



Original Article

# Comparison of Tone Burst, Click and Chirp Stimulation in Vestibular Evoked Myogenic Potential Testing in Healthy People

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**OBJECTIVE:** Vestibular evoked myogenic potential (VEMP) is a clinical test used in the diagnosis of vestibular diseases. VEMP uses several stimulants to stimulate the vestibular system and measure myogenic potentials. The aim of this study was to compare the effects of tone burst, click, and chirp stimulation in VEMP on the latency and amplitude of myogenic potentials.

**MATERIALS and METHODS:** We compared the results of 78 ears from 39 volunteers. We measured the sternocleidomastoid muscle potential of each ear following a 500-Hz tone burst, click, and chirp stimulation while in a sitting position and evaluated the latency and amplitude.

**RESULTS:** The tone burst stimulus resulted in waves with longer latency ( $15.8 \pm 1.9$  ms) but higher amplitude ( $35.9 \pm 17.1$   $\mu$ V) compared with the other stimuli, and the chirp stimulus resulted in waves with shorter latency ( $9.9 \pm 2.4$  ms) but lower amplitude ( $33 \pm 18.6$   $\mu$ V) ( $p < 0.001$ ). The VEMP asymmetry ratio did not significantly differ.

**CONCLUSION:** Because the amplitudes and latencies of different stimuli significantly differ, further studies including more patients and stimulus types are needed to obtain standardized VEMP protocols.

**KEYWORDS:** Chirp, click, tone burst, VEMP

## INTRODUCTION

Vestibular evoked myogenic potential (VEMP) is a clinical test used in the diagnosis of vestibular diseases. VEMP uses several stimulants to stimulate the vestibular system and measure myogenic potentials. The most frequently used parameters of VEMP testing are P13 and N23 wave latency and amplitude, peak-to-peak (P13–N23) amplitude, and VEMP asymmetry ratio (VAR). Many parameters are used to obtain normative values for VEMP testing, including stimulus type, electrode location, patient position, and electromyography record method and evaluation<sup>[1,2]</sup>. However, because of differences in testing methods and personal differences, there are no standard procedures or normative values yet<sup>[2,3]</sup>. Thus, the aim of this study is to compare the effects of tone burst, click, and chirp stimulation used in VEMP on the latency and amplitude of myogenic potentials.

## MATERIALS and METHODS

After obtaining approval from the local ethics committee (Number: 2014/6), we prospectively allocated volunteers to the study. A total of 78 ears from 39 volunteers with no history of neurologic or otologic disease, normal otoscopic examinations, and normal pure tone audiometric thresholds were included in the study. Written informed consent was obtained from all participants.

### Measurement of VEMPv

VEMP testing was performed in a quiet room with the subject in a sitting position; surface electrodes were used. By turning the volunteer's face against the tested side, sufficient tension on the sternocleidomastoid muscle was obtained. Click, narrow-band chirp (500–4000 Hz), and 500-Hz tone burst tests were performed with ear phones (Interacoustics Eclipse EP25, Assens, Denmark). VEMPs were recorded using 100 dB nHL. The device was calibrated by authorized technical personnel according to the ISO 389-6 standards. During the tests, the active electrode was placed at the upper one-third region of the sternocleidomastoid muscle, the inactive electrode at the suprasternal notch, and the ground electrode at the middle of the forehead. To prevent sore muscles, the volunteers were instructed to relax for three minutes before each test.

Preliminary results of this study were presented as a poster presentation in 29<sup>th</sup> Politzer Society Meeting, 14-17 November 2013, Antalya, Turkey.

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### Evaluation of the Test Results

The characteristic waveform for each type of stimulus is shown in Figure 1. VAR of each stimulus was also calculated. VAR was calculated according to the formula (P13–N23 amplitude of the left ear–P13–N23 amplitude of the right ear)/(P13–N23 amplitude of the left ear+P13–N23 amplitude of the right ear).

### Statistical Analysis

Data were analyzed with the software SPSS version 15 for Windows (SPSS Inc.; Chicago, IL, USA). The distribution of the results was analyzed using the Shapiro–Wilk test. Normal distribution was observed, and groups were compared using analysis of variance (ANOVA);  $\alpha=0.05$ . When the ANOVA tests resulted in a statistical significance, the groups were compared using a paired t-test;  $\alpha=0.017$ . The results were analyzed using a paired t-test (the right ears were paired with the left ears);  $p<0.05$  was considered statistically significant.

### RESULTS

The results are summarized in Table 1. There were 21 (53.8%) female and 18 (46.2%) male volunteers; their mean age was  $28.6\pm 5.5$  (range, 18–48) years. We were unable to obtain a VEMP response in either ear for two (5.1%) volunteers. Response rate was higher with the tone burst stimulus, which is in accordance with current literature. Wave latency was the longest with the tone burst stimulus and shortest with the chirp stimulus with the click stimulus in between. The wave amplitude distribution results were similar.

The P13 latency was statistically different among the three groups ( $p<0.001$ ). A statistical difference in the P13 amplitude value was found between the burst stimulus and the click and chirp stimuli ( $p<0.001$ ), but not between the click and chirp stimuli. The VAR values did not statistically significantly differ.

When patients within the same groups were compared, the P13 latency, P13 amplitude, and peak-to-peak (P13–N23) amplitude results obtained from the right and left ears of the same patient did not significantly differ.

