Effects of Menstrual Cycles on VOR Gain Functions

Sujeet Kumar Sinha[1] Alfarghal Mohamad[2] Suman Penwal[1]

[1]Department of Audiology, All India Institute of Speech and Hearing, Mysore, Karnataka, India
[2]Department of ENT, King Abdul Aziz Medical City, Jeddah, Saudi Arabia

Address for correspondence Sujeet Kumar Sinha, PhD, Department of Audiology, All India Institute of Speech and Hearing, Manasagangothri, Mysuru - 570006, Karnataka, India (e-mail: sujeetaudiology@aiishmysore.in).

Ann Otol Neurotol ISO 2021;4:69–73.

Abstract

Purpose The aim of the present study was to assess the vestibuloocular reflex (VOR) gain function and VOR gain asymmetry during the various phases of the menstrual cycle in young healthy female participants. The study also aimed to characterize the presence or absence of corrective saccades during the various phases of the menstrual cycle.

Method Twenty-nine young healthy females participated in the study. The video head impulse test (vHIT) was performed in lateral, left anterior right posterior, and right anterior left posterior plane during the various phases of the menstrual cycle to see the changes in VOR gain function and VOR gain asymmetry ratio changes.

Results A repeated measure analysis of variance test did not show any significant main effect for the VOR gain function and VOR gain asymmetry ratio in various phases of the menstrual cycle in all the participants. The result suggested no changes in VOR gain function and VOR asymmetry ratio in healthy females during the menstrual cycle. Also, there was an absence of saccades in the entire participants group during the various phases of the menstrual cycle.

Conclusions As the VOR gain function does not change during the various phases of the menstrual cycle in young healthy females, there is no need to consider the various phases of the menstrual cycle while testing any female participant during the vHIT test.

Keywords
- ► video head impulse test
- ► menstruation cycle
- ► VOR gain

Introduction

The menstrual cycle is the regular natural change in the uterus and ovaries that make pregnancy possible in females.[1] During the menstrual cycle, levels of hormones in healthy females differ during different phases of the cycle. The level of estrogen and progesterone in the body has a dynamic regulation during the ovarian cycle. Estrogen may directly affect steroid receptors in the cochlea, which have been identified both in animals and humans.[2-4]Sampio[5] reported changes in calcium, magnesium, vitamin D, iron metabolism in the body, emotional hypersensitivity, generalized pain, and dietary habits changes during the luteal phase. The concentration of $Na^+/K+$ ions in the cochlea fluid also changes during the menstruation cycle.[5]

It has also been reported that estrogen and progesterone modulate the cochlear blood supply and the cochlear fluids electrolyte balance.[6,7] These changes in the inner ear function result in changes in various auditory processes, such as pure tone thresholds, spontaneous otoacoustic emissions, auditory brainstem responses, speech evoked auditory brainstem response, and auditory event-related potentials.[8-13]

Published online
September 10, 2021

DOI https://doi.org/10.1055/s-0041-1735416
ISSN 2581-9607

During the luteal phase, the amplitude of N1-P2 peak in auditory late latency responses significantly reduces compared with the menstrual and follicular phase of females menstrual cycle.[9] It has also been reported that the latency of wave V of auditory brainstem responses increases during the follicular phase and latency of wave V of auditory brainstem responses decreases during the luteal phase of the menstrual cycle[11] There are also reports suggesting an increase in amplitude and decrease in latency of frequency following responses during the menstrual cycle's mid-phase.[13] Females perform better on dichotic listening tasks during the menstrual cycle's follicular phase, indicating the influence of estrogen level on dichotic listening in women.[14]

As the inner ear's cochlea and vestibular compartments are interconnected with ductus reunions, the inner ear chemical composition changes can affect both the cochlea and the vestibular system during the menstrual cycle in young healthy women. Various reports suggest changes in some of the ocular motor functions in females during the menstrual cycle. Ishii et al[15] reported an alteration in the frequency of spontaneous saccades, spontaneous nystagmus, positional nystagmus different from benign paroxysmal positional vertigo typical nystagmus, and abnormal caloric test findings during the menstrual cycle. Abdel Nabi et al[16] reported spontaneous nystagmus and positional nystagmus in females premenstrual period. It has also been reported that Meniere's disease symptoms exacerbate during the late luteal phase in females.[17] Shahin et al[18] reported better postural stability during the menstrual cycle's mid-phase.

