ORIGINAL ARTICLE

Variation in the gaze, caloric test and vestibular-evoked myogenic potential with advancing age

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Abstract

Objectives: The present study was aimed to investigate age related changes on Caloric test, Gaze Test and Vestibular Evoked Myogenic Potential (cVEMP). **Materials and Methods:** The participants included 50 individuals ranging from 20-70 years having no complaint of dizziness or any major illness. The basic audiological test battery was carried out followed by Caloric test, Gaze Test and the VEMP. **Results:** There was no consistent pattern seen on the caloric test and gaze test with advancing age while VEMP showed significant increase in latency and decrease in amplitude of both P13 and N23 as the age advances. **Discussion:** The comparison of the mean SPV values do not show an age related pattern because the caloric test does not challenge the semicircular canal system enough so as to reveal its defects. The age related changes in the cVEMP parameters could be attributed to the age related degeneration in the vestibular sense organ

Keywords: Gaze test, Caloric test , Vestibular evoked myogenic potential

Introduction

Vestibular system consist of mainly three semicircular canals that responds to angular acceleration (head turn) and an otolith organ that responds to linear acceleration (up/down, forward and backward). They are in conjunction with ocular and proprioceptive system, functioning to maintain equilibrium by means of Vestibulo Ocular Reflex (VOR) and the Vestibulo Spinal Reflex (VSR). VOR helps in angular acceleration and stable gaze when the head is moving whereas VSR helps in linear acceleration and to maintain postural stability during movements.[1]

Among the currently available vestibular test battery, the caloric test is a valuable tool which offers an assessment of the lateral semicircular canal which is innervated by superior vestibular nerve. It is the only portion of the test battery which assesses unilateral labyrinthine function.[2] There are several variants of the caloric test, but the bithermal caloric test is currently the gold standard test which is called as the 'Alternate binaural bithermal caloric test (ABB).[3] On the other hand, the cVEMP is recorded by measuring the potential release of the sternocleidomastoid muscle from a contracted state provoked by delivering auditory stimuli to the ipsilateral ear.[4] It is a useful and non invasive method to determine if the saccule and the inferior vestibular nerve are functioning adequately. Gaze test is another part of videonystagmography test battery which assesses predominantly the integrity of central vestibular system.

Age related morphological changes in the vestibular system at peripheral and central level i.e. end organs, hair cells, nerve fibers, Scarpa's ganglion cells, vestibular nucleus neurons and Purkinge cells are well documented in many studies. More severe degeneration of the saccular macula as compared to the utricular macula after the age of 60 years has been reported by numerous investigators.[5-7] A decrease in the number of macular sensory cells and hair cells in the cristae ampullares with increasing age is also well documented in the

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literature.[8,9] Age related deterioration was also seen in the vestibular nerve fibers and Scarpa ganglion cells.[10-12]

Numerous investigators have also reported the age related physiological changes in vestibular system using rotational chair test, caloric test and VEMP. It has been documented that some parameters of the rotational chair test has been affected while others show no significant differences.[13,14] An effect of age on VOR has been also documented well through the caloric test.[15]It was revealed that the parameters of the caloric test were dependent on age but they did not demonstrate an inverse relationship between the strength of the response and the increasing age. Few other authors documented that parameters related to the caloric test show no significant pattern with age.[16,17] However, few studies showed that slow component velocity across age groups have been observed to be increasing in the caloric test especially in the warm irrigation.[18]

In contrast to caloric test, the VEMP test has been observed to indicate consistent age related effects on vestibular system. A significant decrease in the VEMP amplitude, increase in thresholds and variable latency parameter has been indicated by many researchers.[19-27] Whereas significant decline only after the age of 60 years has been reported by earlier investigators.[28,29]

In summary, there are equivocal results in the notion of the age related anatomic deterioration leading to reduced physiologic vestibular function. Hence the present study was undertaken in order to investigate the age related changes in the gaze test, caloric test and the VEMP. Moreover, the elderly population has been observed to be at a high risk for falling due to various reasons, among which balance disorders and dizziness are considered as potent causes.[30-32] Thus, any consistent pattern observed between the age and the vestibular functioning would further help in early identification and management of the geriatric population.

