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Analysis of the Effects of Regular Yoga on the Adaptive Capacity of the Nervous System

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Abstract:

Introduction: Regular yoga practice positively affects physical and mental health, including stress reduction, emotional regulation, and cognitive enhancement. Recent research highlights yoga's potential to strengthen the nervous system's adaptability, promoting well-being and managing stress and anxiety.

Aim of the study: This review aimed to demonstrate yoga's influence on nervous system adaptability and provide an overview of how yoga practices enhance neuroadaptation, highlighting benefits in improving neural resilience and adaptive capacities.

Materials and methods: This paper analyzes current knowledge on the neurological consequences of excessive body weight. The review focused on clinical studies from 2018 to 2024, including review papers and meta-analyses. Literature was reviewed from PubMed and Google Scholar using keywords: “yoga,” “nervous system,” “stress,” “anxiety,” “depression,” “sleep problems,” “Alzheimer's disease,” “Parkinson's disease,” “epilepsy,” and “emotion regulation.”

Discussion: Yoga significantly impacts the nervous system's adaptive capacity, improving mental and physical health. Regular practice enhances neuronal plasticity, aiding stress management and cognitive functions. Yoga breathing techniques reduce cortisol levels and increase certain neurotransmitters, regulating mood and autonomic nervous system function. The study did not explore different types of yoga on specific disorders, indicating a need for further research.

Conclusions: This paper underscores yoga's role in enhancing the nervous system's adaptive capacity. Yoga shows promise in improving neural resilience and adaptive capacities, making it a valuable holistic healthcare approach. Understanding these benefits can guide healthcare professionals in integrating yoga into strategies to improve patient well-being, emphasizing its role in fostering physical and mental resilience.

Keywords: nervous system, stress, anxiety, depression, sleep problems, Alzheimer's disease, Parkinson's disease, epilepsy, emotion regulation.

Introduction

Traditional forms of yoga include physical postures and exercises, breath regulation, relaxation, and the practice of meditation and mindfulness [8]. Regular yoga practice has long been known for its beneficial effects on physical and mental health. One area that is garnering increasing interest in the context of yoga is its potential impact on the adaptive capacity of the nervous system. The nervous system plays a key role in the body's adaptation to changing environmental conditions and in maintaining homeostasis. This review paper analyzes available scientific studies on the effects of regular yoga on the adaptive capacity of the nervous system. Yoga, through various mechanisms, can significantly improve mental and physical health by reducing stress, improving emotional regulation, reducing symptoms of depression and anxiety, and enhancing sleep quality and cognitive functions.

In recent years, the popularity of yoga has increased not only as a recreational exercise but also as a means to reduce stress and anxiety, enhance physical fitness, and improve mood and overall well-being [18].

Stress

Stress is defined as "a state of mental or emotional strain resulting from adverse or demanding circumstances." It can negatively affect both physical and mental health, contributing to the development of many diseases [2]. Chronic stress is particularly harmful, as it is associated with many detrimental changes in the functioning of the body, both physically and mentally, making it a serious public health issue.

Numerous studies indicate the positive impact of yoga in reducing overall stress levels among participants of various ages. The effect of an hour-long yoga practice combined with 30 minutes of meditation once a week was studied among students aged 19-23. During the six-week study period, anxiety and stress levels significantly decreased [2]. Similar results were observed in another group of individuals aged 18 to 40 [4]. Another group exposed to high levels of stress and a high risk of professional burnout are healthcare workers. During six-week yoga sessions, stress levels, burnout, vitality, sleep quality, and attention were measured among them. An additional objective parameter measured during the study was the level of cortisol in saliva. Statistically significant improvements were observed in perceived stress, professional burnout, vitality, sleep quality, calmness, and mindfulness compared to the control group. However, no significant changes were found in cortisol levels and blood pressure, which was explained by the normal baseline values of these parameters [17].

Psychological stress activates the sympathetic nervous system, which is responsible for the body's "fight or flight" response to stimuli [3]. Yoga can beneficially affect stress levels through several mechanisms. One such mechanism is the impact of controlled breathing on the functioning of the central nervous system (CNS) and the subsequent reduction in sympathetic nervous system tension [7].

