5 P300 EVENT-RELATED POTENTIAL

This section is further divided into two subsections as P300 was used to assess immediate effects of:

i. *Kapalabhati kriya*: Study in P300 and Kapalabhati was conducted as the pilot study, after the standardization of the equipment. As this technique is one of the voluntarily regulated breathing techniques mentioned in yoga. Hence, this study was also included in the thesis though this was not the primary aim of the study.

ii. Voluntarily regulated yoga breathing or *pranayamas*; viz, right-, left-, alternate nostril yoga breathing, breath awareness, and a no-intervention session as control.

5.1 STUDY OF P300 IN *KAPALABHATI KRIYA* [High Frequency Yoga Breathing, HFYB]

5.1.1 METHODS

5.1.2 PARTICIPANTS

5.1.2.1 Sample size:

A sample size of thirty male volunteers with ages between 20 and 35 years were assessed in the study. Thirty people were considered as two groups. Mean age ± S.D. of the group who practiced *kapālabhāti* was 26.0 ± 4.6 years, and for the
breath awareness group it was 27.6 ± 3.7 years. The two groups’ ages did not differ significantly (p>0.05, t-test for unpaired data). The sample size was calculated based on an effect size (2.71) obtained from the previous study of changes in P300 following *sudarshan kriya* (Naga Venkatesha Murthy, Gangadhar, Janakiramaiah, & Subbukrishna, 1998). It was calculated using G-power software, University of Duesseldorf, Germany; where the level was 0.05, power = 0.95 and the recommended sample size were six subjects (Faul, Erdfelder, Lang, & Buchner, 2007).

5.1.2.2 Source of participants:

All the participants were residing at a yoga center, i.e., Swami Vivekananda Yoga University, in Bangalore, India. These two groups were drawn from a larger sample, students undergoing various yoga courses. While all participants were drawn from a comparable larger sample (i.e., persons receiving training in yoga at a residential training center) they were not randomly assigned to the two groups. On the other hand participants did not self-select to which group they would be assigned. Hence they can be considered as two comparable, though non-randomized groups.

5.1.2.2 Inclusion criteria:

Following are the inclusion criteria based on which subjects were selected (i) Males alone were studied as the P300 (evoked by visual stimuli) varied with
gender (Polich, Conroy, 2003). (ii) All subjects having minimum experience of 3 months of high frequency yoga breathing and breath awareness. (iii) Motivation to practice kapālabhāti and willingness to volunteer for the trial.

5.1.2.3 Exclusion criteria:

(i) Subjects who were photo sensitive, or had history of epilepsy. (ii) Those who are taking medication which could influence cognitive functions, or ability to pay attention (D'haenen, Boer, & Willner, 2002), and (iii) any hearing deficit.

5.1.2.4 Ethical considerations:

Participants were told about the aims and methods of the study and the signed consent was obtained from all the participants (a sample copy is enclosed in Appendix-1). Approval was obtained from the Institutions’ Ethical Committee. The test was essentially noninvasive in nature.

5.1.3 DESIGN OF THE STUDY

5.1.3.1 Structure of sessions:

Thirty participants actually comprised two groups (n =15 each). For half of the participants the practice session was HFYB, and for the remaining fifteen participants the practice was breath awareness. Subjects were selected within a specified range.
5.1.3.2 Time allocation within the sessions:

All thirty participants were assessed before and after one-minute practice sessions. Participants were asked to start the practice and after approximately 10 seconds they would reach the final rate (in this case, approximately 2.0 Hz). This was the actual beginning of the one minute session. Hence, their actual breathing session was for 70 seconds, out of which they would have been breathing at the expected rate for approximately 60 seconds and taking 10 seconds to attain the final rate. The fact that approximately 10 seconds is required to reach the expected rate of approximately 2.0 Hz is based on previous unpublished observations. The design has been illustrated in Figure 5.1.3

Figure 5.1.3 DESIGN OF THE RECORDING SESSION

<table>
<thead>
<tr>
<th>Kapalabhati</th>
<th>Duration 1 minute</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P300</strong></td>
<td><strong>(Kapalabhati)</strong></td>
</tr>
<tr>
<td>States</td>
<td>Pre</td>
</tr>
<tr>
<td>Duration</td>
<td>5 min.</td>
</tr>
</tbody>
</table>

Breath Awareness

<table>
<thead>
<tr>
<th>P300</th>
<th>Duration 1 minute</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(Breath awareness)</strong></td>
<td><strong>P300</strong></td>
</tr>
<tr>
<td>States</td>
<td>Pre</td>
</tr>
<tr>
<td>Duration</td>
<td>5 min.</td>
</tr>
</tbody>
</table>

