Explore the effect of Om mantra meditation on brain with wavelet analysis

BHAVNA HARNE[A], DR.A.S.HIWALE[B],
[a] First Electronics Department , [b] Second Electronics Department ,
[a]SSGMCE, Shegaon, [b]MIT College of Engineering, Pune,
India
bdhekekar@yahoo.com

Abstract: - This study uses a discrete wavelet transform based feature extraction method to examine the effect of Om meditation on the brain. With twenty-three healthy engineering college students between the age group of twenty to twenty-two chosen as subjects for the study, EEG signals were obtained before performing Om meditation as well as after performing Om meditation. EEG signals were classified into Gamma, Beta, Alpha, Theta and Delta bands by using detailed coefficients and approximate coefficient obtained by five level wavelet transform. Feature such as relative power using the Welch method was extracted from each band and was analyzed using two way repeated analysis of variance. Findings reveal increased theta power and higher theta amplitude in after condition at all regions in comparison to the before the condition of meditation but results were not significant. No significant results were found in any other band. As described in other studies, increased theta power is a sign of relaxation. Results revealed through the study were promising results for single day testing and immediate effect of Om meditation. The study emphasizes the importance of Om meditation which could work wonders for people under stress if adopted as a daily routine. As Om meditation is simple and easy to practice, it could open a new horizon for naïve meditators.

Key-Words: - Mantra meditation, EEG, Om.

1 Introduction

Meditation is one of the aspects of yoga that can be stated as consciously and voluntarily guiding self-attention for relaxation or for seeking oneself or for personal improvement. Meditation can be categorized into two types: the first type involves focusing attention on a particular object and second being a mental or loud repetition of a chant called mantra meditation [2]. Varieties of mantras can be chosen for meditation. Mantra repetition is a simple method to implement in order to attain meditation [3]. The appearance of the Om syllable in Upanishads, Bhagvat Gita, and Vedas make it holy and sacred [4], thus making it the highest sacred symbol in Hinduism. Om, considered as the name of God, is a sacred syllable in Hinduism from which all other sound came into existence [4].

Many benefits of Om meditation have been revealed from studies conducted using sophisticated mathematics and medical tests to analyze its effect on the human body. Many researchers have found the effects of Om meditation on human by analyzing various parameters such as functional Magnetic Resonance Imaging (fMRI) [5], Evoked Potentials [6-7], Electroencephalograph [8-9] and other variables [10-11]. fMRI study has been conducted on the listening of the Om mantra [12].Even wavelet analysis of uttered Om sound has been done [13]. All analysis shows the positive effect of Om mantra meditation on the human body.

There are mainly two studies based on EEG on loud Om mantra meditation. The first study [8] is the time domain analysis of the EEG signal before and after Om chanting. The second study [9] is based on power spectral analysis which employed a fast Fourier transform (FFT) to examine oscillatory changes in the standard frequency bands (delta, theta, alpha, and beta) after OM chanting. Most of the studies [14-20] related to different meditations used the concept of FFT to explore neural concomitants. Wavelet and FFT are two tools of spectral analysis [21]. Wavelets are localized in both time and frequency whereas the standard FFT is only localized in frequency. Wavelet is proved to be better in detecting brain diseases [21]. In the existing literature on meditation, many studies used wavelet analysis and features from it to classify the EEG patterns [22-26]. A few works of literature have addressed the use of wavelet for power spectral analysis of the EEG signal. In the present study, in contrast to Fourier analysis, wavelet analysis has

been used for spectral analysis of the EEG signal before and after OM chanting. The aim is to compare oscillatory changes in the standard frequency bands (delta, theta, alpha, beta, and gamma) before and after OM chanting. In all studies related to different meditations [14-20] examining EEG measures reported an increase in theta power. Since other meditations have shown modulation in the theta band, it has been therefore hypothesized that like other meditation OM chanting would result in changes in theta activity [9].

In order to find the effect of Om mantra meditation on human beings, subjects with no prior experience of meditation were chosen. Students of Shri Sant Gajanan Maharaj College of engineering were selected as subjects for conducting the study.

This study is an attempt to evaluate the trait changes in EEG pattern due to Om meditation outside meditation, unlike other studies where states are evaluated during meditation. The rest of the paper is organized as follows: at the first section, materials and methods are discussed followed by experimental results. The discussion part is covered in the third section. The last section concluded the study.

