Abstract: An effort was made to analyze the cerebral electrical activity of nine experienced Isha Yoga practitioners by means of EEG recordings. The EEG data was recorded before and after Shambhavi Maha Mudra practice in Isha Yoga, which is considered to be an antidote to stress. A complete spectral and statistical analysis was done on the data collected to analyze the changes in delta, theta, alpha and beta rhythms. The analysis of the mean relative band power of the data collected after the practice showed a high increase in the delta band power \( p<0.05 \) for F4 & F8 accompanied by an increase in theta band power. There was also a marked decrease in beta band power \( p<0.05 \) for O2, C3 & T3 almost throughout the entire hemisphere and a slight decrease in alpha band power in fronto-parietal and midline brain regions. Furthermore, an increase in coherence between the left and right hemisphere was observed accompanied by a high increase in slow-wave progression ([Delta+Theta]/Alpha) in most of the brain regions. The results clearly show a higher level of mental and lower level of physical consciousness experienced in Shambhavi Maha Mudra Practice in Isha Yoga.

Indexing terms: EEG, Band Power, Coherence, Slow-wave Progression, Shambhavi Maha Mudra, Isha Yoga, Consciousness

1. INTRODUCTION

Since last many years, research has been conducted to analyze the effect of meditation on changes in human physiology [1-3]. The fact that different conscious states are accompanied by different neuro-physiological states and the brain electrical activities measured would reflect these changes explains the use of EEG for such studies [4]. Spatio-temporal patterns of these EEG activities could be traced to analyze the relation between meditation and their underlying neuro-physiological changes.

Numerous studies have reported changes in various brain rhythms emphasizing the positive effects of meditative state as compared to any type of non-meditative state [5-8]. Most of these studies have indicated an overall slowing down of brain rhythms after meditation. However variations in changes of rhythms were also observed between different types of meditations. Reasons stated for such variations were the different techniques used in different types of meditations and specific practices leading to specific changes [9].
The present study attempts to explore the effect of Shambhavi Maha Mudra in an Isha Yoga program. Isha Yoga, known as a powerful method for awakening and expanding consciousness, involves simple postures and meditation. In their Inner Engineering program, transmission of the Shambhavi Maha Mudra – a powerful process of immeasurable antiquity – is offered to purify the system and improve health, productivity, balance and inner well being [7]. This study analyzes and discusses the neuro-physiological changes subsequent to this practice using EEG.

2. MATERIALS AND METHODS

2.1. Subjects
Nine healthy experienced Isha Yoga practitioners, (5 F, 4 M) of age between 21 to 36 years (mean = 26.1 ± 4.34 years) participated in this research study as subjects. They were all from Isha Yoga Foundation, Coimbatore with many years of experience (10-11 years) of doing Isha Yoga. The subjects had no history of neurological or psychiatric disorders and none of them were on any medication. The experiment paradigm was explained fully and written consent was obtained from each of the participants.

2.2. EEG Recordings
The EEG data was recorded from 19 electrode positions on the scalp (FP2, F4, C4, P4, O2, F8, T4, T6, FP1, F3, C3, P3, O1, F7, T3, T5, FZ, CZ, PZ) according to the International 10-20 system of electrode placement, referenced to the linked ear lobe electrodes. Fig 1 visualizes the montage showing the electrode placement.

![Electrode montage](image)

Fig 1 Electrode montage

All recordings were done in similar conditions on various days using Comet XL EEG – A Grass Telefactor System with AS40 Amplifier system and Windows® based TWin® 3.5a EEG Record and Review Software at Sir Ganga Ram Hospital, New Delhi. The filter settings were as: LF 1 Hz, HF 70 Hz and sampling frequency fixed at 200 Hz.

2.3. Experimental Paradigm
Artifact-free epochs of 3-seconds duration were selected from the EEG recordings of each of the subjects immediately before and after Shambhavi Maha Mudra practice. These recordings were formally called BASELINE1 and BASELINE2 respectively. The entire procedure was carried out in a quiet room and took approximately 40 minutes including preparation of the subject.

