Test Retest Reliability of Ocular Vestibular Evoked Myogenic Potential

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Abstract: Recently oVEMP testing is used to evaluate the function of utricle, with recording from contralateral ocular muscle. Aim of the present study was to see test retest reliability of oVEMP response. A total of 40 normal healthy participants were included for the present study and they underwent oVEMP testing for three recording sessions i.e. test, intra test and inter test sessions. Excellent and near excellent reliability was obtained for both latencies, and n1-p1 peak to peak amplitude. Thus it can be concluded from the current research study that VEMP testing procedures are reliable in normal hearing individuals across, within and between test recordings.

Keywords: Utricle, Ocular, Amplitude, Latency.

INTRODUCTION

Vestibular evoked myogenic potential (VEMP) test is a relatively new diagnostic advancement that investigates functions of the otolith structures, inferior and superior branch of the vestibular nerve [1]. Ocular VEMP (oVEMP) are the myogenic responses that are recorded from contralateral ocular muscle in response to high intensity stimulus and are measured when the electrodes are placed beneath the eyes. The potential can be measured in response to air conduction, bone conduction, and galvanic stimuli [2-4]. oVEMP in response to acoustic stimuli is presumed to have its origin from the utricle [4]. The pathway is thus thought to travel from the utricle, passing through the superior vestibular nerve, vestibular nucleus, then crossing over to contralateral oculomotor nuclei *via* the medial longitudinal fasciculus, and finally innervating the extraoccular muscles [5]. The normal oVEMP waveform has an initial negative peak at 10-12 msec (n10 or N1) and a subsequent positive peak at 15-20 msec (p15 or P1). Unlike cVEMPs, oVEMPs are excitatory responses, and are indicative of contralateral otolith-ocular function. The testing requires the subject to have an upright posture and fixate the gaze on a stationary visual target that is at an angle of 30 degrees above the horizontal plane [6, 7].

There are comparatively fewer studies that talk about the reliability of oVEMP testing. Acceptable test retest reliability has been reported in the literature [8]. oVEMP response acquired from binaural acoustic stimulation yields excellent test-retest reliability, and shorter test time than monaural oVEMP [9]. The reliability of cVEMP and oVEMP testing showed excellent reliability for peak to peak amplitude of cVEMP and oVEMP when elicited through reflex hammer and tones [10]. In contrast, poor to good reliability was yielded for p13, n23 latencies of cVEMP and n10, and p16 latencies oVEMP responses.

Although, from the literature reports test retest reliability of oVEMPs, there have been equivocal finding with respect to latency. Previous studies have been performed in small sample to see the test retest reliability. Therefore, there is a need to clearly understand the reliability of these response characteristics for accurate clinical evaluations. Thus the current study focused on investigating the test retest reliability of oVEMP testing among normal healthy individuals in larger sample. Such standardization of equipment parameters, testing protocols, and clinical use is essential for these tests to be fully implemented into a clinical setting. Hence the aim of the study was to investigate the test retest reliability of oVEMP testing in normal healthy individuals.

METHOD

A cross-sectional design with a convenient sampling method was utilized to recruit a group of normal healthy participants for the study. 40 normal healthy individuals (80 ears) within the age range of 20-60 years with a mean age of 30±8 years were considered as participants. Among the 40 subjects, 15 participants were males and the rest 25 were females. Prior

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consent was given by the participants before including them in the testing. Participants diagnosed as having normal hearing sensitivity (<15 dB) across 250Hz to 8000Hz frequency range for air conduction and from 250Hz to 4000Hz for bone conduction with 'A' type tympanogram and the presence of both ipsilateral and contralateral acoustic reflexes were included. Individuals who had history/presence of neurologic disorders, spondilitis, diabetes, or high blood pressure were excluded from present study. Additionally individuals with any complaint of vertigo, tinnitus, vomiting, or nausea were excluded.

