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RESEARCH ARTICLE

Study of auditory and visual reaction time across various phases of menstrual cycle

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ABSTRACT

Background: The reproductive system of women shows regular cyclic changes that teleologically may be regarded as periodic preparations for fertilization and pregnancy. These cyclical changes are also associated with cyclical changes in the level of ovarian steroids. Estrogen is said to have widespread effects throughout the brain regions involved in affective state as well as cognition. **Aims and Objectives:** This study was undertaken to observe the effect of gonadal hormones on auditory and visual reaction time (VRT) across various phases of menstrual cycle. **Materials and Methods:** The study was conducted on 30 healthy female volunteers having regular menstrual cycle belonging to the age group of 17-20 years studying in the first year MBBS at P.E.S. Institute of Medical Sciences and Research using pitch change 1000 Hz reaction timer. **Results:** The results of this study reveal that the auditory and VRT was highest during the mid-proliferative phase compared to premenstrual phase and mid secretary phase. **Conclusion:** Thus, the fluctuating levels of ovarian hormones across the normal menstrual cycle influence auditory and VRT and this fact can be taken into consideration during neurological and behavioral assessment of women.

KEY WORDS: Reaction Time; Premenstrual Phase; Mid Follicular Phase; Mid Secretory Phase

INTRODUCTION

The reproductive system of women shows regular cyclic changes that teleologically may be regarded as periodic preparations for fertilization and pregnancy. In humans, the cycle is called menstrual cycle and its most conspicuous feature is periodic vaginal bleeding that occurs with the shedding of uterine mucosa.[1] During menstruation, levels of estradiol and progesterone are low while the follicular phase is characterized by high estradiol levels and the luteal phase by high concentrations of both the hormones.[2] The fluctuations in hormonal levels affect not only the female reproductive tract but also many other tissues of the body.[3]

Gonadal hormones not only influence the reproductive functions but they also display neuroactive effects. Some behavioral and neurological symptoms - such as decreased concentration, nervous irritability, emotional instability, depression, and - tension are seen in women during the premenstrual phase[4] which may be due to the effect of gonadal hormones on neural functions. In females, the mood or psychometric performance changes have been reported during normal menstruation. Some neurophysiologic studies have demonstrated electroencephalogram changes with the menstrual cycle and changing estradiol levels during menstrual cycle have been shown to affect auditory and visual event-related potentials as well as latencies to right and left hemispheres.[2,5]

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Reaction time is defined as the time interval between the application of a stimulus and an appropriate voluntary response from the subject.[6] Reaction time acts as a reliable indicator of rate of processing of sensory stimuli by central nervous system and its execution in the form of motor response.[7]

It represents the level of neuromuscular coordination in which the body, through different physical, chemical and mechanical processes, decodes auditory reaction time (ART) and visual reaction time (VRT), which travel via afferent pathways and reach the brain as sensory stimuli.[8] Processing speed and motor speed appear to be dependent on cerebral dopaminergic systems, and ovarian steroids have widespread effects throughout the brain, on serotonin pathways, catecholaminergic neurons, the basal forebrain cholinergic system as well as the hippocampal formation, thus having measurable effects on affective state as well as cognition.[9] Clinical observations strongly suggest that changes in gonadal function modify auditory, olfactory and taste thresholds.[10] Thus, this study is an attempt to observe the effect of gonadal hormones on auditory and VRT across various phases of menstrual cycle.

MATERIALS AND METHODS

The study was conducted in the Department of Physiology, P.E.S. Institute of Medical Sciences and Research (PESIMSR), Kuppam, after obtaining the approval from Institutional Human Ethics Committee. 30 healthy female volunteers having regular menstrual cycle belonging to the age group of 17-20 years studying in the 1st year MBBS at PESIMSR were included for the study. Subjects with irregular cycles, history of thyroid disorders, history of color blindness, use of contraceptive pills, use of psychotropic drugs (sedatives, hypnotics, and tranquilizers), anti histaminics, antiepileptics, smokers, and those consuming alcohol were excluded from the study. Females with history of psychiatric illness or recent psychological trauma or sleep disorders were also excluded from the study. Informed consent was taken from all the subjects. Pitch change 1000 Hz reaction timer was used to measure auditory and VRT. The subjects were instructed to click on a button as quickly as possible when they see a red light for recording of VRT when she hears a click sound for recording auditory reaction time. The time was measured from the recorded data using audacity software.

