International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Analysis of EEG Changes during Different Phases of Menstrual Cycle in Adult Females

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Abstract: ***Female life cycle is associated with a number of hormonal milestones: like menarche,adolescent, reproductive and menopausal period. All these events and interventions alter the levels of sex hormones and may cause a change in the activity of the brain and EEG at large.Every woman undergoes major hormonal changes in hormone, body temperature, and metabolic rate, characterize the menstrual cycle of female subject. This study was carried out from 25th January 2014 to 24th April 2016 at S.C.B.Medicalcollege, Cuttack to study the Electroencephalographical changes and power spectral analysis during different phases of menstrual cycle. The subjects in the present study were 10 female students in the age group of 25-35 years, having regular menstrual cycle for 28 days. The effects of neurohormonal status on the EEG Alpha activity were studied in 10 women (25-35 years old) during different cycles.The psychometric and electroencephalographic (EEG) indices of α waves, basal body temperature, and salivary progesterone level were monitored every two or three days. The menstrual and follicular recording sessions occurred before the basal temperature rise caused by ovulation, the luteal recording session occurred after the increase in progesterone level by more than 20% compared to the day before, and the premenstrual recording sessions occurred after the decrease in progesterone level by more than 20% compared to the day before. The EEG, electromyographic (EMG) and electrocardiographic (ECG) characteristics of cognitive efficiency and psycho-emotional tension were recorded at rest and during task performance. The experiments were started in the menstrual phase in half the subjects and in the luteal phase in the other half. Psychometric characteristics, EEG Alpha activity, EMG and ECG indices were compared for all the five phases at rest and in response to cognitive task performance. The results have shown that all psychometric and α EEG indices are menstrual-cycle-dependent. The maximum cognitive fluency, α peak frequency, α band width, and power in the α_2 frequency band are observed in the luteal phase, while the maximum power in the low-frequency α_1 band, as well as visual and cognitive activation calculated from α power reduction, are observed in the follicular phase of the menstrual cycle. The hypothesis that EEG Alpha activity depends on the neurohormonal status is supported by the positive correlation of salivary progesterone level with the α peak frequency and the power in the α_2 band and its negative correlation with the power in the α_1 band. It is concluded that psycho-physiological recording sessions in women must be carried out with due consideration of the menstrual cycle phase.***

Keywords: Estradiol; Alpha frequency; Center frequency; EEG, Neurohormonal

1. Introduction

The Normal female life cycle is associated with a number of hormonal milestones: like menarche, adolescent, reproductive and menopausal period. All these events and interventions alter the levels of sex hormones and may cause a change in the activity of the brain and EEG at large. Every woman undergoes major hormonal changes in hormone, body temperature, and metabolic rate, characterize the menstrual cycle of female subject. Many women report that they experience, a feeling of difficulty to initiate activities, confront challenging situations and lack of concentration, suggesting transient changes in frontal lobe functions related with gonadal hormone levels. Gross electrical activity of the brain changes in parallel with changed hormone levels. The changes in performance tests coincides with increasing or decreasing alpha activity in the EEG, due to activation of monoaminergic pathway, known to be involved in steroid feedback. The menstrual cycle is a result of carefully orchestrated sequence of interactions among the hypothalamus, pituitary, ovary and endometrium, with the sex hormones acting as modulators and effectors at each level. Estrogen and progestin have potent effects on central serotonergic and opioid neurons, modulating both neuronal activity and receptor density. These sex hormones have activational effects and modulate brain activity through excitatory or inhibitory mechanism.

2. Material and Methods

This study "Analysis of Eeg Changes During Different Phases of Menstrual Cycle In Adult Females" was carried out from 25th January 2014 to 24th April 2016 at S. C. B. Medical College, Cuttack to study the Electroencephalographic changes and power spectral analysis during different phases of menstrual cycle of healthy adult female students.

The subjects in the present study were 10 female students in the age group of 25-35 years, having regular menstrual cycle for 28 days. None of the subjects had any neuroendocrine, neuropsychiatricand gynecological problems. All the students were right handed and were not under any medication. The electroencephalograph recording was done for 20 minutes, with 10 minutes EEG done with eye open and 10 minutes EEG with eye close.

1) During the luteal phase (day 15-28) on 14th or 15th day of cycle, when the estrogen and progesterone level is more.
2) During the follicular phase (day 1-14) on 1st or 2nd day of cycle, when the estrogen alone is raised.

The electrodes were placed according to 10-20 system of electrode placement. EEG was recorded from the disc electrode which are placed, bilaterally in frontal (F3, F4), Central (CZ) and occipital (O1,O2). The recording was conducted on a 32 channel digital EEG machine (Neurofax EEG-2110, Nihon Kohden, Japan). Monopolar referential

montage is used for recording, with each referred to the contra lateral ear. The electrical impedance was kept below 3K ohms. The EEG machine and the subject were grounded separately. The power spectral analysis of the signals was carried out with the sampling rate of 512 Hz (number of times the signal have been sampled per second). The EEG frequency bands were defined as follows Delta 0-4 Hz, Theta 4-8 Hz, Alpha 8-12 Hz and Beta 13-20 Hz. Topographic mapping of mean spectral power of Delta, Theta, Alpha and Beta bands was carried out.

