State-of-the-art assessment allows for improved vestibular evoked myogenic potential test-retest reliability

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Abstract

The goal of the present study was to evaluate the test-retest reliability values of myogenic responses using the latest guidelines for vestibular assessment. Twenty-two otologically and neurologically normal adults were assessed twice, on two different days. The analyses were carried out using interclass correlations. The results showed that the latest recommendations for vestibular assessment lead to test-retest reliability values that are as high, or greater, than those reported in previous studies. The results suggest that state-of-the-art testing, using the latest recommendations as well as electromyography control, improves reliability values of myogenic responses, more specifically for the cervical vestibular evoked myogenic potentials. The impact of small differences in experimental procedures on the reliability values of myogenic responses is also addressed.

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Key words: Ocular vestibular evoked myogenic potentials; Cervical vestibular evoked myogenic potentials; Reliability; Vestibular.

Contributions: MM, LB, FC designed and performed the experiment and wrote the paper; AD helped with the edition of the manuscript. All authors discussed the results and implications and commented on the manuscript at all stages.

Conflict of interest: the authors declare no potential conflict of interest.

Funding: this research was funded by the Canadian Institutes of Health Research (CIHR) and the Natural Sciences and Engineering Research Council of Canada (NSERC).

Received for publication: 19 April 2018.
Revision received: 22 July 2018.
Accepted for publication: 12 September 2018.

Audiology Research 2018;8:212
doi:10.4081/audiores.2018.212

Introduction

Vestibular evoked myogenic potentials (VEMPs) are used in clinical settings to examine the integrity of the vestibular system. These potentials are further divided into two different categories: a cervical VEMP (cVEMP) and an ocular VEMP (oVEMP). The cVEMP is an inhibitory electromyogenic response measured on the sternocleidomastoid muscle, which is used to assess the functioning of the saccule and inferior vestibular nerve.[1] In contrast, the oVEMP is an excitatory response measured on the inferior oblique muscle, which is used to assess the functioning of the utricule and superior vestibular nerve.[1] Although cVEMPs and oVEMPs are used to assess the functioning of the otolithic organs, little is known about their test-retest reliability, which is critical for the monitoring of peripheral and central vestibulopathies. A strict classification of reliability coefficients is thus mandatory. Unfortunately, previous studies evaluating test-retest reliability did not rely on an evidence-based classification. The present study will use Koo *et al*.'s classification[2] to describe and compare the results of previous studies.

The few studies that have examined the test-retest reliability of cVEMP responses found that these values varied considerably between studies. Using the classification proposed by Koo *et al.*,[2] previous studies have found good to excellent test-retest reliability for peak-to-peak amplitude and large variability for latencies, ranging from poor to excellent.[3,4] In terms of the oVEMP, three studies have investigated test-retest reliability[3,5-11] and these either report moderate to good reliability for peak-to-peak amplitudes or poor to moderate reliability for N1 and P1 latencies.

This discrepancy in research findings might be explained by the different procedures used to elicit myogenic responses. Indeed, small differences in experimental procedures, such as electrode positioning, might affect reliability values.[3] Thus, investigating the reliability of myogenic responses in different experimental set-ups is of utmost importance in order to confirm that test-retest reliability remains constant across procedural methods.

Accordingly, the goal of the present study was to examine the test-retest reliability of cVEMPs and oVEMPs in normal adults. To do so, the latest recommendations of the Canadian Academy of Audiology[6] (CAA) have been used. Using these new recommendations also made it possible to examine whether this recent procedural method affects reliability values.

Materials and Methods

Participants

Twenty-two individuals (13 males) between 18 and 60 years of age participated in the present study (*M* = 40.41 years; *SD* = 13.34 years). The participants had no history of neurological or otological disorders, normal hearing thresholds and normal middle ear function.

Procedure

After each participant signed the consent form, a certified audiologist performed otoscopy and tympanometry in order to rule out the presence of ear pathologies. After the hearing test, participants were evaluated using cVEMPs and oVEMPs (Eclipse EP-25/VEMP; Interacoustics, Denmark) in random order. The protocols followed the recent recommendations of the CAA.

For the cVEMP, an air-conducted 500Hz tone-burst at 133dB SPL was used.[7] The stimulus rate was set at 5Hz, with a maximum of 200 repetitions and a band-pass filter between 5Hz and 2kHz. Each trial was repeated twice to ensure replicability. The active electrode was placed on the superior third of the ipsilateral sternocleidomastoid muscle, the reference electrode was placed on the upper sternum, and the ground electrode was placed on the forehead. Participants were placed in a reclined position and were asked to lift their head and to turn it away from the stimulated ear.[8] In addition, during the cVEMP stimulation, an electromyography (EMG) monitoring was performed and all responses between 49.9uV and 150.6uV were recorded. For the oVEMP, an air-conducted 500Hz tone-burst at 133dB SPL was used, with the same stimulus parameters as those used for the cVEMP. The active electrode was placed under the contralateral eye (on the inferior eyelid), the reference electrode was located 2 cm beneath the active electrode, and the ground electrode was placed on the forehead. Participants sat comfortably and, during stimulation, they were asked to stare at a visual target located on the wall to ensure that their gaze was raised by 30 degrees.

Participants were required to come back within 3 days of the first assessment in order to complete a second vestibular evaluation. The present research project has been approved by the *Comité d'éthique pour la recherche en santé of the Université de Montréal*.

