ANCIENT MEDITATION MODERN APPLICATIONS

What scientific research indicates about the benefits of meditation

Dr Elizabeth Levay BBSc (Hons), PhD

SCHOOL OF PRACTICAL PHILOSOPHY, SYDNEY

INTRODUCTION

What is Meditation?

In a broad sense, meditation is a contemplative practice used by multiple traditions across millennia to train attention and awareness. There are several varieties of meditative practices, making consensus on a definition difficult. A primary distinction between types is that between concentrative (an object of focus or attention, which can be a mantra or one's breath for example), and mindfulness techniques (staying present in the moment and maintaining an alert, aware state in a nonjudgmental way).[1] A third type is meditation with form, or guided meditation, where practitioners attend mindfully on a form, such as feelings of compassion, as in loving-kindness meditation. While the emphasis differs between types, in practice, **all approaches have self-regulation of emotion and attention at their core.**[2]

The Deep Path and the Wide Path

Meditation has become ubiquitous in Western countries as a result of the influx of Eastern philosophy. While Western meditative traditions exist, such as contemplative prayer in Catholic monasticism, the focus of popular interest and scientific study has been on techniques derived from Asia. Eastern meditation was originally imported to the West in an explicitly philosophical-religious context, through Hinduism and Vedic philosophy as well as Buddhism, but has been increasingly secularised. This shift reflects a move from meditation as a means of gaining a deep insight into the mind and ultimately a profound alteration in being (the deep path) to meditation as a balm for psychological or emotional angst or as a means of performance enhancement (the wide path).[3]

Meditation Research

Research investigating meditation has primarily focused on the wide path, and therefore secularised variants, and the corresponding benefits of these. Such variants include Herbert Benson's Relaxation Response, a variation of Transcendental Meditation (mantra-based), and Mindfulness-Based Stress Reduction (MBSR), a variation of Buddhist mindfulness meditation, developed and promulgated by Jon Kabat-Zinn. Scientific interest in meditation started in the 1960s and 70s and has proliferated since this period, reflected in the exponential increase in research publications on the subject. Of all of the practices, mindfulness meditation (MM) and its variants, such as MBSR, have received the most attention, particularly over the last two decades.[2]

Scope of this Paper

The following precis of peer-reviewed publications gives some indication of the research conducted on the benefits of meditation as well as some neurological and molecular correlates of these benefits. The focus will be on research conducted on MM and mantra-based meditation and will include studies reporting either on the effects of short-term or more long-term meditation. Attention will be given to the capacity of meditation to enhance performance, its health benefits and therapeutic applications and neurological and molecular insights that may underlie its benefits, as follows:

1. Enhanced Performance

- *a. Occupational*
- *b. Academic*
- *c. Sport*

2. Health Benefits and Therapeutic Applications of Meditation

- *a. Enhanced Immune System Function*
- *b. Reduced Cardiovascular Disease Risk*
- *c. Pain Management*
- *d. Ameliorated Psychopathology*

3. Neurological and Molecular Insights of Meditation

- *a. Structural and Functional Brain Changes*
- *b. Anti-ageing*

4. Conclusion

What follows is by no means an exhaustive summary but does reflect the breadth of research being undertaken in this burgeoning area. As is always the case in any scientific pursuit, caution is urged against indiscriminately accepting findings, particularly as some areas of investigation are in their infancy and thereby require corroboration by further studies to enable firm claims.

1. ENHANCED PERFORMANCE

a. Occupational

Short meditation training programs have been shown to ***improve workplace performance*** in a number of different settings. In a study investigating the effects of an 8-week modified MBSR program on teaching efficacy in classroom teachers, meditation was found to increase effective teaching behaviour, specifically observer-rated classroom organisation, which incorporated teacher's behavioural management style, overall classroom productivity, and instructional learning format.[4]

Leadership capabilities have also been demonstrated to be ***enhanced*** by mindfulness meditation training.[5] Specifically, a 10-week mindfulness training course with 13 leaders across 6 organisations led to augmented self-leadership capacities – mindful task management, self-care and self-reflection – and two leadership capacities – relating to others and adapting to change.