However, some other reports suggest that the latency and the amplitude of the vestibular evoked myogenic potentials (VEMP) do not change during the various phases of the menstrual cycle in young healthy demales.[19,20] There is a dearth of information on how the vestibuloocular reflex (VOR) gain function changes during the various phases of the menstrual cycle in young healthy females. Recording the VOR reflex in females is crucial as it might affect the video head impulse test (vHIT) interpretations during the various phases of the menstrual cycle. This will help the clinician rule out the possibility of misdiagnosing a case and creating different standard norms for females.

vHIT is a recent test in vestibular test battery that assesses the VOR function in individuals with different vestibular pathologies. The test–retest reliability of the vHIT in individuals with normal hearing is excellent.[21] vHIT is helpful in the diagnosis of various vestibular disorders such as vestibular neuritis, Meniere's disease, benign paroxysmal positional vertigo, vestibular migraine, and posttraumatic vertigo.[22-24]

Aims and Objectives

The current study aimed to see the variations in VOR gain and VOR gain asymmetry ratios of the three semicircular canal planes during the various phases of the menstrual cycle in young healthy females. The aim was also to look for the presence or absence of any saccades during the menstrual cycle three phases.

Method

Participants

Twenty-nine healthy female participants in the age range of 18 to 23 years were recruited for the study. All the participants had normal hearing threshold, "A" type tympanogram in both the ears with the presence of ipsilateral and contralateral reflexes. All the female participants had a regular menstrual cycle and had no complaints of polycystic ovarian disease or any other medical problems related to the menstrual cycle. These participants were not using any contraceptives or steroids. The participants had no vestibular complaints before the testing. The participants were informed about the objective of the study and an informed consent was obtained from all the participants before the testing. The study was conducted as per the guidelines of the Ethical Committee at the Institute.

Procedure

Using modified Hughson and Westlake procedure,[25] pure tone thresholds were measured for air conduction between 250 and 8,000 Hz and bone conduction between 250 and 4,000 Hz for all the participants. Tympanometry was done for all the participants using 226 Hz probe tone. The acoustic

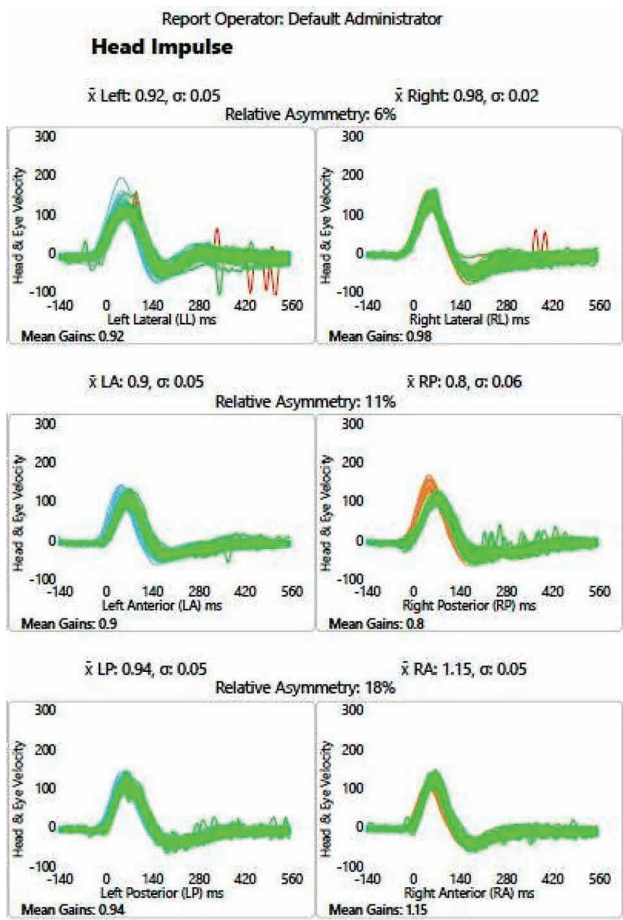

Fig. 1 Waveforms of video head impulse test results of all six semicircular canals from three different planes for the first phase of menstruation cycle.

