

## Characterization of Auditory Acuity in Different Phases of Menstrual Cycle



### Medical Science

**KEYWORDS :** Menstrual Cycle, Auditory Acuity, Pre-menstrual phase, Post-menstrual phase.

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### ABSTRACT

**Background:** Auditory functions are very important for communication, which in turn have leveraging influence on several sectors of lifestyle. Hormonal changes in menstrual cycle can affect fluid homeostasis, which may affect

Auditory functions and thus may impinge women's performance in various aspects of lifestyle.

**Aim:** To determine the Audiological status in different frequencies in different phases of the menstrual cycle.

**Objectives:**

- 1) To perform Pure Tone Audiometry in pre-menstrual phase and post-menstrual phase.
- 2) To compare the results of Audiometry in pre-menstrual phase and post-menstrual phase.

**Methods:** After procuring the Ethical Committee clearance, this prospective study was conducted on 60 healthy female subjects with regular menstrual cycle with consideration of inclusion and exclusion criteria. Written informed consent was taken and Menstrual History Questionnaire was administered. Each subject was instructed to come to the lab twice, once during pre-menstrual phase (18th to 25th day), and then during post-menstrual phase (8th to 12th day) of the Menstrual cycle. Anthropometric measurements were taken. Audiometric tests were performed in both the ears for Auditory Acuity using Pure Tone Audiometry with ARPHI 500 MK in both the phases. Using appropriate tools, results were compiled and statistically analyzed.

**Results:** Statistically significant increase in weight was seen in pre-menstrual phase ( $P < 0.01$ ). Hearing threshold values were compared between the two phases and statistically significant decibel loss was observed at all frequencies in both the ears for air conduction and bone conduction in the pre-menstrual phase ( $P < 0.01$ ).

**Conclusion:** Statistically significant decibel loss was seen in both the ears for all frequencies in both air conduction and bone conduction in pre-menstrual phase attributing to increased Ovarian Hormones modulating the auditory functions at various levels of auditory system.

### INTRODUCTION

Women constitute 48.5% of Indian population, and in them reproductive age group women constitute 22.2% of Indian population (Ministry of Statistics and Programme implementation [MOSPI] 2013). Every woman in reproductive age group undergoes monthly rhythmical cyclical pattern of menstrual cycle. The levels of ovarian hormones Estrogen and Progesterone vary according to each phase of regular menstrual cycle; this variation is controlled by the hypothalamic-hypophyseal-ovarian system (C Ishii et al. 2009).

The Menstrual cycle may be defined as the interval between the first day of the menstruation and first day of the next menstruation. (C Ishii et al.2009) A well defined, predictable pattern of hormonal fluctuations takes place over the course of an Menstrual Cycle. In Eumenorrhic females, an average menstrual cycle has 28 days but may range from 20 to 45 days. Some Studies divide The Menstrual cycle as pre-menstrual, menstrual and post-menstrual phase. Apart from the Menstruation, varying concentrations of Estrogen and Progesterone differentiate the phases of Menstrual cycle. In a 28 day cycle, in post-menstrual Phase (8<sup>th</sup> day -12<sup>th</sup> day) both the hormonal levels are low and in Pre-Menstrual Phase (18<sup>th</sup> -25<sup>th</sup> day) both Estrogen and Progesterone levels are High.(Owen JA, 1975 & Landgren BM et al 1980 & Williams TJ et al 1997)

Most of the changes in women take place in the pre-menstrual phase that arises between 10 to 14 days before menstruation and disappears after it begins. These changes include fluid retention, weight gain, increased energy demands, changes in glucose uptake, a slower gastrointestinal transit time, altered lipid profiles, altered Vitamin D, calcium, magnesium and iron metabolism, emotional hypersensitivity, generalized pain and changes in dietary habits (C Ishii et al. 2009).

Previous study done by Andrew et al (1992) describes women experiencing dizziness, aural pressure and low frequency hearing loss during pre-menstrual time. Because of this possible influence of ovarian hormones in different phases of menstrual cycle on auditory function, there has been an interest in seeking auditory status that might affect hearing during these phases.

Thus, the purpose of this study was to verify whether there was any change in the auditory acuity in women during pre-menstrual phase and post-menstrual period.

