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Relationship Between Cervical Vemp (Cvemp) And Ocular Vemp (Ovemp) Parameters As Measured By Click And Tone Burst In Adults With Normal Hearing Sensitivity.

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Abstract: *Vestibular evoked myogenic potential (VEMP) is one of the clinical tools to evaluate vestibular function. The VEMP can be recorded from sternocleidomastoid muscle by auditory stimulation with various sound stimuli. The aim of this study was to compare parameter of cVEMP and oVEMP responses as measured by click tone and tone burst across gender in healthy young individuals. Total Sixty adult participants were taken, age range from 18-25 years (mean age 21.6 years, S.D. 1.48). Participants were divided into two groups. First group consisted of thirty male (mean age 22.1 years, S.D. 1.74) participants and second group consisted of thirty female (mean age 21.1 years, S.D. 0.96) participants. The puretone average threshold greater than 25dBHL and 'A' type tympanogram with presence of IPSI and CONTRA lateral acoustic reflexes within 70 dBHL was found in all the participants. Electrode placement was different for cVEMP and oVEMP testing. The cVEMP and oVEMP was recorded using 500 Hz click tone and tone burst sound stimuli in all participants. The parameters of cVEMP like peak latency (P13 and N23), amplitude, intraural amplitude difference ratio and threshold range were obtained. The oVEMP parameters of like peak latency (N13, P13 and N21), amplitude, intraural amplitude difference ratio and threshold range were obtained. For cVEMP to peak P13 to N23 amplitude and for oVEMP peak to peak P13 to N21 amplitude were taken for analysis of intra amplitude difference ratio in percentage. .The cVEMP and oVEMP responses were present in all participants. In the cVEMP responses using tone burst stimuli, the P13 peak latency for right ear (p value 0.02), amplitude for both the ears across gender (p-value of right ear <0.0001 & for left ear 0.001), and intraural difference between both the stimulus (p-value 0.0484), showed significant differences. In the oVEMP using the tone burst stimuli, the latency of N10 for right ear across the genders(p-value 0.004), and the latency of P13 for the left ear across the genders(p-value <0.000) showed significant differences which can be attributed to biological factors such as seating position, eye blinking during the test. The latency N23 of click tone cVEMP in our study was significantly different from that of one of the other studies (p-value < 0.05). The cVEMP and oVEMP responses showed no significant difference between click tone and tone burst stimuli, and the norms of different stimuli should be established for clinical interpretations. For clinical diagnosis using for cVEMP and in oVEMP, we recommend click tone and tone burst stimuli for oVEMP and tone burst for cVEMP because the latencies, amplitudes, intra amplitude difference ratio and threshold range were not significantly different for both the stimulus in oVEMP.*

I. Introduction

Vestibular evoked myogenic potential (VEMP) is one of such tests which checks function of otolith organ. VEMP is an inhibitory potential recorded from the sternocleidomastoid muscle in response to loud sounds. VEMP testing is a relatively new diagnostic tool that is in the process of being investigated in patients with specific vestibular disorders. Many different studies have been done regarding VEMP. In Indian context a similar study[1] provided valuable results by comparing the click and tone burst stimuli through cVEMP. Through the present study we hope to find which of the stimuli gives better and reliable response as well as to show the comparison between the responses of males and females through both oVEMP and cVEMP in the Indian population. As very limited research is available in the Indian context through VEMP, the data provided through the present study will be very helpful in identifying the various vestibular disorders as well as can be used to justify and correlate different data in the Indian population.

II. Aim

To establish the relationship between cervical VEMP (cVEMP) and ocular VEMP (oVEMP) parameters as measured by click and tone burst in adults with normal hearing sensitivity.

Objective

1. Parameter of cVEMP threshold, latency and amplitude and intraural amplitude ratio will be investigated with two stimuli and will be compared in male and female.

2. Parameter of oVEMP threshold, latency and amplitude intraural amplitude ratio will be investigated with two stimuli and compare in male and female.
3. Each parameter of cVEMP and oVEMP will be compared with two stimulus mode, (Tone burst and clicks).

Hypothesis

1. There will be a difference in threshold, latency, amplitude and intraural amplitude ratio of cVEMP and oVEMP between two stimuli, click tone and tone burst.
2. There will be a difference in threshold, latency, amplitude and intraural amplitude ratio of cVEMP and oVEMP across genders.

III. Methodology

To determine the sensitivity of cervical VEMP and ocular VEMP testing based on click tone and tone burst of vestibular system were analysed. More specifically, the threshold, latency, amplitude and intraural amplitude ratios of the two types of VEMP test were investigated and compared. Participants were divided into two groups. First group consisted of male participants and second group consisted of female participants. This study was done in two phases, in the first phase basic audiometric test batteries were done and in the second phase VEMP was done.

Participants

Sixty adult participants were taken, age range from 18-25 years (mean age 21.6 years, S.D. 1.48). Participants were divided into two groups. First group consisted of thirty male (mean age 22.1 years, S.D. 1.74) participants and second group consisted of thirty female (mean age 21.1 years, S.D. 0.96) participants.

Inclusion Criteria

- Average pure tone threshold was <25dBHL as measured through standard procedure[2].
- "A" type tympanogram with presence of IPSI lateral and CONTRA lateral acoustic reflexes within 70 dBHL signified as absence of middle ear pathology as well as neural pathology in all subjects.
- No significant history of balance or vertigo problems was present.
- No intake of antivertiginous drug and Psychiatric drug before 48 hours prior to the testing was allowed[3].
- Subjects with any muscular dystrophy and cervical spondalisis were excluded.