2 Materials and methods

2.1 Subjects

A total of 23 naive meditators with a mean age of 20.99 years, between the age group of 18–22 years were assessed. Subjects chosen had no meditation training referred to as naïve meditators. They were chosen from a Shri Sant Gajanan Maharaj College of engineering randomly. Subjects were informed to practice Om mantra meditation and that their brain activity would be recorded before and after OM chanting. Nonsmokers, not frequent drinkers and right-handed subjects with sound mind state were chosen with the explicit consent of each subject. This study is presented and applied to the concerned ethical committee of Government Medical College, Akola, Maharashtra, India [9].

2.2 Design of study

The study was conducted in two sessions with repeated measures: the first session involves EEG assessments before Om meditation and the second involves EEG assessments after Om meditation. Subjects were asked to perform OM chanting for a duration of 30 minutes.

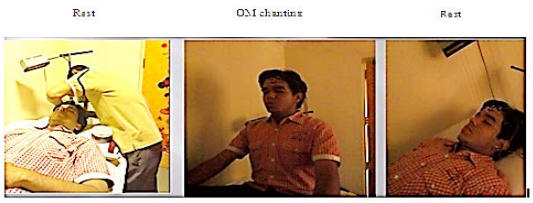

Fig. 1 Experimental setup

The experimental setup for the study is
"Rest →OM chanting →Rest"
as shown in the figure below (Fig. 1). The recording was done in a peaceful and quiet place in order to help the subject to concentrate more effectively. The subject was asked to relax by laying down on a cot with closed eyes. In this relaxing mode, EEG was recorded termed as "EEG before meditation". After recording EEG data, the subject was instructed to sit in an erect position and perform Om chanting for about 30 minutes. During the Om chanting subject was asked to breathe smoothly. During meditation, subjects were asked to inhale for a longer time and exhale with chanting Om. The room of the recording was kept dark for better concentration. Following meditation, the subject was again asked to relax by laying down on a cot with eyes closed. And, again EEG was recorded for more than two minutes which is termed as "EEG after meditation". The subject provided with their detailed experience after experiment [9].

2.3 EEG recording before and after Om mantra meditation

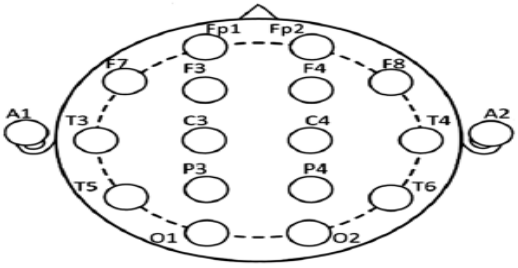

Fig. 2 Electrodes placement

In an electrically shield room of Bilala Hospital, Akola, EEG recording was performed under the guidance of Dr. Saurabh Bilala. EEG signals were recorded using monopolar montages, according to international standard 10-20 from 16 channels using the RMS India system with a 256 Hz sampling frequency. The electrodes and their placement are as shown in fig. 2. The electrodes in the left hemisphere were referred to the left earlobe (A1) with the ground at the forehead [9]. Electrodes placed on the right hemisphere are numbered evenly, whereas those on the left hemisphere are numbered oddly. Electrodes used are prefrontal

electrodes Fp (1,2), frontal electrodes F(7,3,4,8), temporal electrodes T(3,4,5,6) Central C(3,4), Parietal P(3,4), Occipital O(1,2) and reference earlobe A(1,2).

2.4 Discrete wavelet analysis

Out of the two types of wavelet transform: Continuous and Discrete, Discrete wavelet transform (DWT) is used widely in biomedical applications [27]. DWT is a time-frequency analysis technique suitable for analyzing non-stationary signals. EEG signals contain non-stationary characteristics [26], hence DWT is the well-suited technique for analyzing EEG [27-28]. DWT decomposes signal by passing it through a pair of high pass and low pass filter having mirror characteristics. By using a filter bank tree diagram DWT decomposition is shown in the diagram below (fig.3). Using quadrature mirror filters (QMF), DWT split the signal into two equal components: Detail and Approximate. 'Detailed coefficients' (D) are obtained by passing the signal through high pass filter whereas 'approximation coefficients' (A) are obtained by passing through low pass filter. The filtered signal out of low pass filter is again split into two components D2 and A2 corresponding to level 2. Again the low pass filter components of level 2 are split into two coefficients D3 and A3 and so on. As the level goes on, low pass filter components are split further and in this way, DWT decomposition takes place thus forming a bank of continuous bandpass filters spread logarithmically over frequency [27-28].