### OBJECTIVES

1. To perform Pure Tone Audiometry in pre-menstrual phase and post-menstrual phase
2. To compare the results of Audiometry in pre-menstrual phase and post-menstrual phase

### MATERIALS AND METHODS

This prospective study intended to measure auditory acuity in females of reproductive age group and the study was done from April 2014 to October 2014 in the Lifestyle Lab attached to Victoria Hospital of Bangalore Medical College and Research Institute.

### Recruitment

After procuring the Ethical committee clearance, 60 healthy female subjects were recruited for the study based on inclusion and exclusion criteria.

### Inclusion Criteria

1. Regular Menstrual Cycle
2. Intact External Acoustic Meatus
3. Written Informed Consent

### Exclusion Criteria

1. History of specific hearing disorders

2. History of residing in noisy environment
3. History of Ingestion of Ototoxic medications
4. Usage of Contraceptives in last 6 months
5. Ovarian or uterine disorders
6. Kidney or Liver disorders
7. Alcohol consumption and smoking
8. Any Chronic Illness

### Methodology

Sixty healthy female subjects of reproductive age group with regular menstrual cycle gave their written informed consent after knowing the aims and procedure. Menstrual history questionnaire was administered to all subjects in order to rule out the subjects who were on contraceptives and irregular menstrual cycle, and also to know the duration of menstrual cycle and to determine the phase of menstrual cycle. Subjects were instructed clearly to visit lifestyle lab twice, that is during pre-menstrual phase (18<sup>th</sup> to 25<sup>th</sup> day), and post-menstrual phase (8<sup>th</sup> to 12<sup>th</sup> day) of the menstrual cycle. In every visit, general physical examination and systemic examination was done. Height was measured to the nearest 0.5cm on wall mounted stadiometer and weight to nearest 0.1 kg on standard weighing scale with subjects dressed in light clothing and no footwear. Otological examination was done using otoscope and tuning fork, which was followed by Pure Tone Audiometry.

### Pure Tone Audiometry

The method is based on American Society for Speech and Hearing Association [ASHA] 2005 Guidelines for manual pure-tone threshold audiometry. The purpose of pure tone audiometry is to determine hearing thresholds levels for pure tones.

The threshold of hearing is defined as the level of a sound at which, under specified conditions, a person gives 50 percent of correct detection responses on repeated trials. The normal test sound is pure tone pulses at standardized frequencies in range of 125-8000 Hz and the normal presentation mode is monaurally by means of a standardized type of earphones.

After familiarizing the subject about the procedure, the subject was made to wear earphones for air conduction assessment. First, sound at 1000 Hz was presented followed by 2000, 4000, 6000, and 8000 Hz and then again 1000 Hz, followed by 500 and 250 Hz. The intensity was increased in ascending order, 5 dB each time till the subject made a positive response by raising one hand. When the subject could hear the faintest sound, again the intensity was decreased by 10 dB, and another ascending series begun.

For Bone Conduction Assessment, measurements were performed at Octave Intervals from 250 Hz to 4000Hz and at 3000Hz. Standard bone-conduction vibrator was placed on mastoid or forehead. The initial frequency was tested at 1000 Hz. After the initial test frequency, the frequencies at 2000, 3000, and 4000 Hz were tested which was followed by a retest of 1000 Hz before testing 500 and 250 Hz.

The auditory thresholds were measured using ARPHI 500 MK 1 audiometer. All the results thus obtained were tabulated in standard Audiogram. For conventional audiometry, the vertical scale is to be designated *hearing level in decibels*; the horizontal scale is to be labeled *frequency in hertz*.

### STATISTICAL ANALYSIS

The Statistical software SPSS 17.0 was used for the analysis of data. Microsoft Word and Microsoft Excel have been used to generate graphs and tables. Individual comparisons between the two phases were performed with Student's t test. Results were considered significant if P values were less than 0.01. All results are expressed as Mean  $\pm$  SD.

