Techniques for Analysis of the Effectiveness of Yoga Through EEG Signals: A Review

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1 Introduction

People have been carrying out Yoga Practices since time immemorial. Yoga asanas are widely considered as a panacea to a slew of ailments related to mind and body. A yoga instructor may commend yoga for better functioning of organs and the better control over the psychological and physiological functioning of the brain and body respectively. When Yoga Practices are performed properly as they are supposed to be performed, yoga can bring results no less than a miracle. Yoga improves mental as well as the physical fitness of a person and recovers person from psychological disorders [1].

Pranayama and Yoga: Pranayama (AnulomVilom, Kriya Yoga) is the technique which comes under pranayama which helps in stabilizing strength and wakefulness. Pranayama (AnulomVilom, Kriya Yoga) is a phraseology with many definitions. This is the yoga technique in which air is inhaled, retained and then exhaled. The relationship developed between breathing and wakefulness is the function of pranayama [2]. Human brain requires energy to work, and Superbrain yoga is one of the methods which provides energy, and it also activated the mind and with the involvement internal alchemy Super brain yoga awakens the energy in the subject's brain. Super brain yoga involves acupressure technique and also breathing process as both of these are used to make a balance between both left and right part of the brain and also make the brain energetic. We can do this Yoga at any place and also it also very less time consuming and easy process. Electroencephalography allows us to measure brain activity involved in various types of cognitive functions. Experimental goal of this work is to interpret and characterize the EEG electroencephalography activity during Pranayama (AnulomVilom, Kriya Yoga)

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and Super brain yoga. This paper intends to highlight the importance and benefits of pranayama, yoga, superbrain yoga on the subjects mind during normal and mental disordered conditions [3]. These are the yoga techniques in which brain is recharged, peace is induced and improvement in mental disorders are observed due to which brain activities got changed. An electroencephalograph is used for understanding the function of the brain since 1924. Electroencephalography technique is used for mapping mind waves which changed during and after Pranayama and Superbrain yoga respectively. Then the acquired electroencephalography signals are analyzed and various results are discussed [4].

Electroencephalography (EEG): An electroencephalogram is a biomedical device which is used for the detection and amplification of the electrical signal from the mind of living beings by placing electrodes over the scalp of the living being. Electroencephalographs would identify even the minute time frame changes [4]. Our mind has different mind waves,the classification of the mental state and the frequency in the mind state is shown in the Table 1 below.

Non-agitated, relaxed, aware of self surroundings 8–12 khz, beta alternes, thinking, focused agitation, envisioning, integrated thinking 12–3 khz drowsiness .10–4 khz represent the frequency wave denoting the mental state beyond the 40 khz. Delta Deep and dreamless sleep, trance and insensate Table 1 Frequency bands The Alpha signal physiologically represents healthy and relaxed conditions. The two subbands of the alpha frequency is low 8–10 Hz, it is related to the integration between the body and the mind and the self awareness high alpha: 10–12 Hz. It is related to the healing, in the body or the mind connection. Physiologically the beat signal is related to the, active, but not active body and brain that is agitated. The task processing is associate to the gamma signal [5, 6]. physiologically delta signal is related to the resting position, low strength arousal. The Theta signal physiologically co-relates to healing and integration of mind or body [7, 8].

The objectives of this review is to study and understand the various techniques that are employed for analyzing the effectiveness of Yoga through electroencephalography (EEG) signals.

The article remaining is presented with the (1) The related works with the breif explanation, (2) various techniques, comparisons and the (3) Conclusion along with the references below.

