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Evaluation of Balance Using Cervical Vestibular Evoked Myogenic Potentials in Blind Individuals

Görme Engelli Bireylerde Dengenin Servikal Vestibüler Uyarılmış Miyojenik Potansiyeller Kullanılarak Değerlendirilmesi

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ABSTRACT Objective: Our purpose in this study is to investigate whether blindness affects vestibulocollic reflex. **Material and Methods:** This is a prospective case control series. We recorded cervical vestibular evoked myogenic potential in 29 blind and 26 sighted subjects, and compared the latency and amplitude values. **Results:** Twenty one of the blind subjects were male and 8 were female, the average of age was 41.72±11.83 years. Nineteen of the sighted subjects were male and 7 were female, the average of age was 40.64±9.11 years. The average P13 latency value was 16.97±2.12 ms in the blind group and 15.40±0.88 ms in the sighted group. The average P13 latency value was longer in the blind group ($p<0.005$). In the blind subjects, the average N23 latency was 24.92±2.77 ms. In the sighted subjects, the average N23 latency was 23.73±0.85 ms. The average N23 latency value was longer in the blind group ($p<0.005$). The mean P13-N23 interpeak amplitude was 2.76±2.92 µV in the blind group. In the sighted group, it was 2.38±0.33 µV. There were not statistically significant differences between the mean P13-N23 interpeak amplitudes ($p>0.005$). **Conclusion:** We determined that the P13 latency values and N23 latency values were longer in the blind group. Our study has shown that cervical vestibular evoked myogenic potential responses in the blind individuals are different from the sighted individuals.

Keywords: Vestibular evoked myogenic potentials; blindness; posture balance

ÖZET Amaç: Bu çalışmadaki amacımız, körlüğün vestibülokolik refleks yanıtları üzerindeki etkisini araştırmaktır. **Gereç ve Yöntemler:** Bu çalışma, prospektif vaka kontrol çalışmasıdır. Çalışmamızda, 29 görme engelli ve 26 normal görmeye sahip bireyde servikal vestibüler uyarılmış miyojenik potansiyeli kaydettik, latans ve amplitüd değerlerini karşılaştırdık. **Bulgular:** Görme engelli bireylerin 21'i erkek, 8'i kadın olup yaş ortalaması 41,72±11,83 yıl idi. Görmesi normal olanların 19'u erkek, 7'si kadın olup; yaş ortalaması 40,64±9,11 yıl idi. Ortalama P13 latans değeri, görme engelli grupta 16,97±2,12 ms; görmesi normal olan grupta ise 15,40±0,88 ms idi. Görme engelli grupta ortalama P13 latans değeri, görmesi normal olan gruba göre daha uzamış saptandı ($p<0,005$). Görme engelli grupta ortalama N23 latans değeri 24,92±2,77 ms; görmesi normal olan grupta ise ortalama N23 latansı 23,73±0,85 ms idi. Görme engelli grupta ortalama N23 latans değeri, görmesi normal olan gruba göre daha uzamış olarak saptandı ($p<0,005$). Görme engelli grupta ortalama P13-N23 interpeak amplitüdü 2,76±2,92 µV; görmesi normal olan grupta ise 2,38±0,33 µV idi. Ortalama P13-N23 interpeak amplitüd değerleri karşılaştırıldığında, görme engelli olan grup ile görmesi normal olan grup arasında istatistiksel olarak anlamlı fark saptanmadı ($p>0,005$). **Sonuç:** Görme engelli grupta P13 ve N23 latans değerlerinin daha uzun olduğunu belirledik. Çalışmamızda, görme engellilerde servikal vestibüler uyarılmış miyojenik potansiyel yanıtlarının görmesi, normal bireylerden farklı olduğunu ortaya konmuştur.

