ORIGINAL ARTICLE

INFLUENCE OF DANCE TRAINING ON SACCULOCOLLIC PATHWAY: VESTIBULAR EVOKED MYOGENIC POTENTIALS (VEMP) AS AN OBJECTIVE TOOL

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HOW TO CITE THIS ARTICLE:
Swathi VM, Sathish Kumar KN. "Influence of dance training on sacculocollic pathway: vestibular evoked myogenic potentials (VEMP) as an objective tool". Journal of Evolution of Medical and Dental Sciences 2013; Vol. 2, Issue 40, October 07; Page: 7747-7754.

ABSTRACT: Auditory system is shaped by experience and training. Training (sensory experience) induces neurophysiologic changes & plasticity in normal hearing individuals, hearing loss patients, hearing aid users and cochlear implanted subjects. Not only speech stimulus, but music also brings about functional and structural organization of the brain in musician compared to non-musicians. The Vestibular evoked myogenic potentials (VEMP) are a biphasic inhibitory response elicited by loud clicks or tone bursts recorded from the tonically contracted sternocleidomastoid muscle (SCM), being the only resource available to assess the function of the saccule and the inferior vestibular nerve (sacculocollic pathway) **DESIGN:** prospective study. **AIM**: The present study was conducted with an aim of studying plasticity of the sacculocollic pathway in professional dancers who are receiving dance training. **METHOD**: Two groups of subjects participated for the study a) experimental group; b) control group, experimental group was further divided in to two subgroups- Professional dancers who have received training in salsa as well as Bharath natyam. Experimental group consisted of total 40 subjects (80 ears), 20 (40 ears) in each subgroup. Control group consisted of 40 individuals who have not received any professional training in dance (80 ears). **RESULT:** Results showed that there was statistically increase in amplitude of P13, N23 and P13-N23 as well as early latency of P13, and N23 in professional dancers compared to the control group. The difference in amplitude and latency between the two groups was attributed to plasticity of sacculocollic pathway in dancers. **CONCLUSION:** during aging process there is considerable deterioration of balance capability, loss of balance is a major risk factor for falls in middle aged and elderly people, to slow this deterioration of balance one should gradually and continuously stimulate balance through motor activity, People have become more health conscious and they expect to add more socially and economically productive years to their life span and hence dance based therapy can be useful which can be postulated from the results of present study using objective method.
KEY WORDS: Vestibular Evoked Myogenic Potentials (VEMP), Dancers, Plasticity, balance, objective method.

INTRODUCTION: Diagnostic testing of the vestibular system is an essential component of treating patients with balance dysfunction. Until recently, testing methods primarily evaluated the integrity of the horizontal semicircular canal, which is only a portion of the vestibular system. Recent advances in technology have afforded clinicians the ability to assess otolith function through Vestibular Evoked Myogenic Potential testing. This newly developed procedure augments the management of dizzy patients by increasing specificity when investigating the site of lesion. VEMP testing is a new diagnostic tool for the professionals who are dealing with assessment of vestibular and auditory disorders. Normal VEMP responses are characterized by biphasic (positive –negative) waves. The first positive –negative complex is often labeled as P13-N23. [1]. Authors have also reported later serial peaks of VEMP labeled as N34-P44.

VEMP has been utilized for the diagnosis of various disorders such as, Meniere's disease [2, 3], Acoustic neuromas [4,5,6], Superior canal Dehiscence syndrome, [7], Vestibular neuritis [8],Vertigo[9] ,Noise induced hearing loss [10], Auditory neuropathy / audio vestibular neuropathy [11] and in other disorders such as cerebellopontine angle tumor [3] **,** Multiple sclerosis.[2] **.**

Plasticity of the auditory system is not a new entity. Various studies have reported a change in the response of the auditory system after training. [12, 13, 14]. Similarly a remarkable plasticity has been noted in the vestibular system throughout life. Behavioural analyses of vestibular plasticity have focused primarily on the vestibulo-ocular reflex (VOR), which enables retinal images to remain stable during head motion by driving compensatory eye movements. Powerful forms of motor learning occur in the VOR whenever images move persistently on the retina during head movements. [15]. There are various reports which suggest that dance based training improves balance function in young as well as adult subjects. [16, 17].