Table 1 Classifications of mind waves at different psychological conditions

Wave	Frequency (Hz)	Mind State
Delta (δ)	0.1–4	Deep and dreamless sleep, trance and insensate
Theta (θ)	4–8	Visionary, dreamlike, drowsy and knowing, intuitive
Alpha (α)	8–12	Non-agitated, relaxed, conscious state of mind
Beta (β)	12–30	Focused, integrated, agitation, awareness, alertness
Gamma (γ)	≥30	Integrated thought, thinking

2   Related Work

An extensive study for reviewing the most prevalent Yoga, pranayama and meditation techniques which use electroencephalography technique for obtaining signals is done by considering the latest articles of reputed journals. Few of them are briefly elaborated as follows:

Pradhan et al.: The Dimensional studies of complexities involve in electroencephalography is studied in this work. Yogic meditation is employed for evaluating the EEG signal obtained through two subjects. The running fractal dimension and running attractor dimension is utilized for analyzing the four channels for the compressed spectral array in between the yoga process during meditation. Spectacular features are revealed by analyzing the signals through the CSA. Low fractal dimensions values are obtained by running the fractals plots during post and pre-meditation periods [9].

Fu et al.: Loop Control Theory is the basic principle which was defined as basic relation followed by the O/P followed the I/P. Discussion of Loop Control Theory between mind and the environment is proposed in this article. Quality of mind waves affected due to the interrelationship between mind I/P and O/P signal. The objective of remote controlling the mind waves is to enhance the quality of mind waves and also enhance the mind power [10].

Patil et al.: Anulomvilom is the technique which comes under pranayama which helps in stabilizing strength and wakefulness. A person who is performing anulomvilom is subjected to electroencephalogram for the recording of brain signal. Then the recorded signal is subjected to wavelet transformation. Then signals different characteristics are obtained which are then used to develop a model. The developed model and software are accustomed to checking over the different parameters of the human body [11].

Hosseini et al.: Electroencephalograph signal for Epileptic seizures are recognized by using the chaos-ANFIS process. Electroencephalograph quantification is done in two forms Hurst Exponent [H] and Lyapunov Exponent [λ] which is non-linear. The process of electroencephalography examination is done in two stages which are a qualitative and quantitative examination. ANFIS testing method is used to classify the potential of the Hurst and Lyapunov measures. Then the developed technique is used to obtain the results in which a high exactness of above 97% in the inter-ictal case and approximately equals to 97% is achieved in the ictal case when tested with ANFIS classifier and also with the use of four fold cross validation successfully [12].

Meshram et al.: Pranayama techniques are commended for the better functioning of organs mainly for better control over the psychological and physiological functioning of the brain and body respectively. Sudarshan-Kriya advantage over other yoga techniques is that it is less time taking the process and it also enhances brain ability. The advantages of Sudarshan-Kriya yoga and its results overmind are analyzed by using electroencephalographic signals [13].

Ramachandran et al.: The technique is used to interpret and characterize the EEG activity during Pranayama breathing concerning temporal and spatial context, and acquire two-channel data using MyDAQ and Labview. The variation in the EEG wave pattern was explored during different stages of Pranayama as well as the variation of alpha wave level in the left and right frontal, temporal parietal and occipital regions of the brain. The statistical significance test is performed for different cycles of Pranayama to measure the significant change in the alpha power concerning baseline measures. An effort was made to analyze the difference in the cerebral electrical activity among long-term and short-term meditation practitioners. Data was recorded for ten subjects during three cycles of Pranayama, each cycle lasting for two minutes. In order to measure the effects towards the end of Pranayama, the last 20 s of EEG data were analyzed in each cycle of Pranayama [14].

Vijayalakshmi et al.: So many research works have been done in recent time on meditative yoga techniques, and the results proved that meditation is beneficial for psychological disorders and also benefit humans physiologically healthy. Brain signals are obtained with the help of electroencephalography and analyzed with the help of different methodology. Spectral features of electroencephalography throughout the meditation have been traced, and then the Quantitative analysis method is used to find out the changes in electroencephalography signals throughout the meditation. Then brain signals analysis is done by using EEG, and it is found out that theta wave energy is increased which is indicating that the subject brain is in uttermost relaxing position. After the period of meditation almost all the persons who are subjected to the meditation shows rise in alpha (α) and beta (β) waveforms. Finally, the conclusion is that meditation is beneficial to human beings to live a stress-free life, a life free from psychological disorders and physiological disorders [15].