Instrumentation

RMS Medulla AD Instrument with software version 1.2.1.877 was used for VEMP recording. Acoustic stimulus was given by circumaural headphones (TDH 39). Stimulus used for the recording was Click and Tone Burst at frequencies of 500Hz with intensity level 70-90

Calibration

Instruments are calibrated by manufactures by default setting. Table 1 shows the parameters settings for cVEMP and oVEMP during testing.

Table 1. Shows parameters settings of cVEMP and oVEMP.

Parameters	Cvemp	Ovemp
Stimulus		
• Transducer	Tdh-39 Circumaural Headphone	Tdh-39 Circumaural Headphone
• Type	500 Hz Click/Tone Burst	500 Hz Click/ Tone Burst
• Ramping	Blackman	Blackman
Duration	2 Cycles Plateau; 1 Cycle Rise/Fall	2 Cycles Plateau; 1 Cycle Rise/Fall
Intensity	70 – 90 Dbnhl	70 – 90 Dbnhl
Polarity	Rarefaction	Rarefaction
Rate	5.1 Hz	5.1 Hz
Electrode Type	Surface (Ag/Agcl)	Surface (Ag/Agcl)
Electrode Location	Cvemp	Ovemp
Ground	Forehead	Forehead
Active	Upper Half Of Scm Muscle	Just Inferior The Eye
Reference	At Steranal Notch	2-3 Cm Below Of Active Electrode
Filter Settings	30-1500 Hz	10-1500 Hz
Notch	None	None
Amplification	5khz	5000 Khz
Sweeps	200ms	200ms

Phase I

Otoscopic examination, pure tone audiometry and tympanometry were done in phase I.

Otoscopic Examination

This examination shows no obstruction in the ear canal and an intact tympanic membrane was visualized.

Pure Tone Audiometry

Full diagnostic pure tone audiometry was done in a sound treated room at Department of Audiology use of a conventional calibrated[4] MAICO-MA53 clinical audiometer and TDH-39 headphones. The procedure determined the air conduction audiometric thresholds for 250, 500, 1000, 2000, 4000, and 8000 Hz for each subject in each ear[5]. For frequencies where the air conduction threshold was greater than 20 dB HL, bone conduction pure tone audiometry was performed to determine the bone conduction threshold for that frequency.

Tympanometry

Tympanometry test was done by calibrated[6] immitance audiometer (GSI-39 AUTO TYMP) to ensure participants had normal middle-ear impedance, as any conductive hearing loss would reduce the stimulus level that reached the vestibular system. Normal middle ear function was defined as type "A" tympanograms with normal admittance, (0.3 - 1.4 mmho), a pressure peak within ±100 daPa, and an ear canal volume[7] of 0.6 to 1.5 cm^3. All participants who continued on with this study had admittance, ear canal volume and pressure values within normal limits at the time of testing. Acoustic reflexes were present on ipsilateral and contralateral stimulation within 70 dBHL in all frequencies.

Phase II

Recording of cVEMP and oVEMP parameters was done in this phase.

Preparation Of Normal Subjects

Before placing the electrodes, the sites were cleaned using skin preparation paste (Nu Prep) and electrodes was placed with conduction paste (Ten-20) to increase the conductivity. The electrode impedance was checked and it was ensured that the impedance at each electrode site was less than 5K Ω.

Recording Of Cvemp

Subjects were instructed to sit in a relaxed position on the chair. The electrodes were placed at the symmetrical sites over the upper half of each SCM muscle. The reference electrodes were placed at the sternal notch, and the ground electrode was placed on the forehead. During recording, each participant was required turn towards the contralateral ear to that receiving the stimulus and to lift their head from a supine position to maintain tonic muscle activity in the ipsilateral SCM. Activation of the SCM is a key determinant of the VEMP response as the amplitude of the VEMP response is dependent on SCM tonic activity[8]. The band-pass filtered will be set at 30–1500 Hz. The stimulus was presented on ipsilateral ear through headphones (TDH 39) with repetition[9] rate 5.1 Hz at 500Hz at 90 dBnHL. The analysis time was 200 ms for each trial.

During the threshold estimation the stimulus was presented at 90 dBnHL for all participants and was replicated to confirm both present and absent responses. If a response was present, the intensity was decreased in 10 dBnHL. The process of finding thresholds was performed in both ears and threshold range was analyzed.

Recording Of Ovemp

Subject was instructed to sit in the relaxed position on the chair. The Ground electrode was placed on chin or forehead and active electrodes was placed on the face just inferior to each eye. Reference electrodes was placed 2-3 cm below active electrode[10]. The band-pass filtered will be set at 10–1000 Hz. The air-conduction stimulus was presented on contralateral ear through circumaural headphone. Subjects were instructed to maintain an upward gaze approximately 30° above visual plane during recording because responses are the largest at this gaze position. For threshold estimation the procedure was same as the cVEMP test.

Measures

The latency, amplitude, intraural amplitude ratio and threshold of cVEMP and oVEMP responses were analysed and compared to investigate the VEMP testing procedure. Both, the left and right ears of the control group were analysed. In addition to analysis of the waveforms evoked by click tone and tone burst stimulus.

Latency of Cvemp

The time at which these waveform peaks occurred was recorded in milliseconds (ms) for each of the responses. The first positive peak P13 and second negative peak N23 peak latency were identified and labelled by manually in Evoked Potential Analysis programme.