In addition to enhanced workplace performance, meditation practice significantly ***reduces workplace stress***[6,7,8,] high levels of which are associated with poorer mental and physical health, including anxiety and depressive episodes, cardiovascular disease and type 2 diabetes.[9] This reduced stress no doubt plays a role in the abovementioned increase in workplace performance, along with enhanced resilience and improved affect reported as a result of meditation programs in occupational settings.[10]

b. Academic

Academic performance is also found to be ***augmented*** by short meditation training.[10,11] Putative mechanisms of this effect are improved attention, cognition and cognitive flexibility engendered by meditation.[11]

As in a workplace context, academic stress, particularly in high intensity courses such as medicine, can lead to depression and suicidality.[12] In a 2017 review of the literature[13], mindfulness-based interventions were found to decrease stress, anxiety, and depression and improve mindfulness, mood, self-efficacy, and empathy in health profession students.

c. Sport

Meditation techniques are effective in ***optimising athletic performance*** by decreasing anxiety, ruminative thinking and enhancing experience of flow.[14] Additionally, athletes self-report that meditation is an important factor in enhancing sport performance[15] and an 8-week MBSR program was found to increase pain tolerance in seriously injured athletes.[16]

2. HEALTH BENEFITS AND THERAPEUTIC APPLICATIONS OF MEDITATION

a. Enhanced Immune System Function

A review into the effectiveness of mindfulness meditation (6-10-week training sessions) on the immune system[17] suggests it may ***lower a blood marker for inflammation and increase a number of key immune system helper cells***, which destroy infection and help to prevent us from getting sick.

b. Reduced Cardiovascular Disease Risk

Meditation has been linked to ***reduced cardiovascular disease risk*** factors. Specifically, mantra-based meditation reduces blood pressure[18], high cholesterol and thickening of the carotid artery. (reviewed in [19]). A recent review also demonstrates that mindfulness-based meditation is useful in lowering blood pressure in adults with elevated blood pressure or hypertension.[20]

c. Pain Management

Pain syndromes for which meditation has been demonstrated to have significant ***benefits for quality of life and reductions in pain include fibromyalgia, migraine, irritable bowel syndrome*** and ***chronic pelvic pain***.[21] In a study of MBSR for treatment of chronic pain due to failed back surgery syndrome[22], at 12-week follow-up, the analgesic medication logs of the intervention group documented a decrease in analgesic use compared with those in the control group. A recent systematic review revealed that meditation can reduce pain in the perioperative period for patients undergoing invasive procedures[23] and is effective in reducing pain in models of experimentally induced pain in healthy participants.[24]

Mechanisms thought to mediate reductions in pain as a result of meditation include disengagement from pain-related threat, extinction of fear conditioning and acceptance-based coping strategies.[25]

d. Ameliorated Psychopathology

Meditation, and particularly MM, has been studied extensively for the ***treatment of depression and anxiety***. Mindfulness based cognitive therapy (MBCT), a derivative of MBSR, significantly reduces the risk of depressive relapse in patients with recurrent depression.[26] Similarly, in a study investigating the effectiveness of a mindfulness-based meditation practice to improve symptoms of generalized anxiety disorder[27], MBSR led to a significant reduction of anxiety symptoms and was associated with greater reductions in anxiety and distress ratings in response to a stress challenge.

In a recent meta-analysis of MM interventions for psychiatric disorders[28], evidence from across the research literature suggests that as an intervention for depression and anxiety, MM is equivalent to gold-standard evidence-based treatments, such as cognitive behavioural therapy, antidepressant medication and exposure-based therapies.[29]

Meditation interventions have also shown clinical utility for ***substance abuse***[30] and preliminary evidence suggests applicability to ***disordered eating***[31], ***posttraumatic stress disorder***[32], and serious mental illness, such as ***psychotic disorders***[33], though caution is urged with the latter given the complexity of these disorders and the potential of exacerbating psychiatric symptoms.[29]

3. NEUROLOGICAL AND MOLECULAR INSIGHTS OF MEDITATION

The findings cited below note meditation-induced changes to physiology, some of which may provide an explanation for some of the abovementioned changes.

