Original Research Article

Assessment of Sacculocollic Pathway in Individuals with Diabetes Mellitus

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ABSTRACT

Objective and Study Design: The following study was a cross-sectional study and was conducted with an aim of characterizing the VEMP responses in individuals with Diabetes mellitus.
Material and Methods: 2 groups of participants (total=30, 15diabetic and15 no diabetic) within the age rangeof40-60yearsweretaken.Routineaudiological evaluations such as pure tone audiometry, speech audiometry, immittance, auditory brainstem responses were done before administering cVEMP for both the groups.
Results: cVEMP was present in all the 30 years (15 participants) in the control group, whereas it was present in 16 years (8 participants) with diabetes. Mann Whitney U test revealed significant difference in amplitude of P-1N1 complex between the two groups. However, latencies were unaffected in the experimental group.
Conclusion: The above findings suggest that the sacculocollic pathway might be affected in individuals with diabetes.

Keywords: Vestibular, Cervical VEMP, Diabetes Mellitus, Sacculocollic pathway.

List of acronyms: Abbreviations: cVEMP- Cervical vestibular myogenic pathway; ABR- Auditory Brainstem Responses; SCM- Sternocleidomastoid muscle.

INTRODUCTION

A metabolic disorder which results in absolute or relative impairment of insulin leading to metabolic affections, vascular and neuropathic complications is known as Diabetes. [1] It is one of the most common disorders in the ongoing century. The total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030. [2] The prevalence of type-II diabetes mellitus for all age-groups worldwide has been estimated to be 2.8% in 2000 and expected to be 4.4% in 2030 [2] Therefore, there is presence of high risk factors to acquire other possible secondary disorders such as hearing disorders and balance disorders. Hence, a growing concern among health professionals to avoid such disorders which may impact the quality of life in these individuals.

Various studies have shown presence of hearing loss and tinnitus in individuals with diabetes mellitus. [3,4] Similarly, ABR waves latencies (particularly wave V) have been reported to be prolonged for diabetic compared to non-diabetic groups. [5] ABR also shows significantly prolonged absolute latencies and interwave intervals of the wave I to wave V in individuals with diabetes

compared to individuals without diabetes. [6]

Above findings on hearing suggest that the inner ear or the 8th nerve might be affected in individuals with diabetes. Since the inner ear consists of both the hearing and balance system it is possible that the balance functions also might be impaired in individuals with diabetes mellitus. The prevalence of balance disorder in individuals with diabetes mellitus has been reported to be around 60 to 75%. [7]

Several studies have shown an impaired balance function in individuals with diabetes mellitus. [7] These studies have utilized an electronystagmography or computerized dynamic Posturography test to characterize the balance disorder in individuals with diabetic mellitus. A study has reported cVEMP abnormality in a group of individuals with type-1 diabetes mellitus, however there is a dearth of published report on individuals with type –II diabetes mellitus. [8]

The vestibular portion of the inner ear consists of several structures and with one particular test it is not possible to assess all the structure. Particularly, the otolith organs (utricle and saccule) cannot be assessed with Electronystagmography or the Posturography test. Among the recent advancements in objective evaluation of the body balance system, vestibular evoked myogenic potentials have been introduced as a tool to assess the saccular and utricular functions in individuals with various vestibular disorders. There are two types of vestibular evoked myogenic potentials: Cervical vestibular evoked myogenic potentials (cVEMP) and ocular vestibular evoked myogenic potentials (oVEMP). Where cVEMP assess the saccule and its innervating structures and the oVEMP assess the utricle and its innervating structure.

cVEMP has been useful tool for the diagnosis of various vestibular dysfunctions such as Meniere's disease, [9,10] vestibular neuritis, [11] benign paroxysmal positional vertigo (BPPV) [12] noise induced hearing loss (NIHL), [13, 14] auditory neuropathy, [14,15] as well as other disorders such as cerebellopontine angle tumor, [9,10,16] and multiple sclerosis. [9]

Thus, the present study was conducted with an aim of assessing the sacculocollic pathway in individuals with diabetes mellitus through cVEMP.

