Normative Data for Vestibular Evoked Myogenic Potential in Different Age Groups Among a Heterogeneous Indian Population

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Abstract To establish normative data of vestibular evoked myogenic potential in different age groups among a heterogeneous Indian population. Prospective study design using a sample of convenience. Eighty five normal controls ranging between the ages 7 and 71 years were asked to provide a written signed consent for the study. Demographic characteristics of the patients were summarized using descriptive statistical methods using SPSS-17 analysing software. The outcome variable (VEMP recording) was expressed in percentiles as function of age. In all patients the stimulus which gave the best response was 95 dB (97.7 %) and 100 dB (95 %). The mean of wave latencies (p1 & n1) for 95-VEMP were, 11.2 ± 3.2 and 17.3 ± 4.7 ms on the right and 11.0 ± 2.8 and 17.0 ± 4.2 ms on the left respectively. The amplitude was 45.1 ± 54 mV on right and 46.9 ± 61.6 mV on the left. The mean of latency difference was 0.87 ms. The VEMP is a relatively simple test. The VEMP response rate was maximum in the younger age group; the optimum intensity was 95 dB. The asymmetry ratio interpretation should be done according to the age specific values.

Keywords Vestibular evoked myogenic potential · VEMP · Sacculo-colic reflex · Normative data · Electromyography · EMG

Abbreviation

VEMP Vestibular evoked myogenic potentials

Introduction

This study was undertaken to establish normative data for vestibular evoked myogenic potential (VEMP) in different age groups among a heterogeneous Indian population. VEMP testing is relatively a new diagnostic tool being used for investigation of patients with specific vestibular disorders. It consists of a biphasic response elicited from the tonically contracted sternocleidomastoid muscle by loud clicks or tone bursts. Current data suggest that the VEMP is a vestibulo-collic reflex whose afferent limb arises from acoustically sensitive cells in the saccule, with signals conducted via the inferior vestibular nerve [1]. Including VEMP in the test battery for investigation of vertigo is expected to compliment electronystagmography (ENG), (which assesses the lateral semicircular canals and superior vestibular nerve) by providing additional information from the saccule and inferior vestibular nerve and its central connections.

Many studies have been done for evaluating the VEMP using different types of stimuli like tone burst [2] or clicks [3]. The normal values described in different studies varied marginally depending upon the basic setup, the recording machine and the methodology of technique used for performing the test.

Literature search did not reveal any normative data for click induced VEMP in the Indian population. Hence this study was hence done on normal subjects, dividing them into different age groups and parameters such as latency, amplitude and thresholds for VEMP responses were evaluated in order to provide normative data for Indian population.

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The VEMP response consists of an initial positivity (p1 or p13) followed by a negativity (n1 or n23). This is known as early component, which is consistent and is thought to be vestibular in origin. The late component which is not very constant, seen at a latency of 30–45 ms is the n2 (n34) & p2 (p44) is thought to be non-vestibular. Due to the lack of consistency in the late wave complex, interest was focused in the early wave complex. For the VEMP test to detect vestibular component the responses in the first 20–25 ms are used. This early response with a latency of <20 ms has been present in a majority of normal participants as cited in published studies [4].

Aims and Objectives

To establish normative data of VEMP in different age groups among a heterogeneous Indian population.

Materials and Methods

This project incorporated a prospective study design using a sample of convenience. The study was cleared by the IRB and after informed consent was obtained from every subject (in case of children, from parents). All tests done in this study were performed in the audio vestibular unit of ENT department of a tertiary care hospital in Southern India from Sep 2009 to Nov 2010.

Sample Size

As the objective of the study was to generate normative data on VEMP recordings, all, available subjects during a period of time were taken into the study without calculating a constant sample size. Openly recruited 85 subjects were assigned to groups according to age. Normals ranging between 7 and 71 years of age participated in the study. Participants were separated by age into 4 categories from less than 15 to 55 years or above.

Group 1 included subjects between 07 and 15 years (N = 25).

Group 2 included subjects between 16 and 35 years (N = 37).

Group 3 included subjects between 36 and 55 years (N = 14).

Group 4 included subjects between >55 years (N = 9).

Inclusion Criteria

Participant—any person above the age of 7 years with no history of ear related disease, confirmed by a detailed

history (including history of ototoxicity), otoscopic examination and an audiogram. These were relatives of patients coming to ENT outpatient department for other ailments.

Exclusion Criteria

History of any vestibular episode, history of giddiness, hearing loss or tinnitus, medication with potentially ototoxic drugs, exposure to excessive noise, history of ear discharge, head trauma, and any systemic illnesses like diabetes, hypertension, hypothyroidism etc. were considered as exclusion criteria. Inability to attain adequate electromyography (EMG) also was considered as exclusion criteria.