Amplitude of Cvemp

The peak to peak of first positive peak P13 and second negative peak N23 of the cVEMP amplitude were measured by automatically in Evoked Potential Analysis programme. Amplitude was measured in micro-volt (μV) from the zero baselines. The amplitude for right ear and left ear separately.

Interaural Amplitude Difference Ratio Of Cvemp

The intraural amplitude difference ratio (IAD) measured from amplitude between the left and right ears in the all participants.

Intraural amplitude ratio measured by side-to-side differences of VEMP amplitude and it can be expressed as percent[11].

%VEMP asymmetry = 100 | Ar – Al|/(Ar + Al)

Where Ar and Al are the amplitudes of p13–n23 on the right and on the left ear.

Threshold Range

The lowest and highest level in decibels that resulted in a response was determined as the threshold range. The threshold range was recorded in both ears separately in cVEMP.

Latency Of Ovemp

The time at which these waveform peaks occurred was recorded in milliseconds (ms) for each of the responses. The first negative peak N10 and second positive P13 and also third negative peak N21 peak latency were obtained and labelled by manually in analysis programme.

Amplitude Of Ovemp

The peak to peak of second positive peak P13 and third negative peak N21 of the oVEMP amplitude were measured by automatically in Evoked Potential Analysis programme. Amplitude was measured in micro-volt (μV) from the zero baselines. The amplitude for right ear and left ear separately.

Interaural Amplitude Difference Ratio Of Ovemp

The intraural amplitude difference ratio (IAD) measured from amplitude between the left and right ear in the all participants.

Intraural amplitude ratio measured by side-to-side differences of oVEMP amplitude and it can be expressed as percent[11].

%VEMP asymmetry = 100 | Ar – Al|/(Ar + Al)

Where Ar and Al are the amplitudes of p13–n23 of the right and left ear.

Threshold Range

The lowest and highest level in decibels that resulted in a response was determined as the threshold range. The threshold range was recorded in both ears separately oVEMP.

IV. Statistical Analysis

To investigate the objectives of the present study, statistical analysis using statistical package for the SAS software (version 9.2) was carried out on the obtained data, in order to measure and compare the data in all the participants with click tone and tone burst stimuli for cVEMP and oVEMP. The parameters of cVEMP and oVEMP like amplitude, latency, threshold range and intraural amplitude difference ratio responses were analysed using paired test and t-test. Data were tabulated and processed with the software. The descriptive stastics were performed to calculate mean, standard deviation, standard error, lower and upper class limits and minimum and maximum range to evaluate and compare the data. The two tests, t-test and paired test were applied at 95% level of significance. The t-test was performed for pair wise testing of means thus the p value was obtained and considered as statically significant when the p-value <0.05 .

V. Results

This chapter reviews the results and statistical analyses from the sixty participants in this study. The amplitude, latency, threshold and intraural amplitude difference ratio of the cervical and ocular VEMP responses were analysed. Although there are several studies found significant differences on cVEMP and oVEMP parameters but some studies found no significant differences on cVEMP and oVEMP parameters in genders. All analyses were performed to test the null hypothesis of the study, that there is no significant difference in the sensitivity of the cervical and ocular VEMP. Statistical analyses of the results collected from the left and right ears revealed significant difference between the ears. Data were tabulated and processed using the software SAS version 9.2. The means, standard deviations were presented graphically on tables. The paired t-test was applied at 95% level of significance, and the t-test was performed for pair wise testing of means and the p value is obtained from there.

For cVEMP, table 2 shows latency, table 4 shows amplitude, table 6 shows intraural amplitude difference comparisons of both the ears with click tone and tone burst stimulus and table 3 shows latency, table 5 shows amplitude, table 7 shows intraural amplitude difference comparisons of both the ears with click tone and tone burst stimulus across genders.

For oVEMP, table 8 shows latency, table 10 shows amplitude, table 12 shows intraural amplitude difference comparisons of both the ears with click tone and tone burst stimulus and table 9 shows latency, table 11 shows amplitude, table 13 shows intraural amplitude difference comparisons of both the ears with click tone and tone burst stimulus across genders.

Latency Of Cvemp

Table 2 shows mean S.D and p-value of comparison of P13 and N23 latencies (ms) in the right and left ears in click tone and tone burst stimulus and table 3 shows same parametric scores across genders.

Table 2 . Comparison of P13 and N23 latencies (ms) for right and left ears with click tone and tone burst stimulus.

Parameters		P13			N23		
Ear	Stimulus	Mean	S.D.	p-value	Mean	S.D.	p-value
	Click tone(1)	13.12	1.78		22.50	1.25	
	Tone bust(2)	12.97	0.74		22.43	0.94	
Right ear	(1)-(2)	0.15	1.04	0.233	0.07	1.31	0.727
	Click tone(1)	12.94	0.56		22.28	1.49	
	Tone bust(2)	12.88	0.86		22.46	1.10	
Left ear	(1)-(2)	0.06	-0.70	0.672	-0.18	1.39	0.321

Table 3. Comparison of P13 and N23 latencies (ms) in both ears using click tone and tone burst across genders.