5.1.4 ASSESSMENT

5.1.5 P300 Event related potential
P300 cognitive evoked potential was recorded using a NICOLET Bravo NT system (U.S.A.). The P300 event related potential (ERP) reflects fundamental cognitive events requiring attentional and immediate memory processes. This is a positive wave which occurs at the given latency of 250-500 ms. The P300 component is often elicited with a simple discrimination task known as the ‘oddball’ paradigm, since there are two stimuli, which are presented in a random series so that one of them occurs relatively infrequently i.e. the odd ball. The person has to discriminate between both of them covertly (mental counting) (Polich, 1986). P300 is related to the neural activity of the anterior cingulate (Polich, 2004). See figure 5.1.5

5.1.5.1 Specifications of Nicolet Bravo System:

The Bravo EP (Nicolet, U.S.A.) is a 4 channel evoked potential which acquires and analyses data using easy-to-use Windows TM NT base interface. The Bravo EP has options of performing wide variety of tests such as Auditory Evoked Potentials (AEP), Somatosensory Evoked Potentials (SEP), Visual Evoked Potentials (VEP), and P300 Event Related Potentials (ERP). The Bravo EP has optional software package which allows running P300 cognitive response test. The main features of the P300 optional software include 4-channel recording and independent averaging for frequent and rare stimuli. The Bravo EP amplifier has 4 acquisition channels, a headbox for electrode connections and a LED electrode impedance panel. To perform AEP tests, the system has the options of using different auditory transducers such as earphones, tubal insert phones or bone vibrators. Acoustically
shielded earphone (TDH-39, Amplivox, U.K.) were used to deliver either ‘tone’ or ‘click’ stimuli. The acoustic stimulus intensity (in dB) has the following options: sound pressure level (SPL), peak sound pressure level (pSPL), peak equivalent sound pressure level (peSPL) and normal hearing level (nHL) (Bravo EP Users Guide, 1998).

5.1.5.2 Selection of auditory oddball P300 evoked potential:
Six-letter cancellation task is left hemispheric task, which involves sustained attention. An earlier study has shown improvement in six-letter cancellation task following one-minute kapalabhati kriya (Telles, Raghuraj, Arankalle, & Naveen, 2008). Hence, it was interesting to study the effects using an electrophysiological test i.e., P300 as previously no such study has been conducted on kapalabhati kriya.

5.1.5.3 Electrode positions:
Ag/AgCl disk electrodes were affixed with electrode gel (Ten 20 conductive EEG paste, D.O. Weaver and Co. U.S.A.) at Cz vertex scalp sites, referred to linked earlobes (A1-A2) with a forehead ground (FPz); according to the International 10-20 system (Jasper, 1958). The electro-ocular activity (EOG) was recorded with a bipolar derivation from electrodes placed 1 cm above and 1 cm below outer canthus of the right eye. The electrode impedance was kept below 5 kΩ.

5.1.5.4 Amplifier settings:
The P300 ERP was computer averaged in 300 trial sweeps, in between 75-750 ms range. The pre-stimulus delay was kept at 75 ms and the level of artifact rejection was set at 90%. The electroencephalographic (EEG) activity was amplified with a sensitivity of 100μV. The low pass filters were set at 0.01 Hz and the high pass filter were set at 30 Hz.

5.1.5.5 Stimulus characteristics:
Binaural tone stimuli of alternating polarity were delivered at 0.9 ms with a frequency of 1 KHz (50 cycles for the plateau, 10 cycles for the ramp) for the standard stimuli and 2 KHz (10 cycles for the plateau, 20 cycles for the ramp) for the target stimuli was used to trigger online averaging of the EEG. The percent of standard stimuli was set at 80 and for the target stimuli at 20. The stimulus intensity was set at 70 dB SPL.

5.1.5.6 Recording conditions:

The subjects were individually assessed in a sound attenuated and dimly lit cabin. The recording leads were led out of the cabin, and connected to the Nicolet Bravo System (U.S.A.). The subjects were observed on a closed circuit TV and instructions were given through an intercom, so that subjects could remain undisturbed during a session. See Figure 5.1.5.6

5.1.5.7 Recording procedure:

The subjects were asked to avoid substances which would influence cognitive performance (e.g., coffee, containing caffeine) for the day preceding and the day of the recording. Where this was unavoidable the session was taken on other day. A trial session was given to rule out any hearing deficit. P300 evoked potentials were recorded while subjects sat erect on the chair with their eyes closed. The ‘standard’ and ‘target’ auditory stimuli were delivered through close fitting earphones (TDH-39, Amplivox, UK). The subjects were asked to distinguish between the two tones by mentally counting the ‘target’ stimuli. The P300 responses were recorded before
and immediately after the given intervention.

