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Journal of Biomedical Research & Environmental Sciences
Subject Area(s): PHYSICAL THERAPY | MUSCULOSKELETAL DISORDERS
REVIEW ARTICLE

EEG Brain Wave Dynamics: A Systematic Review and Meta Analysis on Effect of Yoga on Mind Relaxation

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ABSTRACT

Background: Yoga is an ancient Indian science and way of life that is prophylactic, promotive and curative leading to good health: physical, mental, emotional and spiritual. Yogic practices like asana, Pranayama, Dhyana and Meditation are extremely beneficial in maintaining sound health and well-being. In this study we reviewed, synthesized, and analyzed published reports on EEG and other changes in neuro-psychological functions associated with Yoga practice.

Methods: Published data till Jun 2020 on topics of Yoga, EEG analysis were included based on PRISM statement guidelines. The data characteristics defined by their objectives, study design, methodology, Yoga interventions, EEG power spectrum and outcomes of the study are presented in this review. The EEG data with mean ± SD was used for statistical analysis.

Results: The reviewed studies are heterogeneous and have used different yoga practices (Asana, Pranayama, Dhyana, and Meditation), brain region and brain wave for effect evaluation. Overall, there was increase in the α-EEG and δ-EEG power (μV^2), but decrease in θ-EEG in many studies. The improvement in α-EEG power was significant at (p = 0.026).

Conclusion: EEG Brain wave analysis is one of the best ways to predict the neuro-cognitive benefits of Yoga practice. After yogic practices there was an increase in delta, alpha and gamma amplitude and duration indicating relaxation following yoga practice.

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- Mind relaxation

INTRODUCTION

Yoga is an ancient Indian practice, which is corroborated in the modern era as human science to improve physical, psychological and neuro-physiological gain of its practitioners. It has been reported that psycho-physiological changes due to yoga help in improvement of muscle strength, breathing, immunity. Scientific publications have reported that yoga improves immunity and helps to manage stress and anxiety. Foreseeing the benefits of Yoga, "21 Jun" was declared as world yoga day in 2014, aiming that its benefits be utilized by the entire world. United Nations (UN) has also recommended on their website, the therapies of guided meditation and yoga incorporate into your regular routine to reduce anxiety and stress. Yogic practices have been recommended by the AYUSH Center of Excellence, Pune for the prevention and post-recovery management of COVID-19 [1]. Different kind of regional meditation are used world-wide to relax the mind and boost attention and cognition [2]. This review was carried out understand concurrent in in this field, as well as support our prospective data on the effect of Bhramari Pranayama on EEG.

Yoga is being practiced in the form of Asana (Posture), Pranayama (breathing manipulation), Meditation (concentration technique) and Dhyana and various kriyas and combinations [3]. Each style having its own beneficial effect based on the posture,

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breathing cycle, technique, combination, duration, and objects used [4]. Asana is the physical practice of yoga poses. These primarily defines the physical aspects of Yoga and is practiced in different postures meant to target specific muscles and physiological systems.

Pranayama is a yogic practice where one practices different breathing maneuvers which increases the blood oxygenation by opening up the dormant lung alveoli and by complete removal of CO_2 from the lungs during expiration. It generates strong connection between the body and mind [5]. This works on the logic that when 'Prana' is irregular mind is unstable and vice-versa. Different types of pranayama produce specific neural and psycho physiological responses and it greatly depends on the type and duration of the practice. Nadisuddhi, Savitri, Kapalbhati, Bhasrika, Bhramari Pranayama, and so on are well known among them. Dhyana is the 7th limb of yoga, where one builds upon control of the senses, moving the focus to the inside. Meditation is a yogic practice where individual use mindfulness and focusing techniques to train attention and awareness to eventually achieve a calm and stable state of mind. The various types of asana, pranayama, dhayana and meditation encountered during this review are listed in table 1.

Researches have reported neuro-physiological alterations in health and diseased states following yoga practice. There are reported findings on brain physiology alterations in prolonged meditation practitioners. One such benefit of yoga is, the increase in cortical thickness amongst advanced practitioners. Research in this area has the enormous potential to reveal many more discoveries about the effects of yoga on the mind. As Yogic practices have sustained effects without side effects, research on the neurological effects of Yoga have increased.

The real time measure of neurological activities during yogic session are obtained using EEG, MRI and fMRI. However, EEG is commonly used to assess changes in mental state of normal as well as individuals with mental disorder [2-6]. EEG is a dynamic signal showing continuous fluctuations. Each individual has a unique EEG signature. The signal shows a large inter and intra-individual variability. The electrical data in EEG is important to study the correlation between yoga practices and neuro-physiological states, because any shift in the EEG frequency range and amplitude (Power) reflects the physiological arousal [7-14]. The EEG is highly complex and is a combination of five different frequency waveforms, namely, Δ (delta), θ (theta), β (beta), α (alpha), and γ (gamma) waves, respectively [2-23]. In EEG recording, the electrical activity generated by voltage fluctuations from the ionic flow provides a quantitative and non-invasive approach to study brain functions. The amplitude of the EEG brain waves is approximately in the range of 10 μV to 250 μV and the frequency varies between 0.5 Hz and 100 Hz. In this study, the paper reviewed had EEG activity measured in all participants' pre and post the yoga sessions.