Parameters			P13			N23		
Ear	Stimulus	Gender	Mean	S.D.	p-value	Mean	S.D.	p-value
		Female	13.05	0.81		22.88	1.10	
		Male	13.21	0.74		22.12	1.31	
	Click tone	Female- Male	-0.16	0.78	0.613	0.76	1.21	0.351
		Female	13.03	0.88		22.30	0.97	
		Male	12.92	0.57		22.57	0.89	
Right ear	Tone burst	Female- Male	0.11	0.74	0.02	-0.27	0.93	0.641
		Female	12.93	0.55		22.21	1.16	
		Male	12.95	0.58		22.35	1.02	
	Click tone	Female- Male	-0.02	0.57	0.740	-0.14	1.10	0.501
		Female	12.95	0.88		22.39	1.27	
		Male	12.77	0.84		22.53	0.93	
Left ear	Tone burst	Female- Male	0.21	0.73	0.80	-0.13	1.11	0.093

Amplitude Of Cvemp

Table 4 shows mean S.D and p-value of amplitude in the right and left ears in click tone and tone burst stimulus and table 5 shows same parametric scores across genders.

Table 4. Comparison of amplitude (µV) in the right and left ears with click tone and tone burst stimulus.

Parameters		Amplitude		
Ear	Stimulus	Mean	S.D.	P-Value
	Click Tone(1)	1.730	0.48	
	Tone Bust(2)	1.732	0.52	
Right Ear	(1)-(2)	-0.002	0.739	0.984
	Click Tone(1)	1.638	0.50	
Left Ear	Tone Bust(2)	1.633	0.52	
	(1)-(2)	0.004	0.771	0.961

Table 5. Comparison of amplitude (µV) in both ears using click tone and tone burst across genders.

Parameters			Amplitude		
Ear	Stimulus	Gender	Mean	S.D.	P-Value
		Female	1.69	0.47	
		Male	1.76	0.50	
	Click Tone	Female- Male	-0.07	0.48	0.712
		Female	2.05	0.53	
		Male	1.41	0.24	
Right Ear	Tone Burst	Female- Male	0.64	0.41	.0001
		Female	1.64	0.53	

	Click Tone	Male	1.63	0.49	
		Female- Male	0.01	0.51	0.69
	Tone Burst	Female	2.15	0.55	
		Male	1.34	0.30	
Left Ear		Female- Male	0.81	0.44	0.001

Intraural Amplitude Differance Of Cvemp

Table 6 shows mean S.D and p-value of intraural amplitude difference ratio in the right and left ears in click tone and tone burst stimulus and table 7 shows same parametric scores across genders.

Table 6. Comparison of intraural amplitude ratio in click tone and tone burst stimulus.

Parameters	Intraural Amplitude Ratio		
Stimulus	Mean	S.D	P-Value
Click Tone(1)	10.83	6.52	
Tone Bust(2)	8.54	4.67	
(1)-(2)	2.29	1.85	0.0484

Table 7. Comparison of intraural amplitude ratio in click tone and tone burst stimulus across genders.

Parameters		Intraural amplitude ratio		
Stimulus	Gender	MEAN	S.D	p-value
	Female(1)	12.26	5.58	
	Male(2)	9.42	7.15	
Click tone	(1)-(2)	2.84	6.41	0.187
	Female	9.79	4.99	
Tone burst	Male(2)	7.28	4.01	
	(1)-(2)	2.51	4.53	0.243

Threshold of Cvemp

The peak of cVEMP were obtained at 90dBnHL to till 70dBnHL but not obtained at 60 dBnHL in both ears with two stimuli in all participants. The findings in this study suggest that normal cVEMP thresholds range from 70 to 90 dBnHL.

Latency of Ovemp

The first peak is negative N10 and second peak is positive P13 and third peak is negative N21 peak of oVEMP were obtained in milliseconds and labelled manually in analysis programme. Descriptive statistics was performed to comparison the data of N10, P13 and N21 Peak latency.

Table 8 shows mean S.D and p-value of comparison of N10, P13 and N23 latencies (ms) in the right and left ears in click tone and tone burst stimulus and table 9 shows same parametric scores across genders.

Table 8. Comparison of N10, P13 and N23 peaks in both ears with click tone and tone burst stimulus.

Parameters		N10			P13			N21		
Ear	Stimulus	Mean	S.D.	P-Value	Mean	S.D.	P-Value	Mean	S.D.	P-Value
Right Ear	Click Tone(1)	10.09	2.55		13.04	1.90		20.78	1.03	
	Tone Bust(2)	10.36	1.20		12.79	0.74		20.54	1.13	
	(1)-(2)	-0.27	1.35	0.127	0.25	1.16	0.102	0.24	1.64	0.248
Left Ear	Click Tone(1)	10.23	0.86		12.83	0.82		20.56	1.00	
	Tone Bust(2)	10.18	0.77		12.75	1.70		20.66	1.12	
	(1)-(2)	0.05	0.95	0.65	0.083	2.00	0.749	-0.10	1.41	0.580

Table 9. Comparison of N10, P13 and N23 peaks of both ears using click tone and tone burst stimulus across genders.