Instrumentation and Procedure

Presence of any vestibular symptoms was ruled out during a detailed case history. Pure tone audiometry was done to obtain the auditory thresholds using modified Hughson-Westlake procedure [11] across octave frequencies from 250 to 8000Hz for air conduction, and from 250 to 4000Hz for bone conduction using GSI 61 clinical audiometer. The uncomfortable level (UCL) was obtained prior to VEMP testing, as the latter requires stimulus presentation of 500Hz tone burst at high intensity level (100dBnHL). Immittance evaluation using 226Hz probe tone was performed to ensure that the participants had normal middle ear function using GSI tympstar.

oVEMP testing was done using the Intelligent Hearing Systems (IHS) (version 3.92) in the Electrophysiological laboratory.The participants were seated in an upright relaxed position. oVEMP was recorded from the contraction of extraoccular muscle. The electrode configuration involved placement of Non-inverting electrode beneath the eye, contralateral to the ear being tested. The inverting electrode was positioned 1-2 cm below the non-inverting electrode over the cheek and the Ground electrode was placed on the forehead. The absolute electrode impedance was maintained within 3kΩ at each electrode site. ER-3A insert earphone was used to deliver the acoustic stimulus. 500Hz tone burst (8ms duration) at a loud stimulus level of 100dBnHL was presented monaurally to each ear. Responses from 200 stimulus sweeps were averaged. A time window of 50msec and the repetition rate of 5.1/sec was incorporated. The EMG signals were amplified 50,000 times and band pass filtered between 1Hz -1000Hz. The participants were instructed to look upward at a visual angle of 30-35 degree vertically above the horizontal plane at a fixed target, which was approximately >2m distance from the eyes. Two consecutive recordings of oVEMP was acquired bilaterally for each participant in the same session with a gap of 5 minutes between the two recordings. Inter session retest recording was performed after a minimum gap of 3 to 5 days following the first recording. Data was analyzed in terms of latency measures which included n1 and p1 and n1-p1 peak to peak amplitude for oVEMP. Reliability measures of test was statistically analyzed using intraclass correlation coefficient analysis (ICC). ICC interpretation was as follows: less than 0.4 shows poor reliability; 0.4-0.75 shows fair to good reliability; 0.75 or greater indicates excellent reliability and 1 represents perfect reliability [10].

RESULTS

oVEMP responses were recorded for all the participants in all three recording sessions: test session (Session 1) and retest sessions i.e. intra session (Session 2) and inter session (Session 3). oVEMP latency (n1 & p1) and peak to peak amplitude was measured.The mean n1 latency for oVEMP was found at 11.9 ± 2.10 (SD) ms for session 1. For session 2 and session 3 the n1 latencies were at an average of 11.89 ± 1.84 (SD) ms and 11.84 ± 1.67 (SD) ms respectively. Further, p1 latencies were at a mean of 16.74 ± 1.64 (SD) ms, 17.04 ± 1.58 (SD) ms and 16.93 ± 1.92 (SD) ms for first, second and third sessions respectively. The n1 and p1 mean latencies showed minimal variations across the three testing conditions. More or less same standard deviation observed for all the three session of n1 and p1 latencies. The above findings are represented in the Figure **1**.

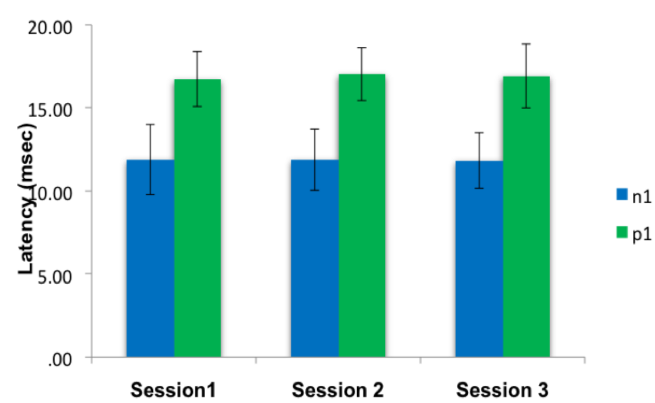

Figure 1: Mean and standard deviation of n1 and p1 latency of oVEMP responses obtained for session1, session 2, and session3. Error bars indicate 1SD of error.

