



Role of Yoga and Meditation as Complimentary Therapeutic Regime for Stress-Related Neuropsychiatric Disorders: Utilization of Brain Waves Activity as Novel Tool

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Abstract

During recent decades, stress-related neuropsychiatric disorders such as anxiety, depression, chronic tension headache, and migraine have established their stronghold in the lives of a vast number of people worldwide. In order to address this global phenomenon, intensive studies have been carried out leading to the advancement of drugs like anti-depressants, anxiolytics, and analgesics which although help in combating the symptoms of such disorders but also create long-term side effects. Thus, as an alternative to such clinical practices, various complementary therapies such as yoga and meditation have been proved to be effective in alleviating the causes and symptoms of different neuropsychiatric disorders. The role of altered brain waves in this context has been recognized and needs to be pursued at the highest level. Thus, the current study provides a review focused on describing the effects of yoga and meditation on anxiety and depression as well as exploring brain waves as a tool for assessing the potential of these complementary therapies for such disorders.

Keywords

depression, anxiety, EEG, brain oscillatory rhythms

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Introduction

Neuropsychiatric disorders are the leading cause of disability worldwide. Epidemiological data suggest that neuropsychiatric disorders can be a burden to society and include several different disorders, including depression, anxiety, tension, and headache. In addition, these disorders may co-exist with other health disorders such as cardiovascular diseases, cognitive deficits, and memory impairments.¹ Neuropsychiatric disorders are being prevalent not only in adults but also among children and adolescents. According to a World Health Organization report, at least 350 million people worldwide live with depression.² As a critical neuropsychiatric disorder, anxiety accounts for, on average, 16 to 31% of prevalence rate worldwide.³ In addition, approximately 3 billion individuals worldwide suffer from tension-type and other forms of headache as per the 2016 report of Global Burden of Disease Study by the Institute of Health Metrics and Evaluation.⁴ Exposure to a varied form of

stress is the largest contributor to neuropsychiatric disorders. Stress can be defined as the situation of emotional and mental strain when a person is exposed to demanding situations.⁵ Modern-day lifestyle has often been attributed to cause unwanted stress. Day to day encounters with a varied form of

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stress results in the transformation of minor stress to chronic stress via psychological factors acting as the catalysts in this transformation.⁶

Psychological stress leads to activation of the sympathetic nervous system, which is responsible for fight or flight response in the body. As a result, the activity of the parasympathetic system is down-regulated. This interference in the autonomic nervous system affects several unconscious activities carried out by the brain, such as respiration, digestion, metabolic reactions, and so on.⁷ A stressor may activate the hypothalamus in the brain to release corticotrophin-releasing factor (CRF), which further stimulates the anterior pituitary to release adrenocorticotropic hormone (ACTH).⁷ ACTH sends a signal to the cortex of the adrenal gland to release the corticosteroids, namely, cortisol and aldosterone.⁸ This cascade, also known as Hypothalamic-Pituitary-Adrenal (HPA) axis, further alters the neuro-hormonal levels in the limbic system of the brain due to a stress stimuli by elevating the production of cortisol as well as the catecholamines (epinephrine, norepinephrine, and dopamine) which lead to a chain of physiological changes in the body like memory impairments, cognitive deficits, and mood disorders.¹ A functional disconnection between the amygdala and prefrontal cortex is often observed in patients suffering from chronic stress. Further, a reduction in 5-hydroxytryptamine (5-HT_{1A}) receptors in the limbic system, specifically within the hippocampus,⁹ and decreased level of serotonin may lead to various mood disorders. The endocannabinoid system is also activated for the purpose of stress regulation, leading to activated HPA axis, increased anxiety, and pain perception.¹⁰

Hyperactivation of HPA axis has also been linked to autonomic changes including increased neural excitability, cardiovascular activity, increased blood sugar level, respiratory problems, and reduction in antibody formation.⁶ These physiological changes further affect the homeostasis process of the body and initiate possible causation of different neuropsychiatric disorders. In addition, chronic stress triggers the release of various inflammatory cytokines such as interleukin 6 (IL-6), interleukin 1 β (IL-1 β), and tumor necrosis factor α (TNF- α). These immune-markers often act as stress biomarkers along with Brain Derived Neurotrophic Factor (BDNF), and over-activated glial cells.¹¹⁻¹⁵ It has also been found that higher NO and COX-2 levels caused due to stress are responsible for neuronal functional impairment and brain cell damage, subsequently resulting in neuroinflammation.¹⁶ In addition, stress is a leading cause of autoimmune disorders in which excessive inflammation acts as the center of reaction. It has been observed that chronically activated acute stress severely affects the immune system resulting in major physical as well as mental health disorders.⁶ Chronic stress is a leading cause of physical disorders such as Type II Diabetes Mellitus, Obesity, Cognitive Impairment and Physical Pain.¹⁷⁻¹⁹ However, a stressor foremostly targets the mental health of an individual causing neuropsychiatric disorders such as depression, anxiety, psychogenic epilepsy and many more.

Stress, Neuropsychiatric Disorders, and Brain Waves

A linear relation between anxiety and depression with daily life stress has been reported in the literature.²⁰ As discussed earlier, interference in the HPA axis leads to the release of large amounts of cortisol in the brain, which in turn triggers the excessive formation of neurotransmitter glutamate, thus damaging the hippocampus of brain.²¹ On the other hand, suppression of BDNF leads to mood disorders, anxiety and depression.²² Researchers have previously observed the implications of these molecular players such as neurotransmitters, and hormones at cellular level. It has been found that the interaction between neurons gives rise to oscillatory rhythms of different frequencies, which can easily depict the mental state and its well-being.²³ There are 5 major types of brain waves, namely delta (0.5-3 Hz), theta (3-8 Hz), alpha (8-13 Hz), beta (13-40 Hz), and gamma wave (40-100 Hz).²⁴ These oscillatory rhythms or brain waves were first detected in a human participant using electroencephalography (EEG) in 1924 by Hans Berger, a German psychiatrist.²⁵ EEG is a fundamental and sensitive method for the detection of the brain pattern of an individual and could easily decipher the mental state of the person depending on the type of prominent wave at that particular instant.²⁶ It has been reported that all types of brain waves are present in the brain throughout the day. However, one particular type of brain wave, as described earlier, is dominant depending on the state of consciousness. For instance, during deep sleep state, delta waves are highly prominent. Similarly, theta waves represent a state of sleepiness, alpha waves represent resting and quiet state of brain, beta waves are representation of active brain involved in cognition and thinking task and gamma waves are usually found in deep meditative state of mind.²⁷ Several successful attempts have been made to capture and classify the brain waves using EEG by the application of advanced algorithms in order to identify the mental task being performed at the instance.^{28,29} Klimesch et al., 1998 successfully demonstrated that slower alpha frequencies are linked to attention and alertness of brain.³⁰ Another study demonstrated the importance of frequency domain feature of EEG signals to predict the level of attention.³¹ Thus, brain waves classification has the potential to identify an unhealthy state of brain from the healthy state.