2.4. Analysis
After computing the Fast Fourier Transform, the absolute band power for prominent EEG spectral bands (Delta: 1-4 Hz, Theta: 4-8 Hz, Alpha: 8-13 Hz and Beta: 13-30 Hz) was calculated. Following this, the relative band power was averaged over all the subjects and is shown in Fig 2.

![Mean relative band powers](image)

Fig 2 Mean relative band powers (a) before and (b) after the practice
Topographic head maps showing the distribution of the various brain rhythms on the scalp are shown in Fig 3, where red depicts the maximum and blue depicts the minimum appearance.

For comparing the actual changes in various rhythms between the stages, the percentage change in mean relative band power before and after practice was calculated and is shown in Fig 4.

To test the effect of Shambhavi Mahamudra practice on the coherence between the hemispheres, the correlation coefficient values were computed between corresponding electrodes in both the hemispheres. Fig 5 shows the change in coherence values after the practice, with the significant changes starred. The progression of slow waves, delta and theta, between the two stages was also calculated as the ratio of Delta+Theta and Alpha for each electrode location (Fig 6).

For statistical analysis, one-way repeated measures ANOVA [11] was performed on the log transform (ln) of the absolute EEG band power to test possible differences between the two stages BASELINE1 and BASELINE2.

The entire spectral and statistical analysis of the recorded data was carried out using Matlab® 7.0 from The Mathworks Inc., USA.

3. RESULTS

Fig 2(a) showing the mean relative band power from the subjects before the Shambhavi Maha Mudra practice clearly shows that the alpha band power is very high at all the electrode positions, thus verifying that the Isha Yoga experts had high levels of relaxation in general.
As observed in Fig 4, there was a high increase in the delta band power (delta-F4: \( p = 0.0128 \); delta-F8: \( p = 0.0326 \)) accompanied by an increase in theta band power throughout the entire hemisphere. It is to be noted that the simultaneous increase of these rhythms was maximum along the midline brain region. There was also a marked decrease in beta band power (beta-O2: \( p = 0.0077 \); beta-C3: \( p = 0.0452 \); beta-T3: \( p = 0.0193 \)) almost throughout the entire hemisphere and a slight decrease in alpha band power in fronto-parietal and midline brain regions. It was seen that there was a maximum decrease in beta rhythm and a maximum increase in alpha rhythm in the temporal region simultaneously.

The changes in coherence between the left and right hemisphere depicted in Fig 5 clearly shows a significant increase in coherence throughout the entire cerebral region after the Shambhavi Maha Mudra practice. A high increase in progression of slow waves was also seen at most of the electrode positions (Fig 6).

4. DISCUSSION & CONCLUSION

The fundamental assumption that any mental experience has a corresponding electrical signature in the brain, which can be extrapolated from the electroencephalogram gave neuroscientists the view that mental and neural activities are highly correlated [4].

Certain EEG frequency bands were stated to indicate activity on different hierarchical levels as given in Table 1 [12].

<table>
<thead>
<tr>
<th>TABLE 1: Possible sources of activity in certain EEG frequency bands</th>
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<tr>
<td><strong>Frequency Band</strong></td>
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<tr>
<td>Delta (( \delta ))</td>
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<tr>
<td>Theta (( \theta ))</td>
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<td>Alpha (( \alpha ))</td>
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<td>Beta (( \beta ))</td>
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Mental tensions, excitement and anxiety cause an increase in both amplitude and frequency of the beta rhythms. Alpha waves, which signify conscious awareness, are the bridge to the unconscious, which is represented by the lower frequencies, theta and delta. When one comes close to unconscious memories during deep meditation, the theta activity tends to increase. In order to have conscious access to and remembrance of the unconscious content, alpha waves must be present in the EEG. Without alpha, the unconscious content remains unconscious [13]. For the present experiment, all subjects showed the presence of high alpha power in both the states.

Delta waves are associated with the deepest states of consciousness. Some consider that delta signifies contact with the collective unconscious. Delta rhythms combined with alpha are known to reflect an inner intuitive empathetic radar, a kind of sixth sense [13]. It is to be noted that there was a marked increase in Delta band power in all subjects after the practice.