Scaling function dependent on low pass filter $\Phi_j,k(n)$ is given by

$$\Phi_j,k(n) = 2^{\frac{j}{2}} h(2^j n - k) \quad (1)$$

and the wavelet function dependent on high pass filter $\Psi_j,k(n)$ is given by

$$\Psi_j,k(n) = 2^{\frac{j}{2}} g(2^j n - k) \quad (2)$$

where $n = 0,1,2,.....,M-1$; j represents resolution

$j = 0,1,2,....,2j-1$; k represents sampling ratio

$J=\log_2(M)$ M is the legth of the signal[29]

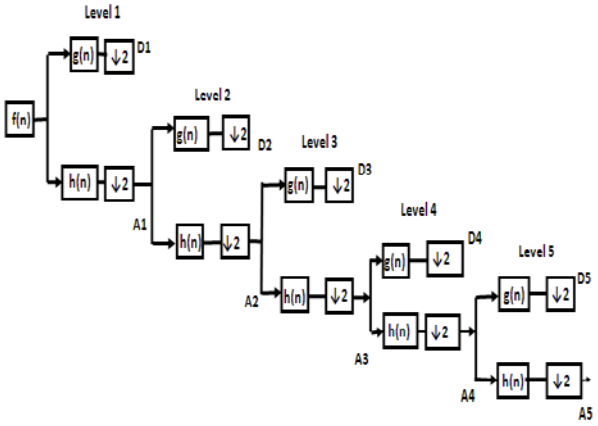

Fig. 3 DWT sub-band decomposition

Approximation coefficients in the ith level is given by:

$$A_i = \frac{1}{\sqrt{M}} \sum_n f(n)\Phi_j,k(n) \quad (3)$$

Detail coefficients in the ith level is given by:

$$D_i = \frac{1}{\sqrt{M}} \sum_n f(n)\Psi_j,k(n) \quad (4)$$

With the sampling frequency of 256 Hz, the maximum level L chosen for decomposition is 5. In this study, DWT has been carried out using various mother wavelets namely:

Daubechies db2, db3, db4, db5, db6, db7, db8, db9, db10.

Coiflets coif1, coif2, coif3, coif4, coif5

Symlets sym1, sym2, sym3, sym4, sym5, sym6, sym7, sym8.

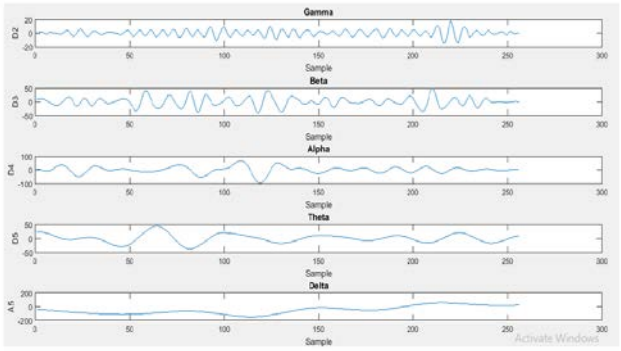

Fig. 4 Approximate and detailed coefficients of one second EEG using db4 wavelet taken from a subject before Om meditation

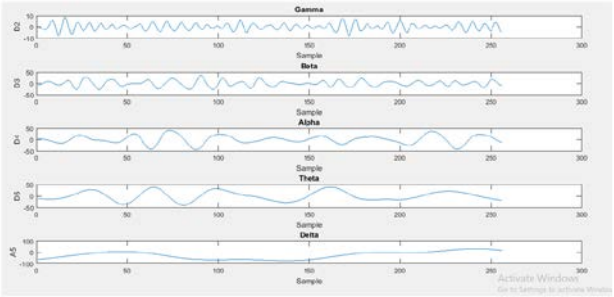

Fig. 5. Approximate and detailed coefficients of one second EEG using db4 wavelet taken from a subject after Om meditation

Table 1 Bands with five level DWT

Level	Wavelets coefficients	Frequency bands (Hz)	Correspondi ng Band
2	Detail coefficient D2	32-64	Gamma
3	Detail coefficient D3	16-32	Beta
4	Detail coefficient D4	8-16	Alpha
5	Detail coefficient D5	4-8	Theta
5	Approximate coefficient A5	0-4	Delta

Analyzing the coefficients in sub-bands yields classified signal into five bands namely Gamma (32 – 64 Hz), Beta (16-32 Hz), Alpha (8-16 Hz), theta (4-8 Hz) and delta (0 - 4 Hz) (table 1).Fig.4 and fig 5 show the approximate and detailed coefficients for one second EEG.

