ABSTRACT

Background: Previous studies have shown that spontaneous shifts in nostril breathing, forced uninostril breathing, as well as yoga based breathing with nostril manipulation influence: (i) autonomic and respiratory variables and (ii) activity of the cerebral hemispheres selectively based on electrophysiology and performance in specific tasks.

Aims: The present study was designed to evaluate (i) autonomic and respiratory variables and (ii) middle latency auditory evoked potentials (MLAEPs) related to the practices of right nostril yoga breathing (sūryānuloma viloma, SAV), left nostril yoga breathing (candrānuloma viloma, CAV), alternate nostril yoga breathing (nādiśuddhi, NDS), breath awareness (BAW) and random thinking (CTL).

Subjects: The subjects were twenty one male volunteers with ages between 18 to 45 years, group average age ± SD, 27.48 ± 6.28 yr) and experience of the yoga breathing techniques ranging between 4 to 48 months (group average ± SD, 14.62 ± 10.67 months). It was verified that none of them had any abnormalities of the external nares (such as nasal polyp or septal deviation).

Design: The self as control design was adopted for this study. Each subject was studied in ten sessions. Five sessions for the recordings of autonomic and respiratory variables and five sessions for recording evoked potentials. The sessions were SAV, CAV, NDS, BAW and CTL. The order of the sessions was varied from one subject to another to ensure that the order of the sessions would not influence the results. For each subject the ten sessions were at the same time of the day on different days. Each session lasted for 40 minutes, and consisted of three states; 'pre' 5 minutes, 'during' 30
minutes and 'post' 5 minutes. The 30 minutes of the during period was further subdivided as (i) 10 minutes to 'get into' the practice and (ii) 20 minutes as four epochs of 5 minutes.

**Assessments:** There were two types of assessments (i) autonomic and respiratory variables, this included the heart rate (HR) (based on the electrocardiogram, EKG), breath rate (BR) (derived from the polygraph trace) skin conductance level (SCL), finger plethysmogram amplitude (FPA, recorded with a photoelectric transducer), the heart rate variability (HRV) spectrum, and blood pressure (systolic, diastolic and mean pressure). (ii) MLAEPs were recorded using binaural click stimuli of alternating polarity 50 µs in duration, 5 Hz frequency and 80 dB nHL. The amplifier settings were kept with a sensitivity of 50 µV and filter bandpass 5 to 1000 Hz. The recordings were made from C2, C3 and C4 referenced to ipsilateral earlobes with FP2 as the ground position.

**Intervention:** The right nostril yoga breathing (SAV) involves breathing exclusively through the right nostril with the left nostril occluded using the ring and little fingers of the right hand. The left nostril yoga breathing (CAV) involves breathing through the left nostril exclusively with the right nostril occluded using the thumb of the right hand. The alternate nostril yoga breathing (NDS) starts with exhalation through both nostrils, followed by closing the right nostril with the thumb of the right hand and inhaling slowly through the left nostril. After complete inhalation, the left nostril is closed with the little and ring fingers of the right hand followed by opening the right nostril and exhaling through it. This forms one round of NDS. During breath awareness (BAW) the subjects were asked to be aware of their breathing without any
manipulation. In the control (CTL) session the subjects were seated quietly in random thinking and without being aware of breathing.

**Data extraction:** (i) Autonomic and respiratory variables: the HR was calculated by counting the R waves of the QRS complex in the EKG trace of the polygraph record. The breath rate was calculated by counting the number of breath cycles in a minute from the respirogram. The SCL values were noted every 30 seconds. The FPA was calculated by measuring the ascending portion of the wave for every 30 seconds. (ii) MLAEPs: the peak amplitudes and the peak latencies of the following components of MLAEPs were calculated: the Na wave (which was the maximum negative peak preceding the Pa wave), the Pa wave being a positive component occurring between 25 and 32 ms and the Nb wave was taken as the first maximum negative component immediately following the Pa wave. The peak amplitudes were calculated from the '0' DC baseline. The peak latencies were calculated from the time of the stimulus delivery without delay.

**Data analysis:** The data were analyzed using repeated measures ANOVA. For autonomic and respiratory variables, there were two within subjects factors; these were Sessions and States. For MLAEPs, there were three within subject factors; these were Sessions, States and Sites.

