

Ageing effect on air-conducted ocular vestibular evoked myogenic potential

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Abstract

One of the recent diagnostic tests to assess the function of otolithic organs is through vestibular evoked myogenic potential (VEMP) testing. There are equivocal findings on effect of aging on ocular VEMP (oVEMP) parameters with reference to latencies. Hence this study was taken up to investigate the age related changes in oVEMP parameters. This present study considered 30 participants in each age group *i.e.*, young adults, middle-aged adults and older adults. oVEMP were recorded using insert earphone at 100dBnHL at 500Hz short duration tone burst. The results showed in older adult significant difference in response rate, latencies and amplitude as compared to young and middle adult. Hence age should be taken into consideration when interpreting oVEMP results.

Introduction

To assess the vestibular system one of the recent diagnostic test is vestibular evoked myogenic potential (VEMP). Earlier tests like the caloric test and electronystagmography were used as vestibular tests to assess vestibular dysfunction. Since these tests assess only one of the three vestibular end organs *i.e.*, the horizontal semicircular canals, it does not provide a comprehensive depiction of the vestibular system. With the advent of the VEMP test, which assesses the otolithic func-

tion, along with video head impulse test, it gives clinicians a clear understanding of the functioning of the balance system. This procedure plays a significant role in the management of patients with dizziness by investigating the site of lesion.

Ocular VEMP (oVEMP) testing is a recently introduced a technique for evaluating the integrity of the vestibular system.¹⁻³ oVEMP is produced by otolith afferents in the superior division of the vestibular nerve. Differently from the cervical VEMP, which analyzes the ipsilateral descending vestibular pathway, the oVEMP has been validated for evaluation of the ascending vestibular pathway via the vestibular-ocular reflex Todd *et al.*⁴ found a short-latency negative-going evoked myogenic potential with an initial negative peak at latency of 10 ms (n1) followed by a positive peak around 15 ms (p1) elicited from electrodes placed below the lower lid of the eyes. Isu *et al.*⁵ proposed that, the vestibular ocular pathway, which occurs through means of the vestibular ocular reflex, is likely to be dysynaptic. From the stimulation of oculo motor nuclei results in excitatory input to the ipsilateral and contralateral superior rectus muscle, the contralateral superior oblique and ipsilateral inferior rectus muscles as well as inhibitory stimulation of the ipsilateral and contralateral inferior recti muscles. A stronger contralateral response for ocular VEMP testing when compared to cervical VEMP testing results due to this crossed nature of the projections. Tseng *et al.*⁶ reported 100% oVEMP in the age groups of 20-59 years, 55% in the group of 60-69 years and 40% in the group of >70 years. The latencies n1 and p1 showed significant prolongation in subjects above 60 years, and reduced n1-p1 amplitude was observed over 40 years of age. Nguyen *et al.*⁷ reported that subjects above 50 years of age had considerably reduced oVEMP amplitudes. Age-related changes for latencies and asymmetry ratios were not observed by them. Similar finding were observed by Piker *et al.*⁸ where they found amplitude of oVEMP has greatest age effects after 50 years and older.

From the above study it is observed that there is an equivocal finding on oVEMP findings related to latency, amplitude and response rate in old age. Hence the present study was taken up to see if there are any changes in the oVEMP parameters while recording the oVEMP response across different age groups.

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Materials and Methods

A cross sectional study was conducted using convenient sampling method to select the participants for the study. The participants included in this study were placed under three groups based on their age *i.e.*, young adults (21-40 years), middle-aged adults (41-60 years) and older adults (above 60 years). The mean and standard deviation of the age groups were 25.3±5.35, 49.25±5.25 and 69.89±8.39, respectively. A total number of 90 participants with 30 in number for each group were considered. Equal numbers of male and female were included in present study in each group. Informed consent was taken from each participant prior to conducting the procedures. All the participants had

either normal hearing or sensory neural hearing loss with *A* type tympanogram with present or absent acoustic reflexes. All participants had uncomfortable level (UCL) for 500Hz tone greater than 100dBHL. Presence of any conductive hearing component, symptomatic neurological symptoms, symptomatic spondylitis, diabetes or high blood pressure had been excluded from the present study.