Parameters			N10			P13			N21		
Ear	Stimulus	Gender	Mean	S.D.	P-Value	Mean	S.D.	P-Value	Mean	S.D.	P-Value
Right Ear	Click Tone	Female	10.16	0.98		12.91	0.80		20.72	1.09	
		Male	10.02	1.02		13.16	0.56		20.86	0.98	
		Female-Male	0.14	1.00	0.848	0.11	0.69	0.05	-0.14	1.03	0.571
	Tone Burst	Female	10.56	1.51		12.83	0.61		20.63	0.93	
		Male	10.16	0.76		12.74	0.85		20.46	1.31	
		Female-Male	0.403	1.19	0.004	0.08	0.74	0.086	0.163	1.14	0.067

Left Ear	Click Tone	Female	10.15	0.95		12.93	0.85		20.69	1.08	
		Male	10.33	0.75		12.74	0.79		20.42	0.90	
		Female-Male	-0.18	0.86	0.213	0.19	0.82	0.700	0.27	1.00	0.327
	Tone Burst	Female	10.25	0.82		12.96	0.74		20.56	1.02	
		Male	10.12	0.73		12.54	2.29		20.76	1.23	
		Female-Male	0.13	0.78	0.528	0.41	1.70	<0.000	0.19	1.13	0.319

Amplitude Of Ovemp

Table 10 shows mean S.D and p-value of amplitude in the right and left ears in click tone and tone burst stimulus and table 11 shows same parametric scores across genders.

Table 10. Comparison of amplitude (µV) in the right and left ears with click tone and tone burst stimulus.

Parameters		Amplitude		
Ear	Stimulus	Mean	S.D	P-Value
Right Ear	Click Tone(1)	1.76	0.49	
	Tone Bust(2)	1.80	0.50	
	(1)-(2)	-0.04	0.67	0.651
Left Ear	Click Tone(1)	1.69	0.43	
	Tone Bust(2)	1.80	0.44	
	(1)-(2)	-0.11	0.56	0.137

Table 11. Comparison of amplitude (µV) in both ears using click tone and tone burst stimulus across genders.

Parameters			Amplitude		
Ear	Stimulus	Gender	Mean	S.D.	P-Value
Right Ear	Click Tone	Female	1.73	0.47	
		Male	1.79	0.52	
		Female- Male	-0.06	0.49	0.579
	Tone Burst	Female	1.71	0.44	
		Male	1.89	0.55	
		Female- Male	-0.18	0.50	0.212
Left Ear	Click Tone	Female	1.64	0.40	
		Male	1.74	0.45	
		Female- Male	0.09	0.43	0.564
	Tone Burst	Female	1.72	0.43	
		Male	1.88	0.44	
		Female- Male	-0.16	0.44	0.879

Intraural Amplitude Ratio Of Ovemp

Table 12 shows mean S.D and p-value of intraural amplitude difference in the right and left ears in click tone and tone burst stimulus and table 13 shows same parametric scores across genders.

Table 12. Comparison of amplitude (µV) in both ears with click tone and tone burst stimulus.

Parameters	Intraural Amplitude Ratio		
Stimulus	MEAN	S.D	P-Value
Click Tone(1)	8.34	4.57	
Tone Bust(2)	7.55	5.77	
(1)-(2)	0.79	-0.80	0.353

Table 13. Comparison of amplitude (µV) in both ears using click tone and tone burst stimulus across genders.

Parameters		Intraural Amplitude Ratio		
Ear	Stimulus	Mean	S.D	P-Value
Click Tone	Female(1)	6.95	4.31	
	Male(2)	9.74	4.45	
	(1)-(2)	-2.21	4.38	0.870
Tone Bust	Female	6.87	4.85	
	Male(2)	8.22	5.24	
	(1)-(2)	-1.65	5.05	0.678

Threshold Of Ovemp

The peak of oVEMP were obtained at 90dBnHL to till 70dBnHL but not obtained at 60 dBnHL in both ears with two stimuli in all participants. The findings in this study suggest that normal oVEMP thresholds range from 70 to 90 dBnHL.

VI. Discussion

The hypothesis of this study was to measure the relationship between cVEMP and oVEMP parameters like threshold, latency, amplitude and intraural amplitude difference ratio in click and tone burst across genders in young participants with normal hearing. The study was conducted on 60 participants of which 30 were males and 30 were females. The study was conducted in two phases; the first phase was to do the basic audiometric tests on the participants to fulfil the inclusion criteria. The second phase was to administer the cVEMP and oVEMP. RMS Medulla AD Instrument with software version 1.2.1.877 was used for VEMP recording. A detailed statistical analysis using SAS software (version 9.2) was used to investigate the objectives after which the results were tabulated.

Latency Of Cvemp:

According to table 2 P13 and N23 latency (ms) was done in click tone and tone burst for right ear the mean of P13 for click tone was 13.12 and SD was 1.78 and for tone burst the mean was 12.97 and SD was 0.74. The comparison of P13 between both stimuli like click tone and tone burst in right ear had p-value (0.233) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

For left ear the mean of P13 for click tone was 12.94 and SD was 0.56 and for tone burst the mean was 12.88 and SD was 0.86. The comparison of P13 between both stimuli like click tone and tone burst in left ear had p-value (0.672) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

For right ear the mean of N23 for click tone was 22.50 and SD was 1.25 and for tone burst the mean was 22.43 and SD was 0.94. The comparison of N23 between both stimuli like click tone and tone burst in right ear had p-value (0.727) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

For left ear the mean of N23 for click tone was 22.28 and SD was 1.49 and for tone burst the mean was 22.46 and SD was 1.10. The comparison of P13 between both stimuli like click tone and tone burst in left ear had p-value (0.321) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

According to the first hypothesis of the present study, the results showed there were no significant differences between both the stimuli. In a similar study, it is reported[12] that tone-burst evoked myogenic responses were similar to click-evoked responses but required lower stimulus intensities.

Table 3 showed the data of comparison of peak latency in both ears with click tone and tone burst stimulus across the genders.