It has been shown that there is plasticity not only in the VOR system but also the utricle and the saccule. [18]. Vestibular evoked myogenic potential (VEMP) response was recorded to evaluate saccular function in 12 professional divers shortly after a dive and after an interval of at least 24 hours. The control group consisted of 12 matched non-divers. Wave latencies and amplitudes, asymmetry ratio, and the response threshold were compared between the groups. Results revealed a statistically significant shortening of N23-wave latency was in the divers compared with the control group.

Dance is generally recommended to maintain good dexterity and coordination, fluid movements of the joints, muscle tone and trophism. In dance, movement of the head and trunk and the shifting of the centre of gravity in every direction from the axis of support allow the development of all those factors which contribute to the maintenance of balance, such as coordination and joint mobility. It is well known that the best defense mechanism against injuries and risk of fall is well toned, strong flexible body. Appropriate alignment and range of motion of large joints are required for dance activity; in the same way, dance exercises represent a potentials relevant support in both increasing balance and decreasing the risk of falls and injuries.

Along with improving the muscle tonicity and other joint movements the dance can also improve the responses of the vestibular systems. During the dance exercises the body requires more balance, it is possible that the neuronal discharge may increase from the vestibular system in order to balance the body. In this process the vestibular system in dancers may be more responsive and thus the dancers may have a better balance system.

The present study was conducted with an aim of investigating plasticity of utricle and saccule using vestibular evoked myogenic potential in dancers.

METHOD: Two groups of subjects participated for the study:

1) In the experimental group, 40 professional dancers (80 ears) in the age range of 20 to 40 years participated in the study. The experimental group was further subdivided into two groups.
    a. Professional dancers who have received training in Salsa dance [Total 20 subjects, (11females, and 9males)]

b. Professional dancers who have received training in bharath natyam dance [Total 20 subjects, (13 females, 7 males)] only those dancers were included who have received the training and are continuing with the dance practice were subjected for the study. All the participants had at least two years of dance experience/regular practice of dancing. The criteria for 24 months of dance practice is based on the studies which has shown that dance based training improves that balance in adult and elderly subjects in three months .[16].

In the control group, 40 individuals (80 ears), included 30 females and 10 males in the age range of 20 to 40 years, who have not got any professional training in the dance, participated in the study.

Participant Selection criteria: All the participant's hearing sensitivity were within normal limits (i.e., pure tone average of 500Hz, 1 kHz and 2 kHz should be less than ≤15 dB HL).None of the participants had history or presence of any otological problems such as ear discharge, ear pain, itching, tinnitus etc, history or presence of any history of neuromuscular problem, history or presence of intake of drugs that may lead to vestibulotoxicity, history or presence of symptoms of vestibular problems such as vertigo, giddiness, nausea, blurring of vision and no other associated neurological problems.

Instrumentation: Calibrated EYMASA single channel Audiometer (AD-100) with TELEPHONICS TDH -39P
Headphones – was used to obtain pure tone thresholds and UCL (uncomfortable loudness level)

- RADIO EAR B-71- was used to obtain bone conduction thresholds
- GSI -38 Auto tym – was used for tympanometry and reflexometry
- Intelligent hearing system [I. H. S, Smart EP (4 .00 USBez) with ER-3A Insert ear phone] was used for testing of Vestibular Evoked Myogenic Potentials for all the participants.

Procedure: A detailed case history was obtained regarding the condition of the hearing system from all the participants.

Pure tone thresholds were obtained by using modified Hughson – Westlake procedure [19], for octave frequencies from 250Hz to 8 KHz for air conduction stimuli and from 250Hz to 4 KHz for bone conduction stimuli. For Tympanometry 226Hz probe tone was used, ipsilateral and contralateral reflexes at 500Hz, 1000Hz, 2000Hz and 4000Hz were obtained for both the ears.UCL for all the participants was obtained by presenting speech stimuli at 100dB, Participants were instructed to respond to the stimuli by saying whether it is comfortable or not. Rectified VEMPs was recorded for both the groups by an averaging of the acoustically evoked electromyogram of the sternocleidomastoid muscle. Subjects were instructed to turn their neck towards the non-stimulation ear side i.e., to rotate towards the contralateral side of the testing ear. A visual feedback was given to the participants in order to monitor their sternocleidomastoid muscle tension. The muscle tension was monitored with EMG level feedback system provided by I.H.S system. The EMG level was maintained between 100% to 200 %(50μv to 100μv) for all the participants. The site of the electrode placement was prepared with skin preparation gel, silver chloride disc electrodes with conducting gel was used. Absolute electrode impedances and Inter electrode impedances of less than

