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Original Article / Çalışma - Araştırma

Ocular vestibular evoked myogenic potentials in response to air conducted stimuli: clinical application in healthy adults

Hava yolu uyaranına karşı verilen yanıtta oküler vestibüler uyarılmış miyojenik potansiyeller: Sağlıklı erişkinlerde klinik uygulama

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Objectives: This study aims to determine the normal values for ocular vestibular evoked myogenic potentials in response to air conducted stimuli in healthy adults.

Patients and Methods: Thirty-six healthy adult participants with no ear complaints were enrolled. Ocular vestibular evoked myogenic potential tests were performed to all participants. Latency and amplitude values of the waves were recorded.

Results: The mean N1 latency was 9.62±2.02 (4.30-16.00) msec and the mean P1 latency was 14.90±2.33 (9.0-21.00) msec. The mean amplitude was 3.36±1.36 (1.06-8.48) µV. There was a positive correlation between N1 and P1 latencies and age (r=242, p=0.0359 for N1; r=250, p=0.030 for P1).

Conclusion: Ocular vestibular evoked myogenic potentials can be obtained easily and can be used in the evaluation of vestibular disorders. However, the effect of age should be considered when interpreting results.

Keywords: Ocular vestibular evoked myogenic potential; vestibular evoked myogenic potential; vestibuloocular reflex.

Amaç: Bu çalışmada sağlıklı erişkinlerde hava yolu uyaranına karşı verilen yanıtta oküler vestibüler uyarılmış miyojenik potansiyeller için normal değerler belirlendi.

Hastalar ve Yöntemler: Çalışmaya işitme sorunu olmayan 38 sağlıklı erişkin katılımcı dahil edildi. Tüm katılımcılara oküler vestibüler uyarılmış miyojenik potansiyel testleri yapıldı. Dalgaların latans ve amplitüd değerleri kayıt edildi.

Bulgular: Ortalama N1 latansı 9.62±2.02 (4.30-16.00) msn. ve ortalama P1 latansı 14.90±2.33 (9.0-21.00) msn. idi. Ortalama amplitüd değeri 3.36±1.36 (1.06-8.48) µV idi. N1 ve P1 latansları ile yaş arasında pozitif bir ilişki vardı (N1 için r=242, p=0.0359; P1 için r=250, p=0.030).

Sonuç: Oküler vestibüler uyarılmış miyojenik potansiyeller kolayca elde edilebilir ve vestibüler hastalıkların değerlendirilmesinde kullanılabilir. Ancak, sonuçların değerlendirilmesinde yaşın etkisi göz önünde bulundurulmalıdır.

Anahtar Sözcükler: Oküler vestibüler uyarılmış miyojenik potansiyel; vestibüler miyojenik potansiyel; vestibülooküler reflex.

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Vertigo and dizziness comprise a common public health problem. Diagnosis and treatment still pose difficulties for medical professionals such as medical doctors, audiologists and physiotherapists. Causes of symptoms may vary from a range of self-limiting disorders to life threatening conditions including otologic, neurologic, cardiovascular, psychiatric, orthopedic, and ophthalmologic disorders.

The vestibuloocular reflex (VOR) stabilizes the vision of the world on the retina during head and body movements. Non-physiologic stimulants such as high level sounds and vibration may stimulate reflex ocular movements without head movement.[1] This condition allows the VOR to be evaluated by indirect means.[1-3] Most of the tests in use evaluate the VOR by caloric or rotational stimulation. On the other hand, neurophysiologic studies show that the vestibular system, especially the saccule is sensitive to sound stimuli.[4,5] Conventional clinical vestibular tests assess lateral semicircular canal and superior vestibular nerve, however, cervical vestibular evoked myogenic potentials (cVEMP) assess the saccule and inferior vestibular nerve.[6] Recently introduced ocular VEMP (oVEMP) on the other hand, assesses the utricle and superior vestibular nerve. Here, the reflex arc is independent from corneoretinal potentials and follows the route of the otolith organ, superior vestibular nerve and extraocular muscles.[2]

The aim of this study was to obtain the normative data of oVEMP in a healthy adult population and use these data for future studies. Since oVEMP is an easily applicable and reliable test, we aim to use it in the evaluation of vertiginous patients in our vestibular laboratory.