Materials and Methods

The participants of the study included 50 individuals ranging from 20-70 years who had no complaint of dizziness. They were further divided into five groups (Group A- 20 to 30 yrs, Group B- 30 to 40 yrs, Group C- 40 to 50 yrs, Group D- 50 to 60 yrs and Group E- 60 to 70 yrs). The subjects had pure tone audiometric thresholds within 25 dBHL at all frequencies, except subjects in group E and D, who had a sloping sensorineural hearing loss ranging from mild to moderate degree (i.e. pure tone average ranging from 20 to 40 dBHL). Individuals with a history of cervical spine pathology, occular malalignment, traumatic head injury, Road Traffic Accident (RTA), cerebrovascular accident (CVA), vertebrobasilar insufficiency (VBI), Psychotic/neurotic disorders and hypertension or cardiac problem were excluded from the study.

Procedure

The basic audiological test battery was carried out followed by Caloric test and Vestibular Evoked Myogenic Potential (VEMP). Participants were explained about the study in detail by using a Participant's information sheet and written consent was taken to participate in the study. They were instructed against the consumption of caffeinated beverages or food 4 hours prior to testing and alcohol or Antivertiginous medicines 48 hours prior to test. They were also asked to wear loose comfortable clothing during the time of testing. They were asked to refrain from applying eye makeup or oil on the head. Alternate binaural bithermal caloric test and Gaze test was performed using SYNAPSYS Digital- Nystagview V3.2 RevL with Ulmer video nystagmoscopy.Videonystagmography with monocular approach was performed on all the participants in which the eye movements were recorded using an infrared video camera. Once the participants were seated in a comfortable position, the goggles were placed on the face and the tension of head band was adjusted as per required. The goggles were placed such that there was no light entering the eyes. First, the gaze test was done followed by caloric test and cVEMP.

For gaze test, all the participants were asked to fixate visually on stationary targets placed directly in front of them. First, the recording was done with vision enabled condition at the centre for 30 Sec then to 30 degree to the right side of the centre point for 30 sec and finally to 30 degree to the left side of the centre point for 30 seconds. The recording was analysed for the presence of any nystagmus at either of these points.

Alternate binaural bithermal caloric test was carried out on all the participants. All the participants were made to lie down in supine position with the head anteroflexed in 30 degrees throughout the testing and the VARIO air caloric irrigator was used to irrigate the ear with cold air and warm air. The temperatures maintained for the cold irrigation was 27 °C ±0.4 °C and 44 °C ± o.4 °C for warm irrigation. The irrigation of warm and cold air was delivered separately in both ears one at a time, starting with a warm stimulus to the right ear, then to left ear, followed by a cold stimulus to the right ear and then finally to the left ear. Each irrigation was delivered for duration of 45 seconds. A break of 6-10 min was given after each stimulation, allowing the inner ear fluids to return to their normal temperature. Slow phase velocity was recorded for all the warm as well cold irrigation in the caloric test. The maximum nystagmus activity was identified in a time window of approximately 60 to 90 seconds after the irrigation for 45 sec.

Unilateral weakness was also calculated by considering the maximum SPV values of each irrigation. The unilateral weakness was determined by comparing the sum of the SPV of the right ear warm and right ear cold and the sum of SPV for left ear warm and left ear cool responses. Following formula was used to measure the Unilateral Weakness:

$$\frac{(RC+RW)-(LC+LW)}{(LC+LW)+(RC+RW)}\times 100 = \text{Unilateral weakness}$$

Where, RW - Right ear warm response, RC - Right ear cold response, LW- Left ear warm response, LC- Left ear cold response.

