Immediate effect of stimulation in comparison to relaxation in healthy volunteers

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Received 14 March 2008; revised 20 October 2009

In this self-control, cross over study carried out over two consecutive days, 43 healthy male volunteers aged 20-45 yrs practiced 20 minutes Kapalbhati and 20 minutes Breath Awareness. Subjects were assessed before and after both practices for State Anxiety, sustained attention (Six Letter Cancellation and Digit Letter Substitution tests), and verbal and spatial memory. After Kapalbhati, scores reduced significantly on State Anxiety, and increased on both sustained attention, and verbal and spatial memory; statistical significance was high on all variables (p<0.001). After Breath Awareness, changes were also significant (p<0.001) on all variables except State Anxiety (p>0.05).

Keywords: Yoga, Kapalbhati, Anxiety, Attention, Memory

IPC Int. Cl.: A61P25/00

Modern business trends both reduce physical activity and increase mental strain, making for life-styles that are tamasic, yet hyperactive. Minimal physical activity results in lethargy, yet rajasic influences of ambition fueled by strong desire drive attached modes of action. This combination creates stress and fatigue. One solution is a two fold process of sadhana contained in Mandukya Upanishad: laye sambodhayet chittam (when the mind becomes lethargic, stimulate and awaken it); and vikshiptam samyet punah (when it speeds up and distractions set in, calm it). A pranayama process combining Kapalbhati (stimulating) and breath awareness (calming) can achieve this, removing stress of all kinds, and developing attention span and memory. Studies suggest that yoga breathing increases spatial rather than verbal scores without a lateralized effect. In one study, the yoga group showed significant increases in spatial memory test scores, while verbal memory test scores remained the same in all subjects. Improvement in spatial memory scores following yoga can be related to reduced anxiety, which improves performance on memory tasks. Practicing yoga may help in memory development by deepening perception, reducing distractibility/increasing the attention span, activating dormant areas and sifting useful memories from useless ones for our overall development. kapalbhati, breathing practices and pranayama techniques are known to develop and to improve memory. Study of a student group (mean age 20.7 yrs), showed that forced left nostril breathing increased spatial performance on a cognitive task.

Kapalbhati is a pranayama technique, which invigorates the entire brain and awakens dormant centers responsible for subtle perception. The Hath Ratnavali defines it as fast rotation of the breath from left to right / right to left, or exhalation and inhalation through both nostrils together. Kapalbhati helps eliminate CO\textsubscript{2}, cleans air passages, stimulates abdominal organs, and improves autonomic balance. Increased blood circulation and O\textsubscript{2} levels revitalize and activate brain cells concerned with memory and other functions, increasing concentration, improving memory, and stimulating intellectual faculties. Other studies found unilateral forced nostril breathing to improve spatial and verbal performance, and that 30-45 seconds kapalbhati increases breath holding time (important for yoga sadhana). For anxiety and depression, alternating fast and slow breathing practices for 20-30 minutes, starting with kapalbhati (fast breathing) before pranayama (slower breathing), stops persistent worry. Relaxation with Guided Imagery (RGI) script yields short term reduction in State-Trait Anxiety Inventory (STAI) scores, as shown in each of three tests on nursing students. A previous study has investigated the effect of stimulants on psycho-motor performance. Subjects
were served either a hot drink without coffee or a hot
drink with coffee before taking the digit letter
substitution (DLS) or six letter cancellation (SLC)
tests. Results indicated significant increases in scores
on both tests following coffee administration,
confirming coffee’s stimulating effects on psycho-
motor functions, and suggesting that that improved
test performance.14. No previous study has assessed
kapalbhati on measures of anxiety, sustained
attention, or verbal and spatial memory, nor has it
been compared with breath awareness for its effects
on these variables. Hence, the reasons for this study
being carried out.

Methodology

Subjects
Forty three healthy males aged 20-45 yrs
(mean 28 yrs) volunteered from groups completing
SVYASA one month residential yoga courses. They
were divided into 2 groups labeled kapalbhati (KB)
and Breath Awareness (BA).

Inclusion Criteria
Subject health was verified by routine clinical
examination and general health questionnaire (GHQ)
scores (<4). None was taking medication. Aims and
methods of the study were explained to them; all gave
written informed consent.

Designs
This was a crossover self-control study. The KB
group did kapalbhati on the first day and breath
awareness the second day; for the BA group, the order
was reversed.