In one study, the effects of different breath control techniques, varying in the ratio of inhalations to exhalations, were evaluated in terms of well-being and physiological parameters. The breathing exercises were also compared with mindfulness meditation, which is based on observing natural breath without actively controlling it. Three controlled breathing techniques were compared: (1) cyclic sighing with an emphasis on prolonged exhalations; (2) breathing with equal durations of inhalation, pause, and exhalation; and (3) cyclic hyperventilation with a pause, longer inhalations, and shorter exhalations. Participants noted a significant reduction in anxiety and negative affect after the exercises compared to their state before the exercises. Among the breathing techniques studied, the most effective was cyclic breathing with an emphasis on prolonged exhalations. Additionally, it was shown that cyclic breathing most significantly contributed to a decrease in breathing rate, which may indirectly indicate a reduction in sympathetic tension in the study group [7].

This beneficial effect of breathing exercises on mood improvement can be explained by increased vagus nerve activity during slow exhalation [32, 7]. Furthermore, breathing can influence interoceptive processes, which are the conscious perception of internal processes, affecting self-regulation, emotions, and awareness [7]. Additionally, increased flow of oxygen-rich blood can lead to a cascade of neuron activation in the limbic areas of the brain [32].

There is also a possibility that controlled breathing affects higher brain structures associated with the feeling of calmness [7]. Similar conclusions were drawn from another clinical study, where regular practice of slow breathing for 12 weeks (regardless of the ratio of inhalation to exhalation duration) contributed to a reduction in perceived stress, assessed using the computer-adaptive test PROMIS Anxiety (CAT). However, no reduction in physiological stress, measured by heart rate variability, was noted [33].

Chronic stress also leads to the release of pro-inflammatory cytokines such as interleukin 6 (IL-6), interleukin 1β (IL-1β), and tumor necrosis factor α (TNF-α). These immunological markers, along with brain-derived neurotrophic factor (BDNF) and excessively activated glial cells, can serve as biomarkers of stress [3]. Pro-inflammatory cytokines and C-reactive protein (CRP) significantly influence the pathomechanism of stress. There is increasing scientific evidence regarding the influence of yoga practice on modulating levels of inflammatory markers and stress hormones such as cortisol [10].

A randomized study in 2019 demonstrated a decrease in IL-6 levels in individuals practicing yoga compared to non-practicing individuals among those suffering from depression [5]. Furthermore, during a 48-week randomized controlled trial among breast cancer patients practicing yoga, significant reductions in IL-1β and IL-10 levels were noted [42]. Another analyzed study observed reductions in cortisol levels, systolic blood pressure, and resting heart rate in the yoga-practicing group [1]. In young adults, a 10-week yoga program resulted in reduced stress and positive changes in heart rate variability (HRV), suggesting greater involvement of the parasympathetic nervous system [15]. In elementary school children, there was a trend towards increased parasympathetic activity with yoga practice, although it did not significantly surpass the control group [14]. Thus, regular yoga practice may lead to a significant reduction in subjective and physiological measures of stress, although further research is needed in the latter aspect.

Emotion Regulation

Yoga can also be an effective method for enhancing emotion regulation abilities, which is crucial for psychological adaptation in stressful situations. Appropriate emotion self-regulation significantly impacts learning and relationship-building in childhood, and at the preschool stage, it is likely much more important than substantive knowledge [11]. One study aimed to examine the impact of an eight-week yoga practice on self-regulation and emotion regulation in children aged 4-6 years. After the intervention, no changes were observed in metacognitive processes such as attention focus; however, differences were noted in emotion assessment scales (subdued emotional discharge and coping in response to problems and emotions). It is possible that mindfulness of bodily sensations present during yoga practice helped the children better regulate their emotions [11]. Another clinical study showed that yoga has a significant positive impact on externalizing behaviors (behavioral problems, hyperactivity) and internalizing behaviors (emotional problems, peer problems) [12].

Adolescence is another challenging period for young people, where emotional instability significantly complicates life, affecting both self-acceptance and peer relationships, potentially contributing to various psychosocial problems. Teenagers who practice yoga can regulate their emotions much more effectively.

