Effect of Intermittent Photic Stimulation (IPS) on Electroencephalogram (EEG) of females with Premenstrual dysphoric disorders (PMDD)

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ABSTRACT

Around seventy-five percent of women with regular menstrual cycles report unpleasant physical or psychological symptoms just before the beginning of a monthly menstrual cycle. For the majority of women, these symptoms are mild and tolerable. However, for a certain group of women, these symptoms can be disabling and may cause significant disruption in their lives and are often the reason for seeking medical treatment. Those symptoms are called as premenstrual syndrome (PMS), with the modern concept the severe form of PMS is named as premenstrual dysphoric disorders (PMDD). In order to assess an effect of intermittent photic stimulation on electroencephalogram (EEG) of females with PMDD, the current study was conducted on thirty females confirmed having PMDD based on research criteria (DSM-IV). Thirty female with symptomatic PMDD were selected, based on the inclusion and exclusion criteria. They were screened with questionnaire and research criteria (DSM-IV). After taking written consent, all the participants were explained about the procedure and anthropometric, cardiorespiratory variables were recorded followed by EEG recordings with 5, 10, 15, 20, 25, 30 Hz frequencies of intermittent photic stimulation were done. The first phase of EEG recordings was done before menses or during the peak of symptoms reported by them and were repeated immediately after menses. EEG recordings were dissected out into its constituent frequency bands by Fast Fourier Transformation. The data of EEG power spectra were non-normally distributed and hence subjected to log transformation and statistical analysis was done. The EEG power spectra were expressed as the mean ± standard deviation. Paired sample t-test was used for comparison of anthropometric variables, cardio-respiratory variables, and EEG power spectra between the premenstrual and postmenstrual recordings. The EEG power spectra of before the beginning of menstruation or during the peak of symptoms were compared with an EEG power spectra of immediately after the menses is over. There was significant ($p<0.05$) increase in beta activity at frontotempoparietal (F3, C3, T3 and P3) area of left hemisphere when premenstrual EEG recordings were compared with postmenstrual EEG among PMDD. Therefore the study concluded that the increased in beta activity at left hemisphere under intermittent photic stimulus among females with PMDD is indicative of the presence of anxiety, stress, insomnia, and obsessive or negative thinking.

Keywords:

Premenstrual dysphoric disorder (PMDD),
Electroencephalogram (EEG),
Intermittent photic stimulation (IPS)

I. INTRODUCTION

Most of the women in reproductive age group experience various emotional, behavioral and physical symptoms several days to weeks before their menstrual period and symptoms disappear following menstruation. These symptoms are generally called as Premenstrual syndromes (PMS). These symptoms may be mild to severe, and thereby causing significant impact on the quality of life. There are significant individual variations of symptoms among women with PMS. Depending on the severity of the symptoms of PMS, the functional impairment tend to be highest at home, followed by social, school, and occupational situations.[1] The 4th edition of Diagnostic and Statistical Manual of Mental disorders (DSM-IV)[2] have adapted diagnostic criteria for PMDD.

Intermittent Photic stimulation (IPS) is commonly used noninvasive method during routine electroencephalography for cerebral activation. It can be used for eliciting proximal EEG activity and also for localization of focal cerebral dysfunction.[3-5] The activating techniques by intermittent photic stimulation can bring out focal asymmetries or epileptiform activity in an EEG.[6] Previous study has shown increase in alpha and beta waves in an electroencephalogram of the female with PMDD during menstrual cycle as compared to age matched healthy control.[7] specifically, increase in slow EEG wave at the onset of menstruation.[8] The studies have shown the indirect and direct influence of light on mood and cognitive functions and also the light treatment has beneficial effects in non-seasonal and seasonal depression.[9-10] In the study done by Rode et al.[11] showed that figure comparison task given to women during menstrual cycle showed hemispheric asymmetry was more pronounced in early follicular phase but reduced in the luteal phase. However, the verbal task produced more pronounced left hemisphere dominance in the luteal phase and musical task produced the more asymmetry in the follicular phase. [12] So we aimed to see an effect of intermittent photic stimulation during EEG among the females with PMDD.