The mean peak to peak amplitude and standard deviation for n1-p1 of oVEMP responses across three testing conditions are shown in the Figure **2**. In session 1 the mean n1-p1 amplitude was 7.03 ± 3.99 (SD) μV, session 2 had an average amplitude of 6.81 ± 3.77 (SD) µV, and session 3 showed 7.13 ± 3.91 (SD) µV. All the three session it was observed mean n1-p1 amplitude approximately same. The standard deviation was also observed more or less same for all the session for n1-p1 amplitude.

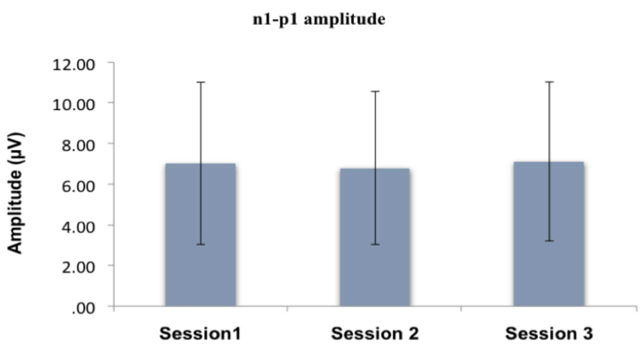

Figure 2: Mean and standard deviation of peak to peak amplitude of n1-p1 of oVEMP response obtained for session 1, session 2, and session 3. Error bars indicate 1SD of error.

Intra class correlation analysis was carried out to evaluate the test retest reliability of oVEMP measures. The ICC values of n1 indicated fair to good reliability across the three session. The excellent test retest reliability was observed for p1 latency and n1-p1 amplitude. On the whole, the latency of n1 also showed reliability near to excellent, and on the other hand the p1 latency showed highest reliability among latency and amplitude measured for oVEMP response. The results are depicted in Table **1**.

DISCUSSION

The current study showed fair to good reliability for n1 and excellent reliability for p1 latencies which is in congruence with the findings that indicated fair to good reliability (ICC=0.44) for n1 latency and excellent test retest reliability (ICC=0.76) for p1 latency of monaural oVEMPs. Compared to monaural, binaural oVEMPs had higher test retest reliability for latencies and amplitudes. Fair to good reliability for n1 and excellent reliability for p1 was observed for monaural and binaural stimulation of oVEMP response [9]. Similar finding was reported for n1 latency with fair to good reliability of oVEMP response. With respect to p1