PATIENTS AND METHODS

The study was carried out among 38 healthy volunteers (18 males, 20 females; mean age 40.2±11.6 years; range 22 to 58 years) with no ear complaints in the Baskent University Department of Otorhinolaryngology. Seventy-six ears of 38 subjects were examined. Audiological evaluation and positional tests were conducted on participants after a thorough otorhinolaryngologic examination. Participants that had pure tone averages lower than 20 dB and that had no nystagmus during the positional tests were included in the study. The study was approved by the Başkent University Institutional Review Board and Ethics Committee, and written informed consent was obtained from all participants.

Exclusion criteria were defined as the presence of a neurological disorder, middle ear pathology, an air-bone gap of more than 10 dB between 500-4000 Hz frequencies, a history of head trauma, or audiovestibular disease including imbalance and/or dizziness.

Ocular VEMP test technique

Grason-Stadler (GSI) Audera (Grason-Stadler Inc., MN, USA) equipment was used for myogenic activity recordings. We used Blackman tone bursts at 500 Hz and condensating polarity. The stimuli were presented monoaurally via air conduction either at 130 dB sound pressure level (SPL) or in 5 dB decrements from 125 to 100 dB SPL via ER3A insert earphones. Repetition rate was 8 Hz. The rise and fall time was 2-0-2 msec. The sample window was -20 msec to 30 msec.

First, the skin was cleaned with alcohol and peeling gel. Five disposable self-adhesive Ag/AgCI surface electrodes (Ambu Blue Sensor N ref No N-00-S/25) were used for each testing. Non-inverting electrodes were placed 3-4 mm below the inferior eyelid, on the level of infraorbital rim, and inverting electrodes were placed 2 cm below those. A ground electrode was placed on the mid-forehead. Skin resistance was kept below 5 μΩ. 256 stimuli were used in a single recording. The subject was requested to look at a predefined object that was placed 2 meters away and above, making a 30-40 degrees of angle with the horizontal line, and look slightly to the side of the stimulated ear. Stimulation was given with an insert earphone and recordings were obtained from the contralateral eye. The threshold was determined as the same waveform and latency were obtained in at least two repetitive tests. The peak points of the first waveform following stimulation were noted as N1 and P1 (Figure 1). Latency and amplitude of the waves were calculated.

Statistical analysis

Statistical analyses were made using SPSS for Windows version 17.0 (SPSS Inc., Chicago, IL, USA) software program. The means of the groups were assessed with Student's t test and Mann-Whitney U test. The correlation between age, latency and amplitude were assessed with Pearson correlation analysis. A p value of <0.05 was considered as statistically significant.

(a)

(b)