a. Structural and Functional Brain Changes

Increased cortical thickness

The brains of long-term mindfulness meditators (average 9 years) show increases in cortical thickness in regions associated with attention and sensory processing (prefrontal cortex and right anterior insula).[34] These changes suggest that long-term meditation leads to ***changes in cortical plasticity***. In the same study, differences in prefrontal cortical thickness were most pronounced in older participants, suggesting that meditation might offset age-related cortical thinning. A complementary finding to this latter result, is that meditation (many forms investigated) can ***attenuate age-related cognitive decline***, with positive effects reported on attention, memory, executive function, processing speed and general cognition.[35]

Increased grey matter

Grey matter holds the majority of brain cell bodies and includes areas of the brain involved with higher-order processes such as memory, speech, decision-making and self-control. An increase in grey matter in an area of the brain may reflect an increase in connectivity. Long-term meditation (average 24 years) of varying types has been found to increase the grey matter concentrations in brain regions in two areas of the brain (orbito-frontal and hippocampal regions) implicated in emotional regulation and response control.[36] This may account for meditators' abilities to promote positive emotions, retain emotional stability and engage in mindful behaviour.

Increases in grey matter have also been observed in response to an 8-week MBSR program.[37] Specifically, increases were reported in brain regions involved in learning and memory processes (hippocampus), emotion regulation (posterior cingulate cortex), self-referential processing, and perspective taking (temporo-parietal junction).

Reduced amygdala activation

The amygdala plays a crucial role during stress responses, including the detection of stressful and threatening stimuli and the initiation of adaptive coping responses.[38] Abnormal amygdala function has been demonstrated across several stress-related psychopathologies, including anxiety[39] and depression.[40]

In one landmark study, an 8-week MM intervention led to a significant lowering of activity in the amygdala after participants were exposed to unsettling photos.[41] This finding suggests that the effects of meditation training on emotional processing might transfer to non-meditative states.

Default mode network brought under control

The default mode network (DMN) is activated when we are doing nothing that demands mental effort; day-dreaming, ruminating on the past or future, any of the thoughts and feelings that focus on ourselves (often negative) and develop a cohesive self-narrative.[3] Higher DMN activity is implicated in anxiety[42] and depression.[43]

A review of the literature has found DMN activity to be reduced during meditation compared to control conditions across neuroimaging studies of meditation involving either focused attention or a mantra[44], suggesting a quietening of the self-obsessed mind. A recent clinical trial also demonstrated stronger coupling between the DMN and brain regions involved in self-monitoring and cognitive control in subjects who had undergone 31 days of MM.[45] Importantly, long-term meditators (1000 hours of meditation experience) demonstrate a permanent reduction in DMN activity[46], indicating that this characteristic has become an enduring trait. Also see[47] for a recent systematic review on how meditation affects the DMN.

Changes in activation in various brain areas

Short-term mindfulness meditation (8 weeks) leads to increased activation in areas of the brain involved with focussing attention and corporeal awareness (right dorsolateral prefrontal cortex) and decreased activation in areas associated with mentalising (rostral prefrontal cortex).[48]

b. Anti-ageing

Meditation can help ***slow down our biological clocks*** as measured by the length of our telomeres – segments of DNA on the end of our chromosomes – short telomeres being a biomarker for worsening health and early death. In a review investigating telomere length and meditation[49], meditators were found to have longer telomeres and a greater number of hours of meditation was associated with a greater impact on telomere biology. This finding suggests that meditation exerts an anti-ageing effect through preventing telomere shortening or by increasing telomere length.

A notable structural change in the brains of long-term mediators is the attenuation of age-related grey matter loss in areas associated with mood regulation, autonomic processing, and the integration of emotion and cognitive processes.[50,51]

4. CONCLUSION

In summary, meditation, a tool used to gain self-regulation of emotion and awareness, has a wide range of applications from increasing workplace performance to slowing ageing at a molecular level. As is characteristic of the current Western canon, science is increasingly substantiating these findings through additional rigorous testing and critical evaluation, lending greater support to and thereby further popularising meditative techniques. Research to date has predominantly involved wide approaches, secularised variants of meditation that are pursued for the purposes of performance enhancement, health improvements or as a balm for modern angst. Consequently, this research and its outcomes no doubt have significant import, particularly as human suffering ceaselessly endures. Perhaps the weight of evidence provided by science will prompt a return to deep approaches of meditation, approaches pursued for the purpose of gaining wisdom and a profound, enduring shift in consciousness.