Lastly, the right-beating (right warm + left cool) responses were compared to left-beating (left warm + right cool) responses to determine if a directional preponderance (DP) was present. Following formula was used to measure the Directional Preponderance :

$$\frac{(LC+RW)-(LW+RC)}{(LC+LW)+(RC+RW)}\times 100 = \text{Directional preponderance}$$

Where, RW - Right ear warm response, RC - Right ear cold response, LW- Left ear warm response, LC- Left ear cold response.

Patient's alertness was maintained throughout the test by giving suitable mental tasks such as asking the patient to describe a room in their house or asking him/her to perform mental arithmetic.

Following the caloric, VEMP test was carried out on all the participants. All the participants were placed in a comfortable environment and made to sit in an upright position on an arm chair. The electrode montage for VEMP testing included a non-inverting electrode on the middle of the sternocleidomastoid muscle (SCM), an inverting electrode on the top of the sternum or its junction with the clavicle and the ground electrode on the forehead. The supraaural head phones were placed on the participants through which acoustic stimulus i.e. clicks were presented. The subject was asked to turn their head to one side (opposite to the ear which was stimulated) to tense the sternocleidomastoid muscle (SCM) using a visual target.

The Nicolet Viking Quest Master software V8.1 was used to record VEMP. The impedance and EMG activity was also monitored. Once low impedance and good EMG activity was achieved, acoustically evoked VEMPs were recorded. The stimulus used was 500 Hz tone pip at 95 dBnHL at the rate of 5.1/sec with 300 sweeps. The recording was done twice to check for its reliability and stored in the computer.

Results

On gaze test no abnormal nystagmus was noted even when subject was asked to look at five different stationary points at different which were placed at different angles.

On caloric test SPV values were analyszed for warm as well cold irrigations for all participants across different age groups and is represented in the Figure 1.

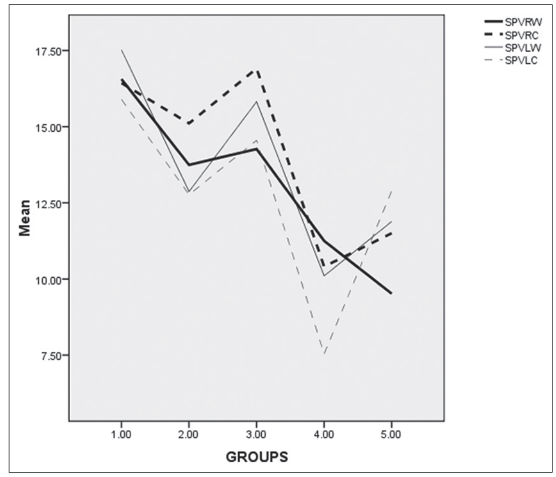

Figure 1: Mean and standard deviation of slow phase velocity for warm and cold irrigation across different age groups

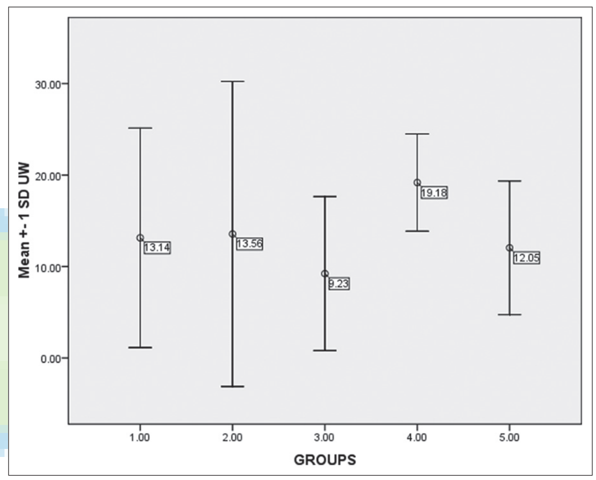

Figure 2: Mean and standard deviation of unilateral weakness and directional preponderance