Despite growing awareness and acceptability, the neurophysiological mechanism by which yoga benefits brain and mental health is not very well understood, and that poses a very important research question: Does relaxation therapy change the absolute powers of various wave patterns of the brain? To elucidate whether or not there is some measurable oscillation of the EEG activity due to Yogic practices in healthy subjects, the researchers have compared the spectral power of the EEG at frequencies 1-4Hz(δ), 4-8Hz(θ), 8-12Hz(α) and 12-30Hz(β), pre and post yogic interventions. Though researches suggest that different yogic practices stimulate specific receptors in the body, which in turn activates localized brain wave frequency,

Table 1: Yogic Practices (Asana, Pranayama, Dhyana, Meditation).

Sr.No.	Name	Description
1.	Alternate nostril breathing (ANB)	ANB is the techniques of slow, deep, quiet breaths using one nostril at a time.
2.	Savita Dhyan	This is Meditation on rising Sun. Mental concentration is kept focused on the rising Sun.
3.	Gayatri Mantra	Gayatri Mantra, also known as the Sāvitri Mantra, is a prayer to the Divine light, is a yoga chant to practice daily gratitude.
4.	Pranraksha Mantra	It is a technique to control the mind through conserving pranic energy from cosmos.
5.	Bhramari Pranaya	This is the breathing exercise where a humming sound is produced during the expiration that mimics flying wasp.
6.	Jyoti Dhyan\	Focusing on the light (jyoti) to bring out also a most effective of relaxation techniques
7.	Relaxation Therapy	In these yogic techniques special breathing practices and progressive muscle relaxation exercises are designed to reduce physical and mental tension
8.	Bhoot Suddhikriya	It is an ancient yogic purification process to purify the five elements within the human system.
9.	Pran Yoga	In this method, one needs to be able to perform a number of breathing exercises to bring Prana i.e. primary energy into your body.
10.	Acem Meditation	One repeats a meditation sound mentally without effort, while thoughts and impressions are allowed to come and go freely

there are no big- data to consolidate the outcome. This paper analyses and further summarize the published research on the neurological effects of a series of Yogic sessions *via* Electroencephalogram (EEG).

METHODOLOGY

Study design: Retrospective analysis

The study design was Systematic Review of published research articles, extraction of data based on inclusion and exclusion criterion set, and interpretation after statistical analysis. The methodical literature review and selection criteria to extract EEG brain wave dynamics due to Yoga therapy were in accordance with the PRISMA statement depicted in figure 1.

Data extraction

The Yoga exercise data of therapy type, period of practice, sample population, their age, EEG analysis, Brain region, types of brain wave, their power and duration of recording, were extracted from published articles on PubMed, Google-scholar, Researchgate, Sciencedirect, MedRxiv sites. Further the references from articles' were used to increase database. Only English Language articles were searched and retrieved.

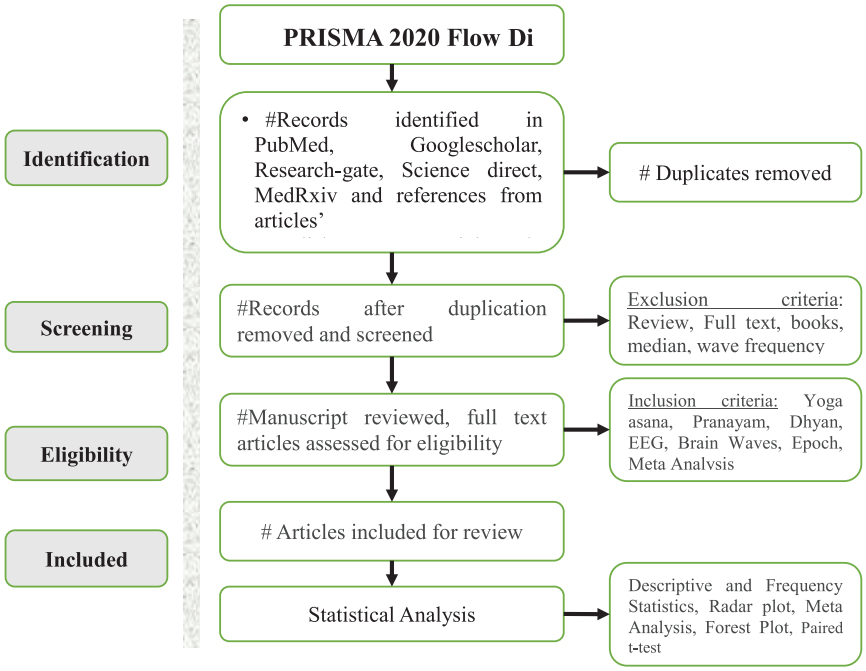

Figure 1 PRISMA Statement - Block diagram of the Review Study Design.