Since neurotransmission is carried out with the help of neurotransmitters such as serotonin, dopamine, nor-epinephrine, stress often affects the level of these neurotransmitters as observed through alteration in brain waves pattern.⁷ In a similar study, decreased serum cortisol levels have been found to have negative correlation with alpha wave activation.³² Another study demonstrated the roles of cholinergic, dopaminergic, serotonergic and GABAergic systems in modulating the EEG power spectral peaks,³³ thus establishing the fact that neurotransmitter level changes directly alters the brain waves pattern. Thus, stress not only imbibes the neuropsychiatric disorders within the human body but also contributes to alterations in normal state brain wave patterns.

Moreover, brain waves pattern has been potentially explored for the identification and classification of several psychological disorders with the help of EEG as a tool. A study by Perlis et al. (2000) confirmed the changes in beta and gamma activity during primary and secondary insomnia.³⁴ Several other studies also classified sleep disorders and sleep stages, as well as epileptic seizures using machine learning tools for EEG analysis.³⁵⁻³⁷ Additionally, EEG signal processing has also been vastly explored for the diagnosis of mental disorders like schizophrenia, major depressive disorder and anxiety disorders.³⁸⁻⁴² Hence, brain waves analysis is a novel diagnostic and therapeutic tool for synergism with complimentary therapies in the treatment of stress related neuropsychiatric disorders as it could efficiently measure the efficacy of interventions and could be utilized in providing a better prognostic index.

Complementary Therapies for Stress Related Neuropsychiatric Disorders: Yoga and Meditation

Conventional treatments for stress related neuropsychiatric disorders depend on the neurobiology of a particular disorder such as depression or anxiety. In order to suppress the causes and symptoms of depression, anti-depressants like ketamine act by regulating the levels of glutamate neurotransmitter and its corresponding NMDA receptor in the brain.⁴³ Other anti-depressants like tricyclic anti-depressants (TCAs), selective serotonin reuptake inhibitors (SSRI), serotonin, and norepinephrine reuptake inhibitors (SNRI) provide relief from the depressive mental state by regulating the levels of serotonin and norepinephrine neurotransmitters in brain, as well as by activating their anti-inflammatory mechanistic route.⁴⁴ Similarly, various anxiolytic drugs are used to treat anxiety disorders. Benzodiazepine derivatives are most extensively used anxiolytics acting on GABA receptors in order to suppress the anxious state. Some anti-depressants like ketamine have also found their use as anxiolytic drugs.⁴⁵ These drugs, although effective, have a major side effect of addiction thereby making an individual drug-dependent.

TCAs have been associated with higher cardiovascular disorders and drop-out rates. On the other hand, SSRIs and SNRIs have been found to produce sexual dysfunctionality and hyponatremia when used long-term.⁴⁶ As a consequence of these drug-related side effects, many studies are being conducted nowadays to identify complementary ways for the treatment of neuropsychiatric disorders. Some of the therapies include music, acupuncture, dietary plans, mind-body relaxation exercises, yoga, and meditation. Among these therapies, yoga and meditation have been vastly explored for their beneficial effects in the treatment of neuropsychiatric disorders,⁴⁷ due to their strong neurotransmitter levels alteration abilities.

Yoga and meditation therapies have been associated with changes in the levels of several neurotransmitters in brain which are crucial for the maintenance of mental health. Xiong et al., 2009 in their study argued that meditation practice could

potentially elevate the level of BDNF in brain and eventually enhances brain plasticity.⁴⁸ A similar study demonstrated the increase in brain GABA levels among regular yoga practitioners.⁴⁹ Another study explicitly highlighted the modulations in neurotransmitters like serotonin, norepinephrine, dopamine and melatonin post meditation and yoga exercises.^{50,51} Since neurotransmitter levels are reliable measures to examine psychological disorders, these evidences further provide a deep insight on the positive effects of complementary therapies such as yoga and meditation on human body.

Yoga involves various breathing exercises and asanas (postures), which exhibit a positive effect while dealing with stress disorders (Table 1). Anulom-Vilom pranayama is an alternate nostril breathing exercise which when studied as a 3-month intervention program, showed a significant reduction in anxiety and depression levels among 30 participants (age range = 60-70 years).⁵² In another study, the effects of controlled breathing exercises were studied among patients with acute Chronic Obstructive Pulmonary Disease (COPD) with co-existing moderate to severe anxiety and depression. It was found that 30 minutes of daily breathing exercise significantly improved the healthy state of these participants from their prior anxious states. Also, personal domains such as self-care, mobility, usual activities, discomfort exhibited an improvement for the overall quality of life of these patients.⁵³ A month's regular practice of Iyengar yoga, a kind of yoga involving both breathing exercises and yoga asanas, has also been reported to result in decreased levels of depression and anxiety.^{54,55} In addition, Hatha yoga, a kind of controlled breathing exercise, has been observed to create substantial improvement in levels of anxiety, depression, and anger among psychiatric in-patients as well as result in a significant reduction of post-traumatic stress disorder symptoms.^{56,57} Finally, significant improvements have been reported due to practice of breathing exercises for 1 month leading to changes from depressive symptoms to a relatively normal healthy state among participants.⁵⁸

Apart from yoga, meditation practices such as mindfulness-based cognitive therapy and mindfulness meditation have been reported to alleviate symptoms of depression and anxiety (Table 1). A study examining the effect of mindfulness meditation on patients of chronic pain in back, neck, shoulder, and chronic headache has reported a significant reduction in pain rating indices as well as improvement in mood disturbances and lifestyle of participants.⁵⁹ Pain rating scoring was completed both before and after the intervention, and the scores were then statistically analyzed for significant improvement. Anxiety and depression were measured with Hamilton anxiety (HAM-A) and Hamilton depression (HAM-D) scales, respectively.⁶⁰ Mindfulness meditation showed a positive effect on patients of depression and generalized anxiety disorder. Mindfulness-based cognitive therapy was examined in another study to determine any possible reduction in levels of acute depression and chronic pain. Depression and pain levels were analyzed using a set of questionnaires, both pre and post-meditation sessions. A significant reduction in the levels of depressive state and pain was observed after completion of the

Table 1. Overview of the Effects of Complementary Therapies on Various Stress Related Neuropsychiatric Disorders. Studies Conducted Only Analyzed the Effects of Complementary Therapies on Stress Related Neuropsychiatric Disorders and Did Not Consider the Changes in Brain Waves of the Test Subjects.