**5.1.5.8 Variables measured:**

The peak amplitude (in µV) was defined as the voltage difference between a pre-stimulus baseline and the largest positive peak of the P300 within a 250–450 ms latency window. The peak latency (ms) was defined as the time from stimulus onset to the point of maximum positive amplitude within the latency window. The peak latency and peak amplitude were measured for potential recorded at Cz referred to linked earlobes.
Figure 5.1.5: Schematic illustration of Oddball Paradigm.
5.1.6 INTERVENTIONS

Following are the two intervention sessions:

(i) HFYB or *kapalabhati* practice involves rapid breathing with a frequency of approximately 2.0 Hz, during which only exhalation is an active process. Throughout the practice the practitioners sit upright, close their eyes and breathe in and out through their nose (Nagendra, 1999).
(ii) Breath awareness was the ‘alternate’ intervention. During this practice the participants were asked to sit quietly being aware of their breath without manipulating their breathing. They were asked to be aware of the flow of air as it enters and passes through the nasal passage. Hence, throughout the practice the attention was directed towards the breath.

5.1.7 DATA EXTRACTION

The following components were measured peak latencies (ms) and amplitude (μV) of P300 responses at Cz vertex scalp site. Peak latency was measured as time from the stimulus onset to the point of maximum positive wave in the given latency of 250-450 ms and amplitude as voltage difference between pre-stimulus baseline and largest positive ongoing peak (Polich, 1999).

5.1.8 DATA ANALYSIS

The raw data type for each subject before and after both the sessions i.e., HFYB, and breath awareness was obtained and tabulated. The data was analyzed using Statistical Package of Social Science (SPSS version 16.0). The group average and standard deviation were calculated for each peak latency and amplitude, and the data was verified for it’s normality using Shapiro-Wilk test.
The peak amplitudes and peak latencies obtained before and after HFYB practice and after breath awareness were compared using a repeated measures ANOVA, with one Between subjects factor (i.e., Groups, with two levels, HFYB group and Breath awareness group), and one Within subjects factor (i.e., States, with two levels, Pre and Post).

Post-hoc analysis with multiple comparisons and Bonferroni adjustment was carried out to compare values recorded before and after HFYB, as well as before and after breath awareness.

5.1.9 RESULTS

Recapitulation

P300 event-related potential were recorded on thirty subjects, who had a minimum experience of three months in pranayama. Peak amplitude and latency were studied in the latency window 250-450 ms in two sessions i.e., kaplabhati and breath awareness session from Cz sites, referred to linked earlobes. As described under Methods (Data analysis), repeated measures analysis of variance (RMANOVA)
were performed to analyze the data. The group mean values ± S.D., of the P300 peak latencies and peak amplitudes recorded from Cz are given in Table 5.1.9.

Table 5.1.9: Peak latencies and peak amplitudes of P300 pre and post High Frequency Yoga Breathing (HFYB) and Breath Awareness. Values are group mean ± S.D.

† p<0.05 (one-tailed), * p<0.05 (two-tailed), post-hoc tests with Bonferroni adjustment, comparing ‘Post’ with respective ‘Pre’ values

5.1.9a Peak amplitude

Repeated measures of analysis of variance (RMANOVA)

For the P300 peak amplitude there was a significant interaction between Groups

<table>
<thead>
<tr>
<th>Latency, (ms)</th>
<th>HFYB (n=15)</th>
<th>Breath Awareness (n=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE</td>
<td>358.20 ± 32.53</td>
<td>362.80 ± 25.32</td>
</tr>
<tr>
<td>POST</td>
<td>339.20 † ± 29.99</td>
<td>340.40 ± 45.57</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amplitude, (µV)</th>
<th>HFYB (n=15)</th>
<th>Breath Awareness (n=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE</td>
<td>8.25 ± 4.90</td>
<td>5.23 ± 4.04</td>
</tr>
<tr>
<td>POST</td>
<td>6.79 ± 2.79</td>
<td>6.55 * ± 3.96</td>
</tr>
</tbody>
</table>

(i.e., HFYB and Breath awareness groups) and States (i.e., Pre and Post) [F= 4.746, df = 1, 14, p<0.05].
5.1.9a.1 Kapalabhati (HFYB): There was no significant difference between any comparisons. \( P > 0.05 \) in all cases and Hyunh-Feldt epsilon < 1 for all comparisons.

5.1.9a.2 Breath awareness (BAW): Following breath awareness on the other hand, the P300 peak amplitude increased significantly compared to before (\( P < 0.05 \), two-tailed).