This is confirmed by a study in which the introduction of yoga practice led to a significant increase in self-esteem, better emotional regulation, and an enhancement of positive feelings among teenagers [9].
In the adult population, yoga practice also seems to have a positive impact on emotion regulation. Research has shown that yoga practice influences the activity of brain areas critical for emotion control. MRI studies of individuals practicing yoga have shown lower prefrontal cortex activity and greater activation of the supramarginal gyrus. These individuals also exhibited a slightly lower response to potentially stressful emotional situations compared to those who engage in other recreational sports [13].

Depressive and anxiety disorders

In 2019, there was a significant increase in the prevalence of depressive and anxiety disorders, exceeding 970 million cases worldwide [25]. These disorders are prevalent among both adults and children and adolescents. Globally, over 13% of teenagers struggle with various mental disorders, with depressive and anxiety disorders being the most frequently diagnosed, constituting approximately 40% of all mental health cases [23]. Additionally, the impact of the COVID-19 pandemic has exacerbated this issue. It is estimated that the pandemic has led to 53.2 million new cases of major depressive disorders, marking a 27.6% increase. Furthermore, an additional 76.2 million cases of anxiety disorders were observed during this period [24]. Regardless of age group, depressive disorders rank highest among mental health issues, except for the 0–14 age group where behavioral disorders predominate [25].
Given the significant public health concern posed by depressive disorders, it is worthwhile to examine studies analyzing the impact of yoga practice on this aspect of health. In a pilot study, the effects of a 6-week yoga and meditation practice on stress perception, anxiety levels, and mindfulness among students were evaluated. The study demonstrated reductions in anxiety and stress levels among participants, along with significant improvement in mindfulness skills [2]. In women in the early stages of breast cancer, introduced exercises significantly alleviated anxiety and depressive symptoms, and improved quality of life [16]. Significant mood improvement was also noted in a study involving 160 elderly patients. The impact of yoga practice on the lives of elderly individuals who experienced mental disorders during the COVID-19 pandemic was assessed. The study group showed a significant reduction in depressive symptoms and anxiety compared to the control group, where these symptoms worsened [22]. Similar benefits of yoga were demonstrated in the population of patients with primary anxiety disorders. However, yoga was not found to have an equivalent effect compared to cognitive-behavioral therapy. Therefore, while yoga can be helpful, it should not be considered as the sole or most effective method for managing anxiety [8].
One of the mechanisms responsible for the beneficial impact of yoga on depressive and anxiety symptoms involves the regulation of hormone and neurotransmitter secretion. A group of participants in a winter expedition to Antarctica who practiced yoga for 10 months was studied. It was found that the serotonin level in the serum of yoga practitioners increased, whereas it remained stable in the control group. Additionally, cortisol levels decreased by 19.9% in the yoga practicing group, compared to a 2.8% increase in the control group [26].
Yoga practice also influences the level of γ-aminobutyric acid (GABA), the main inhibitory neurotransmitter responsible for regulating cortical excitability and neural plasticity.

Increasing GABA system activity is one mechanism for improving mood in patients with depression. An increase in this neurotransmitter was observed after approximately 4 days of daily yoga practice, and its concentration remained stable after 8 days [19].
Another mechanism through which yoga may alleviate depressive symptoms is by reducing the level of IL-6. This is evidenced by a study where participation in a 12-week yoga exercise program led to a decrease in the level of this interleukin and a reduction in depression levels among participants [5].

Sleep Quality

Sleep problems are among the most common medical complaints reported by patients. Regular yoga practice can lead to improved sleep quality, which is crucial for the body's regeneration and adaptation to changing conditions. According to statistics, one in four people sleeps less than the optimal recommended time for their age. Among teenagers, over half sleep less than the optimal 8–10 hours [29]. In seniors, nearly one in five suffers from insomnia [28]. The most common sleep-related issues reported by adult patients are sleep quality problems and insomnia [29].
A meta-analysis of 19 randomized controlled trials involving a total of 1832 women diagnosed with sleep disorders practicing various forms of yoga showed significant improvement in sleep quality compared to control groups without any physical activity. The main evaluated indicators were sleep quality and severity of insomnia, measured using both subjective methods such as participant-filled scales and objective techniques including polysomnography, actigraphy, and intervention safety assessment [6].
A six-week yoga intervention among healthcare workers resulted in statistically significant improvement in sleep quality, as well as reduction in perceived stress, burnout, and increased vitality, calmness, and mindfulness compared to the control group [17].
Further randomized controlled trials conducted among postmenopausal women and those in the perimenopausal period showed that a 20-week yoga practice significantly improved the sleep quality of the participants [20]. Individuals participating in yoga classes showed improvement in overall sleep quality, subjective sleep assessment, reduction in nocturnal awakenings, decreased daytime dysfunction, and increased sleep efficiency. Additionally, a reduction in stress levels, improvement in cognitive function, and quality of life were observed, possibly due to one of yoga's mechanisms of action: regulation of sympathetic nervous system activity during sleep [21].
In another study, the impact of yoga was assessed not only on nighttime sleep quality but also on daytime sleepiness. This effect is likely due to the activation of the vagus nerve during yoga exercises, contributing to the reduction of excessive sympathetic system arousal and regulation of cholinergic and GABAergic system activity [27].
In the population aged over 65 years, after 2 months of yoga exercises, participants in the intervention group significantly increased their Pittsburgh Sleep Quality Index (PSQI) scores, indicating better sleep quality compared to the control group in this age group [22].