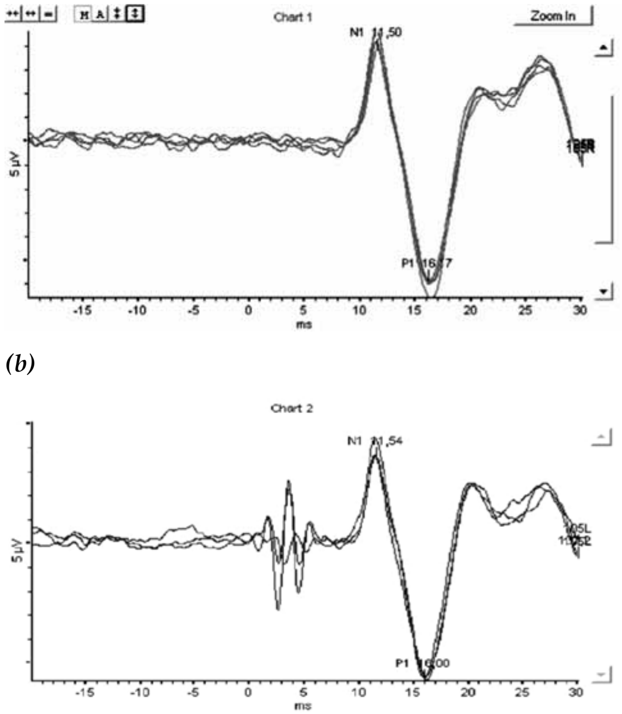

***Figure 1.** Ocular vestibular evoked potentials in right **(a)** and left **(b)** ear. N1 and P1 are plotted on the curve.*

RESULTS

Ocular VEMP results for both ears

Latency and amplitude values for left and right ears are given in Table 1. The results obtained from left and right ears did not differ significantly (p>0.05).

Ocular VEMP results according to sex

Latency and amplitude values for male and female gender are given in Table 2. The values did not differ significantly (p>0.05).

Ocular VEMP results according to age

There was a positive correlation between N1 values and age (r=242, p=0.0359). Similarly there was a positive correlation between P1 values and age (r=250, p=0.030). There was no statistically significant relationship between amplitude and age (r=052, p=0.653).

Overall ocular VEMP results for the study group

Since the sex and side of the ear tested did not interfere with the results, test parameters for 76 ears were calculated (Table 3).

DISCUSSION

We aimed to determine the normal range of oVEMP test values in healthy adults before we use oVEMP in routine clinical practice. We used the air-conducted stimuli to activate the vestibular organ separately on each side. We recorded oVEMPs in response to air-conducted stimuli and determined the test values for 76 ears of 38 healthy adults. N1 latency was found as 9.62±2.02 (range 4.30-16.00) msec, whereas P1 latency was 14.90±2.33 (range 9.0-21.00) msec. The mean amplitude was 3.36±1.36 (range 1.06-8.48) µV. These values are comparable to previously reported values in the literature.[1,3,6-11]

Since Colebatch et al.[4,5] reported the properties of surface potentials from the sternocleidomastoid (SCM) muscles in response to loud clicks in 1992, air-conducted stimuli, bone-conducted stimuli or galvanic stimulation are used to assess the

Table 1. Ocular vestibular evoked myogenic potentials results of the subjects with regard to laterality of the ear tested

Test parameter	Right ear	Left ear	
	Mean±SD	Mean±SD	*p*
N1 (msec)	9.8±2.1	9.3±1.9	0.312
P1 (msec)	15.0±2.3	14.7±2.2	0.651
Amplitude (µV)	3.3±1.5	3.3±1.1	0.919

SD: Standard deviation.

Table 2. Ocular vestibular evoked myogenic potentials results of the subjects with regard to sex

Test parameter	Female	Male	
	Mean±SD	Mean±SD	*p*
N1 (msec)	9.6±1.7	9.6±2.2	0.993
P1 (msec)	14.9±2.3	14.8±2.3	0.973
Amplitude (µV)	3.4±1.0	3.1±1.5	0.88

SD: Standard deviation.

Table 3. Overall values for the study group

Test parameter	Minimum	Maximum	Mean±SD
N1 latency (msec)	4.30	16.00	9.62±2.02
P1 latency (msec)	9.0	21.00	14.90±2.33
Amplitude (µV)	1.06	8.48	3.36±1.36

SD: Standard deviation.

sacculocollic pathway. Some primary vestibular afferent neurons respond to air-conducted sound (ACS) and bone-conducted vibration (BCV) stimuli. Air-conducted sound and BCV activate afferents in both saccule and utricle, even at intensities close to or below auditory brainstem response threshold.[12-15] New clinical tests of vestibular function have been developed using ACS and BCV, since it is easier and safer to present these stimuli in a test, rather than using whole head or whole-body acceleration.[16] Chihara et al.[3] obtained oVEMP responses to ACS in about 90% in their subjects. Cheng et al.[9] reported oVEMP responses to ACS in 80%, and to BCV in 100% of their subjects. The absence of the oVEMP responses to air conducted sound stimuli in normal young adults may be related to inadequate gaze elevation, stimulus level, stimulus duration or combination.[11] In our study, we could obtain oVEMP responses to ACS in all of the participants.