Anahtar Kelimeler: Vestibüler uyarılı miyojenik potansiyeller; körlük; postür dengesi

Balance is your ability to control your body without movement against gravity. Balance is controlled by visual, somatosensory and vestibular systems. These three systems should work coherently in order to maintain balance.[1] In clinical practice head shake test, head trust test, fistula test, Romberg test,

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dynamic positional tests (Dix-Hallpike, supine roll) can be used for evaluation of balance. On the other hand, videonystagmography, pursuit test, optokinetic test, caloric test, ocular vestibular evoked myogenic potentials (oVEMP), cervical vestibular evoked myogenic potentials (cVEMP), video head impulse testing and computerized dynamic posturography are the objective tests used to evaluate balance. Each of these tests has a special importance in the evaluation of balance but cVEMP differs from others due to being the only source available for providing information about the inferior vestibular nerve through the sacculus and is an indicator of vestibulocollic reflex.[2]

Blindness is visual perception of less than 3/60, or a consequent field of vision loss less than 10°, in the better eye with the best probable correcting. Vision has a vital function to code and process of the information accepted by other sensation.[3] Defective or decreased vision causes alteration in motor functioning and balance.[4] Moreover, closing the eyes causes gait instability alongside postural static and dynamic instability.[3]

Blind individuals have poorer performance than sighted individuals in balance control. Moreover, sighted individuals have poorer performance with closed eyes in postural balance control.[5] Vestibulospinal reflex seem to be affected when visual input is insufficient.[3]

We hypothesized that in the blind individuals, vestibulocollic reflex responses may be weakened similar to vestibulospinal reflex responses. cVEMP is an indicator of vestibulocollic reflex. In this study, we investigate whether blindness affects vestibulocolic reflex using cVEMP.

MATERIAL AND METHODS

This cross-sectional comparative study was performed on 29 blind and 26 sighted individuals aged between 18-65 years old without hearing loss and vestibular disorders. Subjects with severe psychiatric illness, chronic otitis media, Meniere disease, obstructive sleep apnea syndrome, hearing loss, who are under medication that affects balance system and who use antiepileptic drugs were excluded from the study. All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Ethics approval for the study was given by the Ümraniye Research and Training Hospital Ethics Committee (number: 18569, date: 12/24/2015). Individual written informed permission was acquired from all participants in the study.

Following a full head and neck and ocular examination, pure tone audiometry, head shake test, head trut test, Fukuda test, Dix-Hallpike test, roll on test was performed to exclude possible vestibular pathologies. Then cVEMP tests were performed to all subjects.

cVEMP

cVEMP is an indicator of vestibulocollic reflex resulting from activation of the inferior vestibular nerve, vestibular nucleus, vestibular tract, accessory nucleus, accessory nerve and sternocleidomastoid muscle (SCM) used in the diagnosis of various peripheral and central vestibular diseases in clinical practice.[6] During the cVEMP test, the biphasic electromyography (EMG) response (positive-negative) is recorded from the contracted sternocleidomastoid after the acoustic stimulation of the ipsilateral ear. The first response wave, known as P13, has a positive polarity with a latency around 13 ms. Then the second wave, known as N23, appears 10 ms after P13 with a negative polarity.[7] Absence of wave, delayed reflex and decrease in amplitude are considered pathological.[8,9]

cVEMP RECORDING

cVEMP was recorded using a Vivosonic Integrity V500 device (Vivosonic Inc; Toronto, ON, Canada). The test was performed in a silent environment with each subject awake and in sitting position. The active electrode was placed in the middle of the SCM, the reference electrode on the upper 2/3 of SCM, and the centering electrode in the middle of the forehead. Evoked myogenic potentials were measured from SCM. Ipsilateral recordings were taken after the stimulation of the right and left ears. Electrode impedance was <5 kΩ. An acoustic stimulation of 500 Hz frequency and 100 dB nHL was delivered to each ear seperately for 1 ms. Signals of the EMG were improved and bandpass strained (10-1,000 Hz). P13 and N23 peak latencies and P13-N23 interpeak amplitudes were analyzed using 100 ms analysis window.

STATISTICAL ANALYSIS

Statistical analysis was performed using the Statistical Package for the Social Sciences version 20 (SPSS, IBM Corporation; Armonk, NY, USA) program. In addition to the standard statistical calculations (mean, median and standard deviation), the qualitative parameters corresponding to normal distribution were compared with the independent sample t-test and the abnormally distributed parameters were compared with the Mann-Whitney U test. Fisher exact test was used to investigate the association between categorical variables. Statistical significance level was determined at p<0.05.