Figure 5.1.9a: Peak amplitude in microvolts (\( \mu V \)) of P300 recorded at CZ (auditory oddball paradigm) in pre and post states of Kapalabhati and Breath Awareness; values are group mean ± SD.

* \( P < 0.05 \) post-hoc tests with Bonferroni adjustment, comparing ‘Post’ with respective ‘Pre’ values

5.1.9b Peak latency

Repeated measures of analysis of variance (RMANOVA)
The peak latency of the P300 potential showed a significant difference between States [i.e., Pre and Post, with $F = 7.829$, df = 1, 14, $p < 0.05$].

5.1.9b.1 *Kapalabhati (HFYB):* There was a significant reduction in the P300 peak latency following KB compared to before ($p < 0.05$, one tailed).

5.1.9b.2 *Breath awareness (BAW):* There was no significant difference between any comparisons. $P > .05$ in all cases and Hyunh-Feldt epsilon <1 for all comparisons.

Figure 5.1.9b: Peak latency in milliseconds (ms) of P300 recorded at CZ (auditory oddball paradigm) in pre and post states of *Kapalabhati* and Breath Awareness; values are group mean ± SD.

* $p < 0.05$ post-hoc tests with Bonferroni adjustment, comparing ‘Post’ with respective ‘Pre’ values
5.2 STUDY OF P300 IN FOUR YOGA VOLUNTARILY REGULATED BREATHING WITH NOSTRIL MANUPILATION

5.2.1 METHODS

5.2.2 PARTICIPANTS

5.2.2.1 Sample size:

Twenty-nine healthy male volunteers participated in the study and their ages ranged from 20 to 45 years (mean age ± SD, 26.0 ± 5.5 years). The sample size was calculated based on an effect size (2.71) obtained from the previous study of changes in P300 following *sudarshan kriya* (Naga Venkatesha Murthy, Gangadhar, Janakiramaiah, & Subbukrishna, 1998). It was calculated using G-power software,
University of Duesseldorf, Germany; where the level was 0.05, power = 0.95 and the recommended sample size were six subjects (Faul, Erdfelder, Lang, & Buchner, 2007). The minimum experience of practicing yoga breathing techniques was 3 months (mean experience ± SD, 25.5 ± 5.0 months). They were all right hand dominant based on the Edinburgh Handedness Inventory (Oldfield, 1971).

5.2.2.2 Source of participants:
The subjects were residential students at Swami Vivekananda Yoga Anusandhana Samsthana, Deemed University, Prashanti Kutiram, Bangalore, who were undergoing various yoga courses.

5.2.2.3 Inclusion criteria:
Following are the inclusion criteria based on which subjects were selected (i) Males subjects alone were studied as the P300 (evoked by visual stimuli) varied with gender (Polich, Conroy, 2004). (ii) All subjects having a minimum experience of 3 months in yoga voluntarily regulated breathing all the subjects had undergone an orientation of one month before actual recording session. (iii) Motivation to practice the prāṇāyāma and willingness to volunteer for the trial. The details of each subject such as their duration of experience of yoga breathing, daily practice of yoga breathing were noted and are given in Table 2 (Appendix-2).

5.2.2.4 Exclusion criteria:
(i) Subjects who had presence of nasal and nasopharyngeal abnormalities. (ii) Those
who are taking medication which could influence cognitive functions or ability to pay attention (D'haenen, Boer, & Willner, 2002). (iii) Upper respiratory tract infection which could cause nasal blockage, and (iv) any hearing deficit.

5.2.2.5 Ethical considerations:

The subjects were told about the aims and methods of the study and the signed consent was obtained from all the subjects (a sample copy is enclosed in Appendix-1). An approval was obtained from the Institutional Ethical Committee. The test was essentially noninvasive in nature.

5.2.3 DESIGN OF THE STUDY

5.2.3.1 Structure of sessions:

It is a self as control design. Each participant was assessed in five different sessions at the same time of the day. The participants were allocated randomly to the five possible sessions using a random number table (Zar, 1999).

5.2.3.2 Order of sessions:

All 5 sessions were at the same time of the day for a particular subject. The order of the session varied to prevent the order influencing the change during the practice (i.e. order effect). These five sequences were randomly given to all the subjects based on random number table (Zar, 1999).

e.g., The order of sessions for 5 subjects is given below.