3. Observations

Table 1: Alpha Activities in Eye Open and Eye Close State in Follicular Phase

Leads	Eye Open(EO)	Eye Close(EC)
F_3- A_2	10.21	21.35
F_4- A_1	11.23	23.46
C_Z- A_2	13.31	34.39
O_1- A_2	12.9	81.48
O_2- A_1	11.76	86.98

This table shows the comparison of Alpha activity during follicular phase in all the electrodes like F_3- A_2, F_4 – A_1, C_Z- A_2, O_1- A_2, O_2- A_1, in eye open & eye close state, where the Alpha activity is significantly increase in eye close state. The Alpha activities eye close state during follicular phase in all leads is higher than that in eye open state. The difference observed between eye open and eye close state is found to be statistically significant ($p<0.05$).

Table 2: Delta Activities in Eye Open and Eye Close State in Luteal Phase

Leads	Eye Open(EO)	Eye Close(EC)
F_3- A_2	319.18	78.94
F_4- A_1	386.04	85.64
C_Z- A_2	155.75	63.94
O_1- A_2	70.13	30.39
O_2- A_1	80.91	39.11

This table shows the comparison of Delta activity during luteal phase in all the electrodes like F_3- A_2, F_4 – A_1, C_Z- A_2, O_1- A_2, O_2- A_1, in eye open & eye close state, where the Delta activity is significantly increase in eye openstate. The Delta activity in eye open state during luteal phase in all leads is higher than that in eye close state. The difference observed between eye open and close state is found to be statistically significant ($p<0.05$).

Table 3: Different Waves during the Eye Open and Eye Close State in Follicular Phase

Leads	Delta		Theta		Alpha		Beta	
	Eye Open	Eye Close	Eye Open	Eye Close	Eye Open	Eye Close	Eye Open	Eye Close
F_3-A_2	279.37	131.04	19.83	17.75	10.21	21.35	11.47	10.46
F_4-A_1	257.28	108.73	19.36	19.68	11.23	23.46	12.45	11.86
C_Z-A_2	266.82	69.42	21.32	25.52	13.31	34.39	9.57	11.78
O_1-A_2	244.98	45.68	10.8	12.51	12.9	81.48	10.7	14.9
O_2-A_1	72.13	93.54	9.72	10.31	11.76	86.98	9.4	13.63

This table shows that the Alpha activity in Follicular Phase is significantly more during eye close state than in eye open state, in all the electrodes ($p<0.05$).In comparison with the other waves like Beta, Theta and Delta, where the increase of Alpha activity in eye close state is statistically not significant($p>0.05$).

Table 4: Different Waves During the Eye Open and Eye Close State in Luteal Phase

Leads	Delta		Theta		Alpha		Beta	
	Eye Open	Eye Close	Eye Open	Eye Close	Eye Open	Eye Close	Eye Open	Eye Close
F_3-A_2	319.18	78.94	22.47	15.12	12.58	22.09	15.64	14.4
F_4-A_1	386.04	85.64	24.21	13.61	12.4	20.84	14.43	11.82
C_Z-A_2	155.75	63.94	20.74	21.34	14.54	33.29	10.26	11.26
O_1-A_2	70.13	30.39	11.3	10.22	12.14	61.49	10.39	12.7
O_2-A_1	80.91	39.11	11.6	10.79	13	79.78	12.12	12.91

This table shows that the Delta activity in Luteal Phase is significantly more during eye open state than in eye close state, in all the electrodes ($p<0.05$).In comparison with the other waves like Beta, Theta and Delta, where increase of the Alpha activity in eye close state is statistically not significant ($p>0.05$).

4. Discussion

Our study shows a significant increase in Delta activity during eye open stage of luteal phase and a significant increase in Alpha activity during the eye closed state of the follicular phase which is consistent with the finding of Ehlers et al 1996, who stated that EEG Alpha activity differs significantly over the menstrual cycle. This finding does not correlate with the reports of Becker et al 1982, Kaneda et al 1997 and Solis et al 2004, who showed that there is increased alpha activity during luteal phase and increased Delta activity during the follicular phase. Increase alpha activity during follicular phase in our study may be responsible for the better performance in the periovulatory phase and the lower performance in the luteal phase is due to the increased Delta activity where $p<0.05$. Increased Delta activity in luteal phase is due to progesterone leading to slight arousal effect, possibly mediated by progesterone via the nor adrenergic system where $p<0.05$.And this increased Delta activity in luteal phase may also be responsible for the mood changes, which commonly experienced in the premenstrual phase. Physiological progesterone and estrogen levels during menstrual cycle modulate task demanding and planning, which is associated with specific EEG changes. Steroidal sex hormones (Estrogen and Progesterone) have an activation effect on the brain and modulate brain activity through excitatory or inhibitory mechanism. Hippocampus is

a target brain area for the action of steroid hormone. Estrogen induces structural and functional changes in hippocampal Neurons. Thus when reporting was done on the EEG of female subjects, the phase of the menstrual cycle should be considered. **EEG appears as a tool for clinical Gynaecological and Neuroendocrine correlation.**

5. Conclusion

Sex hormones acting as modulators and effectors at each level.These hormones have activational effects and modulate brain activities through excitatory or inhibitory mechanism. The predominance of delta activity was responsible for mood changes and lower performances of regular day to day activities, which was seen in the premenstrual and luteal phase, whereas the Alpha activity predominance in the follicular phases, might be due to the increase level of oestrogen, which was responsible for better performance in the routine lifecycle.

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