In right ear the P13 with click tone for females, the mean was 13.05 and SD was 0.81 and for males the mean was 13.21 and SD was 0.74. The comparison of P13 peak for females and males with click tone in right ear had p-value (0.613) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In right ear the P13 with tone burst for females, the mean was 13.03 and SD was 0.88 and for males the mean was 12.92 and SD was 0.0.57. The comparison of P13 peak for females and males with tone burst in right ear had p-value (0.02) which was lower than 0.05 at 95% level of significance concluding that it rejected the null hypothesis. There was significant difference of latency P13 with tone burst stimuli across the genders. It may be due to placement of electrode on best specific site of the sternocleidomastoid muscle[13]. In left ear the P13 with click tone for females, the mean was 12.93 and SD was 0.55 and for males, the mean was 12.95 and SD was 0.58. The comparison of P13 peak for females and males with click tone in left ear had p-value (0.740) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In left ear the P13 with tone burst for females, the mean was 12.95 and SD was 0.88 and for males, the mean was 12.77 and SD was 0.84. The comparison of P13 peak for females and males with tone burst in left ear had p-value (0.80) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In right ear the N23 with click tone for females, the mean was 22.88 and SD was 1.10 and for males mean was 22.12 and SD was 0.131. The comparison of P13 peak for females and males with click tone in right ear had p-value (0.351) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In right ear the N23 with tone burst for females, the mean was 22.30 and SD was 0.97 and for males, the mean was 22.57 and SD was 0.89. The comparison of N23 peak for females and males with tone burst in right ear had p-value (0.641) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In left ear the N23 with click tone for females, the mean was 22.21 and SD was 1.16 and for males, mean was 22.35 and SD was 1.02. The comparison of N23 peak for female and male with click tone in left ear

had p-value (0.501) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In left ear the N23 with tone burst for females, the mean was 22.39 and SD was 1.27 and for males, the mean was 22.53 and SD was 0.93. The comparison of N23 peak for female and male with tone burst in left ear had p-value (0.09) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

According to hypothesis 2 taken for the present study, the results showed that there were no significant differences found in latency using click tone and tone burst stimulus across the genders. In a similar study it is suggested[14] that the VEMP responses exhibit significant interpersonal variation because of variations in muscle tone and mass, especially in males. It is found[15] that no gender differences for latencies P13 and N23 when using 500 Hz tone burst stimulation.

Amplitude Of Cvemp:

Table 4 reflected the data for the amplitude of right ear and left ear with click tone and tone burst stimuli. The mean of the amplitude of right ear with click tone was 1.730 and SD was 0.48 and for tone burst, the mean was 1.732 and SD was 0.52. The comparison of amplitude between both stimuli like click tone and tone burst in right ear had p-value (0.984) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

The mean of amplitude of left ear with click tone was 1.638 and SD was 0.50 and for tone burst, the mean was 1.633 and SD was 0.52. The comparison of amplitude between both stimuli like click tone and tone burst in left ear had p-value (0.961) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In the present study there was no significant difference in amplitude between the click tone and tone burst stimulus. Table 5 showed data of comparison of amplitude in both ears using click tone and tone burst across genders.

According to table 5 the mean of amplitude in right ear for click tone in females was 1.69 and SD was 0.47 and for males, the mean was 1.76 and SD was 0.50. The comparison of amplitude peak for female and male in click tone in right ear had p-value (0.712) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In right ear the mean of amplitude for tone burst in females was 2.05 and SD was 0.53 and for males, the mean was 1.41 and SD was 0.24. The comparison of N23 peak for female and male in tone burst in right ear had p-value (<0.00) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In left ear the mean of amplitude for click tone in females was 1.64 and SD was 0.53 for males, the mean was 1.63 and SD was 0.49. The comparison of N23 peak for female and males in click tone in left ear had p-value (0.69) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In left ear the mean of amplitude for tone burst in female was 2.15 and SD was 0.55 and for male, the mean was 1.34 and SD was 0.30. The comparison of N23 peak for female and male in tone burst in left ear had p-value (0.001) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.It was postulated[16] that the amplitude of tone burst were longer in C-VEMP due to delay of tone burst stimulus. It was showed[17] that the amplitude was increased with duration of stimulation. In a similar study it was suggested[18] that the amplitude was greater for tone burst than click tone.

Intraural Amplitude Ratio of Cvemp:

Table 6 showed the data of comparison of intraural amplitude difference ratio in click tone and tone burst stimulus. The mean of Intraural amplitude difference ratio in click tone was 10.83 and SD was 6.52 and in tone burst, the mean was 8.54 and SD was 4.67. The comparison of intraural amplitude ratio between stimuli had p-value (0.0484) which was lower than 0.05 at 95% level of significance concluding that it rejected the null hypothesis.Table 7 showed the data of comparison of intraural amplitude difference ratio in the right and left ears in click tone and tone burst stimulus across genders.

According to table 7 the mean of intraural amplitude difference ratio in click tone for female was 12.26 and SD was 5.58 and for males, the mean was 9.42 and SD was 7.15. The comparison of intraural amplitude ratio between female and male had p-value (0.187) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.The mean of intraural amplitude ratio in tone burst for female was 9.79 and SD was 4.99 and for males, the mean was 7.28 and SD was 4.01. The comparison of intraural amplitude ratio between female and male had p-value (0.243) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

There were no significant differences in both ears in click tone and tone burst. It is compared[19] vestibular evoked myogenic potential parameters between genders in young individuals. They concluded on the study that there were no gender differences in intraural amplitude difference ratio. Similarly it was investigated[20] the relationship between threshold and intraural amplitude difference ratio in cVEMP testing and pursuit the clinical significance of the parameters. There was no significant difference in intraural amplitude ratio.