<table>
<thead>
<tr>
<th>Day₁</th>
<th>Day₂</th>
<th>Day₃</th>
<th>Day₄</th>
<th>Day₅</th>
</tr>
</thead>
</table>

5.2.3.3 Time Allocation within the sessions:

Recordings of the P300 were made before and after each session. Each session was of 20 minutes in duration. No recordings were made during a session as the practice of yoga breathing resulted in movement artifact. The design has been illustrated in Figure 5.2.3.2
P300 Event related potential

**RNYB Session**

- **States**
  - Pre
  - Post
- **Duration**
  - 5 min (RNYB practice)
- **P300**
  - Pre session duration: 5 min
  - During (20 min)

**CAV Session**

- **States**
  - Pre
  - Post
- **Duration**
  - 5 min (LNYB practice)
- **P300**
  - Pre session duration: 5 min
  - During (20 min)

**ANYB Session**

- **States**
  - Pre
  - Post
- **Duration**
  - 5 min (ANYB practice)
- **P300**
  - Pre session duration: 5 min
  - During (20 min)

**BAW Session**

- **States**
  - Pre
  - Post
- **Duration**
  - 5 min (Breath awareness)
- **P300**
  - Pre session duration: 5 min
  - During (20 min)

**CTL Session**

- **P300**
  - Pre session duration: 5 min
States                  Pre    During (20 min)    Post
Duration    5 min    Control (no-intervention)    5 min

RNYB= Right nostril yoga breathing (*Sūryānuloma viloma*)
CAV = Left nostril yoga breathing (*Candrānuloma viloma*)
ANYB = Alternate nostril yoga breathing (*Nādiśuddhi*)
BAW = Breath awareness
CTL = Control (no-intervention)

5.2.4 ASSESSMENT

5.2.5 P300 Event related potential

P300 cognitive evoked potential was recorded using a NICOLET Bravo NT system (U.S.A.). The P300 event related potentials (ERP) reflect fundamental cognitive events requiring attentional and immediate memory processes. This is a positive wave which occurs at the given latency of 250 – 500 ms. The P300 component is often elicited with a simple discrimination task known as the ‘oddball’ paradigm, since there are two stimuli, which are presented in a random series so that one of them occurs relatively infrequently i.e. the ‘odd’ ball. The person has to discriminate between both of them covertly (mental counting) (Polich, 1986). P300 seems to be related to the neural activity of the anterior cingulate (Polich, 2004).

5.2.5.1 Specifications of Nicolet Bravo System:

The Bravo EP (Nicolet, U.S.A.) is a 4 channel evoked potential which acquires and analyses data using easy-to-use Windows TM NT base interface. The Bravo EP has
options of performing wide variety of tests such as Auditory Evoked Potentials (AEP), Somatosensory Evoked Potentials (SEP), Visual Evoked Potentials (VEP) and P300 Event Related Potentials (ERP). The Bravo EP has optional software package which allows running P300 cognitive response test. The main features of the P300 optional software include 4-channel recording and independent averaging for frequent and rare stimuli. The Bravo EP amplifier has 4 acquisition channels, a headbox for electrode connections and a LED electrode impedance panel. To perform AEP tests, the system has the options of using different auditory transducers such as earphones, tubal insert phones or bone vibrators. Acoustically shielded earphone (TDH-39, Amplivox, U.K.) is being used to deliver either ‘tone’ or ‘click’ stimulus. The acoustic stimulus intensity (in dB) has the following options: sound pressure level (SPL), peak sound pressure level (pSPL), peak equivalent sound pressure level (peSPL) and normal hearing level (nHL) (Bravo EP Users Guide, 1998).

5.2.5.2 Selection of auditory oddball P300 evoked potential:

Previous studies have shown changes following uninostril yoga breathing practices on hemisphere specific tasks using paper pencil. However, no such study has been done earlier to assess hemispheric differences using an electrophysiological test.

5.2.5.3 Electrode positions:

Ag/AgCl disk electrodes were affixed with electrode gel (Ten 20 conductive EEG paste, D.O. Weaver and Co. USA) at C3 and C4 vertex scalp sites, referred to linked
earlobes (A1-A2) with a forehead ground (FPz); according to the International 10-20 system (Jasper, 1958). The electro-ocular activity (EOG) was recorded with a bipolar derivation from electrodes placed 1 cm above and 1 cm below outer canthus of the right eye. The electrode impedance was kept below 5 kΩ at all the scalp sites.

See Figure 5.2.5.3a and Figure 5.2.5.3b

5.2.5.4 Amplifier settings:
The P300 ERPs was computer averaged in 500 trial sweeps, in between 75 -750 ms range. The pre-stimulus delay was kept at 75 ms and the level of artifact rejection was set at 90%. The electroencephalographic (EEG) activity was amplified with a sensitivity of 100μV. The low pass filters were set at 0.01 Hz and the high pass filter were set at 30 Hz.