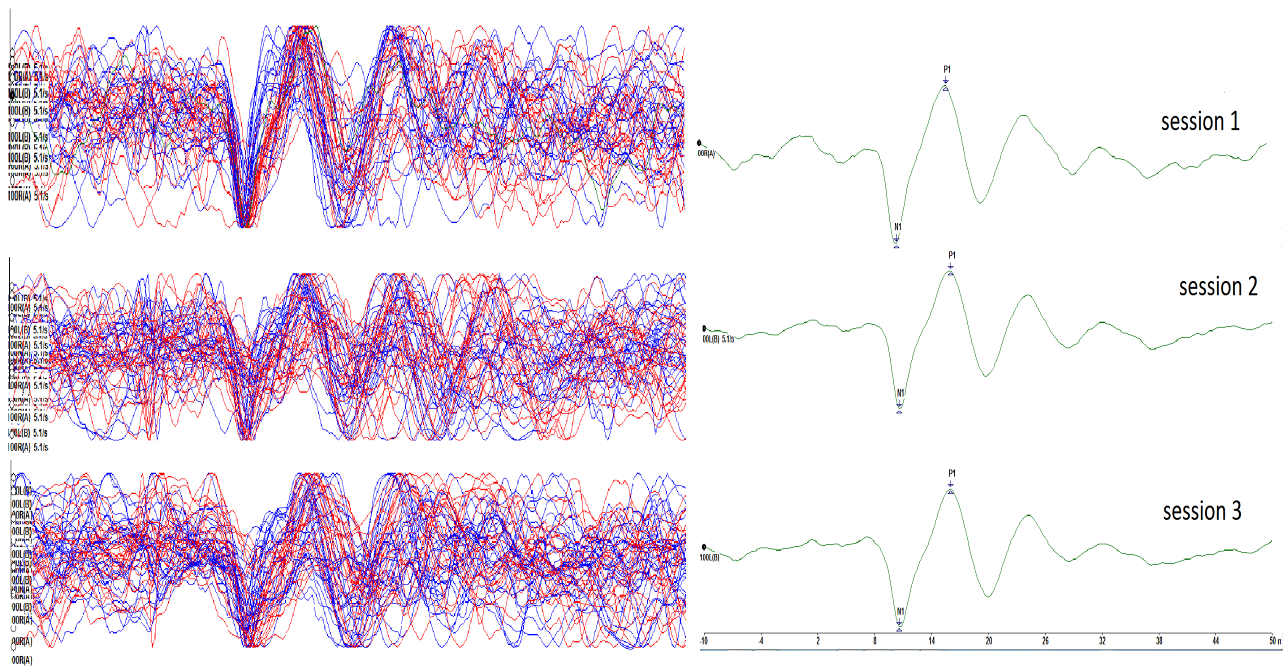

Figure 3: Left side showing individual overlapping oVEMPs waveforms for all the participants in three different sessions. Right side showing grand average waveform depicting n1 and p1 latencies for oVEMP response for session 1, session 2, and session 3.

Table 1: Intra Class Correlation Co-Efficient of Test (Session 1), Intra Test (Session 2) and Inter Test (Session 3) Recordings for n1, p1 Latencies and n1-p1 Amplitude of oVEMP Responses

n1 latency	p1 latency	n1-p1 amplitude
0.73	0.88	0.82

latency, earlier report indicated only fair to good reliability in contrast to the present study [8, 10]. Amidst such controversial results regarding oVEMP latencies, the present study showed excellent or near to excellent reliability for oVEMP latencies. The reason may be due to the difference in the method of recording, the stimuli used, and the duration of the stimulus used in the current study.

The present study showed excellent reliability for n1-p1 peak to peak amplitude which is similar with the earlier reports. Excellent reliability (ICC > 0.75) for n1–p1 amplitude has been quoted [8, 9, 10]. Excellent test retest reliability was observed for peak to peak amplitude for four different tests stimuli (click, tone, hammer & mini-shaker). They also reported absolute amplitude of n10 with excellent reliability for all tests stimuli except for click, which was fair to good reliability [10]. Excellent test retest reliability has been reported for n1-p1 amplitude using monaural and binaural stimulation of oVEMP response. The excellent test retest reliability of peak to peak amplitude might be due to the fact that the response is an excitatory potential measured in the midst of relatively small background noise from the extraocular muscles. Another reason may be due to the surface area of cheek, which is small, allowing less chance for error in optimal placement of electrode. There may be less variability in soft tissue depth on the cheek or may be upgaze producing less fatigue in the extraocular muscle.

Finally, oVEMP testing can be utilized readily for clinical evaluations as they show near to excellent or excellent reliability. Hence the latencies and peak to peak amplitude can be reliably recorded in healthy individuals. However due to different protocols and norms utilized at different laboratories, the latency and amplitude measures might show deviations from the standard values. Therefore norm specific evaluation for these responses can further strengthen the reliability of the tests and might better aid in the identification of vestibular disorders.

CONCLUSION

Excellent or near excellent reliability was obtained for latencies and n1-p1 peak to peak amplitude. Thus, it can be concluded from the current research study that, oVEMP testing procedures are reliable in normal hearing individuals across, within, and between test recordings. However the reliability may vary with respect to different recording parameters and techniques. Therefore, VEMP testing, one of the vestibular assessment test battery, yields reliable results when clinic specific norms are established.

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