Type of complementary therapy	Type of stress disorder	Subjects	Inclusion and exclusion criteria	Period of intervention	Method of analysis	Key findings	Study reference
Anulom Vilom Pranayam	Anxiety and Depression	30 senior citizens; 60-70 years age group	Not Considered	3 months	Pre and Post anxiety and depression scale analysis using Beck depression inventory and Sinha anxiety scale	Significant decrease in the level of anxiety and depression	Gupta et al., 2010
Controlled Breathing	Anxiety and Depression	46 male subjects; 67-86 years age group; hospitalized with acute COPD exacerbation	Patients with cancer, organ failure and non-cooperative behavior were excluded	30 minutes daily exercise till the period of discharge	Pre and Post hospital anxiety and depression scales; quality of life questionnaire	Significant improvement in the anxiety and quality of life	Valenza et al., 2014
Breathing Exercise	Depression	57 patients on hemodialysis	Patients above 18 years in age and without hearing impairment were included in the study	1-month intervention (twice weekly)	Pre and post analysis of scores from BDI II	Significant improvement in depressive state	Siou-Hung et al., 2015
Yogasan, Pranayam and Chanting	Anxiety and Depression	60 caregivers of patients in neurology ward (17 defaulters)	Patients with severe mental illness and substance abuse history were excluded	1-month intervention	Pre and post test scores for anxiety, depression and quality of life	Significant decrease in anxiety and depression	Varambally et al., 2013
Hatha Yoga	Anxiety, Depression, Anger, Tension	113 psychiatric inpatients	Length of stay was considered to be 10 days minimum for inclusion in the study	Single session of 45 minutes	Pre and post session analysis via POMS subscales	Significant improvement in anxiety, depression and mood states	Lavey et al., 2005
Hatha Yoga	PTSD	9 women with chronic treatment resistant PTSD	Subjects with substance abuse, pregnancy, active suicide risk or previous yoga therapy doer were excluded	20-week trauma sensitive yoga involving hatha yoga practice, TCTSY exercise	Pre and post analysis of PTSD scales	Significant reduction in PTSD	Price et al., 2017
Iyengar Yoga	Anxiety and Depression	28 young volunteers with mild depression; 18-29 years age group	Patients without any psychiatric treatment, non-smokers and with no current problem of substance abuse were included in the study	5 weeks intervention (twice weekly)	Pre and Post analysis using BDI, state trait anxiety inventory, POMS, morning cortisol levels	Significant decrease in the symptoms of depression and anxiety	Woolery et al., 2004
Mindfulness Meditation	Anxiety and Depression	22 subjects with generalized anxiety disorder	Patients with severe mental illness and substance abuse history were excluded	8 weeks meditation cycle	Pre and Post analysis using HAM-D and HAM-A scores	Significant reduction in the symptoms of anxiety and depression	Kabat-zinn et al., 1992

(continued)

Table 1. (continued)

Type of complementary therapy	Type of stress disorder	Subjects	Inclusion and exclusion criteria	Period of intervention	Method of analysis	Key findings	Study reference
Mindfulness Based Cognitive Therapy (MBCT)	Chronic Pain and Active Depression	40 participants with persistent chronic pain and depressive symptoms	Patients with serious suicide risk, history of psychotic disorder, personality disorder or severe health illness were excluded	8 weeks intervention (once a week for 2 hrs)	Pre and Post analysis using PCS and QIDS-C ₁₆ scales	Significant effect of MBCT on depressive state and reduction in pain	de Jong et al., 2016
Mindfulness Based Stress Reduction (MBSR)	Stress and Depression	44 college undergraduates; 18-24 years age group	Only those participants who volunteered for the study were included	8-week intervention (once a week); sitting meditation, passage meditation, focused attention, slowing down	Pre and post analysis using a set of questionnaires	Significant reduction in stress	Oman et al., 2008
Mindfulness Meditation	Chronic Pain	51 Chronic pain patients (low back, neck, shoulder, headache)		10 weeks stress reduction and relaxation program (Sweeping, Mindfulness breathing and hatha yoga postures; once a week for 2 hrs)	Pre and Post evaluation via Pain Rating Index and other similar indices	Decrease in the pain rating indices as well as reduction in mood disturbances and psychiatric symptoms	Kabat-zinn., 1982
Brain Wave Vibration Training (BWV), Iyengar Yoga and Mindfulness Meditation	Anxiety and Depression	35 healthy adults; 18-50 years age group	Not considered	5 weeks intervention involving 75 minutes BWV class, Iyengar yoga and mindfulness meditation	Pre and post analysis of various scales for anxiety, stress, depression	All interventions improved stress and depression scales	Bowden et al., 2012

Abbreviations used: COPD: Chronic Obstructive Pulmonary Disease; POMS: Profile of Mood States; PTSD: Posttraumatic Stress Disorder; TCTSY: Trauma Center Trauma-Sensitive Yoga; BDI: Beck Depression Inventory; HAM-D: Hamilton Depression Questionnaire; HAM-A: Hamilton Anxiety Questionnaire; PCS: Pain Catastrophizing Scale; QIDS-C₁₆: Quick Inventory of Depressive Symptomatology- Clinician Rated

intervention period.^{61,62} In conclusion, yoga and meditation practices have been reported to be highly effective not only when practiced individually but also when performed together. For example, when Iyengar yoga is practiced along with mindfulness meditation, the stress levels are reduced more efficiently.⁶³

It is to be noted that Meditation and Yoga exercises have been explored for their effects in other psychiatric illness as well. Several studies have highlighted the merits of Yoga therapies inclusive of yoga postures, breathing exercises and meditation-based relaxation techniques in the treatment of psychiatric disorders such as Schizophrenia, Obsessive Compulsive Disorder, Eating Disorders and Post-Traumatic Stress Related Disorders.⁶⁴⁻⁶⁷ While the research in yoga and meditation has been done in varied styles, the efficacy of yoga and meditation needs to be examined further on other stress-related disorders as well as neuropsychiatric symptoms other than anxiety and depression.

Additionally, it has been found recently that alternative therapies like yoga and meditation sometimes pose adverse effects on the practitioners. For instance, a multicentric survey by Cebolla et al. (2017) concluded that unwanted effects were prevalent among 25% of the participants practicing mindfulness meditation.⁶⁸ A similar study was conducted by Schlosser et al. (2019) highlighting the unpleasant meditation experiences among the regular practitioners.⁶⁹ Anderson et al. (2018) in their work also explored the importance of studying the negative effects associated with meditation practices.⁷⁰ Moreover, some studies have also indicated the potential harmful effects of yoga and meditation practices in some psychological disorders such as clinical or sub-clinical epilepsy highlighting the increased incidence of epileptic seizures post meditation practice.^{71,72} Thus, novel tools such as brain waves analysis using EEG signal processing could potentially provide therapeutic clues among the patients suffering from neuropsychiatric disorders regarding their contraindications.