The pure tone thresholds of each participant were obtained using a calibrated GSI-61 (Grason-Stadler, Eden Prairie, MN, USA) clinical audiometer. Air conduction thresholds were tracked from 250 Hz to 8000 Hz and bone conduction for the octave frequencies 250 Hz to 4000 Hz. The UCL for pure tone of 500 Hz was also checked for in all the participants. For the study, conductive pathology was ruled out in all the participants using GSI TympStar™ (Grason-Stadler). All participants were seated comfortably on a straight back chair while the tympanometry and reflexometry were carried out using 226 Hz probe tone. Initially tympanometry was performed followed by acoustic reflex threshold measurement.

The oVEMP recording was tested using IHS Smart EP Version: 3.92 (Intelligent Hearing Systems, Miami, FL, USA). Ear-Tone 3A insert earphone was used to deliver the 500 Hz tone burst stimuli at 100 dBnHL. For recording oVEMP response analysis time of 50 ms was used with filter setting of 1-1000 Hz. A total of 200 sweeps were averaged using repetition rate of 5.1. Rarefaction stimulus was used with amplification of 50,000 times. Duration of stimulus was kept 7 ms to record oVEMP response. The following electrode montage was used with the Non-inverting electrode (+) placed on the contralateral side of the inferior oblique muscle, the Inverting electrode (-) positioned 1-2 cm beneath the non-inverting electrode over the cheek and the ground electrode was placed on the forehead. While performing the test, all the participants were seated in an upright position. The electrode impedance was less than 5 K ohm. The subjects were trained to look upward at a small fixed target of >2 m with the eyes, with a vertical visual angle of roughly 30-35 degree above horizontal. Participants were requested to keep their eye gaze stable on the target throughout the each procedure. Participants were instructed to avoid extraneous activities of head, jaw and eye while the VEMP recording was going on. Analysis was done taking into consideration the latency and peak-to-peak amplitude of the oVEMP responses. Two expert audiologists had analyzed oVEMP response across all the age groups. Statistical calculations were performed with SPSS (version 17; IBM Corp., Armonk, NY, USA). One-way analysis of variance (ANOVA) *post hoc* Bonferroni test was carried out to see the age related changes in latency and amplitude of oVEMP.

Results

In the present study a decline was observed for oVEMP responses across the three age groups from young adults through middle-aged adults and older adults. The response rate for oVEMP in the young adult group was 98.33% and middle adult group was 85%. However, in the old age, the response rates were found to be 60%.

Age related changes in ocular vestibular evoked myogenic potential response

The oVEMP responses were obtained at mean n1 latencies of 12.00±1.29 ms [standard deviation (SD)] in young adults, 12.36±1.24 ms (SD) in middle aged adults and 14.64±2.13 ms (SD) in older adults respectively. Mean and standard deviation of n1 latency is presented in Figure 1 across different age groups. The p1 latencies were found to be 16.13±1.34 ms (SD) in young adults, 16.58±1.7 ms (SD) in middle aged adults and 19.45±2.21 ms (SD) in older adults respectively. Figure 2 shows mean and standard deviation of p1 latency across different age

groups. One-way ANOVA test revealed a significant difference { $F = (2,153) = 36.21; P = 0.00$ } for n1 latency in the oVEMP testing and { $F = (2,145) = 47.659; P = 0.00$ } for p1 latency across the three age groups. *Post hoc* Bonferroni test showed a significant difference ($P < 0.05$) for latencies of n1 and p1 between the young adults and older adults as well as between the middle-aged adults *vs* older adults groups. However, for the n1 and p1 latencies, when a comparison between young adults and middle adults was made no significant difference ($P > 0.05$) was observed. These findings were similar for both n1 and p1 latencies of oVEMP response.

On analysis of the amplitude it was observed that a mean of 4.96±2.50 μV (SD) was obtained in young adults. However, it was observed that with increasing age the mean amplitude also reduced. The mean amplitude was noted to be 4.47±1.55 μV (SD) in middle-aged adults, which further decreased to a mean of 2.66±1.33 μV (SD) in old age. Figure 3 shows mean and standard deviation of peak-to-peak amplitude across different age groups.