References

[1] Sedlmeier, P., Eberth, J., Schwarz, M., Zimmermann, D., Haarig, F., Jaeger, S., & Kunze, S. (2012). The psychological effects of meditation: a meta-analysis. *Psychological Bulletin, 138*(6), 1139-1171. doi: 10.1037/a0028168.

[2] Tang, Y.Y., Hölzel, B.K., & Posner, M.I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews. Neuroscience, 16*(4), 213-225. doi: 10.1038/nrn3916

[3] Goleman D., & Davidson, R.J. (2017). *The science of meditation.* Penguin Life.

[4] Flook, L., Goldberg, S.B., Pinger, L., Bonus, K., & Davidson, R.J. (2013). Mindfulness for teachers: a pilot study to assess effects on stress, burnout and teaching efficacy. *Mind, Brain & Education, 7*(3), doi: 10.1111/mbe.12026

[5] Rupprecht, S., Falke, P., Kohls, N., Tamdjidi, C., Wittmann, M., & Kersemaekers, W. (2019). Mindful leader development: how leaders experience the effects of mindfulness training on leader capabilities. *Frontiers in Psychology, 10,* 1081. doi: 10.3389/fpsyg.2019.01081

[6] Bostock, S., Crosswell, A.D., Prather, A. A., & Steptoe, A. (2019). Mindfulness on-the-go: Effects of a mindfulness meditation app on work stress and well-being. *Journal of Occupational Health Psychology, 24*(1), 127-138. doi: 10.1037/ocp0000118

[7] Manocha, R., Black, D., Sarris, J., & Stough, C. (2011). A randomized, controlled trail of meditation for work stress, anxiety and depressed mood in full-time workers. *Evidence Based Complementary and Alternative Medicine,* 960583. doi: 10.1155/2011/960583

[8] Fazia, T., et al. (2021). Mindfulness meditation training in an occupational setting: Effects of a 12-weeks mindfulness-based intervention on wellbeing. *Work, 70(4)*, 1089-1099. https://doi.org/10.3233/wor-210510

[9] Ganster, D.C., & Rosen, C.C. (2013). Work stress and employee health: A multidisciplinary review. *Journal of Management, 39*(5), 1085-1122. doi: 10.1177/0149206313475815

[10] Lebares, C.C., Guvva, E.V., Olaru, M., Sugrue, L.P., Staffaroni, A.M., Delucchi, K.L., Kramer, J.H., Ascher, N.L., & Harris, H.W. (2019). Efficacy of Mindfulness-Based Cognitive Training in Surgery: Additional Analysis of the Mindful Surgeon Pilot Randomized Clinical Trial, *JAMA Network Open, 2*(5), e194108. doi: 10.1001/jamanetworkopen.2019.4108

[11] Ching, H.H., Koo, M., Tsai, T.H., & Chen, C.Y. (2015). Effects of a mindfulness meditation course on learning and cognitive performance among university students in Taiwan. *Evidence Based Complementary and Alternative Medicine, 254358*. doi: 10.1155/2015/254358

[12] Lebares, C.C., Guvva, E.V., Ascher, N.L., O'Sullivan, P.S., Harris, H.W., & Epel, E.S. (2018). Burnout and stress among US surgery residents: psychological distress and resilience. *Journal of the American College of Surgeons, 226*(1), 80-90. doi: 10.1016/j.jamcollsurg.2017.10.010

[13] McConville, J., McAleer, R., & Hahne, A. (2017). Mindfulness training for health profession students-the effect of mindfulness training on psychological well-being, learning and clinical performance of health professional students: A systematic review of randomized and non-randomized controlled trials. *Explore (NY), 13*(1), 26-45. doi: 10.1016/j.explore.2016.10.002

[14] Colzato, L.S., & Kibele, A. (2017). How different types of meditation can enhance athletic performance depending on the specific sport skills. *Journal of Cognitive Enhancement, 1*, 122–126.

