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Analysis of cervical and ocular VEMP responses in healthy individuals

Análise das respostas do VEMP cervical e ocular em indivíduos hígidos

Análisis de las respuestas VEMP cervicales y oculares en individuos sanos

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Abstract

Introduction: Vestibular evoked myogenic potentials (VEMP) are electrophysiological responses that can provide information on the otolithic organs saccule, utricle and of the vestibular nerve. VEMP is a complementary exam to the vestibular assessment; it is a quick exam, easy to apply and objective. **Purpose**: to analyze the parameters of latency, amplitude, threshold and asymmetry index of the cervical (cVEMP) and ocular VEMP (oVEMP) responses of individuals without vestibular complaints. **Methods:** cross-sectional study carried out with 53 individuals of both genders without hearing and vestibular complaints. **Results:** response symmetry was found in the latencies, amplitudes and thresholds of cVEMP test responses. However, there was a difference between the ears of the P15 latency of the oVEMP exam, and this was greater on the right ear in females. **Conclusion:** symmetry was found in the responses of all cVEMP evaluated parameters. There was asymmetry in oVEMP P15 latency only in female patients. The response thresholds found in the cVEMP and oVEMP tests were equal or greater than 75 dBHL.

Keywords: Vestibule, Labyrinth; Ear, Inner; Saccule and Utricle, Evoked Potentials, Motor; Vestibular Function Tests

Resumo

Introdução: os potenciais evocados miogênicos vestibulares (VEMP) são respostas eletrofisiológicas que conseguem fornecer informações dos órgãos otolíticos sáculo, utrículo e do nervo vestibular. O VEMP é um exame complementar à avaliação vestibular, consistindo num exame rápido, de fácil aplicação e objetivo. **Objetivo:** analisar os parâmetros de latência, amplitude, limiar e índice de assimetria das

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Authors'contributions:
MBNR: idealized the study, realized data collection, participated of statistic data analysis, article writing and revision.
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respostas do VEMP cervical (cVEMP) e ocular (oVEMP) de indivíduos sem queixas vestibulares. **Métodos**: estudo transversal realizado com 53 indivíduos de ambos os sexos, sem queixas auditivas e vestibulares. **Resultados:** encontrou-se simetria de respostas nas latências, amplitudes e limiares de respostas do exame cVEMP. Entretanto, verificou-se diferença entre orelhas da latência P15 do exame oVEMP, sendo maior à direita no sexo feminino. **Conclusão:** Encontrou-se simetria nas respostas de todos os parâmetros avaliados do cVEMP. Houve assimetria apenas na latência de P15 do oVEMP no sexo feminino. Os limiares de resposta encontrados nos exames cVEMP e oVEMP foram iguais ou maiores que 75 dBNA.

Palavras-chave: Vestíbulo do Labirinto; Orelha Interna; Sáculo e Utrículo; Potencial Evocado Motor; Testes de Função Vestibular

Resumen

Introducción: los potenciales miogénicos evocados vestibulares (VEMP) son respuestas electrofisiológicas que pueden proporcionar información sobre los órganos otolíticos el sáculo, el utrículo y el nervio vestibular. El VEMP es un examen complementario a la evaluación vestibular; es un examen rápido, fácil de aplicar y objetivo. **Objetivo:** analizar los parámetros de latencia, amplitud, umbral e índice de asimetría de las respuestas VEMP cervical (cVEMP) y ocular (oVEMP) de individuos sin quejas vestibulares. **Métodos:** estudio transversal realizado con 53 individuos de ambos sexos, sin quejas auditivas y vestibulares. **Resultados**: Se encontró simetría de respuestas en las latencias, amplitudes y umbrales de respuestas en el examen cVEMP. Sin embargo, hubo una diferencia entre los oídos de la latencia P15 del examen oVEMP, siendo mayor a la derecha en el sexo femenino . **Conclusión:** se encontró simetría en las respuestas de todos los parámetros evaluados de cVEMP. Hubo asimetría solo en la latencia P15 de oVEMP en el sexo femenino. Los umbrales de respuesta encontrados en las pruebas cVEMP y oVEMP fueron iguales o superiores a 75 dBHL.

Palabras clave: Vestíbulo del Laberinto; Oído Interno; Sáculo y Utrículo; Potenciales Evocados Motores; Pruebas de Función Vestibular

Introduction

The vestibular evoked myogenic potential (VEMP) is an electrophysiological examination that assesses the integration of otolithic organs and the vestibular nerve with the brainstem and the muscular system[1,2]. This test began to be assessed in 1960; however, in 1994, Colebatch and Halmagyi found evidence of small myogenic potentials caused by sound, due to the otolithic function[3].