Assessments
Assessments were made before and after KB and
BA practice at the same time on two consecutive
days.

Instruments
STAI is a self-report instrument, for study of state
and trait anxiety. State anxiety (STAI A-State)
reflects transitory emotional states characterized
by subjectively perceived feelings of tension,
apprehension, and heightened ANS activity. Intensity
may fluctuate over time.15. The test consists of a
worksheet with 4 statements describing different
states of anxiety, said to be the most common in
measuring present anxiety. Subjects select score
numbers against each statement indicating frequency
of occurrence of these states: almost never,
sometimes, often, and almost always. STAI-A scores
have a direct interpretation: high scores mean more
state anxiety; low scores mean less. The six letter
cancellation (SLC) test and digit letter substitution
(DLS) test require visual selectivity and repetitive
motor response. They assess selective, focused and
sustained attention, visual scanning and activation and
inhibition of rapid responses, helping isolate major
components of performance like detection,
perception, recognition, processing and integration.
Both have been standardized for Indian populations.16
They are valid for the study of immediate effects.14

The SLC test consists of a worksheet containing
22 rows × 14 columns randomly arranged letters of
the alphabet, and specifying 6 target letters to be
canceled. Subjects strike out as many target letters as
possible in the specified time (90 seconds). The DLS
test consists of a worksheet containing 12 rows × 8
columns randomized digits, with a key specifying
pairings between digits 1-9 and Roman letters.
Subjects substitute as many target digits as possible
in the specified time of 90 seconds.16 These 2 tests
are standard measures of attention span, hence
their selection. The verbal memory test consists of
4 different sets of 10 nonsense syllables, e.g. ZOC
enough to be presented both pre and post the KB and
BA interventions. The spatial memory test consists
of 10 line drawings of easily described geometrical
or other shapes, that are simple and reproducible
(not square or circle). As for verbal memory, 4 similar
sets of drawings are used, one each, pre and post
KB and BA interventions.3,17 Each test is projected
on a laptop for the subjects allowing 10 seconds
for each slide. Immediately after the slides, subjects
are shown a mathematical problem on the screen
(e.g. 3+5-2+4-2-5+6-3). Subjects are then asked to
recall and write down (or draw in the case of spatial
memory) as many of the 10 test items as they can
within 60 seconds.

Test Reliability and validity
Reliability refers to consistency of measurement,
reflected in score reproducibility. Validity concerns
how well a test measures what it purports to. The
STAI and sustained attention tests have been
evaluated for them based on standard criteria. A-State
anxiety scores have high degrees of internal
consistency.15 Their point–biseral r (Pb) correlations
are 0.60 and 0.73, respectively.15 For the SLC test,
reliability is ascertained based on temporal stability
and internal consistency.18 In the first, the correlation
coefficient was calculated using unpublished pilot data collected on 29 healthy male volunteers. Spearman’s correlation coefficient was calculated between data collected before and after a 23 min non-specific intervention: subjects read a book of their choice, while remaining seated. The net score variable for which correlation was calculated remained stable ($r=.781$, $p=.002$). As the SLC test consists of one variable, internal consistency cannot be calculated. Content validity of this test is adequate for its intended purpose. Corresponding data on the DLS test are unfortunately not available. The tests of verbal and spatial memory developed at SVYASA clearly test the intended variable and are valid; their reliability is currently being more precisely evaluated.

**Interventions**

Instructions were delivered by audiotape for the 20 minutes performance of both practices; one minute practice was followed by one minute relaxation, repeated 10 times. Subjects sat with their spine straight. For *kapalbhati*, instructions were as follows: *Sit straight keeping your head, neck, spine erect. Take a deep inhalation, exhale forcibly, blast out the air using abdominal muscle, inhale passively relaxing the abdominal muscles, and repeat these movements as quickly as possible starting with 60 strokes per minutes and increasing gradually up to 80 strokes per minute. There is no holding of breath*. The rapid active exhalation with passive effortless inhalation is accomplished by flapping movement of the abdomen, continued at a uniform speed of 80 strokes per minute. It is continued for 1 minute, slowing down gently at the end. Following each minute’s KB practice, relaxation instructions were given as follows: *Relax … relax …yourself. Allow your abdominal muscles to relax; relax your whole body and mind, enjoy the deep silence of the mind, relax… relax…*! Breath awareness practice was performed similarly: one minute practice was followed by one minute relaxation, repeated ten times. Instructions were as follows: *Sit comfortably, relax yourself, become aware of your breathing, just observe your breathing pattern, simply observe, do not manipulate, just go on observing, maintain your awareness towards breathing, just observe, now relax, relax yourself totally from toes to head, allow relaxation to continue all your body and mind.*! The same relaxation instructions were used as in the KB session.