## RESULTS

**Table 1: Comparison of Weight of subjects in pre-menstrual and post-menstrual phases**

Average Pre-menstrual Weight (Kg)	Average Post-menstrual Weight (Kg)	P-Value
53.02	52.01	< 0.01

**Figure 1: Comparison of Weight of subjects in pre-menstrual and post-menstrual phases**

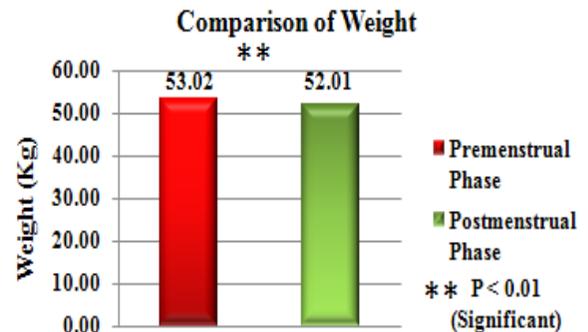


Table 1 and Figure 1 show the statistically significant increase in the mean average weight in the pre-menstrual phase ( $P < 0.01$ )

**Table 2: Comparison of Hearing thresholds in decibels for different frequencies in Pre-menstrual and Post-menstrual phases (Mean  $\pm$  SD) in Right Ear (Air Conduction)**

Frequency	Air Conduction of Right Ear (n = 60)		
	Pre-menstrual	Post-menstrual	P-value
250 Hz	23.92 $\pm$ 4.23	20.33 $\pm$ 4.77	< 0.00001
500 Hz	21.17 $\pm$ 5.55	17.41 $\pm$ 5.08	< 0.00001
1000 Hz	19.92 $\pm$ 5.79	17.33 $\pm$ 5.25	0.000328
2000 Hz	18.67 $\pm$ 5.81	15.83 $\pm$ 5.22	< 0.00001
4000 Hz	16.67 $\pm$ 6.42	14.33 $\pm$ 5.16	0.000528
6000 Hz	14.83 $\pm$ 6.17	11.83 $\pm$ 5.29	< 0.00001
8000 Hz	12.67 $\pm$ 5.56	10.17 $\pm$ 4.60	< 0.00001

**Figure 2: Comparison of Hearing thresholds in decibels for different frequencies in Pre-menstrual and Post-menstrual phases (Mean ± SD) in Right Ear (Air Conduction)**

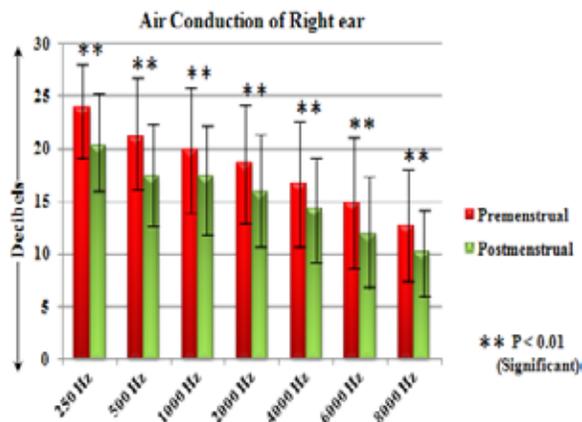


Table 2 and Figure 2 show statistically significant increase in the hearing thresholds at all frequencies in the Pre-menstrual phase in the right ear (Air Conduction) (P < 0.01)

**Table 3: Comparison of Hearing thresholds in decibels for different frequencies in Pre-menstrual and Post-menstrual phases (Mean ± SD) in Left Ear (Air Conduction)**

Frequency	Air Conduction of Left Ear (n = 60)		
	Pre-menstrual	Post-menstrual	P-value
250 Hz	23.67 ± 4.77	20.33 ± 4.77	< 0.00001
500 Hz	20.67 ± 5.33	17.41 ± 4.91	< 0.00001
1000 Hz	20.67 ± 5.33	17.41 ± 4.91	< 0.00001
2000 Hz	19.17 ± 5.14	16.08 ± 5.30	< 0.00001
4000 Hz	16.67 ± 5.26	14.08 ± 4.91	0.000007
6000 Hz	14.50 ± 4.85	12.58 ± 4.74	0.001489
8000 Hz	12.58 ± 4.83	9.91 ± 4.16	< 0.00001

**Figure 3: Comparison of Hearing thresholds in decibels for different frequencies in Pre-menstrual and Post-menstrual phases (Mean ± SD) in Left Ear (Air Conduction)**

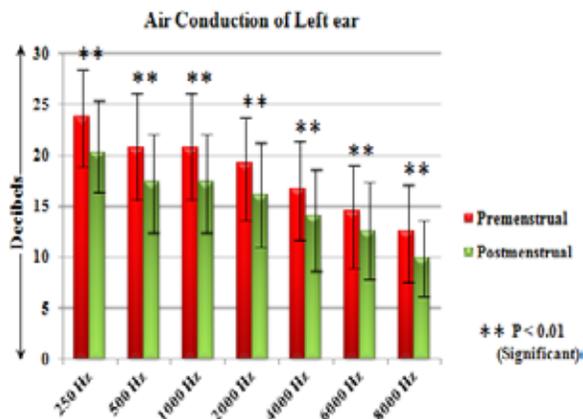


Table 3 and Figure 3 show statistically significant increase in the hearing thresholds at all frequencies in the Pre-menstrual phase in the left ear (Air Conduction) (P < 0.01)