Setting

VEMPs were recorded using an evoked response computer with a sound generator and surface electrodes. SmartEP VEMP device by Intelligent Hearing Systems in the ENT department was used for this purpose. The subject was seated in a comfortable and sound proofed environment, sitting upright in a comfortable chair. The patient's neck was turned to one side to tense the sternocleidomastoid muscle (head rotation method) to attain adequate EMG level. This was assisted by the use of a biofeedback available in the system. The opposite ear was stimulated with a definite intensity click sound. Recordings were obtained from surface electrodes placed on,

1. Sternoclavicular junction—inverting electrode.
2. Midpoint of sternomastoid muscle both sides—non inverting electrode.
3. Forehead—ground electrode.

Settings of Smart EP

Stimulus—0.1 ms click or 500 Hz, rate—3.1 to 5 per second, polarity—rarefaction, transducers—ear insert, intensity—85,90,95,100 dB nHL, masking—none, amplification—5 K, filters—30 to 1,500 Hz, notch filter—off, RMS—min: 50 uV, max: 250 uV, analysis time window—130 ms (–80 to 50 ms), sweeps—75 to 250.

The appropriate stimulus was selected with the required intensity, rate and number of sweeps. Recordings were done for 4 intensities (85, 90, 95, 100 dB). The peaks of the two positive and negative VEMP responses were marked as p1 and n1 respectively. The left and right recordings were compared for latency, amplitude and thresholds and data saved for later evaluation. The values of the parameters were obtained using the smart EP software and the final calculations were done using SPSS 17 version.

Variables Recorded

Outcome variable was the VEMP recording (p1 & n1 latencies, p1n1 amplitude, latency difference and asymmetry ratio) and the predictor variable was age gender and intensity of the stimulus applied.

Statistical Methods

Demographic characteristics of the patients were summarized using descriptive statistical methods by SPSS-17 analysing software. The outcome variable (VEMP recording) was expressed in percentiles as function of age. Age was also categorized into four distinct groups and the outcome variables compared between the groups.

Results

Among 85 normal subjects who underwent VEMP, 68 were males and 17 were females. Their ages ranged from 7 to 71 years with a mean age of 28. Smallest age group was those above 55 years. The mean age for males was 28 years and females were 26 years (Table 1).

All the 85 normal volunteers (170 ears) completed VEMP tests using click stimuli. The p1/n1 was elicited using 85, 90, 95 and 100 dB acoustic click stimuli and obtained a response in 8.4 % (08/85), 50.6 % (43/85), 97.7 % (83/85) and 96.5 % (82/85) of patients respectively.

Normal Values for 95 dB

Excluding 4 ears with absent waves p1/n1 in 95-VEMP, a total of 166 ears were compared. The mean latencies of waves p1 and n1 of 95-VEMP were, 11.2 ± 3.2 and 17.3 ± 4.7 ms on the right and 11.0 ± 2.8 and 17.0 ± 4.2 ms on the left respectively. The amplitude was 45.1 ± 54 mV on right and 46.9 ± 61.6 mV on the left. The mean latency difference was 0.87 ± 1.5 ms (Table 2).

Normal Values for 100 dB

Excluding 6 out of 170 ears with absent waves p1/n1 in 100-VEMP, a total of 164 ears were compared. The mean

latencies of waves p1 and n1 of 100-VEMP were, 11.3 ± 3.1 and 17.5 ± 4.6 ms on the right and 11.5 ± 3.54 and 17.6 ± 4.3 ms on the left respectively. The amplitude was 56.51 ± 62.92 mV on right and 63.7 ± 69.5 mV on the left. The mean latency difference was 0.92 ± 1.56 ms (Table 3).

Normal Data for 90 dB

Excluding 84 ears with absent waves, a total of 86 ears were compared. The response rate was only 50 % for 90 dB click. The mean latencies of waves p1 and n1 of 90-VEMP were, 11.7 ± 3.22 and 17.4 ± 7.4 ms on the right and 11.3 ± 4.1 and 16.9 ± 5.02 ms on the left respectively. The amplitude was 44.4 ± 52.9 mV on right and 38.9 ± 41.66 mV on the left. The mean latency difference was 1.47 ± 1.92 ms. But for the age group of >55, only one out of 9 patients had a VEMP response (Table 4).

Normal Data for 85 dB

Only 8 patients out of 85 had obvious VEMP with 85 dB intensity click. The response rate was only 8.4 %. Only one subject in the age group 36–55 and none in the >55 age group had VEMP for this intensity. The mean latencies of waves p1 and n1 of 85-VEMP were, 11.2 ± 3.80 and 16.5 ± 5.88 ms on the right and 11.4 ± 4.64 and 17.3 ± 5.28 ms on the left respectively. The amplitude was 43.9 ± 33.9 mV on right and 32.0 ± 20.54 mV on the left. The mean latency difference was $1.8.0 \pm 2.98$ ms.

