

# Effect of Yoga Practice on Sacculocollic reflex in Young Adults

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## Abstract:

Balance is a complex sensorimotor function that requires the integration of information from multiple sensory inputs: vision, proprioception, and vestibular function. The vestibular system is particularly important for maintaining postural balance. Cervical Vestibular Evoked Myogenic Potentials (cVEMP) tests have been used to measure the functional integrity of the sacculo-collic reflex arc. The purpose of the present study was to measure and compare the cVEMP responses in yoga practitioners and non-yoga practitioners, and to examine the correlation between cVEMP responses and the duration of yoga practice. A total of 120 participants aged between 18 and 40 years were included in the study: 60 yoga practitioners with a minimum one-year Hatha yoga practice and 60 non-yoga practitioners. cVEMP tests were carried out using a standard electrode placement with a 500 Hz tone burst stimulus. The parameters that were recorded included P1 and N1 latency, peak-to-peak amplitudes, and threshold. Using statistical analysis with the Mann-Whitney U test, no significant differences in the latency of P1 and N1 were found between the groups. However, significant differences were found in peak-to-peak amplitudes and thresholds, which were higher in the yoga group compared to the non-yoga group ( $p < 0.001$ ). In addition, a significant negative correlation was found between the duration of yoga practice and the thresholds of cVEMP, indicating increased vestibular sensitivity with longer practice durations. However, no significant correlation was found for latency and amplitude. These results indicate that yoga can improve vestibular functions by enhancing the responsiveness and sensitivity of the sacculo-collic reflex arc, which might be attributed to activity-dependent neuroplasticity.

**Keywords:** cVEMP, Cervical Vestibular Evoked Myogenic Potentials, Yoga, Sacculo-collic pathway

## Introduction

Balance is considered to be a complex sensorimotor task that involves the integration of different sensory inputs to ensure the maintenance of balance (Puszczalowska-Lizis et al., 2018). It can be divided into static and dynamic balance, both of which are considered to be the integration of sensory and motor functions (Hrysomallis, 2011). Among the different systems that are involved in the maintenance of balance, the vestibular system is considered to be the most important, as it helps to detect movements of the head and the gravity vector, thereby facilitating the reflex required to maintain balance.

One of the main reflexes responsible for the stability of the head and neck region is the vestibulo-collic reflex (VCR), which is mediated by the sacculo-collic reflex pathway (Uchino & Kushiro, 2011). This

reflex pathway starts from the saccule, which is an otolith organ responsible for the detection of vertical linear acceleration and sound waves. The afferent fibers from the saccule travel through the inferior vestibular nerve to the vestibular nuclei. From the vestibular nuclei, efferent fibers travel through the lateral and medial vestibulospinal tracts to the spinal cord and synapse with the motor neurons responsible for the sternocleidomastoid (SCM) muscle (Zhou & Cox, 2004).

The functional integrity of the sacculo-collic reflex arc can be objectively measured by Cervical Vestibular Evoked Myogenic Potentials (cVEMP). cVEMP is an electrophysiological procedure used to record short-latency inhibitory responses from the SCM muscle following acoustic or vibratory stimulation (Colebatch et al., 2016). The biphasic waveform of cVEMP includes a positive peak (P1) followed by a negative peak (N1). The waveform of cVEMP is a result of saccular activation and neural conduction through the inferior vestibular nerve (Colebatch & Halmagyi, 1992; Young, 2013). The reflex response of cVEMP is inhibitory, as it involves a decrease in muscle tone of the SCM (Forbes et al., 2018).

cVEMP has gained significant clinical importance as a non-invasive tool for assessing saccular function and the integrity of the inferior vestibular nerve. It is widely used in the diagnosis of vestibular disorders such as Ménière's disease, vestibular neuritis, and superior canal dehiscence (Fife et al., 2017; Valko et al., 2016). Additionally, cVEMP provides valuable insights into vestibular plasticity and adaptation. Research has demonstrated that the vestibular system exhibits plastic changes in response to physical training and environmental demands (Kumar et al., 2016; Gonshor & Jones, 1976). Activities such as dance and diving have been associated with enhanced vestibular function, reflected in increased cVEMP amplitudes (Sinha et al., 2013; Lavon et al., 2010). Similarly, physical exercise has been shown to improve otolith organ function and reduce balance-related issues (Yardley et al., 1998).

Yoga is a holistic practice that includes controlled movements and postures, referred to as asanas, and breathing techniques. It requires a high level of balance, coordination, and muscle control (Telles et al., 1994). Regular practice of yoga has been shown to enhance postural stability, muscle strength, and overall balance (Omkar & Vishwas, 2009; Wang et al., 2012). The practice of yoga has also been shown to produce plastic changes in the sacculo-collic reflex arc, resulting in enhanced cVEMP values such as decreased latencies and increased amplitudes (Shambu et al., 2017). In addition, the practice of yoga has been shown to positively correlate with the duration of practice.

