Effect of *kapalabhati* on performance of six-letter cancellation and digit letter substitution task in adults

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**ABSTRACT**

**Background:** Attention and concentration are valuable skills for all fields of human activity. Training to improve these skills is described in ancient *hatha* yoga texts.

**Aims:** To study the effect of 1-min *Kapalabhati* (KB1) and 5-min *Kapalabhati* (KB5) practice of the Yoga rapid breathing exercise, *Kapalabhati* (KB), on psychomotor performance, as measured by the six-letter cancellation task (SLCT) and digit-letter substitution task (DLST).

**Materials and Methods:** Thirty-six subjects, 21 male (mean age 25.71 years, SD 2.10), 15 female (mean age 24.13 years, SD 2.23) participated in the study. All were participating in a 3-month *pranayama* training program, part of residential degree courses at Swami Vivekananda Yoga Anusandhana Samsthana, Yoga University. The subjects were divided into two groups, and assessed on the SLCT and DLST, immediately before and after KB on two successive days. The first group did KB1 on day 1, and KB5 on day 2. For the second group, the order was reversed.

**Results:** There were no significant differences on SLCT and DLST on Total and Net Scores between sessions for the same group, and between groups for the same session i.e. the effects of KB1 and KB5 were not distinguishable. However, both groups made more errors on DLST after the interventions, 525% after KB1 and 562.5% after KB5, *P* < 0.018 and *P* < 0.041, respectively (Wilcoxon Signed Rank Test). In contrast, scores on SLCT remained completely unchanged.

**Conclusions:** Both KB1 and KB5 found no change on both SLCT and DLST. But, this kind of breathing practices leads to increases error score.

**Key words:** DLST; high frequency yoga breathing; *kapalabhati*; *pranayama*; SLCT.

**INTRODUCTION**

The word 'Kapalabhati' is constructed from two component words: *Kapala* and *Bhati*. In Sanskrit *Kapal* means forehead and *Bhati* means to shine. Hence, *Kapalabhati* (KB) is an exercise that makes the forehead shine. It consists of fast, shallow, abdominal respiratory movements at about 2 Hz (120 per min). KB is one of the six major *kriyas* (cleansing techniques) described in *Hatha Yoga Pradipika*.

Most systems of *Hatha Yoga* incorporate KB practice, the length of recommended time depending on the program, the teacher and the student’s needs. Some Yoga teachers recommend long practice of KB, and say that it can help remedy almost every physical condition. It is therefore of fundamental interest to the evidence base of Yoga and Yoga medicine to understand the effects of KB practice on the human psychophysiology.

A number of scientific studies have investigated biochemical and physiological effects of KB. Desai and Gharote observed decrease in blood urea, and increases in creatinine and tyrosine. Another study found during KB compared to rest increased cardiovascular and respiratory and increases in heart rate and blood pressure.

In a third study, Stancak *et al.* found increased in Alpha, Beta-1 and Theta activity during the initial 5 min, 10 min and later stages of 15 min KB compared to the pre-exercise period. During rest after KB, Alpha and Beta-1 activity decreased, but Theta activity was maintained at the same
Pradhan: Effect of kapalabhati on performance on psychomotor performance

level as during the initial resting period. Subjects reported a sense of rest and relaxation after KB.

Heart rate variability (HRV) is an indicator of cardiac autonomic control. A study assessed before and after KB practice and found increase in low frequency (LF) power, and LF/HF ratio, and decrease in high frequency (HF) power, following KB.[6]

In a recent study of the effects of KB on Six Letter Cancellation (SLC) task in three different age groups (medical students, middle-aged adults and older persons) both total errors and net scores improved after 10 min KB practice.[7]

Since KB practice has been found to influence EEG i.e., cortical electrical activity, connected to cognitive processes, it is surprising that there has not been more investigation of the effects of KB on cognition. This study compares the effects of two different lengths of KB practice on attention task performance using the six-letter cancellation (SLC) and digit letter substitution (DLS) tests. The use of this DLS protocol to study immediate effects has already been validated for the Indian population.[8]

MATERIALS AND METHODS

Subjects

Twenty-one male and 15 female (total group: mean age 25.05 years, SD 2.27) were selected for the study. They were free from neurological, respiratory diseases, and students of Yoga courses. They were right handed based on the Edinburgh Handedness Inventory[9] and familiar with KB. All gave their signed informed consent.

Study design

Subjects were assigned randomly into two sessions that is KB for 1 min (KB1) and KB for 5 for min (KB5). On day one, who were performed KB1 session and KB5 session. The next day they were reversed their order of session. They were assessed before and immediately after the each session i.e., KB1 and KB5.

Intervention

In performing KB, subjects sat cross-legged, keeping their head, neck and spine erect. Active exhalation is effected by rapid contraction of the abdominal muscles, inhalation is passive. The two durations were 1 min (KB1) and 5 min (KB5). They were trained prior to the start of the study.