Asymmetry Ratio

The mean asymmetry ratio for 95 dB for 7–15 age group was 37.1 %, 16–35 group was 29.7 %, 36–55 group was 21.3 % and for >55 group was 26.9 %. Asymmetry ratio was maximum for the 85 dB (low intensity) click and was maximum for the old age groups. It was also noted to increase in the children than the adults (Table 5).

Discussion

The primary objective of this study was to establish normative data for VEMP in the Indian population. Although

Table 1 Males and female in the different groups

Age groups	7–15 years	16–35 years	35–55 years	>55 years	Total
Male	19 (27.8 %)	30 (44.1 %)	10 (14.7 %)	9 (13.2 %)	68
Female	6 (35.3 %)	7 (41.2 %)	4 (23.5 %)	0	17
Total no. of patients	25 (29.4 %)	37 (43.5 %)	14 (16.5 %)	9 (10.6 %)	85

Table 2 Mean values and standard deviation of different parameters among different age groups with 95 dB

Age groups		Latency p1-Rt	Latency p1-Lt	Latency n1-Rt	Latency n1-Lt	Amplitude Rt	Amplitude Lt	Latency difference
7–15	Mean	11.50	11.30	17.09	16.67	63.10	60.48	0.69
	SD ^a	2.27	1.87	2.61	2.29	34.94	30.49	–
16–35	Mean	11.01	11.08	17.37	16.90	42.08	47.01	0.81
	SD	0.98	0.918	2.19	2.12	21.28	33.14	–
36–55	Mean	11.33	11.55	17.23	17.75	30.76	32.31	0.68
	SD	1.47	1.46	2.60	1.50	12.26	19.81	–
56+	Mean	11.33	12.06	17.62	16.84	27.43	31.85	1.84
	SD	1.77	1.51	2.23	2.45	10.06	19.82	–
All	Mean	11.24	11.33	17.29	16.96	45.05	46.96	0.87
	SD	1.61	1.42	2.36	2.12	27.42	30.80	–

^a Standard deviation**Table 3** Mean values and standard deviation of different parameters among different age groups with 100 dB

Age groups		Latency p1-Rt	Latency p1-Lt	Latency n1-Rt	Latency n1-Lt	Amplitude Rt	Amplitude Lt	Latency difference
7–15	Mean	11.40	11.88	17.19	17.08	71.97	80.60	0.92
	SD ^a	2.13	2.63	2.85	2.49	41.27	37.16	–
16–35	Mean	10.97	11.26	17.52	17.99	51.02	65.86	0.78
	SD	0.99	1.13	2.20	2.08	21.95	32.51	–
36–55	Mean	11.50	11.10	17.70	16.55	51.65	44.07	0.87
	SD	1.52	1.11	2.07	1.11	28.22	25.91	–
56+	Mean	11.80	12.16	17.88	18.53	41.59	34.43	1.56
	SD	1.61	1.46	1.47	1.87	23.28	9.02	–
Total	Mean	11.27	11.53	17.49	17.56	56.46	63.72	0.92
	SD	1.56	1.77	2.31	2.15	31.46	34.75	–

^a Standard deviation**Table 4** Mean values and standard deviation of different parameters among different age groups with 90 dB

Age groups		Latency p1-Rt	Latency p1-Lt	Latency n1-Rt	Latency n1-Lt	Amplitude Rt	Amplitude Lt	Latency difference
7–15	Mean	11.90	11.70	16.16	16.80	56.53	46.71	1.37
	SD ^a	2.15	2.98	5.11	2.77	33.23	28.32	–
16–35	Mean	11.59	11.05	18.31	17.02	40.23	32.92	1.35
	SD	1.41	1.36	2.85	2.60	22.56	15.93	–
36–55	Mean	11.33	10.50	16.37	16.33	32.21	39.31	2.03
	SD	1.5	0.97	1.80	0.99	13.76	9.97	–
56+	Mean	11.80	13.80	18.80	20.80	37.66	57.20	2.00
	SD	–	–	–	–	–	–	–
Total	Mean	11.66	11.25	17.35	16.94	44.36	38.87	1.47
	SD	1.66	2.03	3.70	2.51	26.45	20.83	–

^a Standard deviation

the criteria for selection was uniform, there were fewer subjects in the age groups more than 55 years as those accompanying patients are likely to be younger. It was more difficult in cases >55 years as some developed neck

pain, stiffness and fatigue. In the >55 years group there were only 9 who could acquire the adequate EMG levels to get a VEMP response. The other 8 subjects were excluded from the study because of inability to attain adequate EMG

Table 5 Mean asymmetry ratios for different age groups

Age groups		Asymmetry-100	Asymmetry-95	Asymmetry-90	Asymmetry-85
7–15	Mean	44.24	37.07	38.75	71.96
16–35	Mean	42.57	29.72	28.84	73.07
36–55	Mean	29.20	21.33	30.42	99.53
56+	Mean	40.89	26.86	78.81	

as per inclusion and the exclusion criteria. We also found it difficult to attain the adequate EMG among thin ladies because of which five subjects were excluded from the study as per exclusion criteria. The test was easier to be carried in younger age groups and children compared to >55 years group.