Alzheimer's Disease

Regular yoga practice may be a promising form of prevention for cognitive disorders in Alzheimer's disease [7, 30]. Aging leads to gradual decline in cognitive functions, manifested by issues such as memory problems, attention deficits, and speech fluency difficulties. Yoga can positively impact verbal fluency among older adults [44]. Improvement in cognitive functions resulting from yoga practice can be achieved through previously mentioned mechanisms, such as its influence on neurotransmitters and pro-inflammatory factors. Elevated cortisol levels and increasing IL-6 levels with age are associated with the risk of faster cognitive decline and contribute to the development of Alzheimer's disease (AD) [10]. Studies have shown a link between levels of inflammatory markers, specifically IL-6 in blood, and future cognitive decline. Individuals with high IL-6 levels were nearly one and a half times more likely to experience global cognitive decline compared to those with low levels. This can be explained by the increased susceptibility of the nervous system to peripheral inflammatory cytokines with age, due to progressive permeability of the blood-brain barrier. This is particularly noticeable in areas responsible for learning and memory, such as the hippocampus [31]. However, it has been demonstrated that regular yoga practices can lower IL-6 levels, thereby potentially slowing down these processes [5]. Yoga, however, is not an ideal preventive method for memory disorders, as evidenced by a study comparing the impact of yoga with memory-enhancing training in older women at risk for Alzheimer's disease. Analysis of magnetic resonance imaging (MRI) images led to the conclusion that yoga combined with meditation may improve connectivity between stress-affected hippocampal regions and positively influence connectivity of the anterior-posterior subregion of the hippocampus to a greater extent than memory training, which could have a positive impact on memory. However, according to researchers, memory training may demonstrate superiority over yoga in terms of hippocampal sensory integration, including the use of verbal, visual, and spatial association techniques. Despite the small sample size, it seems likely that yoga is particularly useful for patients at risk for Alzheimer's disease experiencing high levels of stress [30]. This is supported by another study demonstrating that yoga training may provide neuroprotective effects compared to memory-enhancing training, preventing neurodegenerative changes and cognitive decline [35].

Epilepsy

Another group in which researchers evaluated the impact of yoga on disease progression was children aged 8-12 suffering from epilepsy. According to interview data at the beginning of the study, epileptic seizures occurred in the control group in three children in the last 3 months, whereas in the yoga group, it occurred in four children. Analysis of results after 3 and 6 months showed that in the yoga group, no child experienced seizures. In contrast, in the control group, four children had seizures after 3 months and three children after 6 months. Moreover, EEG recordings normalized in a significant number of children practicing yoga. Based on a literature review, it was suggested that these effects may be due to yoga's influence on brain wave activity and stimulation of the vagus nerve, which reduces seizure frequency [34].

A randomized controlled trial involving 160 adults diagnosed with epilepsy showed significantly higher odds of >50% reduction in seizures and complete seizure remission under the influence of yoga [41].

However, an audit based on literature data from 15 studies up to 2020 found a lack of strong clinical evidence confirming the efficacy of yoga as demonstrated in interventional studies, indicating a need for further research in this direction [36].