5.2.5.5 Stimulus characteristics:
Binaural tone stimuli of alternating polarity were delivered at 0.9 ms with a frequency of 1 KHz (50cycles for the plateau, 10cycles for the ramp) for the standard stimuli and 2 KHz (10 cycles for the plateau, 20 cycles for the ramp) for the target stimuli was used to trigger online averaging of the EEG. The percent of standard stimuli was set at 80 and for the target stimuli at 20. The stimulus intensity was set at 80 dB SPL.

5.2.5.6 Recording conditions:
The subjects were individually assessed in a sound attenuated and dimly lit cabin. The recording leads were led out of the cabin, and connected to the Nicolet Bravo
System (U.S.A.). The subjects were observed on a closed circuit TV and instructions were given through an intercom, so that subjects could remain undisturbed during a session.

5.2.5.7 Recording procedure:

The subjects were asked to avoid substances which would influence cognitive performance (e.g., coffee, containing caffeine) for the day preceding and the day of the recording. Where this was unavoidable the session was taken on other day. A trial session was given to rule out any hearing deficit. P300 evoked potentials were recorded while subjects sat erect on the chair with their eyes closed. The ‘standard’ and ‘target’ auditory stimuli were delivered through close fitting earphones (TDH-39, Amplivox, U.K.). The subjects were asked to distinguish between the two tones by mentally counting the ‘target’ stimuli. The P300 responses were recorded before and immediately after the given intervention.

5.2.5.8 Variables measured:

The following variables were measured:

1. Peak latencies (ms) of P300 responses at (i) C3 (left hemisphere electrode site) and (ii) C4 (right hemisphere electrode site).

2. Peak amplitudes (μV) of P300 responses at (i) C3 (left hemisphere electrode site) and (ii) C4 (right hemisphere electrode site).
Figure 5.2.5.3a: Close up of participant showing scalp electrode positions for recording i.e., C3 (left side, not seen here), and C4 (right side), linked to reference electrodes (A1-A2), with ground electrode at FPz.

Figure 5.2.5.3b: Electrode placement International 10-20 System (Jasper, 1958)
5.2.6 INTERVENTIONS

Each participant was tested in five sessions, this included four experimental sessions and one session with no intervention as control session. Each session lasted for 20 minutes and sessions were on five separate days at the same time of the day.

The five sessions were (1) right nostril yoga breathing (RNYB) or सूर्यानुलोम viloma pranayama practice which involves breathing exclusively in and out through the right nostril while the left nostril is occluded, (2) left nostril yoga breathing (LNYB) or चन्द्रानुलोम viloma pranayama practice, which involves breathing through the left nostril exclusively in and out while the right nostril is occluded, (3) alternate nostril breathing (AYNB) or नादीसुध्दी pranayama practice involves breathing through left and right nostrils alternately and (4) In the breath awareness session, participants maintained awareness of the breath without manipulation of the nostrils (Nagendra, Mohan, & Shriram, 1988). Throughout the practice the practitioners sit upright, closed eyes on a chair, and being aware of their breath and attention was directed to the flow of air as it moved through the nasal passages. (5) In the control session a participant was asked to sit but without being aware of their breath. Though the participants were long term yoga practitioners trained to be aware of their breath, by a conscious effort they
were able to remain without a state of breath awareness. This session served to assess the retest effect. The three pranayamas involved nostril manipulation. The thumb and the ring finger of the right hand were used to manipulate or occlude the nostrils. This is a characteristic yoga gesture (nasika mudra in Sanskrit) prescribed during pranayama practice (Swami Niranajanananda Saraswati, 1994).

5.2.7 DATA EXTRACTION

The peak amplitude and peak latency of the P300 were assessed from C3 and C4, electrode sites. The peak amplitude (µV) was defined as the voltage difference between a pre-stimulus baseline and the largest positive peak of the ERP waveform within a 250-450 ms latency window (Polich, 1999). The peak latency (ms) was defined as the time from stimulus onset to the point of maximum positive amplitude within the latency window.

5.2.8 DATA ANALYSIS

The raw data table for each subject for five different types of sessions (i.e., RNYB, LNYB, ANYB, BAW and CTL) during all the phases (pre, and post) was...
obtained and tabulated. The data was analyzed using Statistical Package of Social Science (SPSS version 16.0). The group average and standard deviation were calculated for each peak latency and amplitude, and the data was verified for it’s normality using Shapiro-Wilk test.

Repeated measures of analyses of variance (ANOVA) were performed using SPSS (version 16.0) with three Within - subjects factors i.e., Factor 1 (Sessions: RNYB, LNYB, ANYB, BAW and CTL; 5 levels), Factor 2 (States: pre, and post, 2 levels), and Factor 3 (Sites: C3, and C4, 2 levels).