5 KΩ and less than 2 KΩ respectively were maintained. Subjects were made to sit in upright position and also were instructed to tense the sternocleidomastoid muscle during runs of acoustic stimulation and relax between runs.

VEMP was recorded with the following protocol:

Stimulus parameters		Acquisition parameters	
Transducer	Insert ear phones ER-3A	Amplification	5000
Type of stimulus	500Hz tone burst	Analysis window	-10 to 70ms
Intensity	95 dBnHL	Filters	30 – 1500 Hz
Polarity	Rarefaction	Electrode montage	
No of sweeps	200	Non- Inverting (+) electrode	Upper half of sternocleidomastoid muscle
Repetition Rate	5.1/sec	Inverting (-) electrode	Sternoclavicular junction
Notch filter	Off	Ground electrode	Forehead

Table 1: Recording protocol for VEMP

500Hz tone burst stimulus was selected based on the earlier studies which show a better amplitude and response rate with 500Hz tone burst .[20,21] **.**

Analysis: VEMP was recorded for both the ears for all the subjects. The responses were morphologically analyzed to interpret the VEMP findings**.** Two recordings were obtained for the same ear to ensure reliability of the waveform**.** The first positive peak and the first negative peak of the biphasic wave with the latency of 13ms and 23ms was considered as p13and n23 respectively, peak to peak amplitude was calculated in order to obtain amplitude of p13-n23 complex.

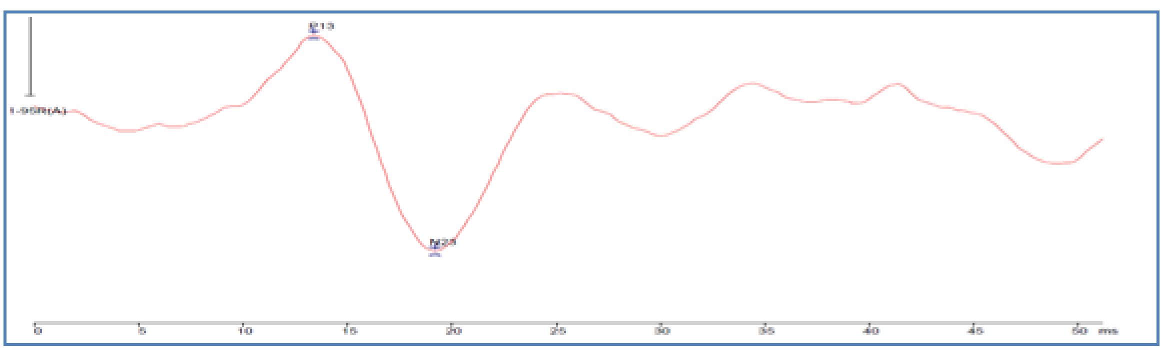

Figure 1: Wave form of VEMP response showing P13 and N23.

1. Latency of P13 was analysed for the control and experimental group.
2. Latency of N23 was analysed for the control and experimental group.
3. Amplitude of P13 was analysed for the control and experimental group
4. Amplitude of N23 was analysed for the control and experimental group
5. Amplitude of P13-N23 complex was compared across the two groups.

RESULTS AND DISCUSSION: The latency and amplitude of different peaks of vestibular evoked myogenic potentials were analyzed for the two groups i.e. the experimental group and the control group. Latency of P13 peak, N23, amplitude of P13, N23 peak, amplitude of P13, N3 and peak to peak amplitude of P13-N23 complex were compared across the two groups.