II. MATERIALS AND METHODS

The study consisted of thirty females of reproductive age between 18 to 30 years with regular menstrual cycle (28±7 days) confirmed having PMDD based on research criteria (DSM-IV). All subjects were undergraduates and postgraduates students of medical institute with no history psychiatric, neurological or any major medical illness. All the participating females were explained about the study and procedures. Detailed medical history and physical examinations were documented and informed written consents were taken. The subject selection was based on DSM-IV criteria. EEG recordings were preceded by anthropometric and cardiorespiratory variables measurements.

EEG recording and analysis

The first EEG recordings were done before menses or during the peak of symptoms reported and were repeated immediately after menses over. All subjects were instructed to relax and close eyes and photic stimulation of 5, 10 , 15, 20, 25, 30 Hz frequencies were administered in increasing order for 30 sec each with an interval of 10 sec; by using a photo stimulator and white flashing lamp placed 20 cm from the subject's eyes.

EEG records were visually inspected for the presence of any artifacts like an eye blink, detectable eye movement, and body movements. After visual inspection, three artifact-free-5-second epochs selected from each frequency band of intermittent photic stimulation. Selected epochs were place on Fast Fourier Transformation (FFT) method for decomposition of EEG waveforms into sine wave components in terms of respective frequencies in the ranges of delta (0.5-4.0 Hz), theta (4.0-7.0 Hz), alpha1 (7.0-10.0 Hz), alpha2 (10.0-13.0 Hz), and beta (13.0-32.0 Hz) bands. The power spectrum for each band obtained for different regions of the brain as provided by the selected montage was exported to Microsoft Excel worksheet files for further analysis. The powers from three epochs were averaged for each subject.

III. STATISTICAL ANALYSIS

The data obtained were exported to SPSS (version 18) and tested for normal distribution. The data of anthropometric variables, cardio-respiratory variables, were normally distributed and expressed in terms of mean ± standard deviation (SD). Log transformation of the EEG power spectra was done to normalize the data and statistical analysis was done. The EEG power spectra were expressed as mean ± SD.

Paired sample t-test was used for comparison of anthropometric variables, cardio-respiratory variables, and EEG power spectra between premenstrual recording and postmenstrual recording. A p-value of ≤ 0.05 was considered statistically significant.

IV. RESULT

There was no any stastistcal significance for the premenstrual anthropometric variables (age, weight, height, and BMI) and cardiorespiratory variables (systolic and diastolic blood pressure, pulse rate, respiratory rate, and arterial oxygen saturation), when compared with postmentrual recording. However, the premenstrual EEG power spectrum when compared with postmenstrual EEG between EEG of PMDD showed significantly increased beta activity at sites T3 (p=0.013), F3 (0.007), C3 (0.014); T3 (p=0.010), T5 (p=0.002), F3 (p=0.039), P3 (p=0.009); F7 (p=0.002), T3 (p=0.015), T5 (p=0.001), F3 (p=0.002), C3 (p=0.017), P3 (p=0.009); Cz (p=0.018), T4 (p=0.031), T6 (p=0.018), P4 (p=0.001), T3 (p=0.013), T5 (p=0.022), F3 (p=0.046), C3 (p=0.022), P3 (p=0.019), O1 (p=0.009); F3 (p=0.027), C3 (p=0.024) ; F3 (p=0.019), C3 (p=0.041), P3 (p=0.010), O1 (p=0.039) during photic stimulation with 5,10,15,20,25 and 30 HZs respectively as shown in the **table1.**

Table1. Comparison of EEG power spectrum between premenstrual and postmentrual recording under various frequency bands.

