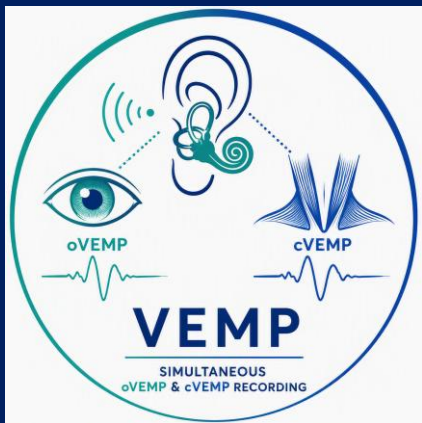




Reducing Vestibular Test Time by 68%: Simultaneous Recording of cVEMPs and oVEMPs Using Bone-Conducted Stimulation

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Background

Vestibular evoked myogenic potentials (VEMPs) are used to assess otolith organ function. Cervical VEMPs (cVEMPs) evaluate saccular function, while ocular VEMPs (oVEMPs) assess utricular function. These tests are usually performed separately using air-conducted stimuli, increasing test duration and limiting assessment in individuals with conductive hearing loss. Bone-conducted stimulation overcomes middle-ear transmission limitations and can be used in a wider patient population. Evidence for simultaneous bone-conducted cVEMP and oVEMP recording using the B81 bone vibrator remains limited.



Aim

To evaluate the feasibility, reliability, and efficiency of simultaneous cVEMP and oVEMP recordings using bone-conducted stimulation delivered via a B81 bone vibrator



METHOD

A cross-sectional method-comparison study was conducted in 28 healthy adults (50 ears) aged 18-60 years (mean age: 36.5 years). VEMP responses were recorded using 500 Hz bone-conducted tone bursts delivered to the mastoid via a B81 bone vibrator. Each ear underwent both conventional separate cVEMP and oVEMP recordings and a simultaneous recording using a two-channel protocol. Latency and amplitude parameters were compared using Linear Mixed Models, Bland-Altman analysis, and Intraclass Correlation Coefficients (ICC). To assess clinical efficiency, test duration was recorded for each participant and mean testing times between the separate and simultaneous recording protocols were compared. Equipment: Interacoustics Eclipse Evoked Potentials System (EP25, Version 4.6.1)

Recording Parameters

Parameter	value
Transducer	B 81 – Bone vibrator
Stimulus Location	Mastoid
Stimulus frequency	500 Hz
Stimulus type	Tone burst
Stimulus polarity	Alternate
Stimulus rate	5.1/s
Stimulus ramp	2-2-2
Filter	10 – 1000 Hz
Number of sweeps	100
Window length	80 ms
Recording channel	2 channel recording
Electrode type	Disposable surface electrodes

Electrode location



Negative electrodes:
Sternocleidomastoid (cVEMP) and below the lateral canthus (oVEMP)

Positive electrodes:
Sternum (cVEMP) and adjacent to the medial canthus (oVEMP) (connected by a jump cable)

Common electrode: Forehead



RESULT

Simultaneous cVEMP and oVEMP recordings produced waveforms comparable to conventional separate recordings (Figure 1)

LATENCY MEASURES				
Measure	Mean $\pm$ SD (ms)		Mean Difference	p-value
	Separate	Simultaneous		
cVEMP P1 Latency	15.02 $\pm$ 2.02	14.79 $\pm$ 1.93	0.22	0.149
oVEMP N1 Latency	25.51 $\pm$ 2.40	25.09 $\pm$ 2.18	0.426	0.042
oVEMP n1 Latency	9.86 $\pm$ 0.34	9.87 $\pm$ 0.44	0.009	0.849
oVEMP p1 Latency	14.37 $\pm$ 1.20	14.87 $\pm$ 1.58	-0.502	0.006

❖ No significant differences were observed for: cVEMP P1 latency & oVEMP n1 latency

❖ Small but statistically significant differences were observed for: cVEMP N1 latency & oVEMP p1 latency, but these differences were not clinically significant.