5.2.9 RESULTS

Recapitulation

The P300 auditory evoked potential (peak latency and peak amplitude) were recorded pre and post in twenty nine subjects in five sessions i.e. right nostril yoga breathing, left nostril yoga breathing, alternate nostril yoga breathing, breath awareness, and control session from C3, and C4 electrode sites, referenced to linked earlobes. As described under Methods (Data analysis), repeated measures analysis
of variance (RMANOVA) were performed to analyze the data. There were three within-Subject Factors and these factors were (i) Sessions i.e. right nostril yoga breathing, left nostril yoga breathing, alternate yoga breathing, and control, 5 levels, (ii) States i.e. pre, and post, 2 levels, and (iii) Sites C3 or left side, C4 or right side, 2 levels. *Post-hoc* tests with Bonferroni adjustment for multiple comparisons were used to detect significant differences between mean values. There was a significant difference between C3 and C4 after right nostril yoga breathing (RNYB). The group average values ± S.D. are given in Table 5.2.9
Table 5.2.9: Peak latency and peak amplitude of the P300 component recorded before and after 5 sessions; values are group mean ± SD.

<table>
<thead>
<tr>
<th>Electrode Sites</th>
<th>Variables</th>
<th>Right nostril yoga breathing</th>
<th>Left nostril yoga breathing</th>
<th>Alternate nostril yoga breathing</th>
<th>Breath awareness</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>C3 (left side)</td>
<td>Latency (ms)</td>
<td>360.41* ± 33.24</td>
<td>350.90 ± 34.69</td>
<td>361.34 ± 25.94</td>
<td>357.34 ± 32.20</td>
<td>365.90 ± 25.94</td>
</tr>
<tr>
<td></td>
<td>Amplitude (µV)</td>
<td>5.35 ± 3.88</td>
<td>6.06 ± 3.80</td>
<td>5.65 ± 3.29</td>
<td>5.41 ± 3.62</td>
<td>5.52 ± 3.88</td>
</tr>
<tr>
<td>C4 (right side)</td>
<td>Latency (ms)</td>
<td>362.90 ± 32.17</td>
<td>356.17 ± 34.61</td>
<td>364.76 ± 26.39</td>
<td>354.93 ± 37.18</td>
<td>366.83 ± 34.61</td>
</tr>
<tr>
<td></td>
<td>Amplitude (µV)</td>
<td>5.57 ± 4.37</td>
<td>6.16 ± 3.94</td>
<td>5.88 ± 3.24</td>
<td>5.34 ± 3.74</td>
<td>5.70 ± 4.21</td>
</tr>
</tbody>
</table>

*p<0.05, post right nostril yoga breathing, comparing C3 and C4, post-hoc analysis with Bonferroni adjustment.
5.2.9.1 Peak Latency

5.2.9.1 Repeated measures of analysis of variance (RMANOVA)

5.2.9.1 A1 C3- There was no significant difference in any of the comparisons, P>.05 in all cases and Hyunh-Feldt epsilon < 1 for all comparisons.

5.2.9.1 A2. C4- There was no significant difference in any of the comparisons, P>.05 in all cases and Hyunh-Feldt epsilon < 1 for all comparisons.

5.2.9.1.B. Sūryānuloma viloma (RNYB) – There was a significant decrease in peak latency of P300 at C3 compared to C4 [(F= 4.801, df = 1, 28), p<0.05, Hyunh Feldt epsilon = 1.000]. The actual data of individual subjects at C3-A1 and C4-A2 are presented with group mean ± SD in Table 5.2.9.1A1a and Table 5.2.9.1.A2a respectively. Peak latency at C3-A1 is presented in figure 5.2.9.1A1a and for C4-A2 presented in figure 5.2.9.1.A2b. See figure 5.2.9.1.A1c for post comparisons following right nostril yoga breathing.

5.2.9.1.C. Candrānuloma viloma (LNYB) – There was no significant difference in any of the comparisons. The actual data of individual subjects at C3-A1 and C4-A2 are presented with group mean ± SD in Table 5.2.9.2.A1b and Table 5.2.9.1.A1b respectively. Peak latency at C3-A1 is presented in figure 5.2.9.1A1a and for C4-A2 presented in figure 5.2.9.1.A1b.

5.2.9.1.D. Nādiśuddhi (ANYB) – There was no significant difference in any of the comparisons. The actual data of individual subjects at C3-A1 and C4-A2 are presented with group mean ± SD in Table 5.2.9.1.A1c and Table 5.2.9.1.A2c.
respectively. Peak latency at C3-A1 is presented in figure 5.2.9.1A1a and for C4 – A2 presented in figure 5.2.9.1.A1b.