Brain Waves as a Tool for Assessing Potential of Yoga and Meditation as Complementary Therapies

When complementary therapies such as yoga and meditation are practiced, positive alteration in brain waves is observed. Brain relaxation exercises are known to elevate the activity of brain waves. For example, a study conducted on healthy yoga practitioners practicing Bhramari pranayama found an increase in gamma activity in the left temporal lobe. Paroxysmal gamma activity was detected using 128 channels EEG, recorded in 1 or 2 consecutive sessions of Bhramari pranayama.⁷³ In another study, Ujjayi breathing pranayama was found to elevate the activity of alpha waves in 40% of healthy subjects with a 30% decline in beta activity.⁷⁴ The activity of brain waves was calculated using the power of alpha, beta, theta, and delta by fast Fourier transform and independent component analysis (Table 2).

In a similar study involving the practice of alternate nostril breathing exercises (based on classical Hatha yoga description), a significant increase in mean power of alpha and beta bands was observed along with a balancing effect on the functional activity of participants left and right hemisphere. The activity was observed using spectral power and spectral maps of various frequency bands.⁷⁵ The amplitude of P300 waves was found to be increased significantly at Fz, Pz, and Cz electrode sites after 40 minutes of alternate nostril breathing exercise and breath awareness among 20 yoga practitioners. The study findings suggested enhanced learning and memory in these participants.⁷⁶ It was also observed that the amplitude of the P300 wave, which is elicited in the process of decision-making increases after the practice of rhythmic breathing along with anti-depressant behavior of the exercise.^{77,78} An important form of yoga exercise, Yoga Nidra has a substantial effect on mental relaxation and is responsible for alpha dominance in brain after 40 days of yoga nidra practice among young students.⁷⁹ In addition, regular practitioners of Sahaja Yoga have shown prominent increase in theta-1, theta-2 and alpha-1 waves activity in midline frontal and central regions during meditative state. Increased activity has also been found after examining the non-linear dynamic complexity of EEG recorded during the meditative state.⁸⁰ Sahaja Yoga meditation is found to enhance the alpha and theta waves synchronization in anterior frontal region of brain. Increased activity has also been observed by examining the spectral power changes and coherence analysis in theta and alpha bands.⁸¹

Specific to Transcendental Meditation (TM), individuals practicing this routine have been observed to have increased frontal theta and alpha activity along with decreased levels of anxiety and stress.^{82,83} A significant increase in alpha and theta wave activity was also found after 20 minutes practice with non-directive acem meditation. Mean spectral power values of all brain waves were analyzed for all the regions of brain such as frontal, temporal, central, and occipital.⁸⁴ In another study, the effects of Zen meditation was examined among healthy subjects by observing any increase in theta and alpha power of brain wave within the frontal regions using Fast Fourier Transform analysis.⁸⁵ Mindfulness meditation typically activates the left anterior region of brain as found after examining changes in 4 anterior electrode sites (Table 2), and alteration of the gamma and delta waves.⁸⁶ Further, 20 minutes of breathing meditation has been reported to be associated with a significant increase in the level of alpha bands among other rhythmic oscillatory bands of beta, theta, and delta waves.⁸⁷

As discussed in previous section, yoga and meditation when performed together, complements the effects of each other. For example, Sudarshan Kriya yoga along with Sahaja Samadhi Meditation enhance the theta activity in frontal region of brain along with increased theta coherence as indicated in a study conducted on healthy subjects. These routines have been found to improve the overall health of an individual along with improved sleep patterns, depression symptoms, and anxiety. EEG data was analyzed for spectral and coherence analysis for various extracted blocks from different portions of Sudarshan

Table 2. Overview of the Effects of Complementary Therapies on Brain Waves of Healthy Subjects. Studies Under This Class Were Conducted Only for Healthy Subjects and Brain Waves Analysis Was Not Done for the Depressed and Anxious Patients Along With the Intervention Practices.

Type of complementary therapy	Subjects	Period of intervention	EEG recording and analysis	Key findings	Study reference
Bhramari Pranayam	3 healthy meditators (Beginner, Intermediate and Expert)	20 breathing episodes; short inhalation and long exhalation period during which subjects produced a typical humming sound	128 electrodes; recorded in 1 or 2 consecutive sessions of Bhramari Pranayam; detection of paroxysmal gamma waves	Increase in gamma activity in the left temporal lobe	Vázquez et al., 2013
Ujjayi Breathing Pranayam	10 healthy subjects	3 cycles of pranayam of 2 minutes each	10-20 electrode system; 32 channels EEG; Calculation of power of alpha, beta, theta and delta using FFT; independent component analysis of EEG signals	Increase in alpha and beta (40% subjects); decrease in beta (30% subjects)	Vijayalakshmi et al., 2014
Alternate Nostril Breathing	18 healthy yoga practitioners; 27-32 years age group	3 minutes alternate nostril breathing exercise according to classical hatha yoga description during EEG recording	EEG recorded during 3-5 minutes of exercise; spectral power and spectral maps of various frequency bands were analyzed	Increase in mean power of beta and alpha bands during exercise; hemisphere asymmetry in beta band decreased; exercise had balancing effect on the functional activity of the left and right hemisphere	Staňák and Kuna, 1994
Alternate Nostril Yoga Breathing (Nadisuddhi Pranayam)	20 male adult yoga practitioners; 21-38 years age group	40 minutes intervention involving alternate nostril yoga breathing and breath awareness	Peak amplitude and peak latency of P300 were measured at 3 electrode sites, F _z , P _z , C _z ; statistical data analysis	Significant increase in P300 peak amplitude and significant decrease in peak latency at Fz	Telles et al., 2013
Yoga Nidra	40 students; 18-25 years age group	40 days practice of yoga nidra for 30 minutes daily	Statistical analysis of pre and post values of alpha EEG	Mental relaxation and alpha dominance	Kumar and Joshi, 2009
Sahaja Yoga	20 experienced meditators; 20-40 years age group	Regular practitioners	Recorded during eyes closed, rest and meditative state; 62 channel EEG; Non-linear dynamic complexity of human EEG; EEG maps at rest and meditating states; comparison of mean values of theta and alpha (1 and 2) waves in rest and meditation state	Theta-1, theta-2 and alpha-1 waves are increased in midline frontal and central regions in the meditative state	Aftanas and Golocheikine, 2002
Sahaja Yoga	27 regular practitioners (2 groups: short term and long-term practitioners)	Sahaja yoga meditation practice during recording	Pre, during and post meditation; EEG spectral power and coherence analysis; spectral power changes b/w eyes closed and meditation conditions in theta, alpha-1 and alpha 2 bands	Increased anterior frontal and midline theta synchronization; increased alpha synchronization	Aftanas and Golocheikine, 2001
Non-Directive Meditation (Acem Meditation)	18 acem meditators; 28-63 years age group	20 minutes acem meditation and 20 minutes quiet rest condition	Recorded during meditation and relaxation periods; 20 scalp electrode sites; Mean spectral power values for all brain waves in meditation and resting state as well as in different regions of the brain such as frontal, temporal- central and parietal	Increased theta in frontal and temporal-central regions during meditation; Increased alpha in posterior region in meditation state	Lagopoulos et al., 2009

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Table 2. (continued)