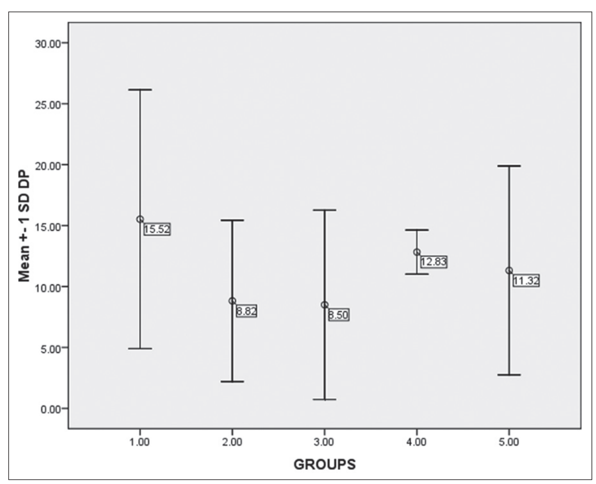

Figure 3: Mean and SD of directional preponderance

It was observed that mean slow phase velocity (SPV) for the right warm irrigation was 16.56°/sec, 13. 74°/sec, 14.26°/sec, 11.25°/sec, and 9.52°/sec whereas mean SPV values for right cold irrigation are 16.43°/sec, 15.11°/sec, 16.90°/sec, 10.4°/sec and 11.50 °/sec. for group A, B, C, D, E respectively. Similarly mean slow phase velocity (SPV) for left warm irrigation is 17.52°/sec, 12.87°/sec, 15.82°/sec, 10.10°/sec and 11.88 °/sec and 15.82°/sec, 12.77°/sec, 14.55°/sec, 17.54°/sec and 12.89°/sec.

UW and DP was also computed using the SPV values across four irrigation values for all individuals. Then mean and standard deviation (SD) for UW and DP was calculated across five groups which are represented in Figures 2 and 3, respectively.

Multivariate analysis of variance (MANOVA) was also carried out to assess the significant effect of age on the various parameters of the caloric test, that is, SPV, DP, and UW. Multivariate analysis of variance revealed that there exists a significant difference in the SPV values of the left cold [F (4,45) =3.254, $P < 0.05$] and left warm [F (4,45) =2.631, $P < 0.05$] across five groups; however, there was no significant difference observed between right warm and right cold. In order to determine particularly among which of the five groups a significant difference exists, Bonferroni *post hoc* test was also performed. The *post hoc* analysis revealed that there is a statistically significant difference in the SPV of left cold irrigation and warm irrigation between group A and group D; group B and group D; and group C and group D.

On VEMP test, responses could be recorded in all individuals below the age of 60 years, that is, prevalence rate was 100%. However, in individuals above the age of 60 years the prevalence rate dropped to 60%. The mean and SD of the latency, amplitude, and the peak to peak amplitude of both the ears were obtained for P13, N23 peaks [Tables 1-3].

One way analysis of variance was used to assess the significant effects of age on the various parameters of the VEMP test. The statistical analysis revealed that there is a significant difference in the P13 latency [F (4,95) =13.16, $P = 0.000$], N23 latency [F (4,95) =6.46, $P = 0.000$], P13 amplitude [F (4,95) = 8.209, $P = 0.000$], N23 amplitude [F (4,95) =16.27, $P = 0.000$] and peak to peak amplitude [F (4,95) =12.00, $P = 0.000$] among the five groups. In order to determine particularly among which of the five groups a significant difference, Bonferroni *post hoc* test has was performed. There was no significant difference was seen for latency, amplitude, and peak to peak amplitude of cVEMP among the groups A, B, C, and D. However, there was a statistically significant difference in the latency of P13 between group A and group E; group B and group E; group C and group E; group D and group E. Similarly, there was a statistically significant difference in the latency of N23 and peak to peak amplitude of p13–N23 was observed.