2.5 Feature extraction using DWT

Since the purpose was to explore brain dynamics as a result of OM chanting, the EEG data of the first one minute before OM chanting was used to assess the control state and the first one minute data after OM chanting to assess state achieved after meditation [9]. One minute data should be used for trustworthy spectral analysis [30]. 256 data points epoch was selected. The DWT was then performed to the selected data. The power spectral density (PSD) of delta (0.3–4 Hz), theta (4.1–8.0Hz), alpha (8.1–16.0 Hz), and beta (16.1–32.0 Hz) and gamma (36.1-64.0) frequency band were obtained by using Welch technique, Hanning windowing function. The resulting values were afterward normalized into a relative power [31-32] as follows:

$$\text{relative power}=\frac{\int_{f_L}^{f_H} S_b(f)df}{\int_0^{f_{\max}} S_T(f)df}\times 100 \qquad (5)$$

Where
f_L - lower frequency of particular band,
f_H - lower frequency of particular band,
f_{max} =55 Hz,
S_b – EEG signal of particular band,
S_T – EEG signal of particular band

Finally, the mean relative power was computed for every electrode. For statistical analysis, all 16 electrodes were divided into 8 brain regions which are as follows: right partial occipital (P4, O2), left partial occipital (P3, O1) right central (C4), left central (C3), right frontal (F8, F4and Fp2), left frontal (F7, F3 and Fp1), right temporal (T4 and T8) and left temporal (T3 and T7). Under each region, the power values of the constituent electrodes were averaged, and the procedure was repeated for all the frequency bands. The descriptive representation of the proposed feature extraction scheme is presented in Fig. 6.

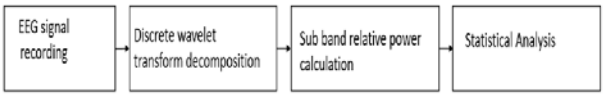

Fig. 6. Flow diagram of proposed approach to qualify the changes in spectral power of each band

2.6 Statistical analysis

For statistical analysis, IBM SPSS software version 2 was used. In order to find the normality of the relative power data distribution, a Kolmogorov–Smirnov test was preliminarily tested. It revealed a normal distribution of the data, justifying the subsequent use of ANOVA analysis. Two-way analyses of variance (ANOVAs) were performed on the relative power values obtained. In order to verify the specificity of a band involved into the OM chanting effect, two way repeated ANOVA was carried out with factor bands namely, delta, theta, alpha, beta, and gamma also considering two conditions namely before and after. In order to analyze the specificity of location involved into the OM chanting effect, each frequency band was submitted to a within-subjects design, analysis of variance (ANOVA) over the factors of condition (before and after) and region (8). A statistically significant value of p is 0.05. Greenhouse-geisser corrected values were reported.

3 Experimental results

Meditation features were quantified by discrete wavelet transform using different mother wavelets namely Daubechies (db2 to db8), Symlets (sym1 to sym8). The result turns out from all different wavelets that are almost the same.
The first two-way ANOVA analysis is conducted to check the involvement of a particular band in OM

meditation on relative power obtained by different mother wavelets. All reveals only band significant results, not any interaction (band x condition) or condition effect.Fig.5 shows relative power in the band before and after condition with the db4 mother wavelet. Research results are the opposite of what was expected. No specific band involved in the OM chanting effect.

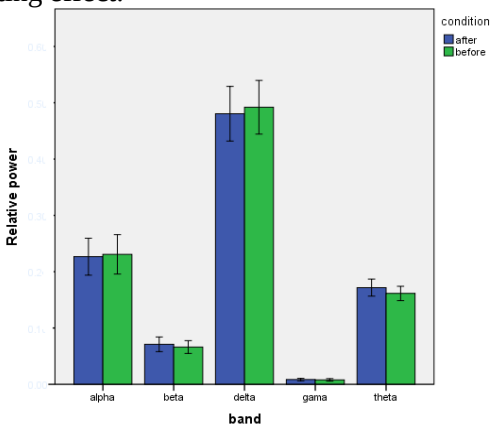

Fig.5 Relative power with DWT (db4 mother wavelet) before and after OM mantra meditation (N=23). No any band exhibited a significant effect.