Type of complementary therapy	Subjects	Period of intervention	EEG recording and analysis	Key findings	Study reference
Zen Meditation (Suzoku Meditation)	20 healthy subjects; 21-26 years	Counting of breaths till 100 while concentrating the mind	During meditation; spectral power analysis of brain waves with FFT using a hamming window; spectral components assigned to 3 power bands based on their frequency- very low, low and high frequency band	Increased theta and alpha power in frontal region	Takahashi et al., 2005
Mindfulness Meditation	25 healthy subjects	8-weeks practice of mindfulness meditation	Pre and post practice recording; examined changes in 4 anterior electrode sites (F3/4, FC7/8, T3/4 and C3/4) and performed multivariate ANOVAs	Left-sided anterior activation	Davidson et al., 2003
Breathing Meditation	8 subjects; 31-62 years	20 minutes of breathing meditation	Statistical analysis of values of alpha, beta, theta and delta waves	Increased alpha and SMR bands	Van Heerden et al., 2013
Yoga and Twin Heart Meditation	20 students	20 days practice of yogic exercise and twin heart meditation for 45 minutes daily	Statistical analysis of pre and post values of alpha EEG	Increase in alpha waves post practice	Singh and Singh, 2016
Sudarshan Kriya Yoga and Sahaja Samadhi Meditation	20 healthy subjects	Sahaja Samadhi meditation during EEG recording	Spectral and coherence analysis for the whole duration and specific blocks extracted from the initial, middle and end portions of meditation	Enhanced theta activity in the frontal areas; Increased theta coherence	Bajjal and Srinivasan, 2010

Abbreviations used: EEG: Electroencephalography; FFT: Fast Fourier Transform; ANOVA: Analysis of Variance; SMR: Sensory-Motor Activity

Kriya yoga in a prior study.⁸⁸ In a similar study, analysis of pre and post intervention data values of alpha EEG after 20 days practice of yoga exercises, and twin heart meditation indicated a significant increase in alpha activity of brain waves post-intervention.⁸⁹

In conclusion, numerous studies have shown significant changes in the level of brain waves among healthy adults following the regular practice of yoga and meditation. However, additional studies are warranted to further study the brain wave changes after practicing relaxation exercise by patients suffering from different stress-related disorders.

Future Perspective

A majority of studies have examined the effects of yoga and meditation on stress-related disorder among patients of moderate to severe anxiety and depression. However, other types of stress-related disorders such as chronic tension headache, migraine, and psychogenic epilepsy have not been studied in details for their improvement after practicing such relaxation therapy. It is possible that participants with these disorders might also show improved levels of symptoms after regularly practicing yoga and meditation therapy. In addition, prior studies have not examined the detailed changes in participants' brain waves. There is a missing gap in the existing literature as the effects of yoga and meditation on changes in brain waves have been examined only among healthy individuals and not among patients of stress-related disorders. Thus, additional studies can be beneficial where patients with stress-related neuropsychiatric disorders are examined for the changes in brain waves pre- and post-intervention of yoga and meditation therapy for more insight into the mechanism of these complementary therapies.

Conclusion

In the present review, we observed that stress is the major contributor to various physical and mental health disorders in the current lifestyle. A stressor directly stimulates a cascade of neurohormonal and inflammatory changes in the body, which further induces a secondary response of physiological changes such as cardiovascular disorders, respiratory disorders, lower immunity, and more prominently, neuropsychiatric disorders like depression and anxiety. It was found that although drugs like anti-depressants and anxiolytics reduce the symptoms of these disorders, they also create long-term side effects. Thus, complementary therapies such as yoga and meditation must be studied to counteract the side effects of these drugs. Evidence from the existing studies on alternative therapies provide evidence for very little or no side effects and higher efficiency in combating these stress-related neuropsychiatric disorders. We examined the efficacy of yoga and meditation practices on stress-related neuropsychiatric disorders and found a significant decrease in the symptoms of anxiety and depression. Breathing exercises such as Anulom-Vilom Pranayama and breathing meditation significantly improved the quality of life

of patients as well as decreased levels of anxiety and depression.⁹⁰ Apart from breathing exercises, various yoga asanas and meditation practices have also been reported to reduce symptoms of anxiety and depression. Studies, when examined for the changes in brain waves, also concluded a significant increase in the levels of brain wave activity.⁹¹ Meditation practices such as mindfulness meditation, non-directive meditation, and breathing meditation increase the alpha and theta waves activity in the frontal region of the brain as well as results in extensive changes in gamma waves frequency.⁹² In addition, yoga has been found to contribute to a prominent level of increased alpha and theta waves activity in the brain.⁹³ In conclusion, yoga and meditation have been reported to exhibit a positive effect for treating stress-related disorders such as anxiety and depression through positive changes in a participants' functioning as well as by significantly altering the activity of brain waves among the tested subjects.

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Ethical Approval

Since this is a review article and no sample collection was done for the same, hence ethical approval was not required.

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References

1. Yaribeygi H, Panahi Y, Sahraei H, Johnston TP, Sahebkar A. The impact of stress on body function: a review. *EXCLI J.* 2017;16: 1057-1072. doi:10.17179/excli2017-480
2. Aquino JP, De Londono A, Carvalho AF. An update on the epidemiology of major depressive disorder across cultures.