Table 2: Data Review Table EEG brain wave dynamics Yoga /Bhramari Pranayam.

Author, year	Yoga / Meditation	Follow up time	Age	Gender	Experimental condition	n	Evaluation Method/ Statistics	Brain region	Brain wave	EEG (min)	Result / Remarks
AA Helman, et al. [2]	Zikr meditation	3 min	25	Male	Neurophysiological EEG for Zikr and Music	05	• 16 channel EEG.	Frontal, temporal , parietal, occipital	α, β	6	Zikr meditation can lead to relaxation
Rebecca Bhikghanie [13]	Open Heart Meditation (OHM), Pranayama yoga sessions	3 week	22	Male	Pre and post Meditation and control groups EEG and heart rate	10	• 5 electrode EEG and pulse tests • MANOVA	Frontal, parietal and temporal	α, β	40	In novice meditators, increased beta frequency within range, no alpha change. Experienced meditators increase beta and alpha.
Sanjay Maharjan, et al. [11]	Alternate nostril breathing (ANB)	15 min	28.33 ± 1.41	Male	Alternate Nostril Breathing (ANB) on EEG median/ range and heart rate	10	16-channel EEG, 5-second epochs, FFT, Friedman test and Wilcoxon Sign Rank test	Frontal, temporal, parietal, occipital	θ, β	20 min	p = 0.398, 0.528. Beta power was decreased after ANB in right frontal area. Theta power decreased in parietal area

Sushma Pal, et al. [8]	Voluntary breath regulation	-	-	-	Review, Alternate nostril yoga breathing, Bumble bee breathing	18+	EEG	Frontal, Central, Occipital	θ, β, γ	-	Yoga breathing practices can alter the EEG by decreasing theta and beta. Generate high-frequency biphasic paroxysmal gamma waves
Shudhansu Verma, et al. [16]	Savita Dhyan, Gayatri mantra, Pragya Yoga, Pranraksha, Shantipaath	45 day, 50min/d	22	Male	Alpha EEG level pre and post yogic intervention	50	Paired t test	Brain Scalp	α	-	$p = 0.016$ Group consciousness plays important role in positive mental activity
Shirley Telles, et al. [9]	Alternate Nostril Yoga Breathing (ANYB)	6 months	24.2 ± 4.7	Male	Hemisphere specific EEG related to alternate nostril yoga breathing	13	EEG, 5min epoch	Frontal, Central, Occipital	δ, θ, α, β	28	$p < 0.05$. relative power in theta band was decreased during ANYB and the beta amplitude was lower after ANYB
Nagendra H, et al. [3]	Asanas (postural exercises), pranayama (breathing techniques), and dhyana (meditation)	5 months	20	M = 27 F = 3	Effect of yoga practice on cognitive skills, autonomic nervous system, and heart rate variability	30	Cognitive skills, autonomic nervous system, and heart rate variability	Frontal, Central Parietal, Occipital Temporal, Total	δ, θ, α, β, γ	10min	Increased α, β, and δ EEG and significant reduction in θ and γ band powers. Heart rate index t/a decreased, Neural activity b/t increased, Attention resource index b/(a + t) increased, executive load index (d + t)/a decreased.
Kamta Prasad Sahu, et al. [7]	Bharamari Pranayam and Jyoti Dhyan	1 month	20 -24	Male	Bharamari Pranayam and Jyoti Dhyan on Haemoglobin & Alpha-EEG counting	50	Hb and α-EEG emission counting	Frontal and temporal	α	5min	Bhramari Pranayama and Jyoti dhyan play a significant role in level increasing alpha waves and Hemoglobin.
Ishwar Bharadwaj, et al. [14]	Gayatri Mantra, Pragya Yoga Nidra , Nadi Shodhan, Shanti patha	1.5 months	32	Female	Effect of Yogic intervention on working women blood pressure and α - EEG level	25	Systolic and diastolic blood pressure alpha EEG	Brain scalp	α	-	Yogic intervention are significantly effective for Blood-Pressure and Alpha-EEG level
Nithiya Amirtham S, et al. [6]	Relaxation therapy	1 month	15.5	Children with ADHD	Impact of relaxation therapy on absolute powers of alpha and theta and attention of ADHDHI case.	8	Brain activation waves, attention scores	Brain scalp	α, θ	-	$p = 0.000$ Increase in alpha, theta and attention scores of the ADHD-HI case.
Madanmohan Trakroo, et al. [21]	Asan-pranayama training	6 Months	24.82 ± 3.20	Male	effects of asan-pranayama training on neurological and neuromuscular functions	11	EEG, nerve conduction, EMG, auditory Reaction time.	Occipital	δ, θ, α, β	10	$p < 0.05$ Alpha, theta, and total power of EEG increased as a result of asan training.
Dushyant Kakar, et al. [23]	Bhootashuddhi Kriya	20 days	21.5	Male	effect of 'Bhootashuddhi Kriya' on Alpha EEG	10	EEG	Brain scalp	α		$p = 0.01$ Positive increase the Alpha EEG
Tapan K. Gandhi, et al. [10]	Prana-Yoga	150 days	18-25	Male	Higher state of cognition followed by consciousness. From the EEG	12	19 electrode EEG, 4 sec Epoch	Frontal , central, temporal, parietal and occipital	θ, α, β, γ	15	Significant rise of gamma power (>40 Hz) after 150 days in frontal, central, temporal region, which plays a significant role in higher cognition