Secondly two -way repeated ANOVA with region [8] and condition [2] as factors were performed for relative power values obtained by different wavelet separately for all the five types of bands (delta, theta, alpha, gamma, and beta) to assess the association between region and condition after OM chanting. Main effects (conditions and regions) and interaction effect for each frequency band with db4 wavelet are given in table 2.Repeated-measures ANOVA demonstrated insignificant main effects for condition and interaction effect for all bands (table.2).

Fig.6, fig7, fig.8, fig.9, fig.10 show mean relative power with symlet2, db8, db7, db6, and db4 mother wavelet. But closer examination shows an increase in theta power in all regions in after condition with all wavelets. These results are very promising and enhanced theta is noticeable with the db4 mother wavelet only.

Table 2 ANOVA results (n=23)

Frequency band	Condition main effect	Region main effect	Condition × region interaction effect
Alpha	F (1, 22) = 0.045 P = 0.835	F(7,154)= 18.796 P = 0.00	F(7, 154) = 1.196 P = 0.308
Beta	F(1,22) = 0.533 P = 0.473	F(7,154)= 15.242 P = 0.000	F(7,154) = 0.608 P = 0.748
Delta	F(1,22) = 0.533 P = 0.473	F(7,154)= 15.242 P = 0.000	F(7,154) = 0.608 P = 0.748
Gamma	F(1,22) = 0.198 P = 0.660	F(7,154) = 7.915 P = 0.000	F(7,154) = 0.848 P = 0.550
Theta	F(1,22) = 1.185 P = 0.288	F(7,154)= 48.064 P = 0.000	F(7, 154) = 0.454 P = 0.866

*significant ($p<0.05$)

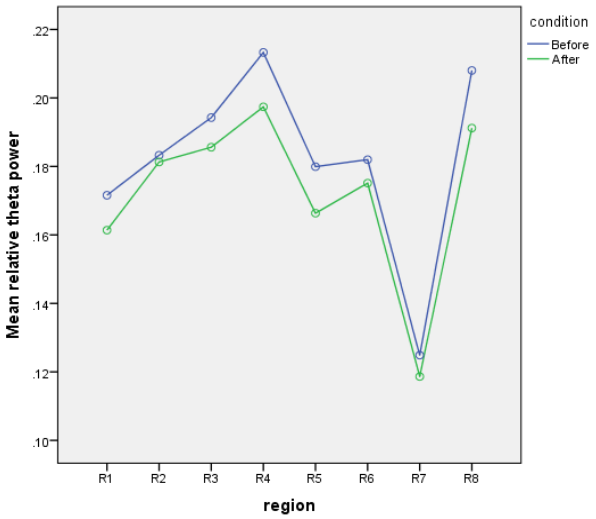

Fig. 6 Profile graph showing changes in relative power in theta band in all eight regions at before and after conditions with symlet2 mother wavelet: Region: R1: Left Frontal; R2: Left temporal R3: Left partial occipital R4: Left central; R5: Right frontal; R6: Right temporal; R7: Right partial occipital R8: Right central

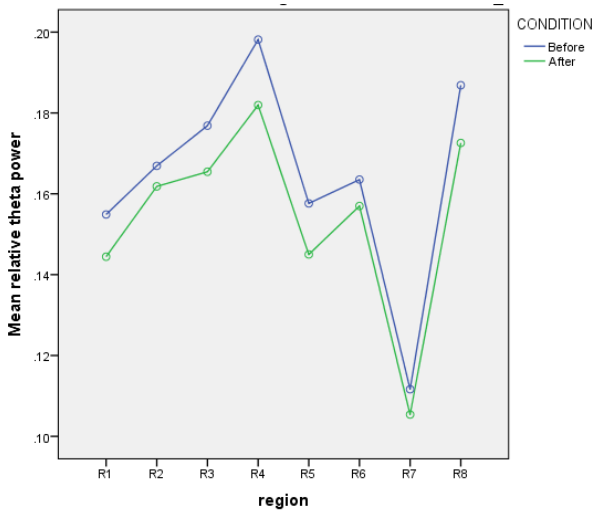

Fig. 7 Profile graph showing changes in relative power in theta band in all eight regions at before and after conditions with db8 mother wavelet