**Table 4: Comparison of Hearing thresholds in decibels for different frequencies in Pre-menstrual and Post-menstrual phases (Mean ± SD) in Right Ear (Bone Conduction)**

Frequency	Bone Conduction of Right Ear (n = 60)		
	Pre-menstrual	Post-menstrual	P-value
250 Hz	27 ± 5.06	23.17 ± 5.75	< 0.01
500 Hz	23.5 ± 6.26	19.83 ± 5.67	< 0.01
1000 Hz	22.17 ± 6.73	19.5 ± 5.94	< 0.01
2000 Hz	21 ± 6.56	18.33 ± 5.80	< 0.01
4000 Hz	19.08 ± 7.51	17 ± 5.61	0.01

**Figure 4: Comparison of Hearing thresholds in decibels for different frequencies in Pre-menstrual and Post-menstrual phases (Mean ± SD) in Right Ear (Bone Conduction)**

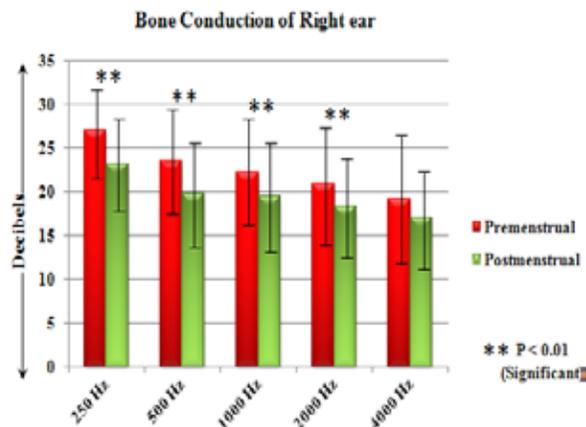


Table 4 and Figure 4 show statistically significant increase in the hearing thresholds at all frequencies in the Pre-menstrual phase in the right ear (Bone Conduction) ( $P < 0.01$ )

**Table 5: Comparison of Hearing thresholds in decibels for different frequencies in Pre-menstrual and Post-menstrual phases (Mean  $\pm$  SD) in Left Ear (Bone Conduction)**

Frequency	Bone Conduction of Left Ear (n = 60)		
	Pre-menstrual	Post-menstrual	P-value
250 Hz	26.5 $\pm$ 5.23	22.83 $\pm$ 5.00	< 0.01
500 Hz	23.08 $\pm$ 5.83	19.5 $\pm$ 5.10	< 0.01
1000 Hz	23.33 $\pm$ 5.65	20.75 $\pm$ 5.51	< 0.01
2000 Hz	21.92 $\pm$ 6.04	19.25 $\pm$ 5.81	< 0.01
4000 Hz	19.5 $\pm$ 6.09	16.33 $\pm$ 5.81	< 0.01

**Figure 5: Comparison of Hearing thresholds in decibels for different frequencies in Pre-menstrual and Post-menstrual phases (Mean  $\pm$  SD) in Left Ear (Bone Conduction)**

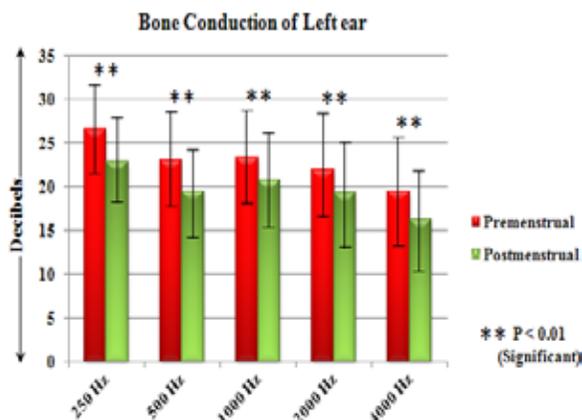


Table 5 and Figure 5 show statistically significant increase in the hearing thresholds at all frequencies in the Pre-menstrual phase in the left ear (Bone Conduction) ( $P < 0.01$ )

## DISCUSSION

Table 1 and Figure 1 show statistically significant increase in mean body weight in pre-menstrual period. These results are in unison with several previous studies done by Mehta V et al (1993), S. Das et al (1997) and Andrews et al (1992). In pre-menstrual phase, there is increase in ovarian hormones. Weight gain can be attributed to increased estrogen levels which in turn has aldosterone like activity which causes fluid and water retention and thus increase in weight gain (P.J. Haybach, 1999).