Kamakhya Kumar, et al. [19]	Yoganindra, Pranraksha	40 days	21.5	Male	Effect of Yoga on Brain wave and biofeedback	40	EEG and GSR	Brain scalp	α	-	$p = 0.01$ The practice of yognidra has been reported to bring alpha dominance in the brain , which is characterised by mental relaxation
Jim Lagopoulos, et al. [22]	Meditation retreat in the past 5 years. 20 min acem meditation	3-week	52	13 Male, 5 Female	Increased Brain EEG During Nondirective Meditation	18	20 channel EEG brain wave power	Frontal and temporal–central, posterior region	θ, α	20	Theta and alpha EEG patterns alter significantly
Rajkishore Prasad, et al. [12]	Bhramari Pranayama		-	-	Effect of Bhramari Pranayama	2	EEG , Relative Spectral Power, Magnitude Squared Coherence	Temporal lobe, parietal lobe and frontal lobe	δ, θ, α, β, γ	1	The Bhramari produces very obvious and noticeable changes in all the brainwave patterns
Gregg D. Jacobs, et al. [15]	Relaxation techniques	1.4	41.3	Female	Acute central nervous system effects off Relaxation Tech.	36	14 Electrode EEG, power spectral analysis	Frontal , central, temporal, parietal and occipital	θ, α	20	• Increased theta EEG activity during the practice of Relaxation Therapy • Theta and not alpha, EEG may be the most reliable marker of central nervous system effects of RT.

The few of the total reviewed journals are listed in table 2 [2-23].

Data synthesis

Microsoft Excel for Windows was utilized to synthesize and organize data. The data were arranged as Author, publication and year, sample population, evaluation test methods applied, sample size and sample characteristics, age and gender, statistical method applied for assessment, psycho-physiological parameters determined and outcomes.

Data analysis

Data analysis was carried out to address the questions whether the yogic interventions are helpful in altering the power of relevant brain waves and bring out mental relaxation. Percentage distribution of Gender, Age, Yoga therapy, meditation period, brain-scalp region, brain waves were plotted and frequency distribution was determined. Radar plot was used to present, which EEG wave was evaluated in all the reviewed studies.

Statistical analysis

Descriptive statistics, established the characteristic of data distribution. The Meta analysis –Forest plot for alpha and theta EEG brain waves were plotted. To investigate the significance of the pre-post effect of yoga paired t- test of brain wave power was carried out.

RESULTS AND DISCUSSION

Studies exclusively assessing yogic practices and EEG brain wave power were included in the review. The systematic search for keywords 'Yoga meditation and EEG brain waves resulted in 14 articles for data input and 8 reference articles that could be utilized. The exclusion criteria were (i) studies published before 2004 (ii) Practices other than yoga techniques (iii) Review articles, (iv) Studies on ERP other than EEG (v) studies only on psycho-physiological parameters. Finally, 13 studies that met the inclusion and exclusion criteria were synthesized for statistical analysis.

Study participant and data characteristics

This review included before and after effect of yoga therapy in normal subjects. Yogic intervention on clinical cases were reviewed, though not included in statistical methods [6]. From review a data of 318 participants, including 249 male participants and 69 female participants were derived. The maximum number of samples for a particular study was 50 males and 36 females [7-16]. The participants comprised of 78% males and 22% female population. The average age of participants was 26.83 ± 9.34 years. The 69% population was in the age group 20-30 years, 25% was in 30-60 years and 8% participants were less than 20 years. Descriptive statistics on sample size, gender, and age and meditation period is presented in table 3 and graphical presentation is given in Pie chart in figure 2.

Classification of meditation practices

All the mediation, Asana, Pranayama and Dhyana under yogic practices were channeling energy towards integrating body and mind. All these therapies depicted in the current review were aimed towards relaxing mind and improving neuro-physiological factors. These practices stimulate the specific brain region to enhance the brain wave power [9]. The working principle of these techniques involves mindful meditation and focused breathing table 1 [10-12].