Parkinson's disease

Another group that may benefit from yoga practice includes individuals suffering from Parkinson's disease, characterized by significant impairment of motor functions such as balance difficulties, gait irregularities, and cognitive decline in later stages of the disease [38]. In one study involving patients aged 40-90 years with Parkinson's disease, an innovative yoga intervention using a special program called YoMed, which combines physical and cognitive mechanisms such as motor imagery (MI) and action observation (AO), was compared with proprioceptive training. Parameters assessed included joint position sense and kinesthesia, balance, fall risk, dynamic posturography, and functional mobility. The yoga program showed significantly greater improvements in balance and joint kinesthesia compared to proprioceptive training, as well as improved functional mobility outcomes [39].

The evaluation of yoga's impact on Parkinson's disease progression was also the subject of a meta-analysis conducted by analyzing studies published up to August 2020 in PubMed, Embase, and Cochrane Library databases. Researchers focused on assessing motor symptoms such as balance and functional mobility, as well as anxiety, depression, and quality of life, which are often associated with Parkinson's disease patients. The meta-analysis of ten studies involving 359 participants demonstrated significant differences between the yoga training group, where patients showed better outcomes in all aforementioned criteria compared to the control group. Thus, yoga was shown to have a positive impact on slowing the progression of Parkinson's disease, alleviating symptoms, and improving patients' quality of life. This could be attributed to yoga's stretching exercises that improve limb and joint flexibility, increase muscle strength, and reduce motor slowness and stiffness [40].

Another study involving Parkinson's disease patients showed that a 12-week yoga practice improved balance and reduced low back pain-related disability. Furthermore, participants in the yoga group demonstrated improved gait stability and a more upright posture. Patients were able to respond more quickly to external stimuli and improved sensory orientation. Additionally, the benefits were significant enough that over three-quarters of the participants intended to continue yoga practice after the study concluded [43].

Summary

Yoga has been proven to have a positive impact on reducing stress, which is crucial in today's fast-paced life. Regular yoga practice can also alleviate symptoms of anxiety and depression, aiding in maintaining mental health. Increasingly, studies indicate that yoga supports combating neurodegenerative diseases such as Alzheimer's and Parkinson's. Making yoga accessible in schools, workplaces, and health centers could significantly enhance the quality of life across all age groups. Therefore, promoting yoga as an effective and natural method for emotional and mental health care is worthwhile. However, further research, including placebo-controlled trials and long-term studies, is necessary to better understand the mechanisms of yoga and identify optimal training protocols for achieving maximum health benefits.

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References:
[1] Mitra S, Mitra M, Nandi P, et al. Efficacy of Yoga for COVID-19 Stress Prophylaxis. Journal of Physical Activity and Health. 2023;20(11):1034-1042
[2] Lemay V, Hoolahan J, Buchanan A. Impact of a Yoga and Meditation Intervention on Students' Stress and Anxiety Levels. Am J Pharm Educ. 2019;83(5):7001
[3] Kaushik M, Jain A, Agarwal P, Joshi SD, Parvez S. Role of Yoga and Meditation as Complimentary Therapeutic Regime for Stress-Related Neuropsychiatric Disorders: Utilization of Brain Waves Activity as Novel Tool. *J Evid Based Integr Med*. 2020;25:2515690X20949451
[4] Szaszkó B, Schmid RR, Pomper U, et al. The influence of hatha yoga on stress, anxiety, and suppression: A randomized controlled trial. Acta Psychol (Amst). 2023;241:104075
[5] Nugent NR, Brick L, Armey MF, Tyrka AR, Ridout KK, Uebelacker LA. Benefits of Yoga on IL-6: Findings from a Randomized Controlled Trial of Yoga for Depression. *Behav Med*. 2021;47(1):21-30