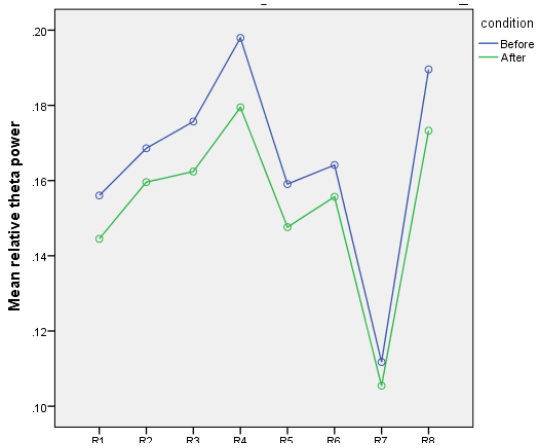

Fig. 8 Profile graph showing changes in relative power in theta band in all eight regions at before and after conditions with db7 mother wavelet

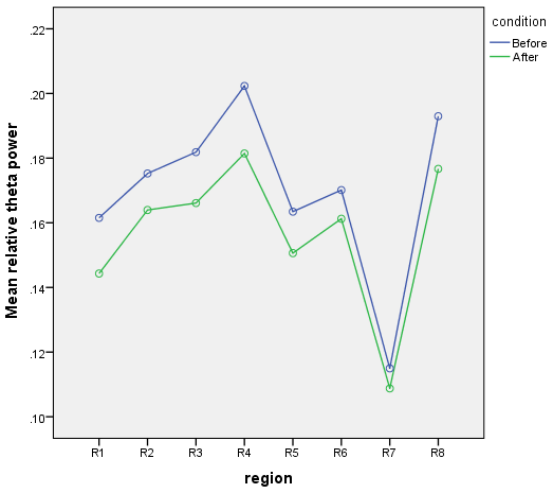

Fig. 9 Profile graph showing changes in relative power in theta band in all eight regions at before and after conditions with db6 mother wavelet

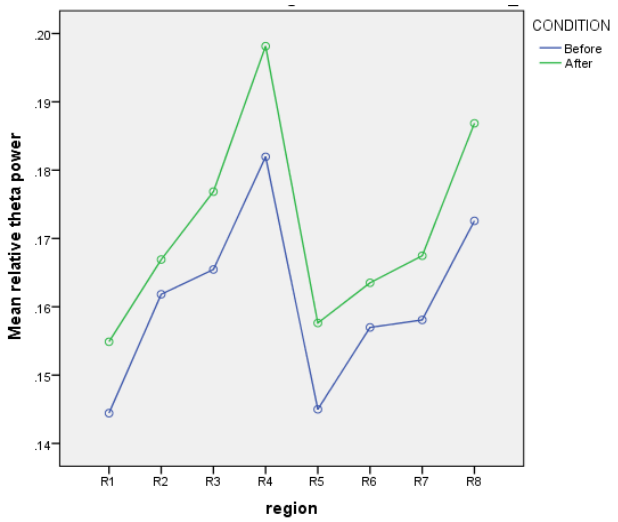

Fig. 10 Profile graph showing changes in relative power in theta band in all eight regions at before and after conditions with db4 mother wavelet

4 Discussion

The focal objective of this study was to explore the effect of Om mantra meditation on the brain through information rendered by the relative discrete wavelet power of all bands of EEG. Any band oscillations as an attribute of 30 minutes OM chanting was not observed with wavelet analysis. But an increase in theta power in all regions of the brain has been observed. Raised theta denote a reduction in cortical arousal [33-36]. The condition of deep relaxation is correlated with a decrement in cortical arousal [37]. Earlier studies have presented the significance of Om mantra meditation in offering relaxation [5, 9]. Thus on the basis of previous literature and our study, OM chanting can be proposed as an effective measure for offering relaxation.

There are many previous reports [14-20] on mediation in which theta power increases during meditation. But these studies usually performed a FFT spectrum analysis of the EEG signal. In our knowledge, only one study on Sudarshan Kriya yoga [38] has been conducted using a similar feature to analyze its effect on brain signals during a working memory task. This is the second effort to use this feature to investigate the effect of meditation on the brain and thus producing promising results with naïve mediators and only thirty minutes Om chanting. The syllable of 'Om' consists of three sound A U M [4] "A" represents the physical plane. "U" represents the mental and astral plane, the world of intelligent spirits, and all the heavens. "M" shows the deep-sleep state [39]. In this study, while recording EEG, subjects were not abided by the time constraints for the recitation of 'A',' U', 'M 'sound of Om mantra. A detailed study can be carried out by keeping fixed time for 'A',' U', 'M 'recitation or with experienced meditators or with a bigger sample size or with control groups. Our study on naïve meditators with immediate effects of loud Om mediation can work as an impetus for naïve meditators to practice Om meditation on a daily basis and may provide solace to people under stress.