5.2.9.1.E. Breath Awareness (BAW) – There was no significant difference in any of the comparisons. The actual data of individual subjects at C3-A1 and C4-A2 are presented with group mean ± SD in Table 5.2.91.A1d and Table 5.2.2.1.A2d respectively. Peak latency at C3-A1 is presented in figure 5.2.9.1A1a and for C4 – A2 presented in figure 5.2.9.1.A1b.

5.2.2.1. F. Control (CTL) – There was no significant difference between comparisons. The actual data of individual subjects at C3-A1 and C4-A2 are presented with group mean ± SD in Table 5.2.2.1.A1e and Table 5.2.2.1.A2e respectively. Peak latency at C3-A1 is presented in figure 5.2.9.1A1a and for C4 – A2 presented in figure 5.2.9.1.A1b.
Figure 5.2.9.1A1a: Peak latency in milliseconds (ms) of P300 recorded at C3 (auditory oddball paradigm) in pre and post states of 5 sessions; values are group mean ± SD.

![Graph showing peak latency in milliseconds for different conditions.]

Figure 5.2.9.1.A2b: Peak latency in milliseconds (ms) of P300 recorded at C4 (auditory oddball paradigm) in pre and post states of 5 sessions; values are group mean ±
Hand grip strength

SD.

* p<0.05, post-hoc tests with Bonferroni adjustment, comparing ‘Post’ with respective ‘Pre’ values

Figure 5.2.9.1.A3c: Peak latency in milliseconds (ms) of P300 recorded at C3 and, C4 (auditory oddball paradigm) in post states of 5 sessions; values are group mean ± SD.
Hand grip strength

5.2.9.2 Peak amplitude

5.2.9.2 Repeated measures of analysis of variance (RMANOVA)

* p<0.05 post-hoc tests with Bonferroni adjustment, comparing ‘Post’ with respective ‘Pre’ values
5.2.9.2 A1 C3- There was no significant difference between any comparisons, P>.05 in all cases and Hyunh-Feldt epsilon < 1 for all comparisons.

5.2.9.2 A2. C4- There was no significant difference between any comparisons, P>.05 in all cases and Hyunh-Feldt epsilon < 1 for all comparisons.

5.2.9.2.B. Sūryānuloma viloma (RNYB) – There was no significant difference between any of the comparisons. The actual data of individual subjects at C3-A1 and C4-A2 are presented with group mean ± SD in Table 5.2.9.2.A1a and Table 5.2.9.2.A1a respectively. Peak latency at C3-A1 is presented in figure 55.2.9.2.A1a and for C4–A2 presented in figure 5.2.9.2.A1 b.

5.2.2.2.C. Candrānuloma viloma (LNYB) – There was no significant difference between any of the comparisons. The actual data of individual subjects at C3-A1 and C4-A2 are presented with group mean ± SD in Table 5.2.9.2.A2b and Table 5.2.9.1.A1b respectively. Peak latency at C3-A1 is presented in figure 55.2.9.2.A1a and for C4 –A2 presented in figure 5.2.9.2.A1 b.

5.2.2.2.D. Nādiśuddhi (ANYB) – There was no significant difference between any of the comparisons. The actual data of individual subjects at C3-A1 and C4-A2 are presented with group mean ± SD in Table 5.2.9.2.A3c and Table5.2.9.2.A1c respectively. Peak latency at C3-A1 is presented in figure 55.2.9.2.A1a and for C4 –A2 presented in figure 5.2.9.2.A1 b.

5.2.2.2.E. Breath Awareness (BAW) – There was no significant difference between any of the comparisons. The actual data of individual subjects at C3-A1 and C4-A2 are presented with group mean ± SD in Table 5.2.9.2.A4d and Table
5.2.9.2.A1d respectively. Peak latency at C3-A1 is presented in figure 5.2.9.2.A1a and for C4 –A2 presented in figure 5.2.9.2.A1 b.

5.2.2.2. F. Control (CTL) – There was no significant difference between any of the comparisons. The actual data of individual subjects at C3-A1 and C4-A2 are presented with group mean ± SD in Table 5.2.9.2.A2 e and Table 5.2.9.2.A1e respectively. Peak latency at C3-A1 is presented in figure 5.2.9.2.A1a and for C4 –A2 presented in figure 5.2.9.2.A1 b.

Figure 5.2.9.2.A1a: Peak amplitude in microvolt’s (µV) of P300 recorded at C3 (auditory oddball paradigm) in pre and post states of 5 sessions; values are group mean ± SD.
Figure 5.2.9.2.A2b: Peak amplitude in microvolt’s (µV) of P300 recorded at C4 (auditory oddball paradigm) in pre and post states of 5 sessions; values are group mean ± SD.

* p<0.05 post-hoc tests with Bonferroni adjustment, comparing ‘Post’ with respective ‘Pre’ values