[6] Wang WL, Chen KH, Pan YC, Yang SN, Chan YY. The effect of yoga on sleep quality and insomnia in women with sleep problems: a systematic review and meta-analysis. *BMC Psychiatry*. 2020;20(1):195
[7] Balban MY, Neri E, Kogon MM, et al. Brief structured respiration practices enhance mood and reduce physiological arousal. Cell Rep Med. 2023;4(1):100895
[8] Simon NM, Hofmann SG, Rosenfield D, et al. Efficacy of Yoga vs Cognitive Behavioral Therapy vs Stress Education for the Treatment of Generalized Anxiety Disorder: A Randomized Clinical Trial. JAMA Psychiatry. 2021;78(1):13-20
[9] Janjhua Y, Chaudhary R, Sharma N, Kumar K. A study on effect of yoga on emotional regulation, self-esteem, and feelings of adolescents. J Family Med Prim Care. 2020;9(7):3381-3386
[10] Voss S, Cerna J, Gothe NP. Yoga Impacts Cognitive Health: Neurophysiological Changes and Stress Regulation Mechanisms. Exerc Sport Sci Rev. 2023;51(2):73-81
[11] Rashedi RN, Rowe SE, Thompson RA, Solari EJ, Schonert-Reichl KA. A Yoga Intervention for Young Children: Self-Regulation and Emotion Regulation. *J Child Fam Stud*. 2021;30(8):2028-2041
[12] Sivashankar JT, Surenthirakumaran R, Doherty S, Sathiakumar N. Implementation of a non-randomized controlled trial of yoga-based intervention to reduce behavioural issues in early adolescent school-going children in Sri Lanka. *Global Health*. 2022;18(1):27
[13] Wadden KP, Snow NJ, Sande P, Slawson S, Waller T, Boyd LA. Yoga Practitioners Uniquely Activate the Superior Parietal Lobule and Supramarginal Gyrus During Emotion Regulation. *Front Integr Neurosci*. 2018;12:60
[14] Ivaki P, Schulz S, Jeitler M, et al. Effects of yoga and mindfulness practices on the autonomous nervous system in primary school children: A non-randomised controlled study. *Complement Ther Med*. 2021;61:102771
[15] Frank J, Seifert G, Schroeder R, et al. Yoga in school sports improves functioning of autonomic nervous system in young adults: A non-randomized controlled pilot study. *PLoS One*. 2020;15(4):e0231299
[16] Liu W, Liu J, Ma L, Chen J. Effect of mindfulness yoga on anxiety and depression in early breast cancer patients received adjuvant chemotherapy: a randomized clinical trial. *J Cancer Res Clin Oncol*. 2022;148(9):2549-2560
[17] Hilcove K, Marceau C, Thekdi P, Larkey L, Brewer MA, Jones K. Holistic Nursing in Practice: Mindfulness-Based Yoga as an Intervention to Manage Stress and Burnout [published correction appears in J Holist Nurs. 2022 Sep;40(3):NP1-NP5
[18] Desai R, Tailor A, Bhatt T. Effects of yoga on brain waves and structural activation: A review. *Complement Ther Clin Pract*. 2015;21(2):112-11
[19] Streeter CC, Gerbarg PL, Brown RP, et al. Thalamic Gamma Aminobutyric Acid Level Changes in Major Depressive Disorder After a 12-Week Iyengar Yoga and Coherent Breathing Intervention. *J Altern Complement Med*. 2020;26(3):190-197
[20] Susanti HD, Sonko I, Chang PC, Chuang YH, Chung MH. Effects of yoga on menopausal symptoms and sleep quality across menopause statuses: A randomized controlled trial. *Nurs Health Sci*. 2022;24(2):368-379
[21] Verma K, Singh D, Srivastava A. Comparative impact of yoga and ayurveda practice in insomnia: A randomized controlled trial. *J Educ Health Promot*. 2023;12:160