5 Conclusion

Power spectral density extracted from DWT transform were calculated to quantify the differences in the various brain areas at varied bands of frequency. For analysis, two way repeated

ANOVA measures were employed which reveals the relaxing effects of Om meditators. This EEG study on naïve meditators for just 30 minutes results in increased theta power which is a sign of relief and relaxation. The study suggests that if such a small duration of Om meditation has such a relaxing effect then it could be used as a stress reliever if adopted as a daily routine. Further research studies with a larger sample size and using advanced signal processing techniques are recommended.

References:

[1] Madanmohan, Introducing Yoga to Medical Students The JIPMER Experience, Advanced Centre for Yoga Therapy. Education and Research, JIP-MER, Puducherry.2008.

[2] Stefan Schmidt, Harald Walach, Meditation – Neuroscientific Approaches and Philosophical Implications, Springer Science & Business Media, 2013.

[3] Burke A., Comparing individual preferences for four meditation techniques: Zen, Vipassana (Mindfulness), Qigong, and Mantra, Explore (NY), vol.8 (4), 2012, 237–242.

[4] Kumar S, Nagendra H, Manjunath N, Naveen K, Telles S., Meditation on 'OM': relevance from ancient texts and contemporary science, International Journal of Yoga ,vol.3 ,2010,pp.2-5.

[5] Kalyani, B. G., Venkatasubramanian, G., et.al., Neurohemodynamic correlates of 'OM' chanting: A pilot functional magnetic resonance imaging study, International Journal of Yoga ,vol.4,2011,pp. 3–6.

[6] Telles S, Nagarathna R, Nagendra HR, Desiraju T., Alterations in auditory middle latency evoked potentials during meditation on a meaningful symbol- "OM", International Journal of Neuroscience, vol. 74, 1994, pp.87-94.

[7] Telles S, Nagarathna R, Nagendra HR, Autonomic changes while mentally repeating two syllables-one meaningful and the other neutral, Indian Journal of Physiol Pharmacol ,vol.42, 1998,pp.57-63 .

[8] B. P. Harne ,Higuchi fractal dimension analysis of EEG signal before and after OM chanting to observe overall effect on brain, International Journal of Electrical and Computer Engineering,vol. 4,2014,pp. 585-592.

[9] Harne, B.P. & Hiwale, A.S.," EEG Spectral Analysis on OM Mantra Meditation: A Pilot Study, Applied Psychophysiology and Biofeedback, vol.43 (2), 2018, pp.1-7.

[10] Das, I., & Anand, H., Effect of prayer and OM meditation in enhancing galvanic skin response, Psychological Thought,vol.5,2012,pp. 141–149.

[11] Telles S, Nagarathna R, Nagendra HR. Autonomic changes during 'OM' meditation, Indian Journal of Physiol Pharmacology.vol.39, 1995, pp. 418-420.

[12] Uttam Kumar, Anupam Guleria and Chunni Lal Khetrapal, Neuro-cognitive aspects of "OM" sound/syllable perception: A functional neuroimaging study, Cognition and Emotion, vol. 29, 2015, pp.432–441.

[13] Gurjar, A. A., & Ladhake, S. A., Time-frequency analysis of chanting Sanskrit divine sound "OM" mantra, International Journal of Computer Science and Network Security, vol. 8(8),2008,pp.170–175.

[14] Cahn BR, Polich J., Meditation states and traits: EEG, ERP, and neuroimaging studies, Psychological Bulletin, vol.132, 2006, pp.180–211.

[15] Chan, A. S., Han, Y. M., & Cheung, M. C., Electroencephalographic (EEG) measurements of mindfulness-based triarchic body-pathway relaxation technique: A pilot study, Applied Psychophysiology and Biofeedback, vol.33, 2008, pp.39–47.

[16] Huang HY, Lo PC.,EEG dynamics of experienced Zen meditation practitioners probed by complexity index and spectral measure, Journal of Medical Engineering & Technology, vol.33, 2009,pp.314–321.

[17] Lagopoulos J, Xu J, Rasmussen I, et.al. Increased theta and alpha EEG activity during nondirective meditation, The Journal of

Alternative and Complementary Medicine, vol.15, 2009, pp. 1187–1192.