- Understand Depress.* 2018;25:309-315. doi:10.1007/978-981-10-6580-4_25
3. Starke J, Fineberg N, Stein D. Anxiety disorders: from bench to bedside and beyond. *Adv Psych.* 2019:33-58. Springer, Cham.
 4. Stovner LJ, Nichols E, Steiner TJ, et al. Global, regional, and national burden of migraine and tension-type headache, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Neurol.* 2018;17(11):954-976. doi:10.1016/S1474-4422(18)30322-3
 5. Butler G. Definitions of stress. *Occas Pap R Coll Gen Pract.* 1993;(61):1-5. <http://www.ncbi.nlm.nih.gov/pubmed/8199583>
<http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC2560943>
 6. Schneiderman N, Ironson G, Siegel SD. Stress and health: psychological, behavioral, and biological determinants. *Annu Rev Clin Psychol.* 2004;1(1):607-628. doi:10.1146/annurev.clinpsy.1.102803.144141
 7. Seo SH, Lee JT. Stress and EEG. *Converg Hybrid Inf Technol.* 2010;1(1):413-424. doi:10.5772/9651
 8. Zannas AS, Chrousos GP. Epigenetic programming by stress and glucocorticoids along the human lifespan. *Mol Psychiatry.* 2017;22(5):640-646. doi:10.1038/mp.2017.35
 9. Jovanovic H, Perski A, Berglund H, Savic I. Chronic stress is linked to 5-HT1A receptor changes and functional disintegration of the limbic networks. *Neuroimage.* 2011;55(3):1178-1188. doi:10.1016/j.neuroimage.2010.12.060
 10. Morena M, Patel S, Bains JS, Hill MN. Neurobiological interactions between stress and the endocannabinoid system. *Neuropsychopharmacology.* 2016;41(1):80-102. doi:10.1038/npp.2015.166
 11. Mahar I, Bambico FR, Mechawar N, Nobrega JN. Stress, serotonin, and hippocampal neurogenesis in relation to depression and antidepressant effects. *Neurosci Biobehav Rev.* 2014;38:173-192. doi:10.1016/j.neubiorev.2013.11.009
 12. Calcia MA, Bonsall DR, Bloomfield PS, Selvaraj S, Barichello T, Howes OD. Stress and neuroinflammation: a systematic review of the effects of stress on microglia and the implications for mental illness. *Psychopharmacology (Berl).* 2016;233(9):1637-1650. doi:10.1007/s00213-016-4218-9
 13. Nijs J, Loggia ML, Polli A, et al. Sleep disturbances and severe stress as glial activators: key targets for treating central sensitization in chronic pain patients? *Expert Opin Ther Targets.* 2017;21(8):817-826. doi:10.1080/14728222.2017.1353603
 14. Deak T, Kudinova A, Lovelock DF, Gibb BE, Hennessy MB. A multispecies approach for understanding neuroimmune mechanisms of stress. *Dialogues Clin Neurosci.* 2017;19(1):37-53.
 15. Kunugi H, Hori H, Ogawa S. Biochemical markers subtyping major depressive disorder. *Psychiatry Clin Neurosci.* 2015;69(10):597-608. doi:10.1111/pcn.12299
 16. Munhoz CD, Madrigal JLM, Lepsch LB, et al. Stress-induced neuroinflammation: mechanisms and new pharmacological targets. *Brazilian J Med Biol Res.* 2008;41:1037-1046.
 17. De Kloet ER, Joëls M, Holsboer F. Stress and the brain: from adaptation to disease. *Nat Rev Neurosci.* 2005;6(6):463-475. doi:10.1038/nrn1683
 18. van der Valk ES, Savas M, van Rossum EFC. Stress and obesity: are there more susceptible individuals? *Curr Obes Rep.* 2018;7(2):193-203. doi:10.1007/s13679-018-0306-y
 19. Hackett RA, Steptoe A. Type 2 diabetes mellitus and psychological stress—a modifiable risk factor. *Nat Rev Endocrinol.* 2017;13(9):547-560. doi:10.1038/nrendo.2017.64
 20. Bremner JD. Does stress damage the brain. *Biol Psychiatry.* 1999;45(7):797-805. doi:10.1016/S0006-3223(99)00009-8
 21. Pilkington K, Kirkwood G, Rampes H, Richardson J. Yoga for depression: the research evidence. *J Affect Disord.* 2005;89(1-3):13-24. doi:10.1016/j.jad.2005.08.013
 22. Andrews B, Wilding JM. The relation of depression and anxiety to life-stress and achievement in students. *Br J Psychol.* 2004;95(4):509-521. doi:10.1348/0007126042369802
 23. Da Silva FL. Neural mechanisms underlying brain waves: from neural membranes to networks. *Electroencephal Clin Neurophysiol.* 1991;79:81-93. doi:10.1016/0013-4694(91)90044-5
 24. Desai R, Tailor A, Bhatt T. Effects of yoga on brain waves and structural activation: a review. *Complement Ther Clin Pract.* 2015;21(2):112-118. doi:10.1016/j.ctcp.2015.02.002
 25. Millett D. Hans Berger: from psychic energy to the EEG. *Perspect Biol Med.* 2001;44(4):522-542. doi:10.1353/pbm.2001.0070
 26. Teplan M. Fundamentals of EEG measurement. *Meas Sci Rev.* 2002;2(2):1-11.
 27. Sawant HK, Jalali Z. Detection and classification of EEG waves. *Orient J Comput Sci Technol.* 2010;3(1):207-213. doi:10.1016/j.infsof.2008.09.005
 28. Harmony T, Fernández T, Silva J, et al. EEG delta activity: an indicator of attention to internal processing during performance of mental tasks. *Int J Psychophysiol.* 1996;24(1-2):161-171. doi:10.1016/S0167-8760(96)00053-0
 29. Liang NY, Saratchandran P, Huang GB, Sundararajan N. Classification of mental tasks from EEG signals using extreme learning machine. *Int J Neural Syst.* 2006;16(1):29-38. doi:10.1142/S0129065706000482
 30. Klimesch W, Doppelmayr M, Russegger H, Pachinger T, Schwaiger J. Induced alpha band power changes in the human EEG and attention. *Neurosci Lett.* 1998;244(2):73-76. doi:10.1016/S0304-3940(98)00122-0
 31. Srinivasan R, Thorpe S, Deng S, Lappas T, Zmura MD. Decoding attentional orientation from EEG spectra. *Int Conference Hum Comp Interact.* 2009:176-183.
 32. KAMEI T. Decrease in serum cortisol during yoga exercise is correlated with alpha wave activation. *Percept Mot Skills.* 2000;90(3):1027. doi:10.2466/pms.90.3.1027-1032
 33. Yamamoto J. Roles of cholinergic, dopaminergic, noradrenergic, serotonergic and GABAergic systems in changes of the EEG power spectra and behavioral states in rabbits. *Jpn J Pharmacol.* 1988;47(2):123-134. doi:10.1254/jjp.47.123
 34. Perlis ML, Smith MT, Andrews PJ, Orff H, Giles DE. Beta/Gamma EEG activity in patients with primary and secondary insomnia and good sleeper controls. *Sleep.* 2001;24(1):110-117. doi:10.1093/sleep/24.1.110
 35. Adeli H, Zhou Z, Dadmehr N. Analysis of EEG records in an epileptic patient using wavelet transform. *J Neurosci Methods.* 2003;123(1):69-87. doi:10.1016/S0165-0270(02)00340-0