Tone burst or click stimuli can be used for both cVEMP and oVEMP tests. The results of earlier studies demonstrate that when click stimulants are used, oVEMPs and cVEMPs can be identified in 50% and 80% of normal subjects, respectively.[3,10,11] On the other hand, 90% of the normal subjects have cVEMPs and oVEMPs in response to tone burst stimuli.[3,10,11] Accordingly, we preferred to use 500 Hz Blackman tone bursts in our study.

All the stimulation and recording modes are identical for oVEMP and cVEMP, except for the band-pass filter. 10-1000 Hz is suitable for oVEMP and 30-3000 Hz for cVEMP, mainly due to the different frequency spectrums of the respective VEMP waveforms.[17]

As the primary pathway of otolith afferent neurons to the inferior oblique muscle is crossed, oVEMPs can be mainly recorded beneath the eye contralateral to the stimulated ear.[8,18] Since the inferior oblique muscle comes closer to the electrode especially on upward gaze, gaze to superomedial was reported to give the best recording results.[3,19-21] It may be hard to keep the position of the head and gaze for a long time; because of this it is recommended to do oVEMP with the head tilted slightly lateroinferior.[2,3,19,20] In our study, the volunteers were requested to fix their gaze on a previously determined subject, i.e. on a doll that was placed on top of a door. In this way, the eyes were looking upwards at a 30-40 degree angle from the horizontal line. Welgampola et al.[8] reported that the oVEMP amplitudes were decreased 50% or more when the gaze of the subjects changed from upward to straight ahead, and disappeared on downward gaze. Huang et al.[22] showed clear oVEMPs in 23 healthy adults both when the eyes were gazing up or closed. Thus, oVEMP can also be recorded with eyes closed in those who cannot look upward.

Ocular VEMP amplitudes were reported to decrease beyond the age of 50.[1,6,23] This finding may be explained by the loss of hair cells in the utricular macula or degeneration of the afferent or efferent limb of the reflex arc.[1,6,23] Tseng et al.[24] reported reduced response rates, prolonged N1 and P1 latencies and reduced N1-P1 amplitudes with aging. These authors implicated the degradation of central vestibular processing of otolith signals with age as the cause of prolonged latencies. There was no statistically significant relationship between amplitude and age in our study. On the other hand, we found a positive correlation between N1 and P1 latency values and age. Age should be considered an important factor when interpreting oVEMP results. We also found that gender had no significant effect on oVEMP results.

Ocular VEMP seems to have some advantages when compared with cVEMP and caloric testing. While cVEMP is an inhibitory response, oVEMP is an excitatory response. Ocular VEMPs may be obtained more easily even in elderly, disabled or unconscious subjects who could not sustain neck contraction.[25,26] The background artifact is limited because this area includes a small number of muscles. The traditional caloric test may be uncomfortable and intolerable, whereas patient and test interaction is quite good during oVEMP testing.

Conclusions

Normal values of oVEMP responses to air conducted stimuli were defined in healthy subjects of a selected population. The N1-P1 latency and amplitude values were obtained using 500 Hz tone bursts presented at 130 dB SPL during 30° upward gaze. Our test setup and recording parameters may be useful for the clinical application of oVEMP testing via air-conducted stimuli. Age should be considered an important factor when interpreting the oVEMP results and designing future studies.

Declaration of conflicting interests

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