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A Review on Therapeutic Effects of Meditation Using EEG Signals

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Abstract: Brain oscillatory activity is associated with different cognitive processes and plays a critical role in meditation. It is defined as the natural process of manipulating one's state of mind and self-regulating attention level intentionally. In this review, we have reviewed three different meditation techniques using EEG signals and also therapeutic effects of the meditation. EEG is the best diagnostic tool to provide significant information about brain activities and temporal dynamics related to these activities within millisecond range. EEG brainwave signals can help medical practitioners to check the activity level of brain and based on the health state, different meditation practices can be applied to progress mental fitness. From the review, it can be concluded these three different practices included different unique way of attaining focus and object-subject relations and with different degree of attention and with different rate of improvement in the cognitive and emotional states. Numerous researches have been carried out to scientifically explore the underlying brain neuro electrical effects during meditation but still neuro physiological effect of meditation is an open question

Keywords: *Meditation; EEG; Variation of alpha, beta and gamma rhythmic frequency*

I. INTRODUCTION

The mind is a collection of cognitive faculties that includes consciousness, attention, perception, feeling and reasoning. It holds the power of imagination and emotions that result in developing attitudes and taking right or wrong actions. Meditation is a family of complex emotional and focused attention training scheme with an objective to improve emotional balance and nurturing the well being of lifeThe term 'Meditation' is a technique designed to providefocused attention and relaxation to the sensory processing units [1]. Lutz et al has taken efforts to classify the meditation practice styles into two categories: a) Focused attention b) open monitoring. Firstly, practice involves sustained attention on a chosen object. The ability to maintain the intended focus becomes "effortless". It also creates a sense of physical lightness and decrease in emotional re–activity. Open monitoring meditation practice to remain in the monitoring state and attentive to anything that occurs without focusing towards any intended chosen object. It gains a clear reflexive awareness that enables to transform intellectual and emotional balance [2]Travis et al has proposed an other classification of meditation named Transcendental Meditation or Autonomic Transcend meditation. In this type of meditational practice isdesigned to transcend their own/self activity. For instance, focus meditation and open monitoring meditation

involves active mental process whereas in transcendental meditation individual activity keeps the mind transcending. For better understanding the concept, an individual activity of enchanting mantra for a long time, at deep levels, mantra becomes secondary experience and disappears and self awarenessbecomes primary. Conclusively, Transcendental meditation involves automatically transforming through phases into mental silence [3 and 4]. These three meditation categories are not mutually exclusive within a short time period or over the course of a lifelong time of meditation practice.

II. EEG AND MEDITATION

EEG is a non-invasive technique widely used in diagnosing several neurological disorders and abnormalities associated with brain dynamics. The EEG signal is a clear indicator of the electrical activity within the brain and contains vital information about the brain state. EEG signals are highly nonstationary and random in nature. Amplitude and peak values are extracted and used as features. In order to detect the most reliable underlying information from the EEG signals, features can be extracted from any of the three domains namely, time domain, frequency domain and time-frequency domain. [5].Frequency domain features are related to changes in the oscillatory activity of EEG signals. The transition from a disordered to an ordered brain state can be evoked by the mediators. In order to investigate the oscillatory changes in the EEG recordings, the time-domain EEG signals are transformed into a frequency domain signal using Fourier transform. In the frequency domain analysis, the features from the power spectrum are extracted, which attributes variations in spectral power in response to the stimuli. This transformed analysis helps in characterizing the EEG signals with different underlying rhythms. The brain rhythms of the delta band (0.5 to 4 Hz), theta band (4 to 7 Hz), the alpha band (7 to 13 Hz), and gamma band (>20 Hz) were extracted and collectively used as a feature vector to distinguish frequency bands of the brain waves. [6 and 7]

The EEG signals can be analyzed by continuous time wavelet transform to detect the transition state of post-stimulus with minimum loss of information. The wavelet features provide detailed information about EEG response, and this helps to determine the brainwaves. The selection of wavelet parameters such as suitable mother wavelet, center frequency and bandwidth plays an important role in assessing the information from the EEG signals.

A study was made on an artist who experiences strong visual imagery during meditation.A set of EEG recordings were collected during 7 meditation sessions with experienced meditators and non-meditators. Sixty four active electrodes using a BioSemi Activehave been used to acquire the EEG signals. The occipital gamma and alpha brainwaves were extracted from the EEG signals. The author reports that occipital gamma had greater influence on spontaneous visual imagery, which is reflected inexperienced meditators [8].
Masahiro hataet al has analyzed the EEG signals recorded from the post traumatic residualdisability (PTRD) subject with meditative intervention. Ten subjects with PTRD were recruited and EEG signals were recorded before and after meditation intervention. The results show that PTRD subjects exhibited increased gamma frequency bands in the left parietal lobe compared to the normal subjects. Further, changes of delta activity in the right precuneus correlated with changes [9]

Reshma et al [10] have reported the change in frequency bands under the influence of cyclic mediation. Twenty four university students were recruited for the study and data has been recorded using 64 channels EEG. The report shows that there is a significant improvement in the connectivity

between frontal and parietal lobes which enhances preparation, innovation and incubation.

Ramaswamy et al [11] investigated the impact of Raja Yoga meditation by monitoring EEG signals, ECG signals using brain–computer interface. The experimental research has been carried out on two groups: short term meditation volunteers and long term meditation volunteers with more than 10 years of meditation experience. The results show that there is large variation in the brainwaves of the long term meditators and short term meditators.