**Data analysis**

Statistical analysis was done using SPSS (version 10.0). Data were assessed for normality using the Kolmogorov-Shapiro Test. Paired ‘t’ tests and RM ANOVA tests were used to assess significance within and between groups, respectively.

**Results**

The Kolmogorov–Shapiro tests of normality showed pre data of SAS, SLC and DLS tests were normally distributed for both groups, while pre-data of the two memory tests were not normally distributed. The group means values, standard deviation values, p values and percentage change values of both groups, i.e. of *kapalbhati* and breath awareness are given below (Table 1). The STAI A-State (SAS) test of relatively labile state anxiety, Table 1— Pre-post changes in measured variables

<table>
<thead>
<tr>
<th>Test</th>
<th>N=43</th>
<th>Mean ± SD</th>
<th>P-value</th>
<th>Post-pre % change</th>
<th>Mean ± SD</th>
<th>P-value</th>
<th>Post-pre % change</th>
</tr>
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<tbody>
<tr>
<td><strong>KB</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SAS</td>
<td>Pre</td>
<td>8.16 ± 2.44</td>
<td>0.001</td>
<td>11.32</td>
<td>7.79 ± 2.05</td>
<td>0.142</td>
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<tr>
<td></td>
<td>Post</td>
<td>7.33 ± 2.01</td>
<td></td>
<td></td>
<td>7.56 ± 2.11</td>
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<tr>
<td>SLC</td>
<td>Pre</td>
<td>40.65 ± 9.93</td>
<td>0.001</td>
<td>23.69</td>
<td>39.86 ± 11.27</td>
<td>0.001</td>
<td>14.83</td>
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<tr>
<td></td>
<td>Post</td>
<td>50.28 ± 9.62</td>
<td></td>
<td></td>
<td>45.77 ± 12.81</td>
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<td>DLS</td>
<td>Pre</td>
<td>56.53 ± 11.15</td>
<td>0.001</td>
<td>14.89</td>
<td>54.67 ± 9.64</td>
<td>0.001</td>
<td>6.73</td>
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<tr>
<td></td>
<td>Post</td>
<td>64.95 ± 12.1</td>
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<td></td>
<td>58.35 ± 9.77</td>
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<tr>
<td>MMR- VBL</td>
<td>Pre</td>
<td>3.05 ± 1.84</td>
<td>0.001</td>
<td>33.44</td>
<td>3.67 ± 2.04</td>
<td>0.001</td>
<td>-36.51</td>
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<tr>
<td></td>
<td>Post</td>
<td>4.07 ± 2.27</td>
<td></td>
<td></td>
<td>3.33 ± 1.71</td>
<td></td>
<td></td>
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<tr>
<td>MMR- SP</td>
<td>Pre</td>
<td>4.56 ± 1.14</td>
<td>0.001</td>
<td>34.20</td>
<td>4.81 ± 1.72</td>
<td>0.001</td>
<td>-16.84</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>6.12 ± 1.28</td>
<td></td>
<td></td>
<td>4.00 ± 1.46</td>
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</tr>
</tbody>
</table>

SAS-Stai A State, SLC-Six Letter Cancellation, DLS-Digit Letter Substitution, MMR VBL-Verbal, & MMR SP-Spatial Memory

Legend: Table 1 presents Pre-Post Mean ± Standard Deviations, significance p values and percentage changes in value for all measured variables (state anxiety, sustained attention, and verbal and spatial memory) before and after *Kapalbhati* (KB) and Breath Awareness (BA). The contrasting increase and decrease in memory scores are of great significance.
was significantly reduced after kapalbhati practice (p<0.001), but the reduction after breath awareness practice did not reach significance (p>0.142>0.05) (Paired 't' test). Between groups results were significantly different (p<0.02), as given in Table 2 below. Scores on the SLC and DLS tasks of sustained attention were significantly increased for both groups (p<0.001) (Paired 't' test). In contrast, scores on both the verbal (MMR VBL) and spatial memory (MMR SP) tests showed significant but opposite changes. For the kapalbhati group, both significantly increased (p<0.001), but for the breath awareness group, both significantly decreased (p<0.001) (Paired 't' test).