AMPLITUDE MEASURES (PEAK TO PEAK)				
Measure	Mean $\pm$ SD (μ V)		Mean Difference	p-value
	Separate	Simultaneous		
cVEMP P1-N1 amplitude	137.74 $\pm$ 68.70	138.27 $\pm$ 71.63	0.53	0.685
oVEMP p1-n1 amplitude	21.56 $\pm$ 15.11	22.05 $\pm$ 14.20	0.49	0.772

❖ cVEMP P1-N1 amplitude - No significant difference was found between separate and simultaneous recordings

❖ oVEMP p1-n1 amplitude - No significant difference was observed between separate and simultaneous recording methods

TIME TAKEN				
Measure	Mean $\pm$ SD (Minutes)		Mean Difference	p-value
	Separate	Simultaneous		
Time	7.92 $\pm$ 0.58	2.57 $\pm$ 0.27	5.35	< 0.001

❖ Simultaneous recording reduced mean testing time from 7.92 $\pm$ 0.58 minutes to 2.57 $\pm$ 0.27 minutes. This represented an approximately 68% reduction in test duration. ($p < 0.001$).

❖ **Time efficiency** : Simultaneous recording reduced mean testing time by 68%. (Figure 2)

❖ **Bland-Altman plots** demonstrated minimal bias and acceptable limits of agreement between separate and simultaneous recordings, supporting the clinical interchangeability of the two methods. (Figure 3)

❖ **Intraclass Correlation Coefficients (ICC)** demonstrated moderate to good agreement between methods (ICC range: 0.54-0.90). (Figure 4)