Shaw et al.: Electroencephalographic signals are obtained during Kriya Yoga which is a kind of meditation technique and in normal condition, then the statistical characteristics of the electroencephalographic signal have been studied. Practicing meditation leads to change the concentration level in the human brain and then the brain signals from the subject who meditates and non-meditates are cautiously calculated with the help of electroencephalography. Then the overlapped segmented data received with the help of electroencephalograph is divided and the different variables are calculated for every segmented data. We do not use all the data acquired from electroencephalography as in place of it we only use high order statistical information for the analysis [16].

Sreenivasa et al.: Human brain requires energy to work and Super brain Yoga (SBY) is one of the methods which provides energy, and it also activated the mind, and with the involvement, internal alchemy SBY awakens the energy in the subject's brain. SBY involves acupressure technique and also breathing process as both of these are used to make a balance between both left and right part of the brain and also make the brain energetic. We can do this Yoga at any place and also it also very less time consuming and easy process [17].

Tiwari et al.: Electroencephalograph is used for mapping mind signals developed during psychological disorders. The subjects mind signal analysis is done in their different moods, and the analyzed data varies from subject to subject. Basically in this paper electroencephalography technique is used for the analysis of change in mind waves during mood change and also analyze that yoga is preventing the switches in the mood or not. The main targeted area of this technique is the analysis of the frequency which developed during relaxed mental state [18].

3   Comparison

Table 2 The existing yoga analysis methods with the detail explanation on its comparison:

Initially the research work was at elementary level with which the effectiveness of yoga and meditation is evaluated by analysing EEG signals which is executed on few subjects. Later on various advanced Electroencephalographic techniques

Table 2 Comparison

Author and year	Comparison and techniques used
Pradhan et al. (1995)	Yogic meditation is employed for evaluating the EEG signal obtained through two subjects and dimensional complexities during electroencephalography is studied [9].
Fu et al. (2009)	Discussion of Loop Control Theory between mind and the environment is proposed in and the quality of mind waves affected due to the interrelationship between mind I/P and O/P signal [10].
Patil et al. (2011)	A person who is performing anulomvilom is subjected to electroencephalogram for the recording of brain signal. Then the recorded signal is subjected to wavelet transformation [11].
Hosseini et al. (2013)	Electroencephalograph signal for Epileptic seizures is recognized by using the chaos-ANFIS process [12].
Meshram et al. (2014)	An electroencephalogram is used to obtain mind signal during Sudarshan-Kriya yoga [13].
Ramachandran et al. (2014)	Experimental goal of this work is to interpret and characterize the EEG activity during pranayama [14].
Vijayalakshmi et al. (2015)	Spectral features of electroencephalography are traced during meditation and then the Quantitative analysis is done for the signal [15].
Shaw et al. (2016)	The statistical characteristics of the electroencephalographic signal have been studied during Kriya Yoga and normal brain conditions in this paper [16].
Sreenivasa et al. (2017)	Super Brain Yoga significance and advantages are highlighted in this study in this paper [17].
Tiwari et al. (2017)	Electroencephalographic signals analyzed during stress and depression and methods to control these mental disorders are discussed [18].

are utilised at different mind conditions such as mentals disorders, stress, anxiety, depression by collecting huge data base from the large number of subjects.

4 Conclusion

The effects of different yoga techniques are positive on mind wave activities as yoga stimulates the brain functioning as alpha, beta and theta mind waves are activated, which have been associated with improvement in brain functioning, memory, control the mood swings, and relieve mind from anxiety, stress and depression-related brain disorders. Here, in this review paper brain waves from different subjects are analyzed by using electroencephalograph for encompassing mediation impacts, pranayama, yoga on the brain, as variety of signal based processing methodologies are used such as classification methods and frequency bends. Wavelet analysis is used to decompose signals utilizing the statistical approaches into sub-bands and the extracted features. This review work can further be utilized by the emerging researchers to develop advance techniques which can be incorporated to look over the mind activities and the subject's mental health progress can also be monitored at a different stage of mental illness when they are subjected to different yoga techniques, meditation and pranayama during pre and post yoga sessions through electroencephalography signal.