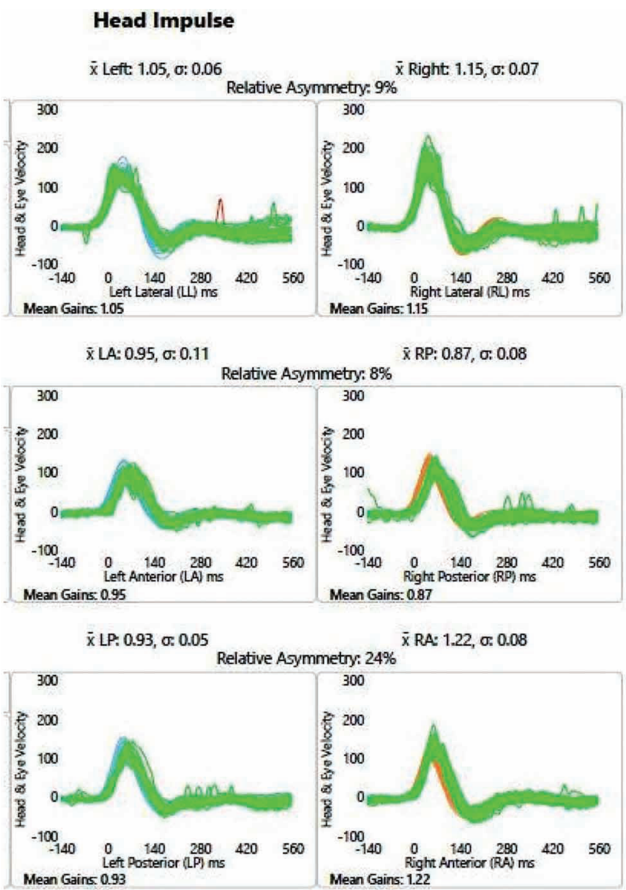

Fig. 2 Waveforms of video head impulse test results of all six semicircular canals from three different planes for the second phase of the menstruation cycle.

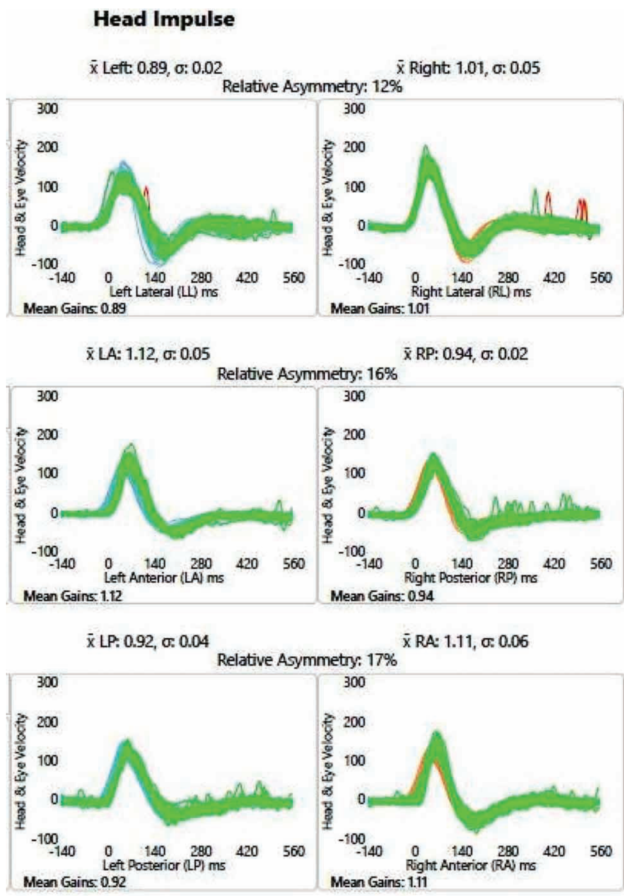

Fig. 3 Waveforms of video head impulse test results of all six semicircular canals from three different planes for the third phase of menstruation cycle.

reflexes were elicited for ipsilateral and contralateral stimulation for 500, 1,000, 2,000, and 4,000 Hz.