RESULTS

Twenty nine blind and 26 sighted participants were recruited for the study. Blind 21 male, 8 female participants and sighted 19 male, 7 female participants were included for analysis. The mean age of the participants was 41.72±11.83 years in the blind group and 40.64±9.11 years in the sighted group. There was no difference in gender distribution and mean age between the 2 groups (p=0.59 and p=0.711) (Table 1).

All participants had no pathological finding in head shake test, head thrust test, Fukuda test, Dix-Hallpike test and roll-on test. No hearing loss was detected in any subjects.

cVEMP response could not be received from 10 of 29 participants in the blind group. While in the sighted group, it was recorded from all 26 subjects.

The mean P13 peak latency was 16.97±2.12 ms in the blind group. In the sighted group, it was 15.40±0.88 ms. When the P13 peak latency results of 2 groups were compared, a statistically significant delay was detected in the blind group (p=0.01) (Figure 1). The mean N23 peak latency in the blind group was 24.92 ms±2.77. In the sighted group, it was 23.73 ms±0.85. A statistically significant delay was detected in the blind group (p=0.045) (Figure 2). The mean P13-N23 interpeak amplitude was 2.76±2.92 µV in the blind group. In the sighted group, it was 2.38±0.33 µV. There were not statistically significant differences between the mean P13-N23 interpeak amplitudes (p=0.45).

DISCUSSION

cVEMP is a strong tool that enables objective evaluation of balance functions. Healthy saccule, inferior vestibular nerve, vestibular nucleus, vestibulospinal pathway and SCM provide normal cVEMP responses.[10,11] Any defect in the structures mentioned above, such as vestibular schwannoma, vestibular neuritis, Meniere disease, otosclerosis, multiple sclerosis, can decrease the incidence of response.[12-17]

In this study, we aimed to investigate whether blindness affects vestibulocolic reflex using cVEMP. We observed a statistically significant difference in P13 and N23 latency between two groups, but there was no significant difference in the P13-N23 interpeak amplitudes.

There are many studies evaluating the balance in the blind individual. In their study with 6 blind individuals and 12 sighted individuals, Seemungal et al. evaluated the vestibular system by performing Barany rotation chair, go back to start test and complete-the-circle test. As a result of the study, the rate of vestibular detection in blind individuals decreased by 50% compared to sighted individuals.[18] In the literature, sighted individuals were shown to have bet-

TABLE 1: Patient characteristics.

		Blind Group	Sighted Group	*p value
Number of subjects		29	26	
Sex (male/female); n		21/8	19/7	^{a}0.59
Age (year)	Mean±SD	41.72±11.83	40.64±9.11	^{b}0.71

^{a}Fisher exact test; bMann-Whitney U test; * p<0.05; SD: Standard deviation.

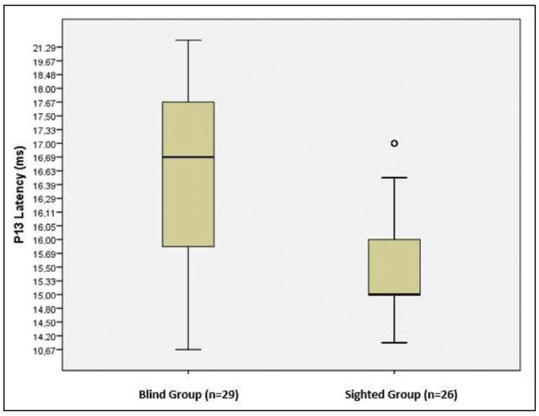

FIGURE 1: P13 Latency Graphic (P13 latency difference between the blind and sighted group was statistically significant; p=0.01).