Latency of P13 and N23 peak: Vestibular evoked myogenic potentials could be recorded for all the subjects in both the control and the experimental group. P13 & N23 peaks in the waveforms were visualized and analyzed for the control (non dancers) group and the experimental (dancers) group.

Parameters	P13 latency		N23 latency	
Groups	Mean(msec)	S.D (msec)	Mean(msec)	S.D (msec)
Control	15.80	2.31	21.30	2.20
Experimental	15.20	1.70	20.00	1.50

Table 2: Mean and standard deviation (S.D) values of latency (msec) of control group and the experimental group

The mean latency for the combined data of the experimental group for the P13 peak and N23 peak was early compared to control group as we can see from the table 1.

To understand the significant differences in the mean values for the latency of P13 & N23 peaks, for the combined data of the experimental and the control group, Independent sample T test was done. Independent sample T showed significant differences for the latency of P13 & N23 ($p < 0.05$) between dancers and the non dancers group.

Amplitude of P13, N23, and P13-N23 complex: Amplitude of P13, N23 peak, amplitude of P13, N3 and peak to peak amplitude of P13-N23 in the waveforms were visualized and analyzed for the control (non dancers) group and the experimental (dancers) group

Parameters	P13 Amplitude		N23 Amplitude		P13-N23 Amplitude	
Groups	Mean (µv)	S.D (µv)	Mean (µv)	S.D (µv)	Mean (µv)	S.D (µv)
Control	16.20	8.30	21.40	9.10	37.59	17.7
Experimental	23.75	6.00	29.00	8.11	52.75	14.10

Table 3: Mean and S.D values of amplitude of P13, N3 and peak to peak amplitude of P13-N23 Complex control group and the experimental group

The mean amplitude for the combined data of the experimental group for the P13, N23 and peak to peak amplitude of P13-N23 complex was higher compared to control group as we can see from the table 2.

To understand the significant differences in the mean values for the P13, N23 and peak to peak amplitude of P13-N23 complex for the combined data of the experimental and the control group, again Independent sample T test was done. Independent sample T showed significant differences for the P13, N23 amplitude and peak to peak amplitude of P13-N23 complex ($p < 0.05$) between dancers and the non dancers group.

Additionally it can also be seen that the standard deviation for the experimental group is again low compared to the control group for both latency and amplitude.

To summarize the results, there was significant difference for both latency of P13 & N23 and the amplitude of P13, N23 peaks & peak to peak amplitude of P13-N23 complex of VEMP response between two groups that is early latency and higher amplitude in experimental group compared to control group.

The results obtained here are just a preliminary report which indicates possible sacculocollic pathway plasticity because of the regular practice of the dance. The early latency and significant improvement in amplitude of the VEMP responses could be due to the fact that the dance requires more balance activity and thus would have resulted in a more responsive vestibular system in the dancers compared to the non-dancers. The plasticity in the vestibular system would have occurred in different anatomical structure which can be measured with the other techniques such as Electronystagmography. Here in the present study only otolith organs were assessed. Similar to the plasticity in other vestibular structures, the plasticity of the otolith organs would have occurred in dancers. Thus, the otolith organs would have become more responsive and an improved functioning of these structures would have resulted in improved amplitude responses of the vestibular evoked myogenic potentials.

CONCLUSION: Loss of balance and diminished gait are major fall risk factors in middle aged and older persons. Loss of efficiency of neuro muscular connections and slowing of information processing leads to slower reaction time and locomotor adjustments, this in turn results in maintaining body's balance during static and dynamic movements thus to slow this deterioration of balance one should gradually and continuously stimulate balance through motor activity. Many studies have reported that dance based exercises/ therapy improves balance and gait in elderly individuals [22, 17, 16], but these are behavioral studies show functional modifications in balance system. Hence from the present study it can be postulated from the objective method that dance based therapy/exercises can be used to reduce fall risks in elderly in order to have significant psycho social benefits and improve their perception of their life.

From the present study it can be concluded VEMP parameters is a better tool to study the plasticity of sacculocollic pathway.

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Date of Submission: 24/09/2013.
Date of Peer Review: 28/09/2013.
Date of Acceptance: 30/09/2013.
Date of Publishing: 04/10/2013