[18] Vialette FB, Bakardjian H, Prasad R, Cichocki A., EEG paroxysmal gamma waves Bhramari Pranyama: a yoga breathing technique, Conscious Cognition ,vol. 18(4),2009,pp.977-88.

[19] Baijal S, Srinivasan N., Theta activity and meditative states: spectral changes during concentrative meditation, Cognitive Processing, vol.11, 2010, pp. 31.

[20] Cahn BR, Delorme A, Polich J.,Occipital gamma activation during Vipassana meditation, Cognitive Processing,vol. 11,2010,pp. 39–56.

[21] Akin M., Comparison of wavelet transform and FFT methods in the analysis of EEG signals, Journal Medical System, vol.26(3),2002,pp.241-247.

[22] C. Liu, P. Lo, Investigation of spatial characteristics of meditation EEG using wavelet analysis and fuzzy classifier, Proceedings of the fifth IASTED International Conference: biomedical engineering, 2007, pp.91 – 96.

[23] Kang-Ming Chang, Pei-Chen LO. , Meditation EEG interpretation based on Novel fuzzy-merging strategies and wavelet features. Biomedical Engineering Applications, Basis & Communications, vol.17 (4), 2005, pp.167-175.

[24] P.-C. Lo and Q. Zhu., Microstate analysis of alpha-event brain topography during Chan meditation, 8th International Conference on Machine Learning and Cybernetics,vol.2,2009,pp.717-721.

[25] Laxmi Shaw and Aurobinda Routray, A Critical comparison between SVM and k-SVM in the classification of Kriya Yoga Meditation state allied EEG, International WIE conference on Electrical and Computer Engineering, 2016.

[26] Laxmi Shaw, Aurobinda Routray, Statistical features extraction for multivariate pattern analysis in meditation EEG using PCA, IEEE EMBS International Student Conference.2016.

[27] Amin HU, Malik AS, Ahmad RF, Badruddin N, Kamel N, Hussain M, Chooi WT , Feature extraction and classification for EEG signals using wavelet transform and machine learning techniques, Australasian Physical and Engineering Sciences in Medicine ,vol.38(1),2015,pp.139–149.

[28] U. Orhan, M. Hekim, M. Ozer,EEG signals classification using the K-means clustering and a multilayer perceptron neural network model, Expert system with application, vol.38(10),pp.13475–13481,2011.

[29] Gonzalez RC, Woods RE, Digital image processing, 2nd edn. Prentice Hall, SL.2002.

[30] Nuwer, M., Comi, G., Emerson, R.,et al., IFCN standards for digital recording of clinical EEG, Electroencephalography and Clinical Neurophysiology,1998,pp.106:259-261.

[31] 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, Neuroscience Letter, vol. 310, 2001, pp.57–60.

[32] Amodio, P., Orsato, R., Marchetti, P., Schiff, S., Poci, C., Angeli, P., et al., Electroencephalographic analysis for the assessment of hepatic encephalopathy: comparison of non-parametric and parametric spectral estimation techniques, Clinical Neurophysiology, vol. 36, 2009, pp.107–115.

[33] Canteros, J. L., Atienza, M., Stickgold, R., & Hobson, J. A., Nightcap: A reliable system for determining sleep-onset latency. Sleep, vol. 25, 2002, pp.238–245.

[34] Jacobs GD, Friedman R.,EEG spectral analysis of relaxation techniques, Applied Psychophysiology Biofeedback, vol. 29(4), 2004,pp. 245–254.

[35] Jacobs, G. D., & Lubar, J. F.,Spectral analysis of the central nervous system effects of the relaxation response elicited by autogenic training, Behavioral Medicine,vol. 15,1989,pp. 125–132.

[36] West, M. A., Meditation and the EEG, Psychological Medicine, vol.10, 1980, pp. 69–375.

[37] Dean Cvetkovic, Irena Cosic, States of Consciousness: Experimental Insights into Meditation, Waking, Sleep and Dreams, Springer Science & Business Media.2011.

[38] Chandra, S., Sharma, G., Mittal, A. P., & Jha, D.,Effect of Sudarshan Kriya (meditation) on gamma, alpha, and theta rhythm during working memory task, International Journal of Yoga, vol.9(1), 2016,pp. 72–76.

[39] Sivananda Swami, Japa Yoga .A comprehensive treatise on Mantra-Sastra. Himalayas, India: A Divine