Threshold Range Of Cvemp:

The peaks of cVEMP were obtained at 90dBnHL till 70dBnHL in both ears with two stimuli in all the participants. The findings in this study suggest that normal cVEMP thresholds range from 70 to 90 dBnHL. It was suggested[21] the normal threshold range of VEMPS were 70 - > 85dBnHL.Normal cVEMP thresholds are approximately 80 to 90 dBnHL when using a 500 Hz air-conducted stimulus and when obtained in a sitting position[22].

Latency Of Ovemp:

The peak latency N10, P13 and N21 of oVEMP were obtained within normal range of both the ears with click tone and tone burst in all the participants. Table 8 depicted the data of comparison of peak latency of the right and left ears with click tone and tone burst stimulus. According to table 8 for right ear the mean of N10 for click tone was 10.09 and SD was 2.55 and for tone burst, the mean was 10.36 and SD was 1.20. The comparison of N10 between both stimuli like click tone and tone burst in right ear had p-value (0.127) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In left ear the mean of N10 for click tone was 10.23 and SD was 0.86 and for tone burst, the mean was 10.18 and SD was 0.77. The comparison of N10 between both stimuli like click tone and tone burst in left ear had p-value (0.65) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis. In right ear the mean of P13 for click tone was 13.04 and SD was 1.90 and for tone burst the mean was 12.79 and SD was 0.74. The comparison P13 between both stimuli like click tone and tone burst in right ear had p-value (0.102) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis. In left ear the mean of P13 for click tone was 12.83 and SD was 0.82 and for tone burst the mean was 12.75 and SD was 1.70. The comparison of P13 between both stimuli like click tone and tone burst in left ear had p-value (0.749) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In right ear the mean of N21 for click tone was 20.78 and SD was 1.03 and for tone burst the mean was 20.54 and SD was 1.13. The comparison of N21 between both stimuli like click tone and tone burst in right ear had p-value (0.248) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis. In left ear the mean of N21 for click tone was 20.56 and SD was 1.00 and for tone burst the mean was 20.66 and SD was 1.12. The comparison of N21 between both stimuli like click tone and tone burst in left ear had p-value (0.580) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.Table 9 enumerated the data of comparison of peak latency of right and left ears with click tone and tone burst stimulus across genders.

In right ear the mean of N10 in click tone for female was 10.16 and SD was 0.98 and for male the mean was 10.02 and SD was 1.02. The comparison of N10 peak for female and male in click tone in right ear had p-value (0.848) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.In right ear the mean of N10 in tone burst for female was 10.56 and SD was 1.51 and for male, the mean was 10.16 and SD was 0.76. The comparison of N10 peak for female and male in tone burst in right ear had p-value (0.004) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.In left ear the mean of N10 in click tone for females was 10.15 and SD was 0.95 and for males the mean was 10.33 and SD was 0.75. The comparison N10 peak for female and male in click tone in left ear had p-value (0.213) which was greater than 0.05 at 95% level of significance conclude that it accepted the null hypothesis.

In left ear the mean of N10 in tone burst for females was 10.25 and SD was 0.82 and for male mean was 10.12 and SD was 0.73. The comparison N10 peak for female and male in tone burst in left ear had p-value (0.528) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.In right ear the mean of P13 in click tone for female was 12.91 and SD was 0.80 and for male mean was 13.16 and SD was 0.56. The comparison of P13 peak for female and male in click tone in right ear had p-value (0.05) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.In right ear the mean of P13 in tone burst for female was 12.83 and SD was 0.61 and for male the mean was 12.74 and SD was 0.85. The comparison of P13 peak for female and male in tone burst in right ear had p-value (0.086) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In left ear the mean of P13 in click tone for female was 12.93 and SD was 0.85 and for male mean was 12.74 and SD was 0.79. The comparison P13 peak for female and male in click tone in left ear had p-value (0.700) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis. In left ear the mean of P13 in tone burst for female was 12.96 and SD was 0.74 and for male mean was 12.54 and SD was 2.29. The comparison of P13 peak for female and male in tone burst in left ear had p-value (<0.000) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.In right ear the mean of N21 in click tone for female was 20.72 and SD was 1.09 and for male mean was 20.86 and SD was 0.98. The comparison of N21 peak for female and male in click tone in right ear had p-value (0.571) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.In right ear the mean of N21 in tone burst for female was 20.63 and SD was 0.93 and for male mean was 20.46 and SD was 1.31. The comparison N21 peak for female and male in tone burst in right ear had p-value (0.067) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In left ear the mean of N21 in click tone for female was 20.69 and SD was 1.08 and for male mean was 20.42 and SD was 0.90. The comparison of N21 peak for female and male in click tone in left ear had p-value (0.327) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis. In left ear the mean of N21 in tone burst for female was 20.56 and SD was 1.02 and for male mean was 20.76 and SD was 1.23. The comparison of N21 peak for female and male in tone burst in left ear had p-value (0.319) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

Overall the above latencies N10, P13 and N21 was showed no significantly difference between the click tone and tone burst stimuli but significant difference shown for peak latency N10 in right ear and P13 in left ear with tone burst stimuli across genders. In present study the latencies of N10 and P13 showed significant difference between the click tone and tone burst stimuli across male and female but latencies of N21 showed no significant differences between the click tone and tone burst stimuli. Similarly it was found[23] significantly better N10 and P13 latencies for click compared to 500Hz short duration tone burst stimuli. Peak-peak amplitude was significantly high for 500Hz short duration tone burst when compared with click stimuli. Peak to peak amplitude showed significant reduction in click stimulation as compared at 500Hz short duration tone burst[24].