A decrease in alpha power was reported in yogic meditation and Transcendental Meditation (TM). Also an increased theta, rather than an increase in alpha, was suggestive of proficiency in meditative practice [9].

EEG coherence is understood as a measure of cortical connectivity. Lower values of coherence are associated with white matter lesions and decreased cortical blood flow. Higher values of coherence have been interpreted as evidence of functional coupling, information exchange or functional coordination between brain regions. EEG coherence is also thought to be a likely predictor of other behavioral and physiologic accompaniments of meditation. Some authors have found significant correlation between EEG coherence as clearer experience of pure consciousness and higher scores on tests of creativity. Some have also reported correlations between coherence and IQ. Increased frontal coherence has been noted in TM, which reflects an enhancement of frontal lobe integration, as increased cognitive flexibility and intelligence and emotional stability [9].

In summary, the present experiment results, showing the considerable increase in delta and theta activity in most regions of the brain, indicate that the brain becomes deeply focused following Shambhavi Maha Mudra, thus reflecting higher level of mental consciousness. The reduction in the beta activity signifies lesser anxiety. Above all, the characteristic changes observed in this experiment established that all subjects showed a specific state effect of meditative practice.
REFERENCE


10. Isha Yoga Foundation. URL: http://www.ishafoundation.org/


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AUTHORS

Jayashree Santhosh completed her BTech in Electrical Engineering from University of Kerala, MTech in Computer & Information Sciences from Cochin University of Science and Technology, Kerala and PhD from IIT Delhi. Presently she is a faculty with the Computer Centre, Indian Institute of Technology Delhi.

She has been associated with teaching and various projects with Centre for Bio-Medical Engineering and Department of Biotechnology at IIT Delhi and many Continuing Education programmes in the area of Information Technology conducted by IIT Delhi. Her research interest focuses on Technology Applications in Healthcare and is presently working on a project with the Ministry of Social Justice for development of technological interfaces for rehabilitation. She received IETE’s Gowri Memorial Award in 2002-2003 and IIT-D Alumni Award for Best Technology in 2006. She is fellow member IETE, IAMI and member and present finance secretary for ISB.

Gracee Agrawal received the B.E. degree in Biomedical Engineering from Manipal Institute of Technology, Karnataka, India in June 2006. She was awarded Gold Medals for first rank in the department as well as the institute. She is currently working as a Project Associate at Indian Institute of Technology Delhi since July 2006.

Her research interests are Biomedical Signal and Image Processing in the areas of Neuro-engineering and Rehabilitation Engineering.

Manvir Bhatia did her DM (Neurology) from AIIMS in 1993 and has been in-charge of the Clinical Neurophysiology Laboratory at AIIMS from 1993-2003. Presently she is working as a Senior Consultant in Dept. of Neurology, Sir Ganga Ram Hospital, New Delhi, India.

She has added many clinical applications for research and clinical service. These include Long-term monitoring for epilepsy patients, sleep study (overnight polysomnography), magnetic stimulation and quantitative sensory evaluation. In addition, she is the Principal Investigator for many projects on sleep studies and magnetic stimulation. She is on the editorial board of International journals and has many publications in National and International journals on topics related to peripheral and central neurophysiology.

Nandeeshwara S.B. has done MBBS from Mysore Medical College, Karnataka. He is now working as a Senior Research Officer in the Dept. of Clinical Neurophysiology at Sir Ganga Ram Hospital, Rajinder Nagar, New Delhi.

His research interests are in the field of clinical neurology, genetics and oncology.

Snehal Anand did her graduation in Electrical Engineering from Thapar College of Engineering and Technology, Patiala in 1970 and MTech and PhD from IIT Delhi in 1976. Since then she has been on the faculty of Centre for Biomedical Engineering at IIT Delhi and AIIMS. Presently she is the head of the same center.

Her principal achievements are in the areas of biomedical sensors with application to physiological diagnostic clinical measurements, reproductive bioengineering and aids for the disabled. With these and other contributions, she has received several national and international awards of NRDC, WIPO, ICMR, IETE and Ministry of Welfare, Government of India.