**Results:** (i) autonomic and respiratory variables: in the SAV session there was a significant increase in the HR throughout the 'during' period and 'after' the session. The SCL also increased throughout the 'during' period and 'after' the session. In contrast the FPA showed a significant reduction throughout the 'during' period and 'after' the session. The breath rate showed a significant decrease throughout the
'during' period of the session. The blood pressure (systolic, diastolic and mean pressure) was significantly increased following the session. However there were no changes observed in the HRV spectrum in this session.

In the CAV session there was a significant increase in the low frequency (LF) component and a significant decrease in the high frequency (HF) component of the HRV spectrum. These changes were observed in the 'during' period of the session. There was an increase in the LF/HF ratio of the HRV spectrum in the later part of the 'during' period. The breath rate showed a significant reduction in the 'during' period. The systolic blood pressure and the mean pressure reduced significantly following the CAV session.

In the NDS session the following changes were observed. The HR was increased significantly both in the 'during' period and 'after' the session. Similarly the SCL increased significantly in the 'during' period and 'after' the session. The FPA significantly decreased in the initial and later part of the 'during' period of the session. The LF component of the HRV spectrum showed an increase in the initial and later part of the 'during' period of the session. The HF component of the HRV spectrum showed an increase in the initial and later part of the 'during' period of the session. The LF/HF ratio of the HRV spectrum showed significant increase in the 'during' period of the session. The breath rate showed a significant decrease throughout the 'during' period of the session and continued to reduce after the session as well. The mean pressure showed a significant decrease after the practice.

In the BAW session there was a significant increase in the SCL throughout the session and also after the session. The FPA decreased throughout the 'during' period
of the session and continued to reduce after the session. There was an increase in the LF component and a decrease in the HF component of the HRV spectrum in the later part of the 'during' period of the session. The LF/HF ratio of the HRV spectrum was significantly high in the later part of the 'during' period of the session. In the CTL session the HR increased during the test period. The FPA showed a significant decrease throughout the 'during' period and after the session. There was a reduction in the mean pressure after the session.

(ii) MLAEPS: (a) changes in the peak amplitudes of the MLAEP components; in the SAV session there was a significant increase in the peak amplitude of the Pa wave on the right side (C4-A1) in the later part of the 'during' period of the session. In the CAV session there was a significant increase in the Na wave peak amplitude on the left side (C3-A1) in the later part of the 'during' period of the session. Similarly the Na wave peak amplitude increased significantly on the vertex (C2-A1) in the later part of the 'during' period. In contrast the Nb wave peak amplitude showed a significant decrease on the vertex after the session. In the NDS session there was an increase in the Na wave peak amplitude on the right side in the later part of the 'during' period of the session. In the BAW session there was a significant decrease in the Nb wave peak amplitude in the initial part of the 'during' period of the session. In the CTL session the Na wave peak amplitude and Pa wave peak amplitudes increased significantly on the right side in the later part of the 'during' period of the session. The Nb wave peak amplitude also increased significantly on the vertex in the later part of the 'during' period of the session.
(b) Changes in the peak latencies; in the SAV session the peak latency of the Nb wave showed a significant decrease in the right side in the later part of the 'during' period of the session. In the CTL session the Na wave peak latency reduced significantly on the right side in the initial part of the 'during' period and the Pa wave peak latency increased on the right side in the later part of the 'during' period of the session. The CAV, NDS and CTL sessions did not show any significant changes.

Summary: (i) The changes in autonomic and respiratory variables support the idea from traditional yoga texts and previous studies on forced uninostril breathing that right nostril yoga breathing increases sympathetic activity. The reduction in the blood pressure following left nostril yoga breathing supports the idea that this practice reduces arousal though the changes in the HRV components suggests that there is some level of sympathetic activation. Alternate nostril yoga breathing did seem to be a combination of the effects of the right and left nostril yoga breathing. The changes in breath awareness suggested sitting for the duration of the session without any intervention may increase levels of sympathetic arousal. The absence of notable changes in the control session suggests that changes observed during the three practice sessions and breath awareness are related to the respective practices and not due to merely sitting for that duration of time.

(ii) The changes in the middle latency auditory evoked potentials during the practices were suggestive of activation of neural generators on the side ipsilateral to the nostril through which the subjects breathed. However during the practice of NDS (alternate nostril yoga breathing) the changes were similar to those during right nostril yoga breathing. Hence in both autonomic and respiratory variables and middle latency
auditory evoked potentials, the three yoga breathing practices (i.e., suryanuloma
viloma, candrānuloma viloma and nādiśuddhi) showed effects different from breath
awareness and from random thinking.