Analysis

Curves of the cVEMP and oVEMP responses were labeled according to the recommendations of the CAA.[6] For the cVEMP, the first positive peak and the first negative peak were labeled P1 and N1, respectively (positive ≈ 13ms; negative ≈ 23ms). Similarly, for the oVEMP, the first negative peak and the first positive peak were labeled N1 and P1, respectively (negative ≈ 10ms; positive ≈ 15ms). P1 and N1 latencies as well as peak-to-peak amplitudes were retrieved for cVEMP and oVEMP responses. Additional measures included the rectified amplitude of the cVEMP responses as well as asymmetry ratios for cVEMP and oVEMPs. The asymmetry ratios were calculated as follows: % = 100 * [(amplitude LE - amplitude RE) / (amplitude LE + amplitude RE)].Two-way mixed effects interclass correlations (ICC) using absolute agreement were carried out to assess the test-retest reliability of VEMP responses. Reliability was determined as follows:[2]
ICC < .50 = poor
.50 < ICC < .75 = moderate
.75 < ICC < .90 = good
ICC > .90 = excellent

Results

The mean cVEMP amplitudes for stimuli presented to the right ear were 104.88 ±13.84mV (test) and 117.11 ±15.64mV (retest) followed by 107.96 ±14.27mV (test) and 129.35 ±17.23mV (retest) for the left ear. The mean oVEMP amplitudes for stimuli presented to the right ear were 4.95±0.53mV (test) and 4.78 ±0.52mV (retest) followed by 4.05 ±0.46mV (test) and 4.04± 0.45mV (retest) for the left ear. For the cVEMP, excellent test-retest reliability was found for rectified amplitude (ICC = .90;), non-rectified amplitude had good reliability (ICC = .89), and P1 and N1 latencies had moderate reliability (P1: ICC = .69; N1: ICC = .63). Asymmetry and rectified asymmetry ratios both had poor test-retest reliability (ICC values of .15 and .10, respectively). For the oVEMP, amplitude and P1 latency had excellent test-retest reliability (amplitude: ICC = .97; P1: ICC =.94), asymmetry ratio had good test-retest reliability (ICC = .87), and N1 latency had poor test-retest reliability (ICC = .31) (Figure 1).

Discussion and Conclusions

The goal of the present study was to examine the test-retest reliability of cVEMP and oVEMP responses using the latest guidelines of the CAA.[6] The results show that, overall, CAA's guidelines have significant effects on the reliability values of VEMP responses – with cVEMP ICC values being higher than those of previous studies.

The present test-retest reliability values for the cVEMP responses are in line with those of Maes *et al*.[9] and Qian *et al*.,[4] but are superior to those of previous studies.[10] Indeed, in the present study, good (ICC = .89) and excellent (ICC = .90) reliability values were found for raw and rectified cVEMP amplitude, respectively. This contrasts with the raw and rectified cVEMP amplitude found in previous studies, which ranged from moderate (ICC = .68) to good (ICC = .89; 3; 11). As for the latencies of cVEMP components, the results of the present study revealed ICC values of moderate reliability, which is in line with most of the previous studies.[9,11]

For the oVEMP responses, in turn, most reliability values were found to be either good or excellent – except for the N1 latency that yielded poor test-retest reliability values, which aligns with previous evidence.[4,11] These results, however, contrast with previously reported values for the test-retest reliability of P1 latency. Indeed, previous findings support a poor to moderate reliability

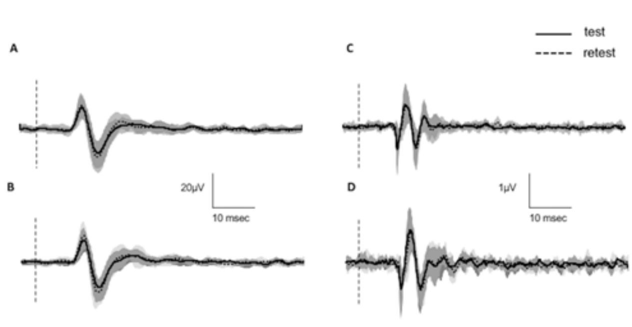

Figure 1. Representation of the grand average of VEMP results and standard deviation: A) cVEMP right ear; B) cVEMP left ear; C) oVEMP right ear; D) oVEMP left ear.

value, as opposed to an excellent ICC value in the present study.

As mentioned earlier, small differences in experimental procedures influence reliability values.[3] It is therefore important to highlight the characteristics of the present experimental procedure that can explain the high reliability values that were found. First, different electrodes have been used during the test and re-test sessions – eliminating electrode positioning differences as the cause of the high reliability values that were found. Second, the individuals who participated in the present study were in a reclined position during the cVEMP procedure and were sitting upright during the oVEMP procedure. In previous studies, the participants were tested only in a reclined position. Because extant evidence suggests that a change in position impacts on myogenic responses,[12] the posture of the participants may have influenced the reliability values. Third, the EMG level was monitored and cVEMP responses was filtered out of the preset EMG level band. Since cVEMP amplitude depends on background EMG level,[13] it should be controlled to make sure it does not influence test-retest reliability values. The control of EMG in the present study might explain why the results differ from those of previous studies.[5]

Altogether, the present results suggest that using CAA's recommendations for vestibular assessment[6] significantly improves test-retest reliability, particularly for cVEMP responses. This indicates that even subtle changes in experimental procedure can affect the reliability of VEMP potentials. More studies are needed to explore not only the clinical importance of these changes, but also their impact on the reproducibility of myogenic responses. Finally, these test-retest reliability data were found in normal healthy adults. Given the fact that the general population is aging, further studies should assess test-retest reliability of these measures in elderly adults as well.

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