MATERIALS & METHODS

Participants: 15 participants (30 ears) in the age range of 40-60 years (mean age-50years) with history of diabetes mellitus (type-2) participated in the present study. Also 15 participants (30 ears) without diabetes mellitus in the age range of 40-60 years with mean age of 52 years as that of experimental group served as control group. The presence of diabetes mellitus (type II) was confirmed through medical reports of the clients. All the participants in both the groups were selected on the basis of random sampling and had no presence or history of conductive hearing loss, no retrocochlear pathology (based on ABR results), no history or presence of any other neurological deficits and uncomfortable loudness level for speech was greater than 100 dB HL. No complaint of giddiness or balance problem was reported. All the participants in both the groups had no other associated problems during the recording.

Instrumentation: Audiological testing was carried out using calibrated instruments. Pure tone audiometry was done using 2-channel calibrated diagnostic audiometer (Orbiter-922 V-2x, G N Otometrics, Taastrum, Denmark). Transducer used for calculating AC Thresholds was TDH-39 (Telephonics, 815 Broad Hollow Road, Farmingdale,

New York 11735) and for BC thresholds was B-71 bone vibrator (Radioear, KIMMETRICS, Smithsburg, MD 21783). Grason Stadler Inc. Tympstar system (GSI VIASYS Healthcare, W isconsin, USA) was utilized to assess middle ear function. For auditory brainstem responses Intelligent Hearing System version 4.3.02 (Intelligent Hearing System, Florida, USA), with ER-3A Insert ear phone (Etymotic Research, Inc., Elk Grove Village, IL, USA) was utilized. Same instrument was used to obtain cVEMP waveform from the participants of the study.

Procedures: Consent was taken from all the participants before the study was conducted. First a detailed case history was taken from all the participants followed by routine audiological evaluations such as pure-tone audiometry, Immittance evaluations, speech audiometry and auditory brainstem responses.

Pure tone audiometry: For estimation of pure tone thresholds subjects were seated in a comfortable position in a sound proof room. Air conduction and bone conduction threshold were obtained using modified Hughson-Westlake method. [17] Air conduction threshold were obtained at octave frequency of 250, 500, 1000, 2000, 4000, and 8000 Hz. Bone conduction threshold were obtained at octave frequency of 250, 500, 1000, 2000, and 4000 Hz.

Immittance: Following to it immittance evaluation was carried out where probe tone of 226hz and pressure varying from -400 to +200 dapa was used to obtain a tympanogram. Later ipsilateral and contra-lateral reflexes at 500, 1K, 2K and 4K were also found out to rule out the chances of middle ear pathology.

Auditory Brainstem Responses: Auditory brainstem responses were recorded to rule out retro-cochlear pathology. ABR was done using vertical montage (positive electrode at forehead,

negative at test ear mastoid and ground at non-test ear mastoid). ABR was recorded using clicks (100µsec) stimuli presented at a repetition rate of 11.1 and 90.1 sec. Later the responses were filtered between 100Hz to 3000 Hz and were amplified 100000 times. 10 msec time windows were used to analyze the brainstem responses.

Cervical -Vestibular myogenic potentials: Once all the above mentioned tests were done c-VEMP was carried out. Cervical vestibular evoked myogenic potentials were recorded from all the participants in both the groups. The non-inverting electrode was placed at around $3/4^{th}$ length of sternocleidomastoid muscle, inverting electrode on sternoclavicular joint and ground electrode was placed on forehead. Subjects were seated in a sound proof room in a comfortable position and were given response LED to monitor the muscle activity of the SCM. EMG was monitored through the EMG monitoring device to ensure an equal amount of muscle contraction from all the participants. cVEMP was recorded twice to ensure the replicability of the responses. The recording protocol consisted of (500Hz) tone burst as stimuli given through Insert ear phone (ER-3A) with duration of 2-0-2 cycle. Twice the recording was administered where Intensity across the subjects was kept constant as 95 dBnHL having repetition rate of 5.1/sec for a total of 200 no. of stimulus analyzed in 60msec time window with rarefaction polarity. Low cut off was set at 30Hz and 1500Hz was the high cut off in single channel recording, with amplification of 5000. Notch filter was kept off throughout the recording of cVEMP. The method carried out for cVEMP was incorporated as mentioned by Kumar et.al [18]

Data analysis: Latency of P1, Latency of N1 and amplitude of P1-N1 complex was measured for all the participants in

both the groups. The first positive peak occurring around a latency of 13 msec was marked as P1 and the first negative peak following the P1 was marked as N1. The peak to peak amplitude of P1-N1 complex was also measured from all the participants.