Table 3: Descriptive statistics of reviewed data on number of participants, Gender, sample age and Yoga meditation period.

	Participants (n)	Males	Females	Age (Years)	Meditation Time (Months)
Mean	22.71	17.79	4.93	26.83	2.23
Minimum	5.0	0.00	0.00	17.00	0.10
Maximum	50	50.00	36.00	52.00	6.00
SD	15.80	17.08	11.15	9.34	2.21
Skewness	0.72	1.13	2.39	1.92	0.97
Total	318	249	69	-	-

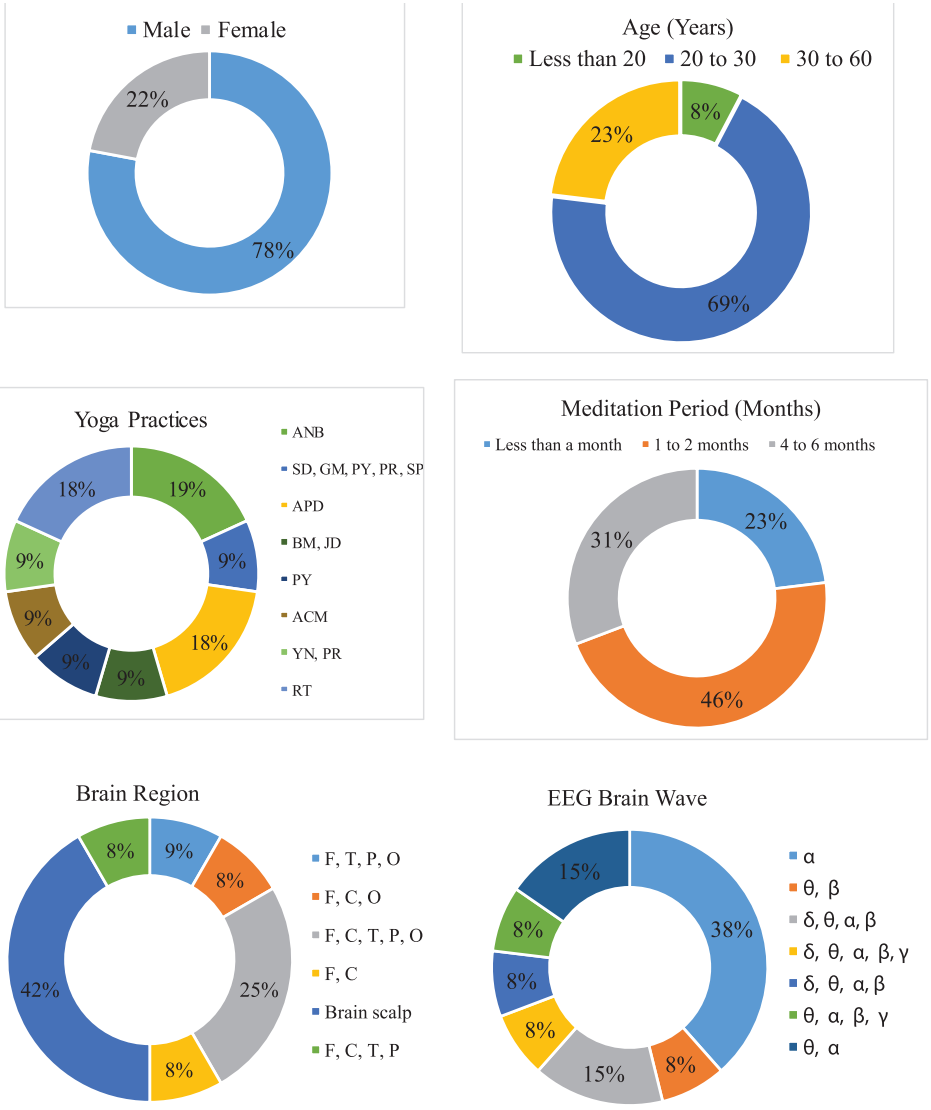

Figure 2 Pie Charts for Data Characteristic Distribution.

The type of yogic practice and their frequency of utilization is presented in table 4. Alternate Nostril Breathing (ANB), Asanas Pranayama Dhyana (APD) and Relaxation Therapy (RT) were used twice and other were used once each [3-21]. The 46% participants performed yoga for 1-2 months, 31% in 4-6 months and 23% performed yoga for less than a month (figure 2).

Research results suggest that long-term meditation practice is associated with the sustainable changes in the brain activity [8]. It can also be associated with change in the brain's physical structure like increased cortical thickness [17-24]. However, in this review, duration dependent impact of Yoga on mental and physical status of the brain was not assessed.

Table 4: Frequency table for Yoga, Brain Regions, Brain waves.