Table 1: Mean and standard deviation of latency and amplitude of P13

Groups	Latency (ms)		Amplitude (µV)		*N*
	Mean (ms)	SD	Mean (µV)	SD	
A	16.58	2.42	24.1	18.04	20
B	16.67	1.84	36.98	24.04	20
C	17.46	2.91	20.56	14.47	20
D	17.7	3.0	18.68	9.53	20
E	21.85	2.9	8.95	4.58	20

M: Mean, SD: Standard deviation, N: Total numbers of participants

Table 2: Mean and standard deviation of latency and amplitude of *N* 23

Groups	Latency (ms)		Amplitude (µV)		
	Mean (ms)	SD	Mean (µV)	SD	
A	25.17	2.7	73.95	31.8	20
B	24.64	1.80	50.82	38.56	20
C	24.66	2.97	36.80	21.58	20
D	25.66	3.33	41.27	19.22	20
E	29.18	5.0	9.47	3.8	20

M: Mean, SD: Standard deviation, *N*: Total numbers of participants

Table 3: Mean and standard deviation of peak to peak p13-N23 amplitude

Groups	Mean	SD	*N*
A	78.65	48.66	20
B	71.09	41.73	20
C	46.73	23.84	20
D	45.93	25.77	20
E	18.11	2.7	20

M: Mean, SD: Standard deviation, *N*: Total numbers of participants

Discussion

The findings of the present study are discussed subsequently with regard to each parameter of the caloric and VEMP test. The findings of the present study are in accordance with few of the earlier investigators who have reported mean SPV values in degree per second to be 26.09 for cold and 34.77 for warm air irrigation with a SD of 7.6 and 12.43 respectively and overall higher SPV values for warm irrigation as compared to cold irrigations.[16-18] The SPV values in the present study are lower than some of the above mentioned studies; this could be due to the mode, temperature and the duration of stimulation. Similarly, the mean value of unilateral weakness in the present study is in the range of 10 to 30 %. This finding is in congruence with the findings reported in the literature.[33,34] While few investigators have report that the mean UW values to be 7.35% (±4.81) for air stimulation and 7% (±5.83) for water stimulation[16,17]. The UW value tends to be negative when the left responses are stronger while they are positive if the right responses are stronger. However in the present study only the magnitude of SPV was considered and the positive and negative sign was ignored while taking the mean.[33,34]

On MANOVA test, results of the present study indicated that though some of the parameters of caloric test seemed to be affected by age, yet no consistent pattern was observed among the five groups as a function of age. This is in accordance with the earlier studies who have measured the effect of age on SPV using caloric test and reported that the parameters of the caloric test were dependent on age but do not demonstrate a consistent pattern with increasing age.[16,17,33,34] Present findings can be attributed to the adaptive mechanism in the central nervous system which remains intact in the older individuals helping in the compensation of the reduced VOR responses in caloric testing. Thus, the signal supplied by the caloric test does not challenge the semicircular canal system enough so as to reveal its defects.

Second part of the present study was aimed at comparing age related changes on cVEMP across the age range of 20-70 years. Unlike the caloric test, the results showed that there is a significant effect of age on the parameters of the cVEMP. The cVEMP could be recorded in all individuals below the age of 60 years i.e. Prevalence rate is 100%. However, in individuals above the age of 60 years the prevalence rate dropped to 60%. This finding is consistent with the earlier reports.[19,25-28] Nevertheless few researchers have reported a response rate of 86% in individuals below the age of 60 years.[21]

With respect to latency, present findings are in agreement with earlier reports which showed positive correlation of P13 and N23 latency with age.[24,29] However, few investigators have found no age related pattern in the latency of N23 but age effect was present in latency of P13.[26] This discrepancy between the two results could be due to the type of stimulus used for evoking VEMP responses i.e. air conduction versus bone conduction and tone burst versus tone pips. The age related changes in the cVEMP parameters could be attributed to the age related degeneration taking place in the vestibular sense organ.[5-8,11]

Conclusion

It can be concluded from the present study that gaze-induced nystagmus is absent in normal individuals up to age of 70 years. There is no significant effect of age seen in the caloric test. However, the effect of age on the parameters of the cVEMP test is very prominent. There is an increase in the latency and decrease in the amplitude of both P13 and N23 as the age advances.

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