RESULTS

cVEMP was present in all the participants (15 participants, 30 ears) of the control group, whereas in individuals with diabetes mellitus the responses were present in 16 out of 30 ears. However, the auditory brainstem response to click stimuli was present in all the individuals in both the groups. The cVEMP waveform obtained in control group and the experimental groups are shown in figure-1.
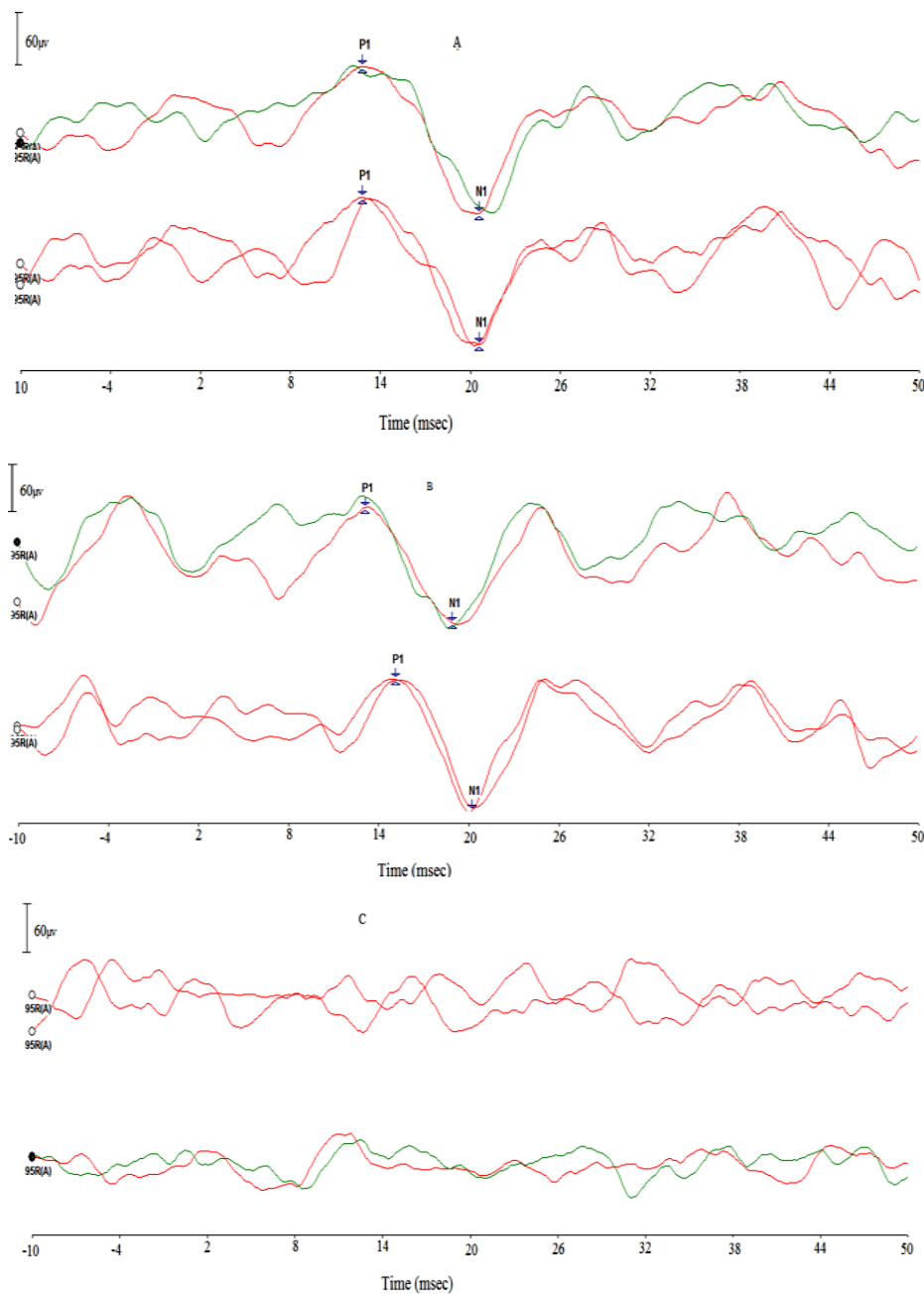
Figure-1: A. Presence of cVEMP waveform in one of the participant in control group B. Presence of cVEMP waveform in one of the participant in experimental group C. Absence of cVEMP in one of the participant in experimental group.