Yoga Practices	Count	Brain Region	Count	Brain Wave	Count
Alternate nostril breathing	2	Frontal, Central Occipital	1	α	5
Asanas Pranayama Dhyana	2	Frontal, Central, Temporal, Parietal, Occipital	3	θ, β	1
Relaxation Therapy	2	Frontal, Central	1	$\delta, \theta, \alpha, \beta$	2
Prana Yoga	1	Brain scalp	5	$\delta, \theta, \alpha, \beta, \gamma$	1
Acem meditation	1	Frontal, Central, Temporal, Parietal,	1	$\theta, \alpha, \beta, \gamma$	1
Gayatri Mantra, Pragya Yoga Nidra, Nadi Shodhan, Shanti Patha	1	Occipital	1	θ, α	3
Bhootashuddhi Kriya	1				
Savita Dhyan, Gayatri mantra, Pragya Yoga, Shantipaath	1				
Bharamari Pranayam, Jjyoti Dhyan	1				
Yognidra Pranraksha	1				

Effect on EEG waves

The thirteen revived articles, depicted EEG recording and related increase in neurological engagement for yogic intervention [3-23]. The EEG was recorded from the Frontal (F), Central (C), Temporal (T), Parietal (P) and Occipital (O) lobe of the brain scalp. The brain region (FCTPO) was used for 23% times and at about 38% times the brain-scalp region (No specification of lobe) utilized for EEG measure was not defined in the study (Figure 2).

The spectral power of delta, theta, alpha, beta and gamma brain waves were compared. The spectral power, at individual location was not assessed separately. The data were expressed as mean ± SD. The data represented in publications with median and interquartile range were reviewed, but not included in the statistical analysis. In the 13 articles reviewed, alpha EEG was measured maximum. The (α)-EEG was measured 5 times and (θ, α)-EEG was measured 3 times. The radar plot of measured EEG brain waves is shown in the figure 3, showing alpha EEG maximum spread. The $\gamma-$EEG was least studied. There were prominent

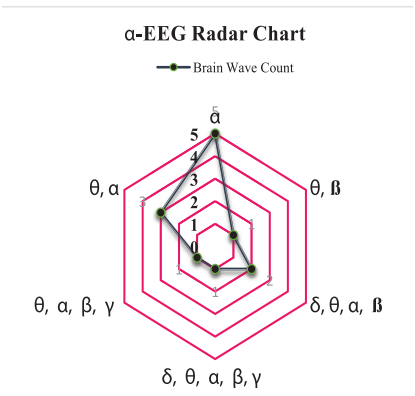

Figure 3 Radar chart-: α-EEG brain waves count in study.

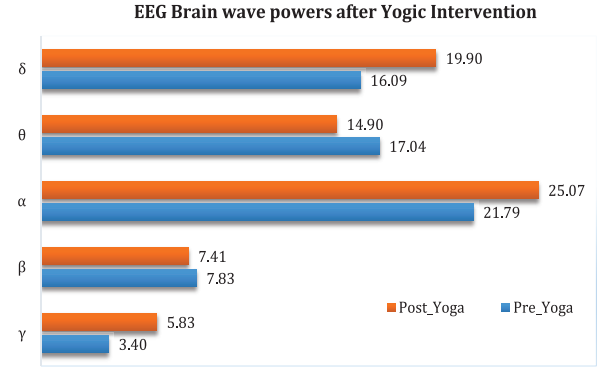

Figure 4 Bar Graph for EEG Data of brain wave power (μV2) distribution.

trait of increased alpha range activity in almost all cases of Yoga asana, pranayama, dhayana and meditation.

The EEG power, pre and post yoga intervention are presented in the bar graph of figure 4. The delta power increased by a factor of 1.23, alpha by 1.15 and gamma by 1.71. These show the improvement in concentration and mind relaxation associated with training of Yoga therapies. The theta power reduced by a factor of 0.87 and beta power by 0.94. An increase in alpha and a decrease in theta power can be very well related to better memory. However, the theta activity increases in drowsiness which can decrease the performance in cognitive tasks. The decrease in theta is suggestive of probable increased power in cognitive task performance. Any kind of arousal and excitement are related to increased beta wave activity. In the present case, slight decrease in beta would be suggestive of no arousal and excitement during yoga practice. It is also iterated here that beta wave activity and its functional correlates are not well understood in most of the studies.

The statistical significance of brain wave power changes was assessed using a paired t-test and is depicted in table

Table 5: Paired t-test significance of brain wave EEG powers, pre and post Yogic intervention

Brain waves	t	Cohen's d	p-value
δ-EEG	-1.134	-0.567	0.339
θ-EEG	0.768	0.313	0.477
α-EEG	-2.607	-0.786	0.026
β-EEG	0.152	0.068	0.887

5. As expected the alpha wave showed significant with p = 0.026. While the differences did not reach statistical significance in case of delta, theta and beta waves, but there were differences in the expected direction. The Frequency shift in the EEG brain waves was not analyzed.