All the participants had undergone a vHIT during the three phases of the menstrual cycle. The three phases were a follicular phase (1–4 days), a luteal phase (12–15 days), and the menstrual phase (22–25 days). For vHIT test, the participants were made to sit on a nonadjustable chair, 1 m away from the target. The target was adjusted to avoid the reflections on the pupil image and fixed at the eye level. The participants were asked to fix their visual gaze on the target. The examiner adjusted the soft band of the vHIT goggles to a comfortably tight position on the head of the participant. The testing was performed by giving the head thrust for all the six semicircular canals. vHIT was performed in the lateral plane, left anterior right posterior (LARP) plane, and right anterior right posterior (RALP) plane. The head thrusts were given abruptly 20 times for each canal. The eye movements during the evaluation were recorded with the help of a high-speed digital infrared camera in-built in the hardware. Also, the gyroscope fixed on the goggle recorded the head velocity.

Results

VOR gain and VOR gain asymmetry were calculated for all the participants in three phases of the menstrual cycle. VOR gain for one of the participants for three phases of the menstrual cycle is given in ►**Figs. 1** to **3** , respectively.

The mean and standard deviation for the VOR gain and asymmetry values for all the three phases are given in ►**Tables 1** and **2** , respectively.

The repeated measure analysis of variance (ANOVA) revealed no significant main effect for the VOR gain values during the three phases of the menstruation cycle in the lateral plane for the left lateral canal [$F(2, 56) = 1.54$, $p = 0.22$], the right lateral canal[$F(2, 56) = 1.89$, $p = 0.16$]; and in LARP plane for left anterior canal [$F(2, 56) = 1.04$, $p = 0.36$], right posterior canal [$F(2, 56) = 1.12$, $p = 0.33$]. However, there was a significant main effect for the VOR gain values between the phases for the RALP plane in the right anterior canal [$F(2, 56) = 3.34$, $p = 0.04$] and left posterior canal [$F(2, 56) = 3.63$, $p = 0.03$]. Bonferroni pairwise comparison revealed significant differences between phase I and phase II of the menstrual cycle in both the right anterior and left posterior canal VOR gain function ($p < 0.05$).

Further, repeated measure ANOVA revealed no significant main effect for the VOR gain asymmetry ratio for the lateral plane [$F(2, 56) = 0.08$, $p = 0.93$], LARP [$F(2, 56) = 0.92$, $p = 0.41$], and RALP planes [$F(2, 56) = 0.1$, $p = 0.91$], during the three phases of the menstrual cycle. Also, there was an

Table 1 Mean and standard deviation values of gain in three phases of the menstrual cycle

Plane	Canal	Mean VOR gain (Phase I)	Standard deviation	Mean VOR gain (Phase II)	Standard deviation	Mean VOR gain (Phase III)	Standard deviation
Lateral	Left	0.98	0.18	1.03	0.19	1.00	0.16
	Right	1.08	0.15	1.11	0.19	1.07	0.14
RALP	Right Anterior	0.88	0.14	0.94	0.16	0.95	0.12
	Left Posterior	0.83	0.11	0.89	0.10	0.90	0.12
LARP	Left Anterior	0.86	0.13	0.89	0.12	0.90	0.13
	Right Posterior	0.80	0.09	0.81	0.09	0.83	0.11

Abbreviations: LARP, left anterior right posterior; RALP, right anterior left posterior; VOR, vestibuloocular reflex.

Table 2 Mean and standard deviation values of VOR gain asymmetry in three phases of the menstrual cycle

Plane	Mean VOR gain asymmetry (Phase I)	Standard deviation	Mean VOR gain asymmetry (Phase II)	Standard deviation	Mean VOR gain asymmetry (Phase III)	Standard deviation
Lateral	9.96	6.61	10.34	5.95	9.75	7.57
LARP	13.24	8.08	12.31	7.86	10.68	8.92
RALP	14.13	11.51	15.13	8.99	14.65	8.59

Abbreviations: LARP, left anterior right posterior; RALP, right anterior left posterior; VOR, vestibuloocular reflex.

absence of saccades in all the participants during the menstrual cycle's three phases.

Discussion

Understanding the results in the context of hormonal fluctuations during the menstrual cycle and their effect on the VOR gain function is essential for differential diagnosis of vestibular disorders. Despite the well-known effects of hormonal changes in inner ear physiology, the present study indicates no VOR gain differences in the menstrual cycle's three phases.