Although research has shown the effects of yoga practice on vestibular functions, little research has been conducted on the cVEMP responses of yoga practitioners. Therefore, the current study aims to explore the characteristics of cVEMP responses of individuals practicing yoga.

### **Aim of the study**

The aim of the present study is to evaluate and compare cVEMP responses between yoga practitioners and non-yoga practitioners, and to examine the relationship between cVEMP parameters and the duration of yoga practice.

### **Method**

The present study adopted a cross-sectional research design to investigate the effect of yoga on cervical Vestibular Evoked Myogenic Potentials (cVEMP) among young adults. A total of 120 participants between the ages of 18 and 40 years were recruited using a convenience sampling method. The participants were divided into two groups: 60 yoga practitioners and 60 non-yoga practitioners. The yoga group consisted of individuals who had been practicing Hatha yoga for a minimum duration of one year (Mean

age =  $25.84 \pm 9.11$  years), while the non-yoga group included individuals with no prior experience of yoga practice (Mean age =  $27.67 \pm 6.11$  years). Both groups were matched for gender. Ethical approval for the study was obtained from the Institutional Ethics Committee, and informed consent was obtained from all participants prior to data collection.

Participants in both groups met specific inclusion criteria, which included normal hearing sensitivity defined as thresholds  $\leq 15$  dB HL with an air-bone gap  $\leq 10$  dB HL across frequencies from 250 Hz to 8000 Hz, the presence of a Type 'A' tympanogram with intact ipsilateral and contralateral acoustic reflexes, and an uncomfortable loudness level greater than 105 dB HL at 500 Hz. In addition, participants in the yoga group were required to have practiced Hatha yoga for at least one year. Individuals were excluded if they had conductive hearing loss, reported neurological symptoms such as vertigo, dizziness, nausea, vomiting, or seizures, or were engaged in other forms of rigorous physical activity.

Audiological tests were performed using a clinical audiometer, which was provided with TDH-50 supra-aural headphones for air conduction testing and a B-71 bone vibrator for bone conduction testing. Middle ear function was tested using a calibrated immittance audiometer, i.e., GSI Tymptstar. cVEMP recordings were performed using an IHS Smart EP system, which was provided with ER-3A earphones. Pure tone audiometry was performed using a two-room setup, whereas immittance and cVEMP tests were performed using a single room setup, ensuring that noise levels were within permissible limits.

The experimental procedure was conducted in two phases. The first phase included pre-assessment for the selection of the subjects, which involved case history, otoscopic examination, pure tone audiometry by the modified Hughson and Westlake procedure, and immittance testing with a 226 Hz probe tone. Uncomfortable loudness levels were also measured for the subjects to ensure that the levels were within safety limits for VEMP testing.

In the second phase, cVEMP recording was conducted. Participants were made comfortable and asked to keep their body as still as possible. The skin at the electrode locations was cleaned with Nuprep gel, and gold-plated electrodes were applied with conductive gel and adhesive tape. The non-inverting electrode was placed on the upper one-third of the sternocleidomastoid muscle of the tested ear, the inverting electrode was placed at the sternoclavicular junction, and the ground electrode was placed on the forehead. Participants were asked to turn their head in a way that the sternocleidomastoid muscle was activated and maintained a tonic contraction in a range of 50-150  $\mu$ V, which was displayed on a screen for feedback. Participants were also asked not to move their upper body, and pauses were given in between trials to prevent muscle fatigue.

A 500 Hz tone burst stimulus with rarefaction polarity was used for the recording of the cVEMP response, which was taken ipsilaterally initially at 100 dB nHL, then decreased in steps of 5 dB until the threshold was established. A total of 150 sweeps were taken at a repetition rate of 5.1 per second. The signals were amplified 5,000 times, and a band-pass filter with a high-pass cutoff of 30 Hz and a low-pass cutoff of 1000 Hz was used for the signal recording. The analysis window for the signal was set at 60 ms, with 10 ms taken as the pre-stimulus and 50 ms as the post-stimulus period. The cVEMP waveform was observed as a biphasic signal, with a positive peak (P1) followed by a negative peak (N1).

Statistical analysis was performed using SPSS. The Shapiro-Wilk test revealed that the data were not normally distributed; therefore, non-parametric tests were employed. The Mann-Whitney U test was used to compare cVEMP parameters between yoga and non-yoga groups, while Pearson's correlation coefficient was used to assess the relationship between the duration of yoga practice and cVEMP parameters.

## Results and Discussion

cVEMP responses were recorded bilaterally in both yoga practitioners and non-yoga practitioners to assess the integrity of the sacculo-collic pathway. The mean P1 latency for yoga practitioners was 15.27 ms (SD = 0.91; median = 15.16 ms), while non-yoga practitioners showed a comparable mean of 15.48 ms (SD = 1.31; median = 15.36 ms). Similarly, the mean N1 latency was 22.30 ms (SD = 1.44; median = 22.00 ms) for yoga practitioners and 21.94 ms (SD = 2.03; median = 21.94 ms) for non-yoga practitioners. Inferential analysis using the Mann–Whitney U test revealed no statistically significant differences in P1 latency ( $U = 1169$ ,  $p = 0.576$ ) or N1 latency ( $U = 1197.5$ ,  $p = 0.717$ ) between the two groups. These findings suggest that yoga practice does not significantly influence neural conduction time along the sacculo-collic pathway. Latency parameters are generally stable and reflect neural transmission velocity, which may not be substantially altered by behavioral interventions such as yoga; additionally, the lack of significant differences could be attributed to sample size limitations and inter-individual variability.