The tracing consists of two biphasic wave complexes and this neural response is formed by a reflex arc of three neurons that surround the inner ear, the brainstem and the vestibulo-spinal path[1,4,5]. The basic principle of this examination is the action of the response-capturing muscle in postural control, through the vestibulo-ocular, vestibulo-colic or vestibulo-spinal reflex[4,5]. Thus, the applicability of VEMP varies according to the type of stimulus and the muscle that captures the electromyographic response[5,6,7].

Cervical VEMP (cVEMP) is captured in the sternocleiodeomastoid muscle and evaluates the descending ipsilateral vestibular pathway, while ocular VEMP (oVEMP) is generated from extra-ocular muscles in response to high intensity sounds, evaluating the superior, contralateral ascending vestibular pathway[1, 2.5.6]. In order to capture vestibular myogenic potentials, the functional integrity of the saccular and utricular macula, of the nerves, nuclei and central vestibular pathways is required, in addition to the neuromuscular plaques involved[1,5,6,8].

The cVEMP biphasic wave consists of a positive peak (P) with an average latency of 13 milliseconds (ms), followed by a negative peak (N) with an average latency of 23 ms[1,4,6,8]. While the biphasic wave of oVEMP consists of a negative peak (N) with an average latency of 10ms, followed by a positive peak (P) with an average latency of 15 ms[1,4,6,8].

Regardless of the type of capture chosen, VEMP is an objective, practical, non-invasive

exam, easy to perform, low cost, fast, with minimal discomfort for the patient[1,2,6,8]. Its application in clinical practice has been increasingly recurrent for a more detailed otoneurological diagnosis, also favoring clinical monitoring[2,6,8]. The VEMP proved to be an important exam for a detailed evaluation of the vestibular system, helping significantly in the topodiagnosis of vestibular injuries[2,8,9].

However, the literature presents few studies that associate the findings of VEMP in individuals without otoneurological changes and in many studies only one type of VEMP is evaluated or they do not present threshold values for responses. This reinforces the need for studies that review all the parameters found in VEMP in individuals without vestibular complaints[1,5,7,10]. Studies that provide normative data are important for comparison in different populations with vestibular disorders and provide data for the improvement of clinical practice in the different possibilities of events that can interfere in the VEMP response. The aim of this study was to analyze the parameters of latency, amplitude, threshold and asymmetry index of cervical and ocular VEMP responses in individuals without vestibular complaints..

Methods

This investigation's procedures were approved by the Ethics Committee of the Universidade Federal de Minas Gerais (UFMG), under No. 56877316.1.0000. 5149 (according to Resolution 466/12 of the *Conselho Nacional de Saúde* (CONEP, National Health Council). The investigation was carried out in the Observatory of Functional Health in Speech Pathology and Audiology, Faculty of Medicine, UFMG.

The sample consisted of 53 individuals of both genders, aged between 20 and 59 years, with no previous or current history of dizziness and hearing disorders according to the questionnaire applied in the survey. The individuals were invited to participate in the investigation before performing the VEMP. Elderly patients were not included in this investigation, since they could present a bias in the data analysis, due to possible vestibular system lack of integrity due to aging[11,12].

The study included individuals aged over 18 and less than 60 years who voluntarily agreed to participate in the study and signed the Free and Informed Consent Form. Patients with abnormal external ear meatoscopy, history of surgery or otological trauma, alterations in the middle ear confirmed by immittanciometry testing, self-reported neurological or neurodegenerative changes, self-reported ocular and cervical changes and significant self-reported emotional disorders were excluded. This was a convenience sample, composed of individuals from the academic community.

Initially, the participants answered a questionnaire that contained information regarding the otology history and the presence of possible hearing and vestibular disorders. For the auditory evaluation of the participants, meatoscopy and tympanometry were performed in an acoustically treated room. For tympanometry, the Otometrics® Otoflex 100 equipment was used and the patient was instructed to remain seated, in silence; a probe was then introduced to capture the response in the external auditory canal of each ear. It should be noted that only individuals with type A tympanometry were considered for this study, according to Jerger's classification[13].