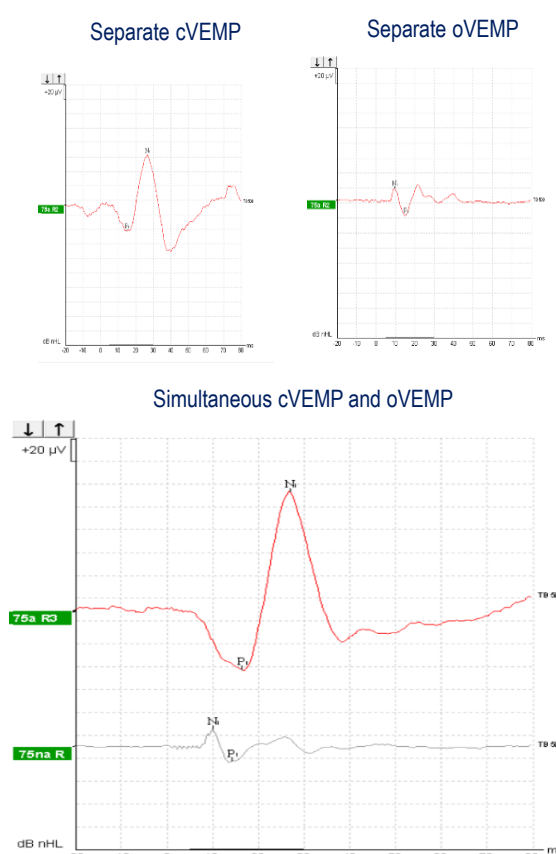


Figure 1 – separate Vs simultaneous VEMPs

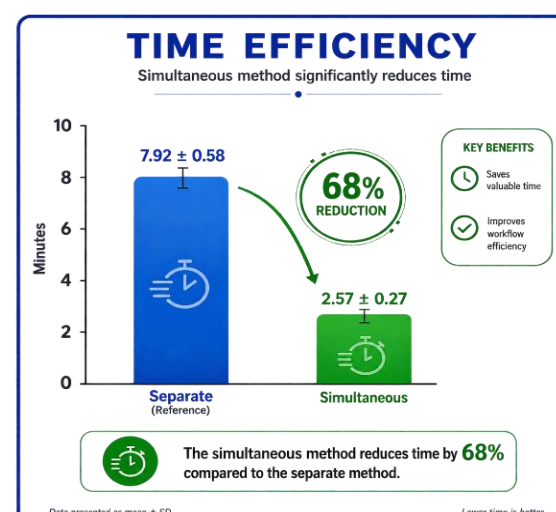


Figure 2 – Time efficiency

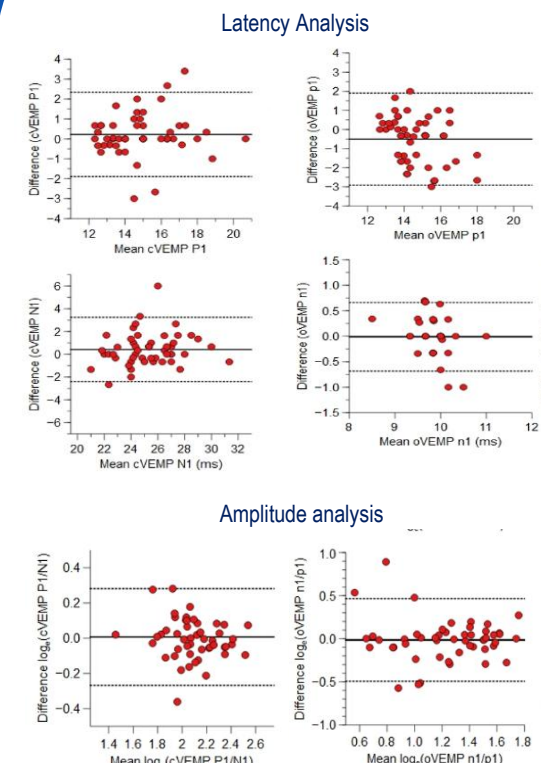


Figure 3 - Bland-Altman analysis

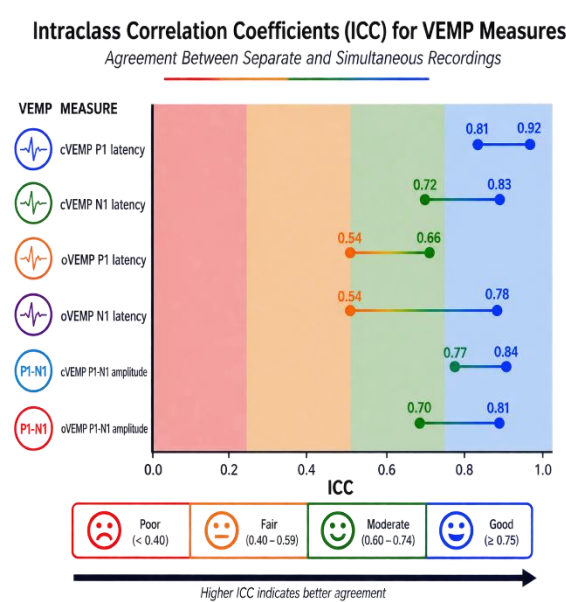


Figure 4 – Intraclass Correlation Coefficients



CONCLUSION

The findings demonstrate that simultaneous bone-conducted cVEMP and oVEMP recording is a reliable and clinically viable alternative to conventional separate testing. Agreement analyses showed minimal systematic bias and moderate-to-excellent reliability, while observed statistical differences were of negligible clinical importance. By significantly reducing test duration without compromising measurement quality, this approach has the potential to streamline vestibular assessment, reduce patient burden, and improve access to VEMP testing particularly for individuals with conductive hearing loss.

References

- Chang, C.M., Young, Y.H. and Cheng, P.W., 2013. Feasibility of simultaneous recording of cervical and ocular vestibular-evoked myogenic potentials via galvanic vestibular stimulation. *Otology*, pp.1278-1284.
- Colebatch, J.G., Halmagyi, G.M. and Skuse, N.F., 1994. Myogenic potentials generated by a click-evoked vestibulocollic reflex. *Journal of Neurology, Neurosurgery & Psychiatry*, 57(2), pp.190-197.
- Freden Jansson, K.J., Hakansson, B., Reinfeldt, S., Persson, A.C. and Eeg-Olofsson, M., 2021. Bone conduction stimulated VEMP using the B250 transducer. *Medical Devices: Evidence and Research*, 14, pp.225-237.
- Hakansson, B., Freden Jansson, K.J., Tengstrand, T., Johannsen, L., Eeg-Olofsson, M., Rigato, C., Dahlström, E. and Reinfeldt, S., 2018. VEMP using a new low-frequency bone conduction transducer. *Medical Devices: Evidence and Research*, 11, pp.301-312.
- Health Research Authority (HRA). (2024). Transparency and Data Protection in Research. Available from: <https://www.hra.nhs.uk>
- Oh, S.Y., Shin, H.J., Boegle, R., Ertl, M., Zu Eulenburg, P., Kim, J.S. and Dieterich, M., 2018. Simultaneous recording of cervical and ocular vestibular-evoked myogenic potentials. *Neurology*, 90(3), pp.e230-e238.
- Shin, H.J., Park, Y.A. and Oh, S.Y., 2015. Simultaneous recordings of cervical and ocular vestibular-evoked myogenic potentials. *Journal of the Korean Neurological Association*, 33(3), pp.156-161.
- Todd, N.P.M., Rosengren, S.M., Aw, S.T. and Colebatch, J.G., 2007. Ocular vestibular evoked myogenic potentials (OVEMPs) produced by air- and bone-conducted sound. *Clinical Neurophysiology*, 118(2), pp.381-390.

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