In contrast, the peak-to-peak amplitude of cVEMP was markedly higher in yoga practitioners (mean = 121.11  $\mu$ V, SD = 47.98; median = 113.11  $\mu$ V) compared to non-yoga practitioners (mean = 77.93  $\mu$ V, SD = 32.69; median = 77.12  $\mu$ V), with the difference being statistically significant ( $U = 574.00$ ,  $p < 0.001$ ). This increase in amplitude reflects enhanced excitability of the saccular afferents and greater responsiveness of the vestibulo-collic reflex pathway. Amplitude in cVEMP is influenced by neuromuscular activation of the sternocleidomastoid muscle and the integrity of vestibular inputs; therefore, the observed enhancement in yoga practitioners may be attributed to improved muscle tone, better neuromuscular coordination, and increased vestibular responsiveness resulting from regular yoga practice. These findings support the concept of activity-dependent vestibular plasticity within the sacculo-collic pathway.

With regard to threshold, yoga practitioners exhibited a significantly lower mean threshold (86.3 dBnHL, SD = 6.77; median = 85 dBnHL) compared to non-yoga practitioners (93.0 dBnHL, SD = 6.29; median = 95 dBnHL), with the difference being statistically significant ( $U = 625.00$ ,  $p < 0.001$ ). Lower thresholds indicate that lesser stimulus intensity is required to elicit a vestibular response, reflecting enhanced sensitivity of the saccule and improved efficiency of central processing mechanisms. This improvement may be attributed to long-term adaptations in the vestibular system induced by sustained yoga practice.

Correlation analysis further demonstrated no significant relationship between duration of yoga practice and P1 latency ( $r = +0.213$ ,  $p = 0.137$ ), N1 latency ( $r = +0.246$ ,  $p = 0.081$ ), or peak-to-peak amplitude ( $r = +0.089$ ,  $p = 0.538$ ). However, a significant moderate negative correlation was observed between duration of yoga practice and cVEMP threshold ( $r = -0.422$ ,  $p = 0.002$ ), indicating that longer duration of practice is associated with lower (improved) threshold values. This finding suggests that prolonged engagement in yoga leads to progressive enhancement of vestibular sensitivity, possibly due to cumulative neuroplastic changes at the level of the otolith organs and their central connections. The absence of correlation with latency and amplitude may be due to variability in the duration of practice (ranging from 1 to 10 years) and limited sample size.

The present findings are in agreement with earlier studies. Shambu et al. (2017) reported improved cVEMP amplitude and asymmetry ratios in yoga practitioners, attributing these changes to plasticity in the sacculo-collic pathway. Similarly, studies on other physically active populations support the role of vestibular adaptation; Lavon et al. (2010) demonstrated improved cVEMP latencies in professional divers, while Swathi and Sathish (2013) reported enhanced amplitudes and earlier latencies in dancers, indicating

adaptive vestibular changes due to repetitive stimulation. Additionally, broader evidence suggests that yoga improves balance, muscle strength, and postural control (Kumar et al., 2016; Woodyard, 2011; Cooper et al., 2018; Prado et al., 2014), which indirectly supports enhanced vestibular functioning, given the vestibular system's central role in maintaining balance.

In summary, the combined results and discussion indicate that yoga practice significantly enhances cVEMP amplitude and improves threshold sensitivity, reflecting increased responsiveness and efficiency of the sacculo-collic pathway, while latency parameters remain unaffected. These findings highlight the role of yoga in inducing functional vestibular plasticity and support its potential as a non-invasive therapeutic approach for improving vestibular function, postural stability, and overall balance.

## Conclusion

The present study concludes that yoga has a beneficial effect on vestibular functions, as reflected by the results of cVEMP, where yoga practitioners showed higher peak-to-peak amplitude and lower threshold values compared to non-yoga practitioners. This suggests that yoga has a beneficial effect on the responsiveness and sensitivity of the sacculo-collic pathway. However, no differences were found between yoga and non-yoga practitioners for P1 and N1 latencies, which suggests that neural conduction times are not influenced by yoga. This improvement in amplitude and threshold values may be attributed to vestibular plasticity, which is a result of increased activity of the vestibular system due to the practice of yoga, which requires postural control, muscle contraction, and balance-related activities. Furthermore, a negative correlation was found between the duration of yoga practice and threshold, which suggests that the longer the duration of yoga, the higher the vestibular sensitivity. Overall, these findings support the role of yoga as a non-invasive and effective approach for enhancing vestibular function, with potential clinical applications in improving balance and postural stability in individuals with vestibular dysfunction.

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