The participant's skin was prepared with gel before placing the electrodes to reduce electrical impedance. In order to perform the cervical and ocular VEMP, Otometrics® auditory evoked potentials, model ICS Chartr EP 200, insert earphones and surface and self-adhesive electrodes were used. The stimuli were conveyed using ER 3A insert headset with disposable foam eartips.

To perform the cervical VEMP, the participant remained seated in a chair in an acoustically treated room. The ground electrode was positioned on the forehead and the active electrodes were positioned on the right and left sternocleidomastoid muscles. The second channel electrodes were positioned below the right and left active electrodes to record surface electromyography, and the reference electrode was placed in the sternum region. Insert earphones were used to produce the air-conducted stimulus. Participants were instructed to perform lateral head rotation to the opposite side of the tested ear, in order to capture the inhibitory response of muscle contraction. Responses with muscle contraction intensity between 50 and 200 μV were accepted. Impedance values below 5 KOhms were accepted. A 95 dBnHL tone burst auditory stimulus in 500 Hz, monaural, initially tested intensity was used [3,7,8].

To perform the ocular VEMP, the active electrode was positioned in the infraorbital region, contralateral to the tested side, and the reference

electrode was positioned just below the active electrode[3,7,8]. Insert headphones were used to cause the air-conduction tone burst stimulus; the initially tested intensity was 95 dBnHL, in 500 Hz, monaural. Participants were instructed to remain with their heads straight up and look upwards, to the point of maximum reach, during the application of the stimulus.

The participant was submitted to at least two stimulations on each side, to verify the replication of the potential, and then the search for the threshold began; the lowest intensity was considered as the threshold where the response was found and it replicated. The impedance values were checked before each record, and should be below 5 KOhms, according to the literature[1,3,4,7,8].

The variables analyzed in the cervical VEMP were: the presence of P13 and N23 latencies, amplitude, asymmetry index, corrected asymmetry index and threshold (Figure 1). In ocular VEMP, the presence of N10 and P15 latencies, amplitude, asymmetry index and response threshold were evaluated (Figure 2).

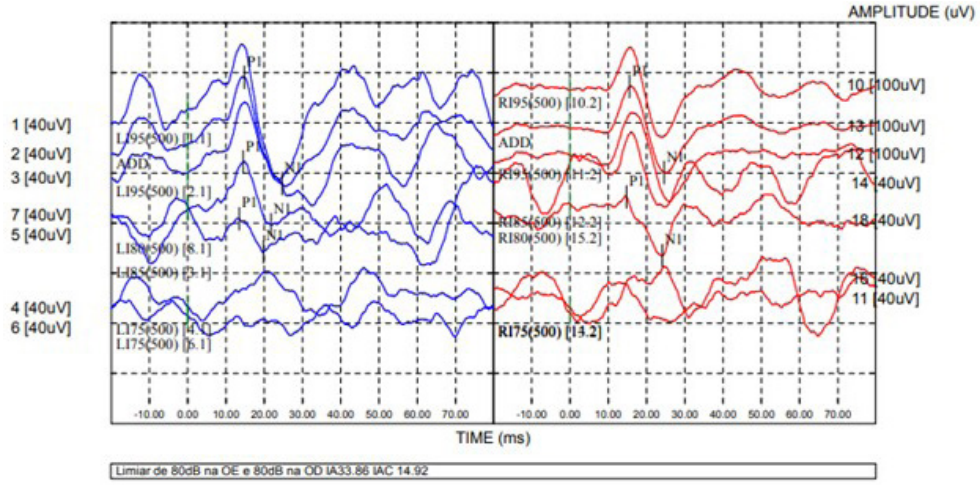

Figure 1. Cervical VEMP exam.