Instruments

The six-letter cancellation task (SLCT) consists of a sheet of 22 rows × 14 columns of randomly arranged letters of the alphabet. The top of each sheet names six target letters. Subjects are given the choice of two possible strategies to cancel target letters (i) all six letters at once or (ii) selecting a single target letter at a time. It is also suggested that, according to their own choice, they follow horizontal, vertical, or random paths on the test sheet. They are told to cancel as many target letters as possible in the test time of 90 sec.

The digit letter substitution task (DLS) test sheet consists of 8 rows × 12 columns of randomly arrayed digits. The key at the top of each sheet, pairs each of the 9 digits with 9 selected letters. Subjects have to write the corresponding letters in the empty box below each digit. Choice of strategy for substituting letters is up to each subject: horizontally, vertically, or selecting one digit at a time. Subjects have to substitute as many letters for digits as possible in the test time of 90 sec. Test supervisors timed each test on a standard stopwatch.

To compensate for test-retest, and memory effects due to short intervening time intervals, i.e. interventions of only 1 and 5 minutes, different worksheets and coding were used for each test, with different digit-letter pairing in the key and differently randomized arrays of digits on the worksheets. Similar rules were followed for the SLCT by changing target letters and using differently randomized arrays of letters on the worksheet.

Assessment

Scoring for both tests counts total substitutions/cancellations attempted, and number of wrong substitutions/cancellations. Net Score was obtained by deducting the wrongly attempted score from total attempted score. Scoring was carried out by blind rater.

Data analysis

Statistical analysis was done using SPSS-10.

RESULTS

Student’s paired ‘t’ Test was used for total and net scores, and Wilcoxon Signed Rank Test for wrong scores [Table 1].

Although none of the differences on SLCT and DLST on total and net scores between sessions for the same group reached significance, the fact that all four improved has a chance of 1/16 = P < 0.0625 according to a sign test, and is borderline significant. Both groups made more errors on
DLST after the intervention, 525% after KB1 ($P < 0.018$) and 562.5% after KB5 ($P < 0.041$). Wrong substitution data has significant implications for subjects’ vigilance following KB practice.

**DISCUSSION**

The present study found wrong letter substitution significantly increased in DLST without significant change in Net Score, while no changes in either total wrong or Net Scores were observed in SLCT after either KB1 or KB5. As measures of sustained attention, the two tests are usually considered equivalent, so at first sight this difference in task performance seems remarkable.

Our results were unexpected contrast to the previous finding. Natu and Agrawal[8] assessed the effect of a stimulant (coffee) on psychomotor performance in third year medical students using the SLC and DLS tasks. Net Scores increased significantly on both tests. Since KB is considered to have a stimulating effect on the central nervous system[6] we had expected to observe similar improvements after KB practice.

The following may help us understand the new result. The substitution tasks involve visual scanning, mental flexibility, sustained attention, psychomotor speed, and speed of information processing[10]. The KB practice may have interfered with the mental flexibility component, which is not present in the cancellation task. In contrast to the cancellation task, which can be performed as a simple reaction to seeing the selected letter(s) without thinking what to do about it, the DLST requires a selective substitution to be made, and this requires an instant of reflective consideration. Our results indicate that KB marginally interferes with this moment of reflection. Possible reasons can be found in terms of *panchamahabhiputta* functions: thought involves prana (Vayu), and KB would initially cause a disturbance in system Vayu functions. However, how to translate this phenomenological explanation into modern scientific terms is an open question, and the effects of different *pranayama* techniques need to be considered, particularly on EEG.

In contrast, an earlier study of the effects of KB on SLCT found contrasting results in different age groups. They observed a decrease in total errors for the younger and medical students group. In the middle age and older persons groups, they found no changes in total errors after KB, but Net Scores were higher after KB in these two groups by 32.5% and 16.4%, respectively. In the medical students group, Net Scores did not change significantly.[7]

Our finding, that both KB1 and KB5 selectively impair DLS task performance, suggests that motor skills are not being improved. Further study is required to understand effect of KB on attention using P300 event-related potentials and sensory motor task. Limitation of the study, it is a comparative study without control group with small sample size.

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**Table 1: Mean values and standard deviation for total scores, wrong substitutions, and net scores of six-letter cancellation task and digit-letter substitution task**

| Variables | Scores | Pre | KB1 | Post | Pre | KB5 | Post |
|-----------|--------|-----|-----|------|-----|-----|------|
| SLCT Total | 47.94±12.75 | 48.78±13.01 | 46.06±13.27 | 47.72±12.93 |
| Wrong | 0.28±0.74 | 0.36±0.59 | 0.31±0.86 | 0.42±0.84 |
| Net | 47.67±12.92 | 48.42±13.01 | 45.75±13.64 | 47.31±12.73 |
| DLST Total | 63.44±14.54 | 64.61±12.32 | 59.84±17.24 | 62.69±14.76 |
| Wrong | 0.08±0.37 | 0.5±1.16 | 0.08±0.37 | 0.53±1.32 |
| Net | 63.36±14.6 | 64.11±12.56 | 59.86±17.27 | 62.69±14.76 |

SLCT = Six-letter cancellation task; DLST = Digit letter substitution Task, *P < 0.05, Wilcoxon signed rank test, post compared with pre of KB1 and KB5.

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