### DISCUSSION

Many different applications of VEMP testing have been reported in literature. A large amount of data has been obtained by changing several parameters, such as electrode positioning, patient position (e.g., supine, sitting), stimulus type (e.g., tone burst, click), and stimulus application (air or bone conduction)<sup>[1-5]</sup>. Current literature reports a VEMP response rate of 80–100%<sup>[2,3]</sup>. Our study also obtained a high response rate.

VEMP testing still lacks standardized normative values for use in clinical evaluation. Because VEMP testing includes many parameters, we are of the opinion that further studies including more patients and stimulus types are needed to obtain standardized VEMP protocols.

Literature reports that the latency of tone burst stimulation is longer compared with that of click stimulus. It is hypothesized that this is due to the comparably longer rise/fall time and therefore, the late peak of a tone burst stimulation response wave. Conversely, the click stimulation response wave, with a shorter rise/fall time, results in a VEMP response before it stimulates the stapes reflex<sup>[1]</sup>. Studies

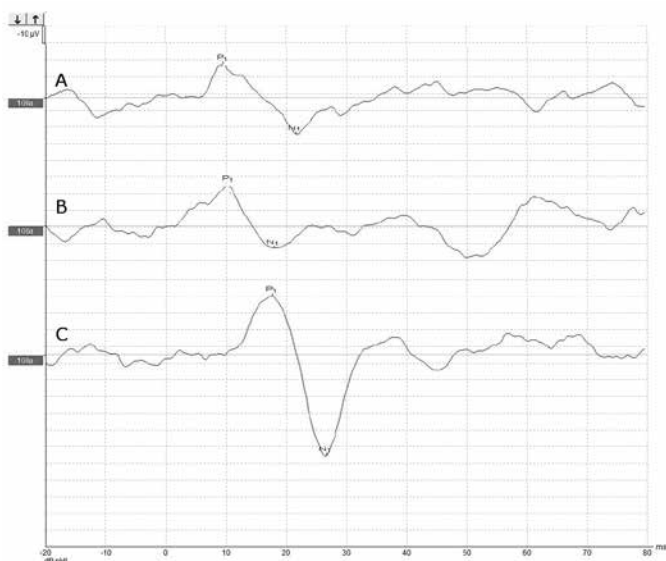
**Table 1.** Results according to stimulus type. VEMP response is given as number (percentage) of volunteers in whom a VEMP response could be obtained. Other data are given as mean±standard deviation (min–max)

	500-Hz Tone Burst	Click	Chirp
VEMP response n (%)	73 (93.5%)	69 (88.4%)	70 (89.7%)
P13 Latency (ms)*	15.8±1.9 (12.6–23.6)	11.6±2.1 (9.3–19.3)	9.9±2.4 (5–18)
P13 Amplitude (µV)*	35.9±17.1 (9.5–75.6)	25.8±12 (7.7–62.1)	20.3±8.4 (1.2–44.3)
P13–N23 Amplitude (µV)*	93.5±41.3 (23.3–196.8)	53.2±26.1 (14.6–159.5)	33±18.6 (12.9–79.7)
VAR**	0.17±0.15 (0.01–0.61)	0.18±0.13 (0.01–0.49)	0.15±0.12 (0.01–0.5)

(Hz: hertz; VEMP: vestibular evoked myogenic potential; ms: millisecond; µV: microvolt; VAR: VEMP asymmetry ratio)

\*Statistically significant difference among all groups,  $p<0.001$

\*\* No statistically significant difference among groups



**Figure 1.** Characteristics of VEMP waveform for each type of stimulus. A) Chirp, B) Click, and C) Tone burst 500 Hz.

using chirp stimulation concentrate more on auditory brainstem response (ABR) tests. In ABR testing, the latency of the fifth wave is shorter compared with other types of stimuli. It is hypothesized that this occurs because stimulation at all frequencies results in shorter cochlear stimulation<sup>[6]</sup>. The P13 latency duration results in our study agree with those reported in literature<sup>[1-3]</sup>. We obtained the longest latency with the tone burst stimulation, which is also in accordance with literature.

The P13 and P13–N23 amplitudes show a wide distribution in studies; therefore, they are interpreted as meaningless. Some studies have reported lower P13–N23 amplitudes in patients with Meniere’s disease<sup>[2,7,8]</sup>. Compatible with current literature, our study found that the tone burst stimulation resulted in statistically significantly higher P13–N23 amplitudes than other stimulus types. To the best of our knowledge, there is only one study comparing chirp stimulus<sup>[9]</sup>. Wang and colleagues suggested that chirp stimulus demonstrates

shorter latencies and increased speed and reliability. We agree with Wang and colleagues that latency is shorter with the chirp stimulus. However, we suggest that the tone burst stimulus is preferred because of its higher response rate and amplitudes.

Another important parameter of VEMP testing is VAR. VAR specifically increases in diseases such as Meniere's disease, and it is also an indicator of disease progression<sup>[8]</sup>. Our study found VAR distributions similar to those found in literature and no statistically significant differences among stimulus types.

In conclusion, VEMP testing lacks standardized normative values for use in clinical evaluations. Tone burst stimulation is the most studied and standardized stimulus type. However, because VEMP testing includes many parameters, we are of the opinion that further studies using different types of stimuli and patients are needed to obtain normative values.

**Ethics Committee Approval:** The approval of local Institutional Review board has been obtained (2016/6).

**Informed Consent:** Written informed consent has been obtained from all participants.

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**Conflict of Interest:** No conflict of interest was declared by the authors.

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