36. Doroshenkov LG, Konyshov VA, Selishchev SV. Classification of human sleep stages based on EEG processing using hidden Markov models. *Biomed Eng.* 2007;41(1):25-28. doi:https://doi.org/10.1007/s10527-007-0006-5
37. Aboalayon KAI, Faezipour M. Multi-class SVM based on sleep stage identification using EEG signal. *IEEE Healthc Innov Conf HIC 2014.* 2014;2015(2):181-184. doi:10.1109/HIC.2014.7038904
38. Nikolin S, Chand N, Martin D, Rushby J, Loo CK, Boonstra TW. EEG correlates of affective processing in major depressive disorder. *medRxiv.* 2020. <https://doi.org/10.1101/2020.04.29.20085571>
39. Hosseinifard B, Moradi MH, Rostami R. Classifying depression patients and normal subjects using machine learning techniques and nonlinear features from EEG signal. *Comput Methods Programs Biomed.* 2013;109(3):339-345. doi:10.1016/j.cmpb.2012.10.008
40. Smit DJA, Posthuma D, Boomsma DI, De Geus EJC. The relation between frontal EEG asymmetry and the risk for anxiety and depression. *Biol Psychol.* 2007;74(1):26-33. doi:10.1016/j.biopsycho.2006.06.002
41. Vialatte FB, Cichocki A. Sparse bump sonification: a new tool for multichannel EEG diagnosis of mental disorders; application to the detection of the early stage of Alzheimer's disease. *Lect Notes Comput Sci (including Subser Lect Notes Artif Intell Lect Notes Bioinformatics).* 2006;4234(10):92-101. doi:10.1007/11893295_11
42. Li Y, Tong S, Liu D, et al. Abnormal EEG complexity in patients with schizophrenia and depression. *Clin Neurophysiol.* 2008;119(6):1232-1241. doi:10.1016/j.clinph.2008.01.104
43. Abdallah CG, Sanacora G, Duman RS, Krystal JH. The neurobiology of depression, ketamine and rapid-acting antidepressants: is it glutamate inhibition or activation? *Pharmacol Ther.* 2018;190(3):148-158. doi:10.1016/j.pharmthera.2018.05.010
44. Galecki P, Mossakowska-Wójcik J, Talarowska M. The anti-inflammatory mechanism of antidepressants—SSRIs, SNRIs. *Prog Neuro-Psychopharmacology Biol Psychiatry.* 2018;80(2017):291-294. doi:10.1016/j.pnpbp.2017.03.016
45. Michel B. Clinical pharmacology of anxiolytics. *Arch Depress Anxiety.* 2018;2018(2):021-025. doi:10.17352/2455-5460.000029
46. Wang S-M, Han C, Bahk W-M, et al. Addressing the side effects of contemporary antidepressant drugs: a comprehensive review. *Chonnam Med J.* 2018;54(2):101. doi:10.4068/cmj.2018.54.2.101
47. Balasubramaniam M, Telles S, Doraiswamy PM. Yoga on our minds: a systematic review of yoga for neuropsychiatric disorders. *Front Psychiatry.* 2013;3(1):1-16. doi:10.3389/fpsy.2012.00117
48. Xiong GL, Doraiswamy PM. Does meditation enhance cognition and brain plasticity? *Ann N Y Acad Sci.* 2009;1172:63-69. doi:10.1196/annals.1393.002
49. Streeter CC, Jensen JE, Perlmutter RM, et al. Yoga Asana sessions increase brain GABA levels: a pilot study. *J Altern Complement Med.* 2007;13(4):419-426. doi:10.1089/acm.2007.6338
50. Newberg AB, Iversen J. The neural basis of the complex mental task of meditation: neurotransmitter and neurochemical considerations. *Med Hypotheses.* 2003;61(2):282-291. doi:10.1016/S0306-9877(03)00175-0
51. Krishnakumar D, Hamblin MR, Lakshmanan S, Diego S, Hospital MG. Meditation and yoga can modulate brain mechanisms. *Anc Sci.* 2016;2(1):13-19. doi:10.14259/as.v2i1.171.Meditation
52. Gupta PK. Anuloma-viloma pranayama and anxiety and depression among the aged. *J Indian Acad Appl Psychol.* 2010;36(1):159-164.
53. Valenza MC, Valenza-Pena G, Torres-Sanchez I, Gonzalez-Jimenez E, Conde-Valero A, Valenza-Demet G. Effectiveness of controlled breathing techniques on anxiety and depression in hospitalized patients with COPD: a randomized clinical trial. *Respir Care.* 2014;59(2):209-215. doi:10.4187/respcare.02565
54. Woolery A, Myers H, Sternlieb B, Zeltzer L, Instructor Y. A yoga intervention for young adults. *Altern Ther Health Med.* 2004;10(2):60-63.
55. Varambally S, Philip M, Gangadhar B, Umadevi P, Ramachandra S. Effect of yoga therapy on anxiety and depressive symptoms and quality-of-life among caregivers of in-patients with neurological disorders at a tertiary care center in India: a randomized controlled trial. *Indian J Psychiatry.* 2013;55(7):385. doi:10.4103/0019-5545.116304
56. Price M, Spinazzola J, Musicaro R, et al. Effectiveness of an extended yoga treatment for women with chronic posttraumatic stress disorder. *J Altern Complement Med.* 2017;23(4):300-309. doi:10.1089/acm.2015.0266
57. Lavey R, Sherman T, Mueser KT, Osbome DD, Currier M, Wolfe R. The effects of yoga on mood in psychiatric inpatients. *Psychiatr Rehabil J.* 2005;28(4):399-402.
58. Siou-Hung T, Mei-Yeh W, Nae-Fang M, Pei-Chuan C, Tso-Hsiao C, Pei S. The efficacy of a nurse-led breathing training program in reducing depressive symptoms in patients on hemodialysis: a randomized controlled trial. *Am J Nurs.* 2015;115(4):24-42.19p. doi:10.1097/01.NAJ.0000463024.48226.d8
59. Kabat-Zinn J, Massion AO, Kristeller Jean P, et al. An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: theoretical considerations and preliminary results. *Gen Hosp Psychiatry.* 1982;4(1):33-47 [http://www.embase.com/search/results?subaction=viewrecord%7B&%7Dfrom=export%7B&%7Ddid=L12088404%5Cnhttp://dx.doi.org/10.1016/0163-8343\(82\)90026-3](http://www.embase.com/search/results?subaction=viewrecord%7B&%7Dfrom=export%7B&%7Ddid=L12088404%5Cnhttp://dx.doi.org/10.1016/0163-8343(82)90026-3).
60. Kabat-Zinn J, Massion AO, Kristeller J, et al. Effectiveness of a meditation-based stress reduction program in the treatment of anxiety disorders. *Am J Psychiatry.* 1992;(6):936-943.
61. Oman D, Shapiro SL, Thoresen CE, Plante TG, Flinders T. Meditation lowers stress and supports forgiveness among college students: a randomized controlled trial. *J Am Coll Heal.* 2008;56(5):569-578. doi:10.3200/JACH.56.5.569-578
62. De Jong M, Lazar SW, Hug K, et al. Effects of mindfulness-based cognitive therapy on body awareness in patients with chronic pain and comorbid depression. *Front Psychol.* 2016;7(6):967. doi:10.3389/fpsyg.2016.00967
63. Bowden D, Gaudry C, An SC, Gruzeliier J. A comparative randomised controlled trial of the effects of brain wave vibration training, iyengar yoga, and mindfulness on mood, well-being, and