Descriptive statistics was done to calculate the mean and the standard deviation for the latency of P1 peak, latency of N1 peak and amplitude of P1-N1 complex for both the groups. The mean and the standard deviation for the latency of P1 peak, latency of N1 peak and amplitude of P1-N1 complex was calculated using the SPSS-20 software for both the groups and are given below in table-2.

As it can be seen from table-2 that the latency of P1 peak is almost similar for both the groups, whereas the latency of N1 peak is slightly larger in control group compared to the experimental group. Also, the amplitude of P1-N1 complex is larger in control group compared to the experimental group. The same can be seen in figure-2.
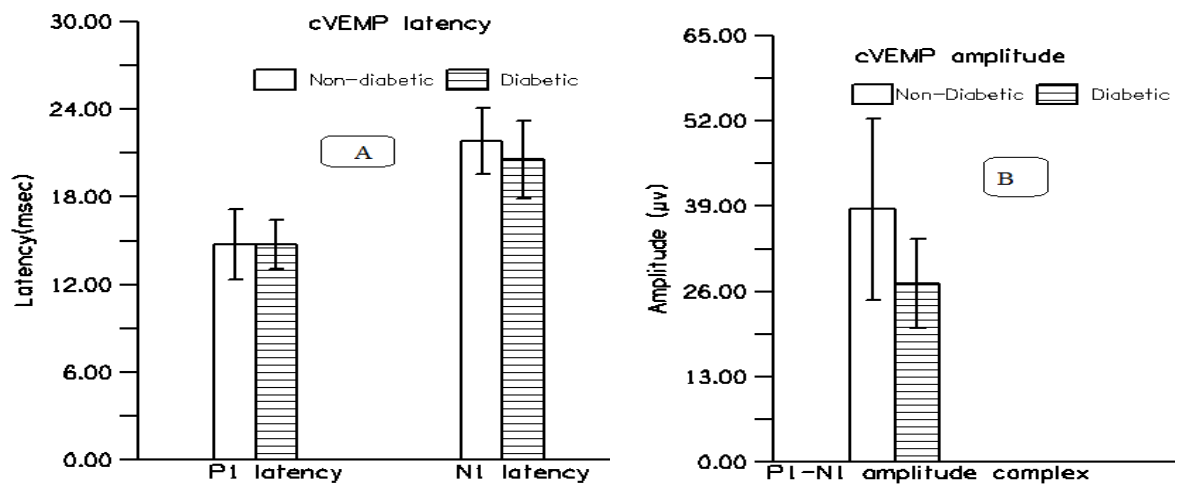

Figure-2: A. cVEMP latency B. cVEMP amplitude in diabetic and non-diabetic individuals

Table-2: Mean and standard deviation (SD) for latency and amplitude parameters of cVEMP for control and experimental group

Group	N (no. of ears)	Mean Latency Of P1 (msec)	SD	Mean Latency of N1 (msec)	SD	Amplitude of P1-N1 complex (μv)	SD
Control group	30	14.75	2.40	21.79	2.26	38.55	13.79
Diabetic group	16	14.76	1.69	20.55	2.68	27.20	6.74

N= number of ears in which the responses were present

Table 3: Z value and significance level for cVEMP wave parameters

S.No	Wave parameters	Z value	Significance Level
1	Latency of peak P1	Z= 0.19	$p > 0.05$
2	Latency of peak N1	Z= 1.85	$p > 0.05$
3	Amplitude of amplitude complex P1-N1	Z= 2.79	$p < 0.05$

To understand the significant difference between the mean and the standard deviations of the two groups a non parametric Mann-Whitney U test was done. Mann- Whitney U test was preferred as there were only two groups of participants in the present study and also the number of presence of data in two groups was unequal. Man-Whitney U test did not show a significant difference in latency of P1 peak and latency of N1 peak between the two groups. However Man-Whitney test showed a significant difference in amplitude of N1-P1 amplitude complex between the two groups. The results of the Mann-Whitney test are shown in Table-3.