Table 2, Figure 2, Table 3 and Figure 3 show audiometric thresholds of hearing for different frequencies for air conduction in both the ears in pre-menstrual and post-menstrual phase. Statistically significant decibel loss was observed at all frequencies

for air conduction in both the ears in the pre-menstrual phase. This is in congruous with the study done by C Ishii et al (2009) but incongruous with the study done by S. Das et al (1997). As discussed earlier elevated estrogen levels can cause fluid retention which causes swelling around the Eustachian tube which interferes with middle ear function. This in an undefined way may lead to hearing impairment (P.J. Haybach, 1999). During pre-menstrual phase there is also increase in Progesterone levels which leads to temporary decompensation due to its depressant's property which leads to temporary hearing impairment (P.J. Haybach, 1999).

Table 4, Figure 4, Table 5 and Figure 5 show audiometric thresholds of hearing for different frequencies for bone conduction in both the ears in pre-menstrual and post-menstrual phase. Statistically significant decibel loss was observed at all frequencies for bone conduction in both the ears in pre-menstrual phase. This is in accordance with the study done by C Ishii et al (2009). In pre-menstrual phase viscosity of the blood increases for unknown reasons, which in turn may compromise blood flow to inner ear and causes changes in fluid balance which in turn produces mild hearing loss. (P.J. Haybach, 1999).

During pre-menstrual phase, there is increase in Estrogen levels. Estrogen has an influence at the cochlear level. At the cochlear level, estrogen receptors alpha ( $ER\alpha$ ) and beta ( $ER\beta$ ) have been identified in the inner ear including spiral ganglion type-I cells, the stria vascularis and cochlear blood vessels in both humans and animal models (rats and mice) (Stenberg et al., 2001 and 1999). The presence of these receptors suggests that estrogen influences auditory transmission and affects fluid electrolyte balance in the cochlear fluids (Lee & Marcus, 2001). In the inner ear, potassium channels KCNQ1-KCNE facilitates the  $K^+$  recycling in endolymph (Geoffrey W. Abbott, 2014). Estrogen decreases secretion of  $K^+$  by inhibition of these potassium channels via a nongenomic mechanism and thus causing hearing impairment due to potassium imbalance (Lee & Marcus 2001). Additionally, Estrogen receptors in cochlear blood vessels influences auditory function by modulating cochlear blood flow (Laugel et al., 1987).

During pre-menstrual phase, there is also an increase in Progesterone levels. Progesterone receptors have not been identified in the auditory system, but progesterone may cross-react with other steroid receptors (such as glucocorticoid and mineral corticoid receptors) present in the cochlea or more proximal areas of auditory system (Lang et al 1990, Nathan et al 1999). Progesterone and its metabolites may influence the auditory system through its interaction with the steroid binding sites on GABA-A receptors acting as GABA-A agonist and thus having an inhibitory action on vestibular nuclei that are involved with the optokinetic, Vestibulo-ocular and Vestibulospinal reflexes (Darlington CL et al., 2001, Follessa et al., 2001). Progesterone also decreases 5-HT levels and this may affect auditory processing indirectly (Birzniece et al., 2006).

Thus, hearing impairment can be attributed to increased ovarian hormones and its modulatory effect on Auditory processing at different auditory levels.

## CONCLUSION

Results of this study show statistically significant decibel loss in both ears at all frequencies for both air conduction and bone conduction in pre-menstrual phase. This can be attributed to increased Ovarian hormones modulating the Auditory functions at various levels of Auditory system, by direct action through the receptors within the auditory system, and also by indirect actions like modulating blood supply, modulating the fluid electrolyte balance of the body fluids and cochlear fluids, and modulating the effects of neurotransmitters along the auditory pathways.

## LIMITATIONS

1. Small sample size
2. Serum Analysis of Estrogen and Progesterone in both the phases would have enhanced the quality of the present study.

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