In each volunteer, reaction time test was done during the following days:

1. One or 2 days before the expected date of menstruation, referred to as premenstrual phase
2. Middle of proliferative phase (10^{th}-12^{th} day)
3. Middle of secretary phase (21^{st}-23^{rd} day).[6]

RESULTS

The results were expressed as mean±standard deviation and analyzed using Student's paired *t*-test for comparison of means. $P < 0.05$ was considered significant.

Table 1 shows that ART was highest during the mid-proliferative phase and lowest during the premenstrual phase, the values being 0.185seconds and 0.178 seconds respectively and the p value being 0.001. The values of ART across the mid proliferative, mid secretory and premenstrual phase are also depicted in graph form (Figure 1).

Table 2 shows that VRT was highest during the mid-proliferative phase and lowest during the premenstrual phase, the values being 0.194 seconds and 0.189 seconds respectively and the p value being 0.024. The values of VRT across the mid proliferative secretory and premenstrual phase are also depicted in graph form (Figure 2).

DISCUSSION

Reaction time measurement includes the latency in sensory neural code traversing peripheral and central pathways, perceptive and cognitive processing, a motor signal traversing both central and peripheral neuronal structures and finally the latency in the end effector activation.[11]

Monthly oscillations in ovarian steroids induce uterine endometrium to enter different stages. The rising levels of estrogen during the mid and late follicular phase of the ovary induce the proliferative phase of uterine endometrium. After ovulation, the corpus luteum produces high levels of progesterone along with estradiol, and the luteal phase of ovary switches the proliferative phase of uterine endometrium to the secretory phase. In the absence of fertilization and implantation, the corpus luteum regresses and dies which leads to dramatic decline in the levels of progesterone and estrogen. The end of luteal function permits the rise in follicle stimulating hormone (FSH) about 2 days before the onset of menstruation. The rise in FSH levels recruits a crop of large antral follicles to begin gonadotropin-dependent growth which causes slow rise in estrogen.[12]

Thus ovarian steroids (estrogen and progesterone) undergo cyclic changes in a normal menstrual cycle. During proliferative phase, progesterone production is low and estrogen levels increase gradually and during secretary phase, both estrogen and progesterone are increased with prominent increase in progesterone.

Besides affecting the hypothalamus and other brain areas related to reproduction, ovarian steroids have widespread effects throughout the brain, on serotonin pathways,

Table 1: Auditory reaction time of the subjects (in seconds) across various phase of menstrual cycle

Phases of menstrual cycle	P	MP	MS
Mean±SD	0.178±0.018	0.185±0.02	0.181±0.02
P	0.001 (P vs. MP)	0.042 (MP vs. MS)	0.14 (MS vs. P)

P: Premenstrual, MP: Mid proliferative, MS: Mid secretary, SD: Standard deviation

Table 2: Visual reaction time of the subjects (in seconds) across various phase of menstrual cycle

Phases of menstrual cycle	P	MP	MS
Mean±SD	0.189±0.019	0.194±0.02	0.190±0.02
P	0.024 (P vs. MP)	0.022 (MP vs. MS)	0.09 (MS vs. P)

P: Premenstrual phase, MP: Mid proliferative, MS: Mid secretary, SD: Standard deviation

catecholaminergic neurons, and the basal forebrain cholinergic system as well as the hippocampal formation, a brain region involved in spatial and declarative memory.[13]

The results of this study reveal that the auditory and VRT was highest during the mid-proliferative phase compared to premenstrual phase and mid secretary phase.