Previous studies have found the presence of several hormones in the inner ear. As these hormones are present in the inner ear, patients with hormonal deficiency, hormonal replacement therapy, and hormonal hypersecretion may cause an abnormal auditory function.[11,26] Several studies have found alterations in the auditory function during the different phases of the menstrual cycle.[27,28] These alterations in the auditory functions could be due to the changes in the concentration of hormones, affecting the inner ear homeostasis in the different phases of the menstrual cycle in females.[29,30]

Since the inner ear consists of the cochlea and the vestibular system, the hormone's concentration could also affect the peripheral vestibular system. However, there are equivocal findings on the hormonal influences on vestibular system functions. Sinha et al[19] recorded cervical (cVEMP) during the three phases of the menstrual cycle in 20 healthy female participants to see the effect of hormonal changes on cVEMP. They also noted no significant impact of hormonal changes during the different phases of the menstrual cycle on the latency or amplitude parameters of cVEMP. Similarly, Sinha and Sahu[20] reported no significant effect of hormonal changes during the menstrual cycle on latency or amplitude parameters of ocular VEMP.

However, several other studies have reported a significant change in various vestibular functions such as saccadic eye movements, directional preponderance, and caloric test results.[16] These authors have hypothesized that in cases with peripheral nystagmus, dizziness and vertigo may be due to salt and water retention occurring in the premenstrual period; this condition is caused by estrogen rise, progesterone, and aldosterone. However, such hormonal changes may not be affecting all the women equally or may not be affecting all the vestibular functions equally in all the females during the menstrual cycle.

Ishii et al[15] reported various vestibular symptoms such as giddiness, vomiting, headache, and nausea occur only in 5 to 20% of the female participants. Darlington et al.[30] also observed that hormonal changes during the menstrual cycle affect the lateral sway in female participants and not the anterior–posterior sway. Additionally, they reported that central vestibular functions such as the optokinetic system are not affected by the hormonal changes during the different phases of the menstrual cycle. The authors concluded that the lateral sway variation is not directly related to the vestibular system but could arise from multiple sources. Hence, we hypothesize that hormonal changes occurring during the menstrual cycle may not influence the VOR gain and VOR gain asymmetry in female participants during different phases menstrual cycle.

However, there was a significant difference in the VOR gain values between the first and the second phase of the menstrual cycle for the RALP plane in the right anterior canal and left posterior canal. Such isolated differences in VOR gain values between the two phases of the menstrual cycle may not be significant. Also, the absence of any saccades in all the participants indicates the absence of any peripheral pathology in all the participants.

Conclusions

The results of the study indicate no significant change in VOR gain function and VOR gain asymmetry during the three phases of the menstrual cycle in healthy females. It can be concluded that there is no need to consider the menstrual cycle as one of the criteria while administering and interpreting the vHIT test.

Conflict of Interest

The authors report no conflict of interest.

References

1 Silverthorn DU, Ober WC, Garrison CW, Silverthorn AC, Johnson BR. Human Physiology: An Integrated Approach. San Francisco: Pearson/Benjamin Cummings; 2010

2 Stenberg AE, Wang H, Sahlin L, Hultcrantz M. Mapping of estrogen receptors α and β in the inner ear of mouse and rat. Hear Res 1999;136(1-2):29–34

3 Stenberg AE, Wang H, Fish J III, Schrott-Fischer A, Sahlin L, Hultcrantz M. Estrogen receptors in the normal adult and developing human inner ear and in Turner's syndrome. Hear Res 2001;157(1-2):87–92

4 Charitidi K, Meltser I, Tahera Y, Canlon B. Functional responses of estrogen receptors in the male and female auditory system. Hear Res 2009;252(1-2):71–78

5 Sampio HAC. Nutritional aspects related to menstrual cycle. Rev Nutr 2002;15(3):309–317

6 Laugel GR, Dengerink HA, Wright JW. Ovarian steroid and vasoconstrictor effects on cochlear blood flow. Hear Res 1987;31(3):245–251

7 Lee JH, Marcus DC. Estrogen acutely inhibits ion transport by isolated stria vascularis. Hear Res 2001;158(1-2):123–130

8 Stein DG. Brain damage, sex hormones and recovery: a new role for progesterone and estrogen? Trends Neurosci 2001;24(7):386–391

9 Walpurger V, Pietrowsky R, Kirschbaum C, Wolf OT. Effects of the menstrual cycle on auditory event-related potentials. Horm Behav 2004;46(5):600–606