[15] Kudlackova, K., Eccles, D. W., & Dieffenbach, K. (2013). Use of relaxation skills in differentially skilled athletes. *Psychology of Sport and Exercise, 14*(4), 468-475. doi.org/10.1016/j.psychsport.2013.01.007

[16] Mohammed, W.A., Pappous, A. & Sharma, D. (2018) Effect of mindfulness-based stress reduction (MBSR) in increasing pain tolerance and improving the mental health of injured athletes. *Frontiers in Psychology, 9,* 722. doi: 10.3389/fpsyg.2018.00722

[17] Black, D.S., & Slavich, G. M. (2016). Mindfulness meditation and the immune system: a systematic review of randomized controlled trials. *Annals of the New York Academy of Sciences, 1373,* 13-24. doi: 10.1111/nyas.12998

[18] Schneider, J.K., Reangsing, C., Willis, D.G. (2022). Effects of transcendental meditation on blood pressure: A meta-analysis. *Journal of Cardiovascular Nursing, 37(3)*, E11-E21. https://doi.org/10.1097/jcn.0000000000000849

[19] Walton, K.G., Schneider, R.H., & Nidich, S. (2004). Review of controlled research on the transcendental meditation program and cardiovascular disease. Risk factors, morbidity, and mortality. *Cardiology in Review, 12*(5): 262-266. doi: 10.1097/01.crd.0000113021.96119.78

[20] Mir, I.A., et al. (2024). Effect of mindfulness-based meditation on blood pressure among adults with elevated blood pressure and hypertension: A systematic review of randomized controlled trials. *Complementary Therapies in Medicine, 85*, 103084. https://doi.org/10.1016/j.ctim.2024.103084

[21] Hilton, L., Hempel, S., Ewing, B.A., Apaydin, E., Xenakis, L., Newberry, S., Colaiaco, B., Maher, A.R, Shanman, R.M., Sorbero, M.E., & Maglione, M.A. (2017). Mindfulness meditation for chronic pain: systematic review and meta-analysis. *Annals of Behavioral Medicine, 51*(2), 199-213. doi: 10.1007/s12160-016-9844-2

[22] Esmer, G., Blum, J., Rulf, J., & Pier, J. (2010). Mindfulness-based stress reduction for failed back surgery syndrome: a randomized controlled trial. *Journal of the American Osteopathic Association, 110*(11), 646-652.

[23] Rajjoub, R., et al. (2024). Meditation for perioperative pain and anxiety: A systematic review. *Brain and Behavior, 14(7)*, e3640. https://doi.org/10.1002/brb3.3640

[24] Brandel, M.G., et al. (2022). Mindfulness meditation in the treatment of chronic pain. *Neurosurgery Clinics of North America, 33(3)*, 275-279.

[25] Zeidan, F., Emerson, N.M., Farris, S.R., Ray, J.N., Jung, Y., McHaffie, J.G., & Coghill, R.C. (2015). Mindfulness meditation-based pain relief employs different neural mechanisms than placebo and sham mindfulness meditation-induced analgesia. *The Journal of Neuroscience, 35(46),* 15307-15325. doi: 10.1523/JNEUROSCI.2542-15.2015

[26] Kuyken, W., Warren, F.C., Taylor, R.S., Whalley, B., Crane, C., Bondolfi, G., Hayes, R., Huijbers, M., Ma, H., Schweizer, S., Segal, Z., Speckens, A., Teasdale, J.D., Van Heeringen, K., Williams, M., Byford, S., Byng, R., & Dalgleish, T. (2016). Efficacy of mindfulness-based cognitive therapy in prevention of depressive relapse: an individual patient data meta-analysis from randomized trials. *JAMA Psychiatry, 73*(6), 565–74. doi: 10.1001/jamapsychiatry.2016.0076