		Electrode sites	Fz	Cz	Pz	Fp2	F8	T4	T6	F4	C4	P4	O2	Fp1	F7	T3	T5	F3	C3	P3	O1
5Hz	Premenstrual	Mean	33.23	43.00	52.47	83.47	10.73	17.92	23.95	30.48	31.58	43.12	48.74	93.15	23.91	28.53	36.71	37.31	44.21	55.38	56.64
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	18.38	34.09	38.37	94.74	5.89	17.33	18.08	18.96	22.33	29.21	36.97	120.29	21.50	26.88	26.07	24.11	29.12	31.79	32.00
	Postmenstrual	Mean	33.83	43.34	49.55	62.51	12.76	16.12	23.44	33.61	31.97	37.74	45.22	83.64	23.83	15.95	24.69	24.08	28.15	45.29	47.45
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	20.72	32.25	40.74	47.90	8.22	13.51	14.48	35.80	19.98	22.27	27.70	66.54	32.62	11.06	16.71	19.20	15.20	37.25	35.30
		p	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**0.013**	NS	**0.007**	**0.014**	NS	NS
10 Hz	Premenstrual	Mean	45.55	53.60	61.22	126.38	14.14	20.84	28.35	39.65	39.90	49.73	62.36	140.28	34.34	35.01	50.25	46.30	53.22	69.32	86.69
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	32.36	33.78	35.70	150.92	9.14	21.98	16.06	25.66	22.99	32.29	43.47	191.37	31.69	37.07	38.44	35.12	38.53	43.46	55.83
	Postmenstrual	Mean	40.97	49.61	57.48	88.67	17.03	16.58	23.59	38.92	38.57	42.70	52.81	120.05	35.45	17.17	28.70	26.07	33.78	50.85	55.88
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	19.36	20.89	30.42	60.25	11.44	11.93	13.60	32.04	14.48	20.35	28.13	93.52	49.71	12.59	20.01	14.24	15.52	35.87	34.46
		p	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**0.009**	**0.010**	**0.002**	**0.039**	NS	**0.009**	NS
15 HZ	Premenstrual	Mean	45.34	60.34	72.25	225.50	16.73	22.82	31.32	41.66	42.94	64.20	75.18	270.91	70.78	74.11	73.59	90.05	101.54	109.81	100.86
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	24.92	38.69	40.35	356.91	11.74	20.65	21.56	32.80	22.91	37.16	54.75	473.88	91.41	108.06	95.17	105.76	115.55	105.14	76.24
	Postmenstrual	Mean	44.32	54.24	70.37	144.25	18.09	20.53	24.95	36.72	42.45	54.79	70.31	221.98	70.39	22.70	31.38	31.93	41.87	61.88	71.56
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	30.14	30.76	46.43	121.69	11.64	12.48	15.49	32.11	23.92	31.49	53.59	202.28	126.14	20.23	23.88	22.13	26.03	40.59	66.90
		p	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**0.002**	**0.015**	**0.001**	**0.002**	**0.017**	**0.029**	NS
20Hz	Premenstrual	Mean	48.79	57.08	74.69	198.17	16.58	22.06	32.46	42.21	43.90	65.35	74.83	214.51	57.88	54.22	68.37	61.36	76.92	96.11	114.80
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	25.52	28.22	39.59	293.15	9.81	16.69	25.22	22.30	21.97	38.73	58.89	382.86	68.09	81.02	76.02	71.67	94.57	90.37	88.55
	Postmenstrual	Mean	40.32	47.05	53.94	132.20	18.84	16.58	21.42	31.41	36.17	40.56	54.29	206.36	67.17	20.95	27.89	30.42	35.92	48.86	59.82
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	23.28	18.90	27.91	102.57	14.14	12.78	13.14	17.06	13.54	21.43	39.17	192.47	114.41	20.64	19.06	21.63	21.25	27.39	43.65
		p	NS	**0.018**	NS	NS	NS	**0.031**	**0.018**	NS	NS	**0.001**	NS	NS	NS	**0.013**	**0.022**	**0.046**	**0.022**	**0.019**	**0.009**
25Hz	Premenstrual	Mean	40.42	50.47	58.05	152.36	12.83	20.25	28.35	36.90	38.92	50.01	54.97	165.05	43.59	46.58	52.98	59.29	66.30	73.25	75.91
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	21.87	38.44	41.41	215.30	7.47	18.17	18.58	28.16	26.67	36.42	38.04	272.32	49.97	61.82	59.05	59.38	58.49	54.98	52.90
	Postmenstrual	Mean	41.56	49.32	53.08	105.37	16.18	19.06	24.43	33.98	39.41	44.83	45.50	168.69	58.79	22.97	28.61	31.79	42.92	50.80	47.89
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	30.87	41.27	42.38	92.75	13.51	14.17	17.94	27.64	28.36	36.61	30.22	154.18	103.85	27.41	26.57	29.05	41.86	39.39	34.96
		p	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**0.027**	NS	**0.024**	NS
30Hz	Premenstrual	Mean	38.52	43.62	52.34	155.70	12.68	18.94	27.10	34.75	34.64	45.24	50.88	177.91	42.56	41.61	49.79	54.37	62.25	71.44	76.10
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	21.03	23.64	28.39	230.76	7.42	20.35	18.82	24.57	18.04	26.57	33.84	293.23	47.72	52.11	50.30	52.46	56.85	56.61	53.63
	Postmenstrual	Mean	36.71	45.63	44.34	102.29	14.95	16.75	21.70	31.15	33.71	37.73	40.77	162.74	52.73	21.50	27.78	28.51	34.31	47.86	42.27
		±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
		SD	22.02	29.01	22.65	79.42	10.74	14.85	13.83	19.53	15.98	18.90	26.22	140.53	88.03	27.31	26.98	28.81	28.49	40.13	29.21
		p	NS	**0.014**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**0.019**	**0.041**	**0.010**	**0.039**