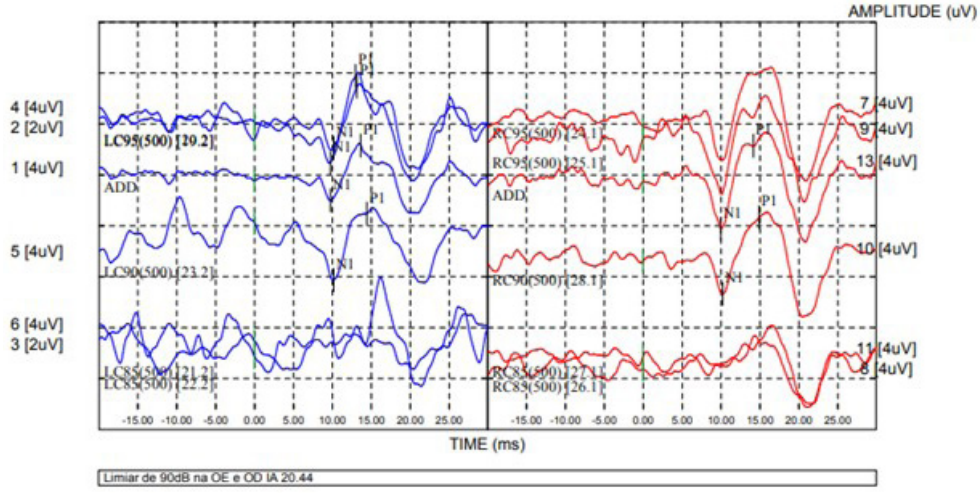

Figure 2. Ocular VEMP exam.

After the data were collected they were tabulated in an Excel spreadsheet and submitted to statistical analysis, performed using the Statistical Package for Social Sciences (SPSS) version 20.0. Initially, a descriptive analysis was performed, which comprised measures of central tendency (mean and median), dispersion (standard deviation) and position (maximum and minimum). Normality of the samples was observed with the Kolmogorov-Smirnov and Shapiro-Wilk test.

For comparison between groups, inferential statistics were also performed using the Student's t test, to compare independent samples whose data showed normal distribution, and the Wilcoxon test when the variables did not show normal distribution. The significance level of 5% (p <or equal to 0.05) was adopted in all analysis.

Results

The sample consisted of nine males and 44 female patients, with a prevalence of females. The average age of the population studied was 35.60 years (standard deviation of 14.16). The females mean age was 36.25 years (standard deviation of 14.74) and, the males mean age was 32.44 years (standard deviation of 11.05). There was no age difference between genders (p = 0.100). The descriptive analysis of the cVEMP and oVEMP exams response is shown in Table 1.

Table 1. Measures of central tendency, dispersion and position for latency (ms), amplitude (μV), asymmetry index, corrected asymmetry index and response threshold for cervical and ocular vestibular evoked myogenic potential (VEMP) (n=53).

Wave parameters	Mean	Median	Standard Deviation	Minimum	Maximum
Right ear stimulation					
Cervical VEMP					
Latency P13	15.21	15.33	1.01	13.33	20.33
Latency N23	24.40	24.17	1.88	21.50	30.67
Amplitude	152.07	160.97	79.47	30.01	396.77
Response threshold	77.36	80.0	6.01	65	90
Asymmetry index	20.18	15.83	17.48	0.23	79.53
Corrected asymmetry index	25.83	17.58	20.81	0.56	80.59
Ocular VEMP					
Latency N10	10.46	10.21	0.91	9.25	14.33
Latency P15	15.03	14.87	1.12	12.75	17.42
Amplitude	5.10	3.64	4.69	0.26	21.25
Response threshold	84.12	85.00	5.89	70	95
Asymmetry index	31.06	25.52	23.35	1.89	78.42
Left ear stimulation					
Cervical VEMP					
Latency P13	15.06	15.00	1.22	11.00	20.00
Latency N23	24.25	24.14	1.99	19.33	29.17
Amplitude	165.18	144.97	111.47	17.82	592.15
Response threshold	77.26	80.0	5.76	65	95
Ocular VEMP					
Latency N10	10.45	10.17	0.90	9.25	13.63
Latency P15	14.65	14.33	1.35	12.33	19.42
Amplitude	4.82	4.08	3.75	0.37	15.67
Response threshold	84.20	85.00	5.92	70	95

As for cVEMP, it can be seen that the mean amplitude values, P13 and N23 wave latency, and response thresholds showed similar values in both the right and left ears. For oVEMP, the mean amplitude values, P15 and N10 latency and thresholds were also close in both ears.

When comparing the results obtained in the right and left ear by gender, a difference was found in the P15 latency in oVEMP only, with higher values being obtained in female's right ear (Table 2).

Table 2. Verification of symmetry between male and female's ears for latency (ms), amplitude (μV) and response threshold, for cervical and ocular vestibular evoked myogenic potential (VEMP) (n=53) (IC=95%).