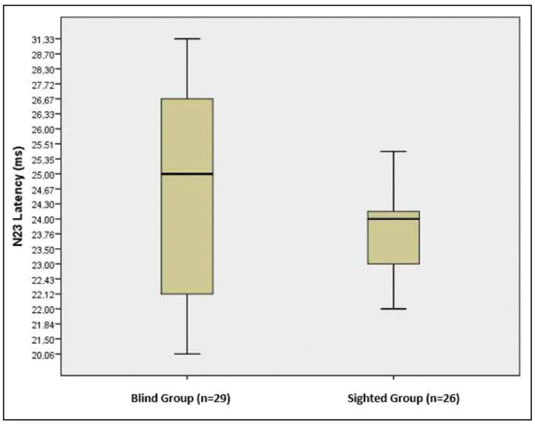

FIGURE 2: N23 Latency Graphic (N23 latency difference between the blind and sighted group was statistically significant; p=0.045).

ter scores in terms of balance and neuromuscular control compared to blind individuals. A study, in which Biodex Stability System was used, compared 20 sighted individuals with 20 blind players and 20 blind individuals with sedentary life. Better scores were obtained in sighted individuals.[19] Rutkowska et al. performed BOT-2 (Bruininks-Oseretsky Test of Motor Proficiency, Second Edition) test on 127 students of whom 61 had total vision loss and 66 had partial visual impairment. They evaluated the results in terms of gender, age and vision. They achieved significantly higher scores in patients with partial visual impairment compared to those with total vision loss.[20] In another study, the posturographic scores of the subjects with unilateral age-related macular degeneration (AMD) were found to be better than those with double sided AMD.[21] Schwartz et al. reported that postoperative scores were better than the preoperative scores in a study comparing preoperative and postoperative posturography scores of 23 patients with cataract.[22] All the studies reviewed so far show that in the blind individuals, balance scores have declined compared to the sighted individuals.

In the literature, there are very few studies conducted with cVEMP to evaluate balance in the blind individuals. In the study to evaluate the balance system in patients with ushers syndrome using cVEMP, oVEMP and video head impulse test, Magluilo et al. recorded absent or abnormal values of cVEMPs in 7 of 15 patients.[23] Adel Ghahraman et al. observed no difference between P13 latency, N23 latency and P13-N23 interpeak amplitudes in their study that compared cVEMP responses between 20 blind and 20 sighted individuals. They concluded that the cVEMP test can be suitable to evaluate the vestibular function of blind individuals.[1] In our study, we could not record any cVEMP wave in 10 (35%) of the blind subjects. Additionally, the P13 latency and N23 latency were significantly delayed in the blind group. P13 and N23 latency delay, which is due to a reduction in conduction velocity along the demyelinated fibres, is typical for multiple sclerosis. Even in some patients, VEMPs responses are absent, perhaps because of severe damage of the myelin sheaths (possibly, but not necessarily with axonal damage).[24] Similarly, we think that the lack of response or latency delays in blind individuals may be due to slowed nerve conduction or damage to vestibular nuclei. Histopathological studies are needed.

The findings in this study are subject to at least two limitations. First, these findings are limited by the use of a cross sectional design. Second, the numbers of patients and controls were relatively small.

So far, however, there has been very few studies conducted with cVEMP in the blind individuals and there is a controversy about the results of these studies. Considerably more work will need to be done to determine whether blindness a effect the cVEMP responses.

CONCLUSION

In conclusion, vestibulocollic reflex responses are negatively affected in the blind individuals. Therefore, cVEMP may not be an appropriate test for the evaluation of balance in the blind.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

***Idea/Concept:** Yaşar Kemal Duymaz, Mehmet Sürmeli; **Design:** Yaşar Kemal Duymaz, İldem Deveci, Ayşe Aslı Şahin Yılmaz; **Control/Supervision:** Çağatay Oysu, Mehmet Sürmeli; **Data Collection and/or Processing:** Reyhan Sürmeli, Yaşar Kemal Duymaz, Gülünay Kıray; **Analysis and/or Interpretation:** Yaşar Kemal Duymaz, Ayşe Aslı Şahin Yılmaz, Rıza Doğan, Mehmet Sürmeli; **Literature Review:** Yaşar Kemal Duymaz, Mehmet Sürmeli, Gülünay Kıray; **Writing the Article:** Yaşar Kemal Duymaz, Mehmet Sürmeli; **Critical Review:** Çağatay Oysu, İldem Deveci, Ayşe Aslı Şahin Yılmaz; **References and Fundings:** Yaşar Kemal Duymaz, Rıza Doğan; **Materials:** Yaşar Kemal Duymaz, İldem Deveci.*

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