### Discussion

It has previously been established that Kapalbhati practice causes autonomic activation: increased heart rate and systolic blood pressure were observed as an immediate effect during 3 continuous kapalbhati sessions of 5 minutes each\(^{19}\). This suggests that practice of kapalbhati increases sympathetic activity\(^{20}\). The study found reduction in anxiety score after practice of kapalbhati (11.32%, p<0.001), but the 3.04% reduction following breath awareness did not reach significance (p=0.142). The difference in anxiety reduction between kapalbhati and breath awareness was significant (p<0.023). This result therefore suggests that, although it temporarily increases sympathetic activation, kapalbhati is more effective than breath awareness in reducing subjects' anxiety levels. This might be thought surprising, because previous work suggests that yoga practice reduces anxiety, because of its ability to reduce psycho-physiological arousal\(^{21}\). This is clearly not the reason in the study. However, a different study supports the idea that practices producing arousal may, in the end, be more beneficial: cyclic meditation, which combines stimulating and calming techniques, practiced with a background of relaxation and awareness, in the end reduces physiological arousal more effectively than supine rest in shavasana, which is only calming\(^{22}\). For the SLC and DLS tasks, the results suggest that kapalbhati augments attention, both enhancing performance, and reducing distraction. The study found increases in sustained attention scores after practice of both kapalbhati (23.69% & 14.89% for SLC & DLS tasks, respectively) (both p<0.001), and breath awareness (14.83% & 6.73% for SLC & DLS, respectively) (both p<0.001), but, again, significantly more after kapalbhati than breath awareness (both SLC & DLS p<0.001). These results support the idea that kapalbhati is more effective in increasing subjects' sustained attention span than breath awareness.

Since Kapalbhati increases psycho-physiological arousal, this finding is consistent with the study on effects of drinking coffee, which suggested that coffee's stimulating effects on psycho-motor function, improve test performance\(^{14}\). With regard to memory, one study of a group trained in yoga found significant increase in spatial memory test scores, while verbal memory test scores remained the same\(^3\). Another study reported effects on memory of 4 pranayama techniques: right nostril breathing, left nostril breathing, alternate nostril breathing and breath awareness without manipulation of nostrils\(^3\). All 4 groups showed a significant increase in spatial test scores (mean 84%), while the control group showed no change. It was suggested that yoga breathing increases spatial memory scores without a lateralized effect\(^2\). It has also been suggested that improvements in spatial memory scores may be due to anxiety reduction, which is known to improve performance on learning and memory tasks\(^2\) e.g. a study of undergraduates (mean age 20.7 yrs) showed that forced left nostril breathing increased spatial performance on a cognitive test of mental rotation, manipulation and twisting of 2 and 3 dimensional objects\(^6\). In this light, the present study's findings that verbal and spatial memory scores both increased significantly after kapalbhati practice (33.44% & 34.20%, respectively, both p < 0.001), but decreased significantly after breath awareness practice (-36.51% & -16.84% respectively, p<0.001), is very important. It was found that kapalbhati does not produce a lateralized effect. Also, the opposite changes in kapalbhati and Breath Awareness demonstrate that the hypothesis that all mind-body techniques have similar effects is erroneous\(^{23}\).
Conclusion
The study suggests that both kapalbhati and breath awareness reduce anxiety and improve sustained attention. However, kapalbhati was significantly more effective in doing so than breath awareness. In contrast, they act oppositely on verbal and spatial memory: whereas kapalbhati significantly increases both, scores on these variables significantly declined after breath awareness. This suggests that breath awareness is intrinsically dulling to the mind, though further experiment is needed determine whether verbal instructions yield better results than the repeated audio tape instructions used in the experiment. This would be a significant experiment, because breath awareness and related techniques are considered important components of many systems of psycho-spiritual development.

Acknowledgement
This work forms part of the first author’s (SSK) dissertation to be submitted to the Swami Vivekananda Yoga Anusandhana Samsthana (SVYASA University) in partial fulfillment of his PhD. SSK is grateful to the authorities of the University for the opportunity given to him. The authors are grateful to Ravi Kulkarni of SVYASA’s division of physical sciences for his assistance in statistical analysis of data, and to Alex Hankey for editorial assistance.

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