Statistical analysis using the one-way ANOVA test revealed a main significant difference { $F = (2,145) = 15.978; P = 0.00$ } for the peak-to-peak amplitude of oVEMP response. Since a significant difference was obtained for amplitude, a *post hoc* Bonferroni test was performed to see the differences across the age groups. With regard to the amplitude, there was no significant difference ($P > 0.05$) seen in between young adults and middle-aged adults. However, when the young adult group was compared to old age group and middle aged adults group was compared to the older adults group, a significant difference ($P < 0.05$) was obtained.

Figure 4 shows the grand average waveform of oVEMP responses across the age groups (young adult, middle adult and old age) and reveals a decrease in amplitude and a prolongation of the p1 and n1 latencies across the three age groups with a significant difference noticed above 60 years of age.

Discussion

The outcomes of the current study revealed that oVEMP responses were present for majority of subjects in the young adult, which reduced with ageing, with a significant decline above 60 years of age. Similar findings were reported by Chang *et al.*⁹ for bone conduction oVEMP responses. Chang *et al.*⁹ had used two stimuli bone conduction and galvanic stimuli to evoke oVEMP in different age groups. They reported that for oVEMP using bone conduction, 100% response rate was elicited in the age ranging from 20-49 years and 86% between 50-59 years while recording oVEMP response. In older adults, 60 years and above, the response rate was significantly reduced to 63% using bone conduction stimuli. With the use of galvanic test stimuli they reported 100% response rate in the age range of 20-59 years for the oVEMP response. However, age group of 60 years and above a response rate of 84% was seen for galvanic stimuli. The decrease in occurrence rate of bone conduction oVEMP instead of galvanic oVEMP in the over 60 years age group may imply age related deterioration of the otolithic systems takes place earlier than that of the afferent vestibular system. Tseng *et al.*⁶ had reported similar findings with the present study; where they got 100% response rate in age ranging from 20-59 years, 55% in 60-69 years age group, and 40% in subjects 70 years and above for oVEMP response. They reported that age above 60 years there is a substantial difference in response rate seen for oVEMP response. From the above studies, it is clear that many factors like type of test stimuli, intensity of stimulus, and stimulation type affect response rate of oVEMP response.

In the present study we found n1 and p1 latencies were prolonged as well as reduced peak to peak amplitude occurred with advancing age 60

years and above. Tseng *et al.*⁶ found prolonged n1 and p1 latencies, and decreased amplitude in individuals above 60 years of age compared to the younger age groups, which is consistent with the findings of the current study. This indicated a clearly significant change in the oVEMP responses between those above and below the age of 60 years. Similar findings were reported by Chang *et al.*⁹ using bone conduction oVEMP response. The deterioration in latency and amplitude with age could be due to a reduction in the number of neurons with aging. This age-linked neuronal loss in the vestibular nucleus might have significant functional implications, which could be a reason for the deterioration in balance that occurs with aging. Piker *et al.*¹⁰ had reported reduced amplitude in oVEMP response above 60 years of age.

Hence, the present study revealed a significant prolongation in the latency and reduction in amplitude of older individuals who are 60 years and above for oVEMP. This finding may be attributed to morphological alterations that are taking place in the otolithic organs and corresponding changes in the neural function. These outcomes might be

due to age-dependent neuronal deterioration of the vestibule-ocular reflex. Another possible reason could be a reduction in the number of myelinated primary vestibular afferents taking place above 40 years and a 37% decrease in fiber count between 70 to 85 years of age as observed by Bergström *et al.*¹¹ It has also been reported that there was age related loss of 3% per decade in individuals above 40 years of age from the vestibular nucleus complex. In the age range of 40 to 90 years a 6% per decade vestibular epithelium hair cell loss was observed by Rosenhall.¹² Therefore, it may be concluded that degeneration occurring with increasing age affects the pathways that mediate the vestibular reflexes at various levels. Hence the current study indicated that there was no change in latency and peak-to-peak amplitude of oVEMP responses, in the young and the middle-aged adults group. However, a significant difference in latencies and amplitude was observed in older adults. Response rate was also reduced drastically for older adults. These outcomes indicate that age must be taken into consideration when interpreting oVEMP results.