V. DISCUSSION

The aim of our study was to assess the impact of intermittent photic stimulations on electroencephalogram (EEG) of females with PMDD before menstruation and after menstruation. Our result showed a significant increase in beta activity at various regions of left hemisphere in PMDD with photic stimulation of frequencies ranging from 5 to 30 Hz in premenstrual EEG recordings.

This result is consistent with the study done in 1985[13] which reported that the greater difference in beta activity between the hemisphere during verbal than spatial task and also a significant effect of emotional valence in the temporal and parietal lobes. This study also showed the presence of more beta activity in the right temporal area during positive than during negative emotional task which correlated with the presence of negative thoughts as the features of PMDD. Perlis ML et al. [14] have demonstrated increase in beta activity is associated with primary insomnia which supports our hypothesis that females with PMDD also presents with difficulty falling asleep few days before their menses.

The cortical discharges vary with menstruation on high-intensity photic stimulation. [15] Our study has documented the increase in beta activity which correlates the changes in electrical activity of the brain during various phases of menstrual cycle. Bethany RL et al. [16] also found that early automatic visual processing is greater in women during mid-luteal phase of menstrual cycle compared to men.

The study done in 1949 [17] showed that rhythmic sensory stimulation at different frequencies can induce somatic, mental and emotional changes which also supports our result that significant increase in beta activity due to photic stimulations of various frequency in premenstrual recording of EEG but disappear in post menstrual recordings which infer with presence of emotional changes before the menses and disappears after menses.

An excessive high-beta (18-30 Hz) activity seen in several brain regions located in the frontotemporal regions among the patient with major depressive disorder was normalized and had complete disappearance of symptoms after the treatment with psychoneurotherapy.[18] This suggests that the normalization of high-beta activity in cortico-limbic/paralimbic regions can be associated with a significant reduction of depressive symptoms. This is also in the line of our findings that the significant increase in the beta activity before menstruation disappeared after menstruation in an EEG recording of the patient with PMDD. Study done by Ulett et al.[19] demonstrated that there is significant correlation between symptomatic anxiety proneness and dysphoria mediated by intermittent photic stimulation by flickering light which also supports our result as patient with PMDD experience with features of anxiety just before the menses and relives of symptoms after the menses.

In contrast to our finding, the study done by D.J Anderson et al. [20] showed a significant reduction in premenstrual symptoms by using photic stimulation with a flickering red light. In this study, seventeen women with PMS treated with a take-home flashing light device for 15 to 20 minutes per day throughout their cycle. Thirteen of the seventeen experienced a greater than 50% reduction in their symptoms which concluded that photic stimulation is an effective treatment for PMS. This study suggested that action of photic stimulation on circadian rhythms have a wider therapeutic application which can be useful for the treatment of premenstrual syndrome.

The study was done by Hans von G et al. [21] showed significant differences in the mood before and after photic stimulation. The photic stimulation produces an increase in theta activity [22] which explains that the subjective sleepiness experienced by the subjects is contradicting to our result. Significant improvement in behavioral outcomes in a CORT-induced mouse model of depression with LED-derived flickering photic stimulation compared with fluoxetine. [23] This suggests that rhythmical photic stimulation at alpha frequencies may aid in the improvement of the quality of life of patients with depression.

VI. CONCLUSION

Females with PMDD reveals a significant increase in high-frequency beta waves at the left hemisphere in an EEG recording under a various frequency of intermittent photic stimulation. This finding concludes that females with PMDD experience features of anxiety, depression, mood swing, negative thoughts, insomnias and emotional changes.

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