10 Serra A, Maiolino L, Agnello C, Messina A, Caruso S. Auditory brain stem response throughout the menstrual cycle. Ann Otol Rhinol Laryngol 2003;112(6):549–553

11 Al-Mana D, Ceranic B, Djahanbakhch O, Luxon LM. Hormones and the auditory system: a review of physiology and pathophysiology. Neuroscience 2008;153(4):881–900

12 Bhatt I, Phillips S, Richter S, et al. A polymorphism in human estrogen-related receptor beta (ESRRβ) predicts audiometric temporary threshold shift. Int J Audiol 2016;55(10):571–579

13 Prabhu P, Banerjee N, Anil A, Abdulla A. Role of sex hormones produced during menstrual cycle on brainstem encoding of speech stimulus. Eur Arch Otorhinolaryngol 2016;273(11):3647–3650

14 Carneiro CDS, Almeida AA, Ribas A, et al. Hormones and auditory perception: study of dichotic listening in women during the menstrual cycle. Int Arch Otorhinolaryngol 2019;23(1):70–76

15 Ishii C, Nishino LK, Campos CA. Vestibular characterization in the menstrual cycle. Rev Bras Otorrinolaringol (Engl Ed 2009;75(3):375–380

16 Abdel Nabi EA, Motawee E, Lasheen N, Taha A. A study of vertigo and dizziness in the premenstrual period. J Laryngol Otol 1984;98(3):273–275

17 Andrews JC, Ator GA, Honrubia V. The exacerbation of symptoms in Menière's disease during the premenstrual period. Arch Otolaryngol Head Neck Surg 1992;118(1):74–78

18 Shahin A, Ulas YH, Deniz E. Effects of menstrual periods on postural stability in eumenorrheic female group. Sci Res Essays 2012;7:3053–3057

19 Sinha SK, Neupane AK, Gururaj K. Menstrual cycle effects on sacculocollic reflex pathway. Hear Balance Commun 2017;15(4):252–259

20 Sinha SK, Sahu M. Menstrual cycle effects on otolith-ocular reflex pathway. Journal of Indian Speech Language & Hearing Association 2019;33(1):18

21 Bansal S, Sinha SK. Assessment of VOR gain function and its test-retest reliability in normal hearing individuals. Eur Arch Otorhinolaryngol 2016;273(10):3167–3173

22 MacDougall HG, Weber KP, McGarvie LA, Halmagyi GM, Curthoys IS. The video head impulse test: diagnostic accuracy in peripheral vestibulopathy. Neurology 2009;73(14):1134–1141

23 Blödow A, Pannasch S, Walther LE. Detection of isolated covert saccades with the video head impulse test in peripheral vestibular disorders. Auris Nasus Larynx 2013;40(4):348–351

24 Sommerfleck PA, González Macchi ME, Weinschelbaum R, De Bagge MD, Bernáldez P, Carmona S. Balance disorders in childhood: main etiologies according to age. Usefulness of the video head impulse test. Int J Pediatr Otorhinolaryngol 2016;87:148–153

25 Carhart R, Jerger JF. Preferred method for clinical determination of pure-tone thresholds. J Sp Hear Dis 1959;24(4):330–345

26 Malik V, Shukla GK, Bhatia N. Hearing profile in hypothyroidism. Indian J Otolaryngol Head Neck Surg 2002;54(4):285–290

27 Al-Mana D, Ceranic B, Djahanbakhch O, Luxon LM. Hormones and the auditory system: a review of physiology and pathophysiology. Neuroscience 2008;153(4):881–900

28 Gurbuzler L, Yelken K, Aladag I, Eyibilen A, Koc S. Comparison of transient and distortion-product otoacoustic emissions during the luteal and follicular phases of the menstrual cycle. Ear Nose Throat J 2012;91(8):322–334

29 Hederstierna C, Hultcrantz M, Collins A, Rosenhall U. Hearing in women at menopause. Prevalence of hearing loss, audiometric configuration and relation to hormone replacement therapy. Acta Otolaryngol 2007;127(2):149–155

30 Darlington CL, Ross A, King J, Smith PF. Menstrual cycle effects on postural stability but not optokinetic function. Neurosci Lett 2001;307(3):147–150