christopher R, et al. (2016) Serum cortisol and BDNF in patients with major depression-effect of yoga. Int Rev Psychiatry 28(3): 273-278.

17. Lee M, Moon W, Kim J (2014) Effect of yoga on pain, brain-derived neurotrophic factor, and serotonin in premenopausal women with chronic low back pain. Evid Based Complement Alternat Med 2014: 203173.

18. Werner H, LeRoith D (2014) Insulin and insulin-like growth factor receptors in the brain: physiological and pathological aspects. Eur Neuropsychopharmacol 24(12): 1947-1953.

19. Bassi F, Fernagut PO, Bezard E, Meissner WG (2014) Insulin, IGF-1 and GLP-1 signaling in neurodegenerative disorders: targets for disease modification? Prog Neurobiol 118: 1-18.

20. Neff NT, Prevette D, Houenou LJ, Lewis ME, Glicksman MA (1993) Insulin-like growth factors: putative muscle-derived trophic agents that promote motoneuron survival. J Neurobiol 24(12): 1578-1588.

21. Gallegos AM (2013) Toward identifying the effects of the specific components of mindfulness-based stress reduction on biologic and emotional outcomes among older adults. J Altern Complement Med 19(10): 787-792.

22. Rosenstein JM, Krum JM, Ruhrberg C (2010) VEGF in the nervous system. Organogenesis 6(2): 107-114.

23. Sondell M, Lundborg G, Kanje M (1999) vascular endothelial growth factor has neurotrophic activity and stimulates axonal outgrowth, enhancing cell survival and Schwann cell proliferation in the peripheral nervous system. J Neurosci 19(14): 5731-5740.

24. Jin K, Zhu Y, Sun Y, Mao XO, Xie L, et al. (2002) Vascular endothelial growth factor (VEGF) stimulates neurogenesis in vitro and in vivo. Proc Natl Acad Sci USA 99(18): 11946-11950.

25. Khaibullina AA, Rosenstein JM, Krum JM (2004) vascular endothelial growth factor promotes neurite maturation in primary CNS neuronal cultures. Brain Res Dev Brain Res 148(1): 59-68.

26. Annex BH, Torgan CE, Lin P, Taylor DA, Thompson MA, et al. (1998) Induction and maintenance of increased VEGF protein by chronic motor nerve stimulation in skeletal muscle. Am J Physiol 274(3 Pt 2): H860-H867.

27. Birot OJ, Koulmann N, Peinnequin A, Bigard XA (2003) Exercise-induced expression of vascular endothelial growth factor mRNA in rat skeletal muscle is dependent on fibre type. J Physiol 552(Pt 1): 213-221.

28. Shvartsman D, Storrie-White H, Lee K, Kearney C, Brudno, et al. (2014) Sustained delivery of VEGF maintains innervations and promotes reperfusion in ischemic skeletal muscles via NGF/GDNF signaling. Mol Ther 22(7): 1243-1253.

29. Popova NK, Ilchibaeva TV, Naumenko VS (2017) Neurotrophic Factors (BDNF and GDNF) and the serotonergic system of the brain. Biochemistry (Mosc) 82(3): 308-317.

30. Henderson CE, Phillips HS, Pollock RA, Davies AM, Lemeulle C, et al. (1994) GDNF: a potent survival factor for motoneurons present in peripheral nerve and muscle. Science 266(5187): 1062-1064.

31. Trupp M, Rydén M, Jörnvall H, Funakoshi H, Timmusk T (1995) Peripheral expression and biological activities of GDNF, a new neurotrophic factor for avian and mammalian peripheral neurons. J Cell Bio 130(1): 137-148.

32. Cheng B, Mattson MP (1994) NT-3 and BDNF protect CNS neurons against metabolic/excitotoxic insults. Brain Res 640(1-2): 56-67.

DOI: 10.19080/OAJNN.2017.6.555680

How to cite this article: T Raju , HR Nagendra . Yoga Induced Brain Plasticity- Role of Neurotrophic Factors. Open Access J Neurol Neurosurg. 2017; 6(1): 555680. DOI: 10.19080/OAJNN.2017.06.555680.