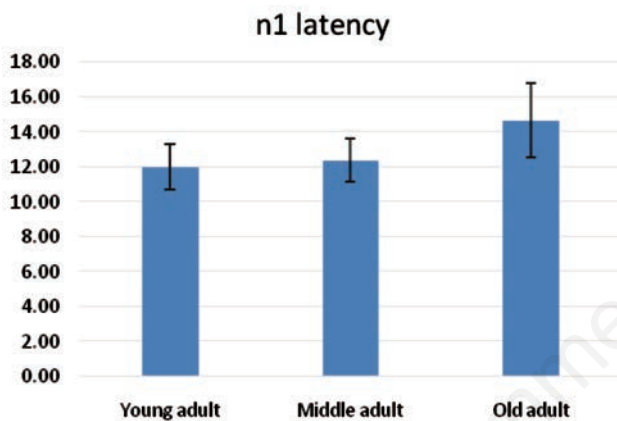


Figure 1. Represents mean and standard deviation of n1 latency across different age groups of ocular vestibular evoked myogenic potential.

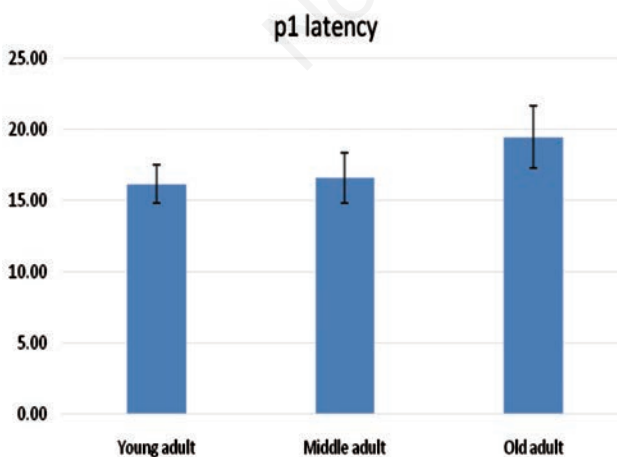


Figure 2. Represents mean and standard deviation of p1 latency across different age groups of ocular vestibular evoked myogenic potential.

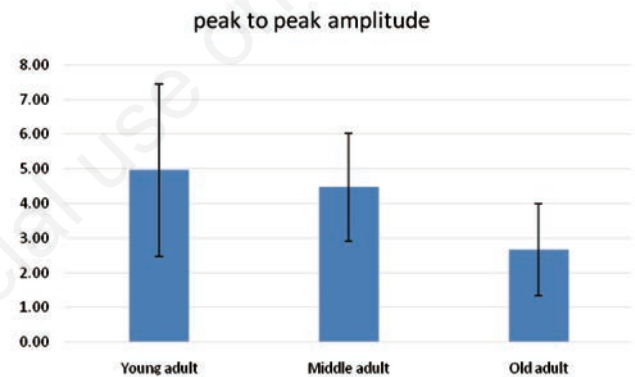


Figure 3. Represents mean and standard deviation of peak-to-peak amplitude across different age groups of ocular vestibular evoked myogenic potential.

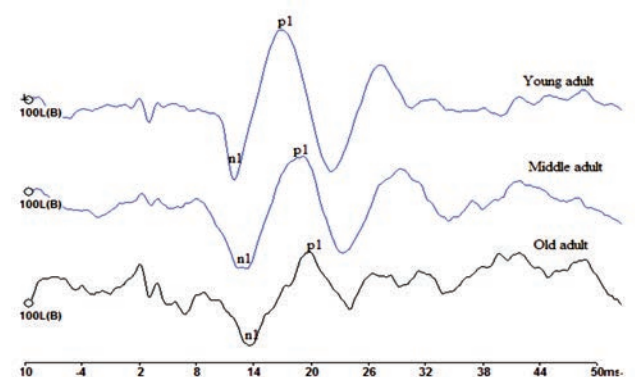


Figure 4. Average grand waveform of ocular vestibular evoked myogenic potential for young adult, middle adult, and older adult.

Conclusions

Present findings indicate there is no change in latency and peak-to-peak amplitude between young and middle adult. However; there is significant difference in response rate, latency and peak-to-peak amplitude in old adult as compare to young and middle adult. Age should be taken into consideration when interpreting oVEMP results.

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