Wave parameters	Right ear			Left ear			P-value
	Mean	Median	SD	Mean	Median	SD	
Male							
Cervical VEMP							
Latency P13	15.14	15.33	0.72	14.96	14.83	1.01	0.459*
Latency N23	24.24	24.67	1.99	23.94	24.67	2.20	0.480*
Amplitude	145.83	123.52	92.64	170.34	94.47	180.97	0.178**
Response threshold	80.00	80.00	5.00	81.67	80.00	6.12	0.282*
Ocular VEMP							
Latency N10	11.10	10.25	1.53	11.19	11.33	0.87	0.843*
Latency P15	15.21	15.08	1.43	14.66	14.42	1.38	0.482*
Amplitude	2.57	1.70	5.51	3.00	1.66	2.58	0.953**
Response threshold	85.56	85.00	5.83	85.89	85.00	8.20	0.257**
Female							
Cervical VEMP							
Latency P13	15.22	15.16	1.07	15.08	15.17	1.27	0.358**
Latency N23	24.43	24.17	1.88	23.71	24.08	1.96	0.964**
Amplitude	153.34	164.29	77.66	164.12	148.16	94.48	0.776**
Response threshold	74.96	75.00	6.10	76.36	75.00	5.32	0.550**
Ocular VEMP							
Latency N10	10.32	10.17	0.65	10.29	10.17	0.83	0.436**
Latency P15	14.99	14.83	1.06	14.65	14.33	1.36	0.019**
Amplitude	5.66	3.88	4.91	5.22	4.30	3.87	0.440**
Response threshold	83.81	85.00	5.92	84.27	85.00	5.42	0.744**

* T Test** Wilcoxon Test. Legend: n= participants number; CI= confidence interval; SD= Standard deviation.

Discussion

Prevalence of the female gender was observed in the sample of the present study; this fact is due to the formation of the sample, which was organized by convenience, and most of the sample members were students, professionals and participants of the *Academia da Cidade* project that takes place at the Faculty where the study was performed. The mean values of latencies, amplitudes and response thresholds are in line with those found in other studies that also investigated the integrity of the vestibular system through VEMP in populations without otoneurological changes[1,7,10], which enhances the findings of this study and allows these data to be compared with future studies.

In this study, no difference was found between the amplitude of response in the analysis between ears in the cVEMP and oVEMP exams, corroborating those studies that did not find asymmetry of responses[1,8,10]. The literature reports that the amplitude reflects the magnitude of the muscle reflex and may present interpersonal variation in muscle mass and tone, and may be greater in males in some cases[1,5,8,10]. To reduce this bias, the asymmetry index is used as a parameter, because, in the present study, it was found that the average data for the cervical and ocular asymmetry index

and its variations are within the normality standards proposed in the literature [1,8, 14,15].

The response threshold also showed no statistical difference between ears, which is in line with the literature, with the values found in this sample equal to or greater than 75 dB NA[1,8,10]. The literature also reports that the threshold of excitability of the saccular macula is around 80 dB Sound Pressure Level, being close to the values found in the present study[7,15].

In this study we found a difference in the symmetry of responses in the P15 latency of oVEMP, being higher on the right side in females; however this result should be viewed with caution, since the median values of this variable are close (14.83 on the right and 14.33 on the left). No difference between latencies was found in the retrieved literature, so that this finding may have occurred at random and should be observed with caution, since all latency values are within the literature normal standards [1,8,10].

Asymmetries in VEMP responses occur when there is unilateral vestibular alteration, such as in Upper Canal Dehiscence or in Meniere's Disease, depending on the stage of the disease[6,8,9,18,19,20]. The sample profile of the present study is different, since it presented integrity of the saccular and utricular macula when evaluated.

Among the limitations of the present study is the scarce number of studies that investigated the VEMP response thresholds, especially in individuals without otoneurological changes, thus making it difficult to confirm or further critically questioning the data found in this study[10,15,16,17,18,19,20,21]. It was not possible to make a comparison between genders on the exam parameters, due to the difficulty in recruiting male individuals for the study.

VEMP is a practical, quick and easy to perform exam; it does not cause discomfort to the patient and is able to objectively assess the vestibular-colic and vestibulo-ocular pathways[1,8,10,18,19,20,21], resulting in an examination reliable in clinical practice both in the evaluation and in the monitoring of individuals with otoneurological disorders[12,17,18,19,20].

Conclusion

The parameters of latency, amplitude, threshold and asymmetry index of cervical and ocular VEMP responses in healthy individuals were symmetrical.

Response asymmetry was found only in the P15 latency of the ocular VEMP between the right and left ears in females. The response thresholds found in the cervical and ocular VEMP were equal to or greater than 75 dBHL.

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