- salivary cortisol. *Evidence-based Complement Altern Med*. 2012; 2012. doi:10.1155/2012/234713
64. Shannahoff-Khalsa DS, Ray LE, Levine S, Gallen CC, Schwartz BJ, Sidorowich JJ. Randomized controlled trial of yogic meditation techniques for patients with obsessive-compulsive disorder. *CNS Spectrums*. 1999;4(12):34-47.
 65. Visceglia E, Lewis S. Yoga therapy as an adjunctive treatment for schizophrenia: a randomized, controlled pilot study. *J Altern Complement Med*. 2011;17(7):601-607. doi:10.1089/acm.2010.0075
 66. Carei TR, Fyfe-Johnson AL, Breuner CC, Brown MA. Randomized controlled clinical trial of yoga in the treatment of eating disorders. *J Adolesc Heal*. 2010;46(4):346-351. doi:10.1016/j.jadohealth.2009.08.007
 67. Gallegos AM, Crean HF, Pigeon WR, Heffner KL. Meditation and yoga for posttraumatic stress disorder: a meta-analytic review of randomized controlled trials. *Clin Psychol Rev*. 2017;1(58):115-124.
 68. Cebolla A, Demarzo M, Martins P, Soler J, Garcia-Campayo J. unwanted effects: is there a negative side of meditation? A multi-centre survey. *PLoS One*. 2017;12(9):1-11. doi:10.1371/journal.pone.0183137
 69. Schlosser M, Sparby T, Vörös S, Jones R, Marchant NL. Unpleasant meditation-related experiences in regular meditators: prevalence, predictors, and conceptual considerations. *PLoS One*. 2019; 14(5):1-18. doi:10.1371/journal.pone.0216643
 70. Anderson T, Suresh M, Farb NA. Meditation benefits and drawbacks: empirical codebook and implications for teaching. *J Cogn Enhanc*. 2019;3(2):207-220. doi:10.1007/s41465-018-00119-y
 71. Jaseja H. Meditation potentially capable of increasing susceptibility to epilepsy—a follow-up hypothesis. *Med Hypotheses*. 2006;66(5):925-928. doi:10.1016/j.mehy.2005.11.043
 72. Lansky EP, St Louis EK. Transcendental meditation: a double-edged sword in epilepsy? *Epilepsy Behav*. 2006;9(3):394-400. doi:10.1016/j.yebeh.2006.04.019
 73. Vázquez M A, Jin J, Dauwels J, Vialatte FB. Automated detection of paroxysmal gamma waves in meditation EEG. In: *2013 IEEE International Conference on Acoustics, Speech and Signal Processing*, 1192-1196. doi:10.1109/ICASSP.2013.6637839
 74. Vijayalakshmi K, Ramachandran S, Chandrasekaran M. Independent component analysis of EEG signals and real time data acquisition using MyDAQ and Labview. *Int J Innov Res Adv Eng*. 2014;1(9):65-74.
 75. Stančák A, Kuna M. EEG changes during forced alternate nostril breathing. *Int J Psychophysiol*. 1994;18(1):75-79. doi:10.1016/0167-8760(84)90017-5
 76. Telles S, Singh N, Puthige R. Changes in P300 following alternate nostril yoga breathing and breath awareness. *Biopsychosoc Med*. 2013;7(1):7-12. doi:10.1186/1751-0759-7-11
 77. Sharma P, Thapliyal A, Chandra T, Singh S, Baduni H, Waheed SM. Rhythmic breathing: immunological, biochemical, and physiological effects on health. *Adv Mind Body Med*. 2015;29(1): 18-25. <http://www.ncbi.nlm.nih.gov/pubmed/25607119>
 78. Naga PJ, Murthy V, Gangadhar BN, Janakiramaiah N, Subhakarishna DK. The healing breath technique/Sudarshan Kriya in the treatment of depression. *Biol Psychiatry*. 1997;42:4. <http://aolre.search.org/pdf/DepressionSummary.pdf>
 79. Kumar K, Joshi B. Study on the effect of Pranakarshan pranayama and Yoga nidra on alpha EEG & GSR. *Indian J Tradit Knowl*. 2009;8(3):453-454.
 80. Aftanas LI, Golocheikine SA. Non-linear dynamic complexity of the human EEG during meditation. *Neurosci Lett*. 2002;330(2): 143-146. doi:10.1016/S0304-3940(02)00745-0
 81. Aftanas LI, Golocheikine SA. Human anterior and frontal midline theta and lower alpha reflect emotionally positive state and internalized attention: high-resolution EEG investigation of meditation. *Neurosci Lett*. 2001;310(1):57-60. doi:10.1016/S0304-3940(01)02094-8
 82. Universitätsklinik N. Maharishi European research university, 6353 weggis, and neurologische Universitätsklinik, 8091 Zurich (Switzerland)}. *Electroencephalogr Clin Neurophysiol*. 1977; 42(3):397-405.
 83. Chiesa A, Serretti A. A systematic review of neurobiological and clinical features of mindfulness meditations. *Psychol Med*. 2010; 40(8):1239-1252. doi:10.1017/S0033291709991747
 84. Lagopoulos J, Xu J, Rasmussen I, et al. Increased theta and alpha EEG activity during nondirective meditation. *J Altern Complement Med*. 2009;15(11):1187-1192. doi:10.1089/acm.2009.0113
 85. Takahashi T, Murata T, Hamada T, et al. Changes in EEG and autonomic nervous activity during meditation and their association with personality traits. *Int J Psychophysiol*. 2005;55(2): 199-207. doi:10.1016/j.ijpsycho.2004.07.004
 86. Davidson RJ, Kabat-Zinn J, Schumacher J, et al. Alterations in brain and immune function produced by mindfulness meditation. *Psychosom Med*. 2003;65(4):564-570. doi:10.1097/01.PSY.0000077505.67574.E3
 87. Van Heerden K, Naidoo N, Edwards S, et al. Investigation into breath meditation: phenomenological, neurophysiologic, psychotherapeutic and sport psychological implications: social psychology. *African J Phys Heal Educ*. 2013;19(2):394-418.
 88. Baijal S, Srinivasan N. Theta activity and meditative states: spectral changes during concentrative meditation. *Cogn Process*. 2010;11(1):31-38. doi:10.1007/s10339-009-0272-0
 89. Singh N, Singh S. A study on the effect of yoga practices on the level of anxiety among college students. 2016;2016(6):5-7.
 90. Travis F, Valosek L, Konrad A, et al. Effect of meditation on psychological distress and brain functioning: a randomized controlled study. *Brain Cogn*. 2018;125(3):100-105. doi:10.1016/j.bandc.2018.03.011
 91. Hata M, Hayashi N, Ishii R, et al. Short-term meditation modulates EEG activity in subjects with post-traumatic residual disabilities. *Clin Neurophysiol Pract*. 2019;4:30-36. doi:10.1016/j.cnp.2019.01.003
 92. Braboszcz C, Rael Cahn B, Levy J, Fernandez M, Delorme A. Increased gamma brainwave amplitude compared to control in three different meditation traditions. *PLoS One*. 2017;12(1): 1-27. doi:10.1371/journal.pone.0170647
 93. Telles S, Gupta RK, Yadav A, Pathak S, Balkrishna A. Hemisphere specific EEG related to alternate nostril yoga breathing. *BMC Res Notes*. 2017;10(1):1-9. doi:10.1186/s13104-017-2625-6