[22] Baklouti S, Fekih-Romdhane F, Guelmami N, et al. The effect of web-based Hatha yoga on psychological distress and sleep quality in older adults: A randomized controlled trial. *Complement Ther Clin Pract*. 2023;50:101715
[23] Moitra M, Owens S, Hailemariam M, et al. Global Mental Health: Where We Are and Where We Are Going [published correction appears in Curr Psychiatry Rep. 2023 Jul;25(7):313. doi: 10.1007/s11920-023-01434-8]. *Curr Psychiatry Rep*. 2023;25(7):301-311
[24] COVID-19 Mental Disorders Collaborators. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. *Lancet*. 2021;398(10312):1700-1712
[25] GBD 2019 Mental Disorders Collaborators. Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Psychiatry*. 2022;9(2):137-150
[26] Nirwan M, Halder K, Saha M, Pathak A, Balakrishnan R, Ganju L. Improvement in resilience and stress-related blood markers following ten months yoga practice in Antarctica. *J Complement Integr Med*. 2020;18(1):201-207
[27] Chaudhari KS, Chaudhari SS, Rankhambe HB, Kochupillai V, Tiwari RR. Effect of Sudarshan Kriya Yoga (SKY) on daytime and situational sleep propensity in novice practitioners: a prospective cohort study. *J Complement Integr Med*. 2020;18(3):585-592
[28] Endomba FT, Tchebegna PY, Chiabi E, Angong Wouna DL, Guillet C, Chauvet-Gélinier JC. Epidemiology of insomnia disorder in older persons according to the Diagnostic and Statistical Manual of Mental Disorders: a systematic review and meta-analysis. *Eur Geriatr Med*. 2023;14(6):1261-1272
[29] Kocevska D, Lysen TS, Dotinga A, et al. Sleep characteristics across the lifespan in 1.1 million people from the Netherlands, United Kingdom and United States: a systematic review and meta-analysis. *Nat Hum Behav*. 2021;5(1):113-122
[30] Kilpatrick LA, Siddarth P, Krause-Sorio B, et al. Impact of Yoga Versus Memory Enhancement Training on Hippocampal Connectivity in Older Women at Risk for Alzheimer's Disease. *J Alzheimers Dis*. 2023;95(1):149-159
[31] Bradburn S, Sarginson J, Murgatroyd CA. Association of Peripheral Interleukin-6 with Global Cognitive Decline in Non-demented Adults: A Meta-Analysis of Prospective Studies. *Front Aging Neurosci*. 2018;9:438
[32] Sevoz-Couche C, Laborde S. Heart rate variability and slow-paced breathing:when coherence meets resonance. *Neurosci Biobehav Rev*. 2022;135:104576
[33] Birdee G, Nelson K, Wallston K, et al. Slow breathing for reducing stress: The effect of extending exhale. *Complement Ther Med*. 2023;73:102937
[34] Kanhere SV, Bagadia DR, Phadke VD, Mukherjee PS. Yoga in Children with Epilepsy: A Randomized Controlled Trial. *J Pediatr Neurosci*. 2018;13(4):410-415
[35] Krause-Sorio B, Siddarth P, Kilpatrick L, et al. Yoga Prevents Gray Matter Atrophy in Women at Risk for Alzheimer's Disease: A Randomized Controlled Trial. *J Alzheimers Dis*. 2022;87(2):569-581
[36] Das S, Tiwari S, Xaviar S. An Audit of the Quality of Reporting and Bias of Studies on Yoga in Epilepsy. *Neurol India*. 2022;70(5):2009-2014

[37] Welford P, Östh J, Hoy S, et al. Effects of Yoga and Aerobic Exercise on Verbal Fluency in Physically Inactive Older Adults: Randomized Controlled Trial (FitForAge). *Clin Interv Aging*. 2023;18:533-545
[38] Gaßner H, Trutt E, Seifferth S, et al. Treadmill training and physiotherapy similarly improve dual task gait performance: a randomized-controlled trial in Parkinson's disease. *J Neural Transm (Vienna)*. 2022;129(9):1189-1200
[39] Cherup NP, Strand KL, Lucchi L, Wooten SV, Luca C, Signorile JF. Yoga Meditation Enhances Proprioception and Balance in Individuals Diagnosed With Parkinson's Disease. *Percept Mot Skills*. 2021;128(1):304-323
[40] Ban M, Yue X, Dou P, Zhang P. The Effects of Yoga on Patients with Parkinson's Disease: A Meta-Analysis of Randomized Controlled Trials. *Behav Neurol*. 2021;2021:5582488
[41] Kaur, Kirandeep et al. “Effectiveness of Yoga Intervention in Reducing Felt Stigma in Adults With Epilepsy: A Randomized Controlled Trial.” *Neurology* vol. 101,23 e2388-e2400. 4 Dec. 2023
[42] Jain M, Mishra A, Yadav V, et al. Long-term yogic intervention decreases serum interleukins IL-10 and IL-1β and improves cancer-related fatigue and functional scale during radiotherapy/chemotherapy in breast cancer patients: a randomized control study. *Support Care Cancer*. 2022;31(1):6
[43] Myers PS, Harrison EC, Rawson KS, et al. Yoga Improves Balance and Low-Back Pain, but Not Anxiety, in People with Parkinson's Disease. *Int J Yoga Therap*. 2020;30(1):41-48