Research trials suggest substantial improvement in cognitive functioning due to regular yoga practice. Nagendra H, et al. [3], studied the cognitive interpretations through EEG brain wave ratios. Performance enhancement index or "well being"- α/θ, Neural activity- β/θ, Cognitive performance and attentional resource index - $\beta/(\alpha+\theta)$, Brain perfusion - α/δ and CNS arousal - θ/β indices have been evaluated to assess the cognitive benefits of the yoga practice along with its well established health benefits. Increase in β band power indicates a higher level of alertness and enhanced engagement task and enhancement in various cognitive abilities.

Meta-analysis

The Meta analysis of the results is graphically represented as forest plots in figure 5 (a & b). The effect size (Cohen's d) was calculated from mean and SD, and then was represented along with Standard Error (SE) on Forest plot. The LHS of the plot represents the name of the studies and RHS represents measured effect. The area of each square represents the weight of the study in Meta analysis. The overall effect is represented as a dashed vertical line. The Forest plot graph is presented in the descending order. The maximum effect size for alpha was 2.84 and the minimum was 0.03. The diamond shape at the end of the graph represents overall effect. The diamond is very close to a vertical line.

Psycho-physiological changes

The strength and resistance of a person depends on certain neuro-physiological and psychological factors

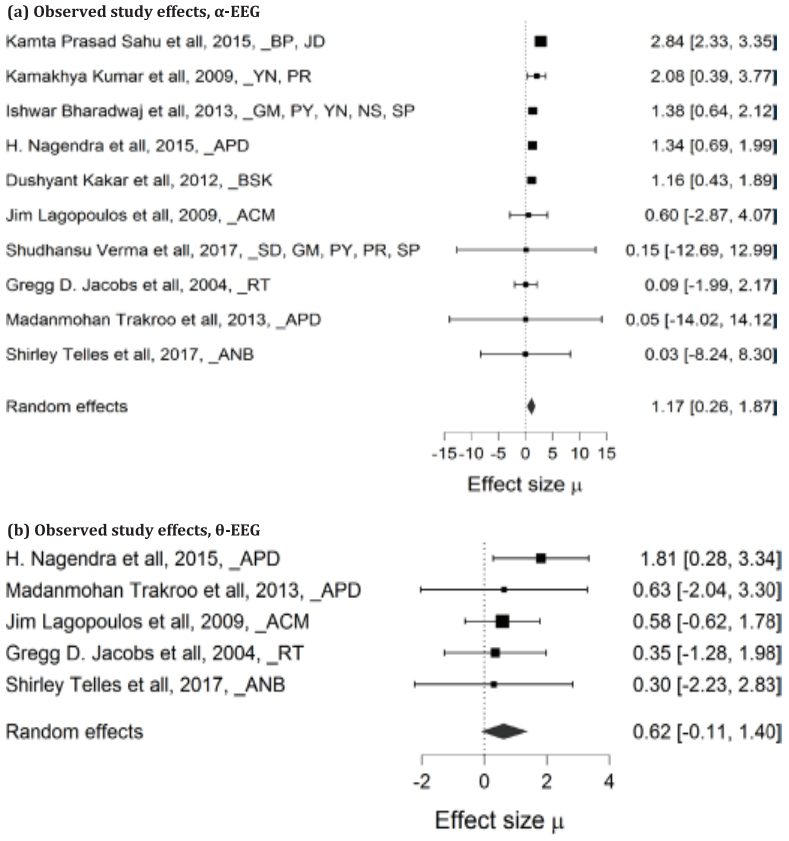

Figure 5 Forest plot for α-EEG and θ-EEG brain waves measured in study.

Table 6: Review of effect of Yoga on Physiological parameters.

Author, year	Physiological parameter	Significance	Results
Rebecca Bhik-Ghanie [5]	Heart Rate	-	Heart Rate increased during yogic sessions
Sanjay Maharjan, et al. [11]	Systolic and Diastolic BP, HR	-	Improvement in Cardiac output
Nagendra H, et al. [3]	HRV /HR	$p < 0.03$	Yoga practicing group showed a significant increase in HRV and reduction in resting HR
Kamta Prasad Sahu, et al. [7]	Hemoglobin	$p < 0.001$	Bharamari Pranayam and jyoti dhyan was found to significantly increase Hemoglobin (Hb)
Ishwar Bharadwaj, et al. [14]	Blood Pressure	$p = 0.01$	Yogic intervention significantly Improve the systolic and diastolic blood pressure
Madanmohan Trakroo, et al. [21]	Nerve conduction, electromyogram, visual evoked potentials, auditory reaction time	$p < 0.01$	A shortening of reaction time signifies an improved and faster processing of visual input. A decrease in resting EMG, signifying better muscular relaxation following pranayama training.
Kamakhya Kumar, et al. [19]	Galvanic Skin Response (GSR)	$p = 0.01$	Significant increase in Post Yoga GSR

like brain evoked potentials, cardiac, visual and muscular outcomes. These includes the physiological parameters like Heart Rate (HR), Systolic and diastolic Blood Pressure (BP), Heart Rate Variability (HRV), Hemoglobin (Hb), Electromyogram (EMG), Visual Evoked Potentials (VEP), and Auditory Reaction Time (ART) and Galvanic Skin Response (GSR) under effect of Yogic intervention. These physiological parameters are relevant to the Quality of Life of the Yoga practitioner. The review on physiological parameters evaluated along with EEG brain waves are listed separately in table 6.