References

1. Desai, R., Tailor, A., Bhatt, T.,: Complementary Therapies in Clinical Practice Effects of yoga on brain waves and structural activation : A review. *Complement Ther Clin Pract*. 2015, 1–7. doi:https://doi.org/10.1016/j.ctcp.2015.02.002.
2. Ahani, A., Wahbeh, H., Nezamfar, H., Miller, M., Erdogmus, D., Oken, B.,: Quantitative change of EEG and respiration signals during mindfulness meditation. *J Neuroeng Rehabil*. 2014, 11(1), 1–11. doi:https://doi.org/10.1186/1743-0003-11-87.
3. Jois, S.N., D'Souza, L., Moulya, R.,: Beneficial effects of superbrain yoga on short-term memory and selective attention of students. *Indian J Tradit Knowl*. 2017, 16(June), S35-S39.
4. Korde, S., Paikrao, L.,: Analysis of EEG Signals and Biomedical Changes due to Meditation on Brain. A Review. *Int. Res J of Eng and Tech.* 2018.
5. Ajay, Khatak, A., Gupta, A., Gesture Recognition Techniques: A comparison on the Accuracy & Complexities. *IEEE International Conference on Intelligent Computing and Sustainable System. ICICSS* 2018.
6. Adhalli, M., Umadevi, H., Guruprasad, S., Hegde, R.,: Design and Simulation of EEG Signals Analysis - A Case Stud. *IJESC*. 2016.
7. Anju, Khatak, A.,: Analysis of the Various Eyes Images using Colour Segmentation Techniques and their Noise effects. *Journal of Image Processing & Pattern Recognition Pro-gress.* 2017; 4:1.
8. Yadav, A., Khatak, A., Sindhu, S.,: A Comparative Analysis of Different Image Restoration techniques. *IEEE International Conference on Intelligent Computing and Sustainable Sys-tem. ICICSS.* 2018.

9. Pradhan, N., Dutt, D.N.,: An analysis of dimensional complexity of brain electrical activity\nduring meditation. *Proc First Reg Conf IEEE Eng Med Biol Soc 14th Conf Biomed Eng Soc India An Int Meet*. 1995:92–93. doi:https://doi.org/10.1109/RCEMBS.1995.511692

10. Fu, H-L.,: Under different conditions of learning memory in the Electroencephalograph (EEG) analysis and discussion. 2009:352–355.

11. Engineering, R.S., Anulom, A.,: Electroencephalograph Signal Analysis During Anulom vilom.

12. Hosseini, S.A., Akbarzadeh, T. M-R., Naghibi-Sistani, M.B.,: Qualitative and Quantitative Evaluation of EEG Signals in Epileptic Seizure Recognition. *Int J Intell Syst Appl*. 2013;5(6):41–46. doi:https://doi.org/10.5815/ijisa.2013.06.05

13. Meshram, Y., Fulpatil, P.,: Review Paper on Electroencephalographic Evaluation of Sudarshan Kriya. 2014;3(7):2012–2014.

14. Vijayalakshmi, K.,: Independent Component Analysis of EEG Signals and Real-Time Data Acquisition Using MyDAQ and Labview. 2014;1(9):65–74.

15. Kochupillai, V.,: Quantitative Analysis of Eeg Signal Before and After Sudharshana Kriya Yoga Chandana. *Int J Public Ment Heal Neurosci*. 2015;2(2):2394–4668.

16. Shaw, L., Routray, A.,: Statistical features extraction for multivariate pattern analysis in meditation EEG using PCA. *2016 IEEE EMBS Int Student Conf*. 2016:1–4. doi:https://doi.org/10.1109/EMBSISC.2016.7508624

17. Sreenivasa, T.,: Ed MP, Phil M, et al. Super Brain Yoga. 2017;11(18):324–325.

18. Tiwari, A., Tiwari, R.,: Monitoring and detection of EEG signals before and after yoga during depression in human brain using MATLAB. 2017;(Iccmc):329–334. doi:https://doi.org/10.1109/ICCMC.2017.8282702