Sunil et al [12] have used one of the fractal dimension estimators detrended fluctuation analysis to evaluate the pre- and post-meditation intervention. In this study, 11 healthy subjects were selected and 14 channel EEG has used for collecting the signals. The focused mediation has been practiced by the selected subjects for the period of 8 weeks. From the results, it can be observed that 9 subjects showed reduction alpha band after meditation intervention. The reduction in DFA values after the meditation intervention shows reduction in the rate of change of intrinsic fluctuation, within same window size. This shows that there is a balance between para-sympathetic and sympathetic activities. Further, DFA can be used as a tool for evaluating the EEG signals in terms of quantifying the pre meditation and post meditation.

Ahmad Dania et al [13] have investigated the development of neuroprosthetics limb using subjects focused meditation to produce the movement of the prosthetic arm. The prosthetic arm has been designed using solidworks software. The hardware has been developed using 3 D printer and material used for the manufacturing was biodegradable polylactic acid. Attention and meditation levels are used to rotate and grasp the servo motors to rotate the hand. The results demonstrate that the control prosthetic arm based on attention and meditation can be used for the implementation of brain waves. Further, it was evident that it has the potential application for the disabilities and deformities.

Paul dennison [14]have investigated the different meditators such as Samantha meditation and progressive levels. Twenty nine subjects were selected from the European nations. The EEG signals were recorded using 31 channel mitstarmodel with a sampling frequency of 500 Hz. From the results, it can be observed that these subjects meditation proves to be safe and helps to reduce the frequency of epilepsy sufferers. Further, it also shows that a significant responsiveness of the brain cortical network.

Melissa et al [15]have applied three methods of meditation such as mindfulmeditation, cognitive therapy and mindfulness based cognitive therapy to evaluate the pain interference and pain intensity for the chronic low back pain subjects. After the pre-assessment of informed consent form, 69 subjects were selected out of 174 subjects. These 69 subjects were divided equally into three meditation groups namely; a) mindful meditation, b) cognitive therapy and c) mindfulness based cognitive therapy. The most common self-reported pain type was spinal pain and neuropathic pain. The findings demonstrate that mindfulness based cognitive therapy is a feasible and acceptable for the chronic low back pain patients compared with other two meditation. Further, the outcome of the research findings shows that optimal amount of therapy can be practiced to minimize or reduce the pain intensity of the patients.

Goldstein et al [16] have designed the study to examine the sleep insomnia patients with intervention therapy of mindfulness based stress reduction and mindfulness based therapy for insomnia. The EEG data has been recorded from 36 patients suffering from chronic insomnia. The

patients were requested to practice meditation at home for 30-40 min at least 6 days/week. These results show that there is an increase in beta frequency band at both post treatment and follow up treatment. The spectral analysis of EEG demonstrates to be a tool for investigation the intervention therapy of mindfulness based stress reduction and mindfulness based therapy for insomnia.

ShrutiPhutke et al [17] have designed an experiment on focused meditation for eight weeks. The activity was measured using EEG signal for pre-meditation and post meditation. Eleven healthy engineering subjects were requested to practice focused attention meditation for 8 weeks. The objective of the study is to find the functional connectivity of the brain by practicing the focused meditation. The results demonstrate that higher order crossing values decreases for the frontal and parietal lobes and increases in temporal lobes. Further, it can be observed that there is an inter-hemispheric connectivity changes after the meditation.

III. DISCUSSION

In this review article, we have reviewed three different meditation techniques using EEG signals and also therapeutic effects of the meditation.In focused attention or concentrative styles of meditations, attention is focused on a given object and brought back to the object of attention when the mind has wandered.Focused meditation lies in frequency band of the Gamma Band (30-50 Hz) and Beta2 (20-30 Hz). Increased gamma activity reflected in the brain areas and involved in the cognitive and emotional process. During meditation, Frontal alpha brain waves and occipital beta power brain waves were higher at the beginning of meditation; while beta2 (20–30 Hz) power brain wave was higher in the middle and end.

In open monitoring meditation practice to remain in the monitoring state and attentive to anything that occurs without focusing towards any intended chosen object. It gains a clear reflexive awareness that enables to transform intellectual and emotional balance. During meditation, higher frontal midline theta was reflected in the EEG frequency band. The long-term meditators had significantly higher 4–5 Hz frontal power and significantly higher frontal power brain waves 6–8 Hz. Further, Vipassana meditation was characterized by higher frontal theta power.

In this type of meditational practice is designed to transcend their own/self activity. For instance, focus meditation and open monitoring meditation involves active mental process whereas in transcendental meditation individual activity keeps the mind transcending. During meditation, higher frontal alpha1 and lower beta1 and gamma power were reflected. While these meditations may be automatic, the rate of transcending may vary, person-to-person, and often meditation-to-meditation, owing to differences in the mind and body.

IV. CONCLUSION

In this study, we reviewed three different meditation categories – focused attention, automatic self transcending and open monitoring. These three different practices included different unique way of attaining focus and object-subject relations and with different degree of attention and with different rate of improvement in the cognitive and emotional states. Each of these methods without any doubt has positive impact on brain cortical regions. Each of these techniques enables to transform intellectual and emotional balance. Currentevidence reveals that meditation, a form of mental training may prevent and intervene in mood.

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