To summarize the results, cVEMP was present in all the participants in control group whereas it was present only in 46.67 % of the individuals in the experimental group.

Also, the amplitude of cVEMP was lesser in experimental group compared to the control group.

DISCUSSION

Vestibular evoked myogenic potentials are a manifestation of the otolith-ocular or otolith-collic pathway, if activated by an acoustic stimulus. The latency of P1 and N1 peak and amplitude of P1-N1 complex of cVEMPs obtained in the present study are similar to earlier reports. [19-23]

But in the present study cVEMP was absent in 53.33% in experimental group indicating vestibular dysfunction. However, one of the previous studies has reported no difference in terms of latency or amplitude between non-insulin-dependent diabetes and controls. [24] The difference in the results could be because of the duration of the diabetes in these individuals. However, some of the other studies utilizing caloric tests and rotatory chair tests have reported a vestibular dysfunction in individuals with diabetes mellitus. [24-26] Vestibular dysfunction has also been demonstrated in animal models having diabetes [27,28]

Absence of cVEMP in 53.33% of the diabetes individuals and the reduced amplitude of cVEMP in individuals with diabetes mellitus are suggestive of pathology in the saccule or its innervating neurons. We can hypothesize that innervating neurons of vestibular nerve remains non-pathological in individuals with diabetes mellitus as the auditory brainstem responses were present normally implying normal functioning of the cochlear nerve fibers. And since cochlear and vestibular nerve, are part of the same 8th cranial nerve, hence chances of presence of lesion in vestibular nerve reduces.

Research Studies have also proved that diabetes mellitus leads to thinning of basal membrane, which may also happen with vascular endothelium. [29] Blood circulation may get hamper in such conditions leading to altered glucose and insulin levels. These morphological changes can reflect as vertigo, hearing loss, tinnitus and ear fullness. Vascular proliferations can occur due to increased density within blood vessels. [30] Individuals with diabetic mellitus are at a risk for such increase in density of capillaries hence such vascular proliferation can happen within first three months of diabetes. [30] The vascular proliferation reflects a decreased efficiency of oxygen delivered by the capillary bed.

Studies have also demonstrated changes in the vestibular end-organ such as increased capillary diameter of small blood cells of the utricle and saccule. Around 25% of the capillaries of utricle and saccule are less than 4 µm in diameter. [30] As the viscosity of the blood increases in individuals with diabetic mellitus, the increased capillary diameter would impair the blood vessel causing a reduced oxygenation to the otolith organs. [31,32] A decreased oxygen supply due to the effects of diabetes over density and diameter of capillaries, and may lead to apoptosis it might result in death of the hair cells located in the otolith organs. No active existence of hair cells in the saccule can also be the reason for the absence of cVEMP in individuals with diabetes mellitus.

Interestingly, these subjects were asymptomatic, i.e. they did not report of any vestibular symptoms. The absence of vestibular symptoms could be due to a bilateral distribution of the disorder (it is generally seen that the vestibular symptoms are more pronounced when there is a functional asymmetry between the two labyrinths). The second reason could be a central compensation would have taken place in these participants and hence they remain asymptomatic.

SUMMARY AND CONCLUSION

The present study revealed cVEMP abnormality in individuals with diabetes mellitus (type II). The result of the present study is also an indicative of saccule involvement rather than the nerve involvement in diabetic participants. The study suggests that the individuals with diabetes mellitus should undergo a detailed vestibular involvement. The results of the different vestibular tests give us a better understanding of the pathophysiology in individuals with diabetes mellitus.

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How to cite this article: Sahu M, Sinha SK. Assessment of sacculocollic pathway in individuals with diabetes mellitus. Int J Health Sci Res. 2015; 5(11):313-320.

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