Prolongation of ART and VRT could be due to the female sex hormones that cause salt and water retention, which in turn influence the process of axonal conduction and availability of neurotransmitters at the synapse.[15] Although both progesterone and estrogen are reproductive hormones the actions of estrogen on the cognitive functions are more apparent. Estrogen exerts a variety of actions on many regions of the nervous system that influence higher cognitive functions, pain mechanisms, fine motor skills, mood, and susceptibility to seizures.[9]

The probable explanation for the prolongation of reaction time during mid-proliferative phase could be due to the effects of estrogen. Estrogens modify the speed of transmission at the brain stem by secretion of gamma-amino-butyric acid (GABA) in a counter-regulatory fashion. It has been seen that estrogen downregulate 5 hydroxytryptamine receptors in motor and frontal cortex, which modulates GABAergic transmission[16] GABA being an inhibitory neurotransmitter, an endogenously produced anxiolytic-like compound favors influx of chloride ions into the cells. Increased chloride entry into brain cells hyperpolarizes the membrane and thereby inhibits neural transmission. This neural transmission inhibition affects sensory-motor association and processing capability of central nervous system.[14,15]

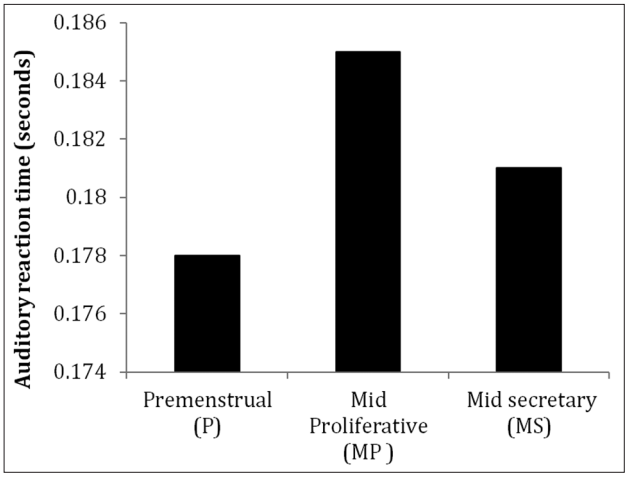

Figure 1: Auditory reaction time of the subjects (in seconds) across various phase of menstrual cycle

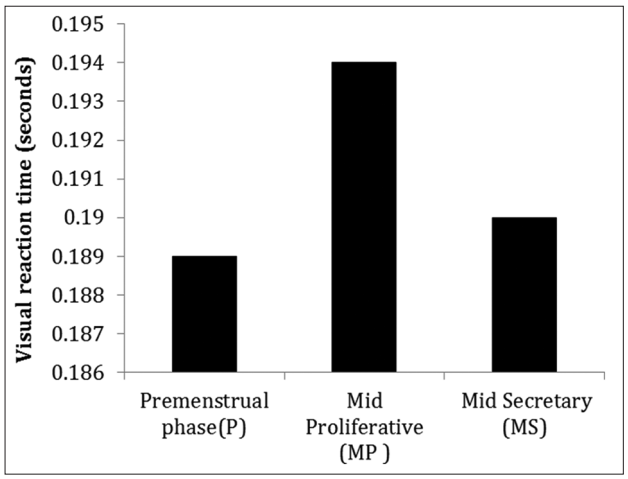

Figure 2: Visual reaction time of the subjects (in seconds) across various phase of menstrual cycle

Progesterone decreases the sensitivity of the neurons to estrogen and also decreases the estrogen potentiated GABA release. This would explain for decreased reaction time during the mid-secretory phase and premenstrual phase as the levels of progesterone is increased during this phase.[17]

CONCLUSION

The results of this study reveal that the fluctuating levels of ovarian hormones (estrogen and progesterone) across the normal menstrual cycle influence auditory and VRT which is an indirect measure of sensory-motor association of an individual. This fact can be taken into consideration during neurological and behavioral assessment of women since ovarian steroids produce a variety of effects on the brain, influencing diverse non-reproductive processes such as cognitive function, seizure susceptibility, pain sensitivity, motor coordination, mood regulation, cardiovascular regulation, neuroprotection, and many others.[18] Estrogens being pleiotropic hormones synthesized not only by ovaries

but also by glia in central nervous system and Schwann cells in peripheral nervous system. Thus, creating a microenvironment having a wide spectrum of effects such as neuroprotective and antiapoptotic or supporting neurogenesis and regeneration.[19] The implications of this study can be explored further by measuring the hormone levels during various phases of menstrual and finding its relation with the reaction time of an individual.

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