[27] Hoge, E.A., Bui, E., Marques, L., Metcalf, C.A., Morris, L.K., Robinaugh, D.J., Worthington, J.J., Pollack, M.H., & Simon, N,M. (2013). Randomized controlled trial of mindfulness meditation for generalized anxiety disorder: effects on anxiety and stress reactivity. *The Journal of Clinical Psychiatry, 74(8),* 786-792. doi: 10.4088/JCP.12m08083

[28] Goldberg, S.B., Tucker, R.P., Greene, P.A., Davidson, R.J., Wampold, B.E., Kearney, D.J., & Simpson, T.L. (2018). Mindfulness-based interventions for psychiatric disorders: a systematic review and meta-analysis. *Clinical Psychology Review, 59*, 52-60. doi: 10.1016/j.cpr.2017.10.011

[29] Wielgosz, J., Goldberg, S.B., Kral, T.R.A, Dunne, J.D., & Davidson, R.J. (2019). Mindfulness meditation and psychopathology. *Annual Review of Clinical Psychology, 15,* 285-316. doi: 10.1146/annurev-clinpsy-021815-093423

[30] Li, W., Howard, M.O., Garland, E.L., McGovern, P., & Lazar, M. (2017) Mindfulness treatment for substance misuse: a systematic review and meta-analysis. *Journal of Substance Abuse Treatment, 75*, 62-96. doi: 10.1016/j.jsat.2017.01.008

[31] Kristeller, J.L., Wolever, R.Q., & Sheets, V. (2014). Mindfulness-based eating awareness training (MB-EAT) for binge eating: a randomized clinical trial. *Mindfulness, 5*(3), 282-297. doi. org/10.1007/s12671-012-0179-1

[32] Hopwood, T.L., & Schutte, N.S. (2017). A meta-analytic investigation of the impact of mindfulness-based interventions on post-traumatic stress. *Clinical Psychology Review, 57,* 12-20. doi: 10.1016/j.cpr.2017.08.002

[33] Chadwick, P., Strauss, C., Jones, A-M., Kingdon, D., Ellett, L., Dannahy, L., & Hayward, M. (2016). Group mindfulness-based intervention for distressing voices: a pragmatic randomised controlled trial. *Schizophrenia Research, 175*(1), 168-173. doi: 10.1016/j.schres.2016.04.001

[34] Lazar, S.W., Kerr, C.E., Wasserman, R.H., Gray, J.R., Greve, D.N., Treadway, M.T., McGarvey, M., Quinn, B.T., Dusek, J.A., Benson, H., Rauch, S.L., Moore, C.I., & Fischl, B. (2005). Meditation experience is associated with increased cortical thickness. *Neuroreport, 16*(17), 1893-1897. doi: 10.1097/01.wnr.0000186598.66243.19

[35] Gard, T., Hözel, BK., & Lazar, SW. (2014). The potential effects of meditation on age-related cognitive decline: a systematic review. *Annals of the New York Academy of Sciences, 1307,* 89-103. doi: 10.1111/nyas.12348.

[36] Luders, E., Toga. A.W., Lepore, & N., Gaser, C. (2009). The underlying anatomical correlates of long-term meditation: larger hippocampal and frontal volumes of gray matter. *Neuroimage, 45*(3)*,* 672-678. doi: 10.1016/j.neuroimage.2008.12.061

[37] Hölzel, B.K., Carmody, J., Vangel, M., Congleton, C., Yerramsetti, S.M., Gard, T., & Lazar, S.W. (2011). Mindfulness practice leads to increases in regional brain gray matter density. *Psychiatry Research. 191*(1), 36-43. 10.1016/j.pscychresns.2010.08.006

[38] Hölzel, B.K., Carmody, J., Evans, K.C., Hoge, E.A., Dusek, J.A., Morgan, L., Pitman, R.K., & Lazar, S.W. (2010). Stress reduction correlates with structural changes in the amygdala. *Social Cognitive and Affective Neuroscience, 5*(1), 11-17. doi: 10.1093/scan/nsp034

[39] Stein, M.B., Simmons, A.N., Feinstein, J.S., & Paulus, M,P. (2007). Increased amygdala and insula activation during emotion processing in anxiety-prone subjects. *The American Journal of Psychiatry, 164*(2), 318-327. doi: 10.1176/ajp.2007.164.2.318