Yoga practices have immense impact on performance of central nervous system. There is an implicit assumption that any relaxation-mediated change in systemic physiology is secondary to alterations within the Central Nervous System (CNS). Relaxation therapy would result in greater acute reductions in CNS arousal as a result of the more systematic mental and physical relaxation. In their study, Gregg D Jacobs, et al. [15], elucidated the CNS effects of Relaxation therapy.

A higher HRV is an indicator of adequate adaptation to the new environment and effective functioning of the ANS. The yoga practicing group showed a significant increase in HRV (< 0.0304) and reduction in resting HR ($p < 0.0389$) in (Nagendra H, et al. [3]), study. The escalation in the HR is due to increased sympathetic and decreased parasympathetic activity. A significant improvement in HRV may be due to an increase in parasympathetic activity or a decrease in sympathetic activity. These indirectly help in reducing the psychological parameters such as distress, anxiety, and depression in young healthy subjects.

Hemoglobin is essential for transferring oxygen in your blood from the lungs to the tissues. Pranayama when done with kumbhaka (retention) like in Bhramari Pranayama, increases the efficiency of hemoglobin to carry more oxygen to the body cells. During the retention phase, there is an increase in the surface area of alveolus of Lungs in turn there is more transportation oxygen molecules to the body cells to help them in normal functioning. These in turn helps in increasing the functions of other tissues, which helps in making the hemoglobin. Yogic exercises significantly improve level of O_2 in body. Bharamari Pranayam and Jyoti dhyan was found to significantly increase Hemoglobin ($p < 0.001$).

Yogic intervention significantly improve the systolic and diastolic blood Pressure (Ishwar Bharadwaj, et al. [14]). An increased muscular activity during the Pragya yoga vayama requires increased blood supply for the oxygen and nutrients such as glucose. Naturally the cardiac output is increased.

A rhythmic breathing activity, a form of Pranayama stimulates physical, mental, emotional, and social well-being optimizing task efficiency and regulating stress [17]. The study provides evidence that regular concentrative meditation can improve emotional stability [18].

Along with the change in the electrical properties of the brain, change in the electrical properties of the skin (Galvanic Skin Response) was studied. Kamakhya Kumar, et al. [19], assessed the effect of Yog-Nidra on GSR biofeedback. GSR was found to increase significantly ($p = 0.01$) post yoga. The increase in GSR can be understood as a drop in electrical resistance of the skin, and indicative of automatic reaction. Thus it was evident that the Hb, GSR and BP has improving trend and HR, HRV, VRT and EMG has decreasing trend.

The influence of the respiratory cycle on the EEG is also observed in literature. In the course of spontaneous breathing and bradypnoe, there was an increase in the delta power [20].

A shortening of visual reaction time signifies an improved and faster processing of visual input as well as a more alert state as well as improved central neural processing. A decrease in resting EMG voltage, signifying better muscular

relaxation following pranayama training. A combination of asan and pranayama training for 6 months produced an improvement in motor and sensory nerve conduction (Madanmohan Trakroo, et al. [21]).

Strength and limitations

Apart from the EEG changes the effect of yoga training on the HRV, HB, BP and GSR were observed. Despite the small sample size of this review study, the recommendations from the study are valuable as that they provide support, understanding trends in yoga and differences in brain activity. The EEG frequency changes were not assessed.

CONCLUSION

The vitality and immunity of a person depends on certain neuro-physiological and psychological factors like brain evoked potentials, cardiac, visual and muscular outcomes. After yogic practices there was an increase in delta, alpha and gamma amplitude and duration, indicating bodily relaxation following yoga practice. These indirectly help in reducing the psychological parameters such as distress, anxiety, and depression in young healthy subjects. The beneficial changes in brain waves after yoga were seen in many articles that were reviewed under this study. From the Meta analysis-α-EEG Forest plot of various studies, gain in α-EEG post yoga is evident, which is also a neurological marker for mind relaxation. The study clearly indicates that the positive effect of Yogic interventions on healthy brain and body, as can be seen from the review analysis of brain waves as well as effect of blood pressure, HRV, HR, Hemoglobin and EMG. This review recommends development of precise, categorized yoga-protocol that can be used as a module for targeted treatment.

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