The procedure was found to be relatively simple and each took about 20–30 min. The machine used was smart EP which had a useful EMG monitor with visual feedback. This EMG monitor helped in ensuring that the patient maintained adequate muscle tension and was found to be very useful.

VEMP was done in all the 85 patients except for those excluded subjects because of inability to acquire adequate EMG. In all patients the stimulus which got the best response was 95 dB (97.7 %) and 100 dB (95 %). The response rate for 85 dB was only 8.4 % which was significantly different from the other 3 groups. The response rate for 90 dB was only 50.6 % which also was different from the other three groups. This finding was similar to a study by Janky et al. [3] which also suggested the optimum intensity to be 95 dB.

Two patients who did not have a response at 95 dB had response at 100 dB and three who had no response at 100 dB had a response at 95 dB. So repeating the test at 100 dB when there is no response at 95 dB and vice versa may be useful practice. The reason for this could not be explained it needs further investigation.

The mean p1 latency for 95 dB on the right was 11.2 ± 3.2 ms and on the left was 11.3 ± 2.8 . There was no significant difference ($p > 0.05$) for p1 latency between the intensities, sides, the genders or the age groups. It was also found that p1 was more constant and reliable than n1 and hence p1 may be used to identify the early complex despite the presence of some artifacts. These values were similar to studies done by Janky et al. [3] and Akin et al. [5]. Zapala et al. [6] noted delayed p1n1 latencies with increasing age using tone bursts.

The mean n1 latency for 95 dB was $17.3 (\pm 2SD -5.72)$ ms on the right and $17.0 (\pm 2SD -4.24)$ ms on the left. There was no significant difference ($p > 0.05$) in the values of latencies for different intensities, between the sides, between the genders, or between different age

groups. However prolonged n1 latency with increased age was noted by Su Young et al. [7] and Kelch et al. [8] using clicks.

The mean p1n1 amplitude was 45.05 mv, with a high variation from the mean (2SD = 58.2). The mean value was comparable to other study by Akin et al. [5] in 2003. It was also noticed that the mean amplitude had a negative correlation to age, age group in 7–15 years having higher values $61.8 (\pm 2SD -65.4)$ when compared to other age groups; $44.6 (\pm 2SD -54.4)$ in 16–35 years, $31.6 (\pm 2SD -32.1)$ in 36–55 years age group and $29.6 (\pm 2SD -29.9)$. There was no difference of values between the genders. This finding correlates with most of the other studies showing the same negative correlation [2, 9]. The reasons suggested for this were, the age induced degenerative changes occurring in saccular hair cells [10] or Scarpa's ganglion cells [11] or vestibular brain stem [12]. Since there was a high variation in the amplitude, it may not have a diagnostic significance. The mean amplitude was highest for 95 dB when compared to other three intensities.

The mean p1 latency difference between right and left was 0.87 ms with a SD of 0.75 ms. There was no significant difference between the age groups ($p = 0.57$) or between the genders. Kentaro Ochi et al. [13] found in their study the latency difference of 0.93 ± 0.77 ms for 95 dB click and it was similar to this study.

Asymmetry ratio was calculated by the formula, $100 \times (A \text{ left} - A \text{ right}) / (A \text{ right} + A \text{ left})$. The ratio was least for 95 dB for 35–55 age group and was higher in lower and higher age group. Asymmetry was also seen increasing when the intensity was either decreasing or increasing from 95 dB level. There was no significant difference ($p = 0.28$) for the values between the groups. Kentaro Ochi et al. [13] found that the mean asymmetry ratio for 95 dB as 12 ± 8.1 % and there was no significant difference between 95, 100 and 105 dBs.

The asymmetry above 33 % was considered abnormal by some authors but this study suggests that the amplitude can change significantly with change in muscle tone or side to side or patient to patient. Thus the asymmetry ratio can increase when subjects are old or in children or when the testing is not done fast enough thus making them strain for obtaining adequate contraction.

Conclusion

The VEMP is a relatively simple test. The VEMP response rate was maximum in the younger age group. The study results were similar to most of the western data, except for the asymmetry ratio. The asymmetry ratio should be done according to age specific values.

Acknowledgments Department of ENT, Christian Medical College Vellore.

Conflict of interest None.

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