[40] Dougherty, D.D., Rauch, S.L., Deckersbach, T., Marci, C., Loh, R., Shin, L.M., Alpert, N.M., Fischman, A.J., & Fava, M. (2004). Ventromedial prefrontal cortex and amygdala dysfunction during an anger induction positron emission tomography study in patients with major depressive disorder with anger attacks. *Archives of General Psychiatry, 61*(8), 795–804. doi: 10.1001/archpsyc.61.8.795

[41] Desbordes, G., Negi, L.T., Pace, T.W.W., Wallace, B.A., Raison, C.L., Schwartz, E.L. (2012). Effects of mindful-attention and compassion meditation training on amygdala response to emotional stimuli in an ordinary, non-meditative state. *Frontiers in Human Neuroscience, 6,* 292. doi: 10.3389/fnhum.2012.00292

[42] Northoff, G. (2020). Anxiety disorders and the brain's resting state networks: from altered spatiotemporal synchronization to psychopathological symptoms. *Advances in Experimental Medicine & Biology, 1191,* 71-90. doi: 10.1007/978-981-32-9705-0_5.

[43] Sheline, Y.I., Barch, D.M., Price, J.L., Rundle, M.M., Vaishnavi, S.N., Snyder, A.Z., Mintun, M.A., Wang, S., Coalson, R.S., & Raichle, M.E. (2009). The default mode network and self-referential processes in depression. *Proceedings of the National Academy of Sciences of the United States of America, 106*(6), 1942-1947. doi: 10.1073/pnas.0812686106

[44] Tomasino, B., Fregona, S., Skrap, M., & Fabbro, F. (2013). Meditation-related activations are modulated by the practices needed to obtain it and by the expertise: an ALE meta-analysis study. *Frontiers in Human Neuroscience, 6*, 346. doi: 10.3389/fnhum.2012.00346

[45] Bremer, B., Wu, Q., Mora Álvarez, M.G., Hölzel, B.K., Wilhelm, M., Hell, E., Tavacioglu, E.E., Torske, A., Koch, K. (2022). Mindfulness meditation increases default mode, salience, and central executive network connectivity. *Scientific Reports, 12(1)*, 13219. doi: 10.1038/s41598-022-17325-6

[46] Taylor, V.A., Daneault, V., Grant, J., Scavone, G., Breton, E., Roffe-Vidal, S., Courtemanche, J., Lavarenne, A.S., Marrelec, G., Benali, H., & Beauregard, M. (2013). Impact of meditation training on the default mode network during a restful state. *Social Cognitive & Affective Neuroscience, 8*(1), 4-14. doi: 10.1093/scan/nsr087

[47] Zagkas, D., et al. (2023). How Does Meditation Affect the Default Mode Network: A Systematic Review. *Advances in Experimental Medicine and Biology, 1425*, 229-245. https://doi.org/10.1007/978-3-031-31986-0_22

[48] Tomasino, B., & Fabbro, F. (2016). Increases in the right dorsolateral prefrontal cortex and decreases the rostral prefrontal cortex activation after 8 weeks of focused attention based mindfulness meditation. *Brain and Cognition, 102,* 46-54. doi: 10.1016/j.bandc.2015.12.004

[49] Schutte, N.S., Malouff, J.M., & Keng, S.L. (2020). Meditation and telomere length: a meta-analysis. *Psychology & Health, 5,* 1-15. doi: 10.1080/08870446.2019.1707827

[50] Kurth, F., Zsadanyi, S.E., Luders, E. (2021). Reduced age-related gray matter loss in the subgenual cingulate cortex in long-term meditators. *Brain Imaging and Behavior, 15(6)*, 2824-2832. https://doi.org/10.1007/s11682-021-00578-6

[51] Kurth, F., Strohmaier, S., Luders, E. (2023). Reduced age-related gray matter loss in the orbitofrontal cortex in long-term meditators. *Brain Sciences, 13(12)*, 1677. https://doi.org/10.3390/brainsci13121677