Amplitude Of Ovemp:

Table 10 showed mean, S.D and p-value of amplitude in the right and left ears in click tone and tone burst stimulusThe mean of right ear amplitude for click tone was 1.76 and SD was 0.49 and for tone burst the mean was 1.80 and SD was 0.50. The comparison of amplitude between both stimuli like click tone and tone burst in right ear had p-value (0.651) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In left ear the mean of amplitude for click tone was 1.69 and SD was 0.43 and for tone burst the mean was 1.80 and SD was 0.44. The comparison of amplitude between both stimuli like click tone and tone burst in left ear had p-value (0.137) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis. Table 11 described the data of comparison of amplitude in both ears with click tone and tone burst across the genders.

In right ear the mean of amplitude in click tone for female was 1.73 and SD was 0.47 and for male the mean was 1.79 and SD was 0.52. The comparison of amplitude peak for female and male in click tone in right ear had p-value (0.579) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis. In right ear the mean of amplitude in tone burst for female was 1.71 and SD was 0.44 and for male the mean was 1.89 and SD was 0.55. The comparison of N23 peak for female and male in tone burst in right ear had p-value (0.212) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In left ear the mean of amplitude in click tone for female was 1.64 and SD was 0.40 and for male, the mean was 1.74 and SD was 0.45. The comparison of N23 peak for female and male in click tone in left ear had p-value (0.564) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis. In left ear the mean of amplitude in tone burst for female was 1.72 and SD was 0.43 and for male mean was 1.88 and SD was 0.44. The comparison of N23 peak for female and male in tone burst in left ear had p-value (0.879) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

In the present study there was no significant difference between amplitude of click tone and tone burst stimuli. Similarly it was investigated[25] that the effects of gender and age on the vestibular-evoked myogenic potential (VEMP). The results showed there was no gender-related differences were detected in the VEMP.It was compared[26] that vestibular evoked myogenic potential parameters between genders in young individuals. They concluded on the study that there were no gender differences in latency and amplitude factors and the sternocleidomastoid muscle strain was monitored during the examination.

Intraural Amplitude Ratio Of Ovemp

Table 12 showed the data of comparison of intraural amplitude ratio in click tone and tone burst stimulus. The mean of Intraural amplitude ratio in click tone was 8.34 and SD was 4.57 and in tone burst mean was 7.55 and SD was 5.77. The comparison of intraural amplitude ratio between stimuli had p-value (0.353) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.

Table 13 showed the data of comparison of intraural amplitude ratio in the right and left ears with click tone and tone burst stimulus across genders. According to table 13 the intraural amplitude ratio in click tone for female mean was 6.95 and SD was 4.31 and for male mean was 9.74 and SD was 4.45. To compare intraural amplitude ratio between female and male had p-value (0.870) was greater than 0.05 at 95% level of significance conclude that it accepted the null hypothesis.

The mean of intraural amplitude ratio in tone burst for female was 6.87 and SD was 4.85 and for male mean was 8.22 and SD was 5.24. The comparison of intraural amplitude ratio between female and male had p-value (0.678) which was greater than 0.05 at 95% level of significance concluding that it accepted the null hypothesis.There was no significance difference in IAD ratio in click tone and tone burst in all the participants. In similar studies it is compared[27] that the VEMP responses evoked by short tone burst (STB) with those evoked by click stimuli in healthy young individuals. Result showed that there was no significant difference in the amplitude ratio between the two stimuli. It is reported[28] significant difference in amplitude on gender which attributed to muscle variance in the muscle bulk between male and female.

Threshold Range Of Ovemp:

The peaks of oVEMP were obtained at 90dBnHL to till 70dBnHL in both the ears with two stimuli in all participants. The findings in this study suggest that normal oVEMP thresholds range from 70 to 90 dBnHL. It is suggested[29] that the normal threshold range of vemps were 70 - > 85dBnHL.

Normal oVEMP thresholds are approximately 80 to 90 dBnHL when using a 500 Hz air-conducted stimulus and when obtained in a sitting position[30].

VII. Conclusion

Limitation

1. In this study VEMP was carried out in intensities ranging from 70dB – 90dB SPL as the maximum intensity of the stimulus was limited by the equipment chosen for this study.
2. There might be some biological factor involved in the variation of VEMP parameters as the testing of cVEMP and oVEMP for each individual was done continuously one after the other.
3. The transducer used during the testing was a pair of circumaural headphones which are large and relatively heavy as a result the headphones had a tendency to move during testing especially because of the test position. The clinician had to ensure that the headphones move as minimally as possible during the whole testing period to ensure that the intensity reaching the vestibular system was constant.

Implication

- The parameters of cVEMP and oVEMP can be used in routine clinical practice in Indian context.
- These parameters will help in diagnosis of various vestibular disorders.

Future Directions Of The Study

1. Same study can be carried out with the change in placement of the electrode like placed on middle or lower position for cVEMP or oVEMP.
2. Same study can be done by altering the position of patient like patient will be in supine position with elevated head at an angle of 30^{o}.
3. For the diagnosis of vestibular lesions VEMP is time efficient and complications were absent after test i.e nausea or vomiting as compared to other vestibular battery like ENG/VNG, Caloric test.

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