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**Finger dexterity and visual discrimination following two yoga breathing practices**

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India**Abstract**

**Background:** Practicing yoga has been shown to improve motor functions and attention. Though attention is required for fine motor and discrimination tasks, the effect of yoga breathing techniques on fine motor skills and visual discrimination has not been assessed. **Aim:** To study the effect of yoga breathing techniques on finger dexterity and visual discrimination. **Materials and Methods:** The present study consisted of one hundred and forty subjects who had enrolled for stress management. They were randomly divided into two groups, one group practiced high frequency yoga breathing while the other group practiced breath awareness. High frequency yoga breathing (*kapalabhati*, breath rate 1.0 Hz) and breath awareness are two yoga practices which improve attention. The immediate effect of high frequency yoga breathing and breath awareness (i) were assessed on the performance on the O«SQ»Connor finger dexterity task and (ii) (in) a shape and size discrimination task. **Results:** There was a significant improvement in the finger dexterity task by 19% after *kapalabhati* and 9% after breath awareness ( $P<0.001$  in both cases, repeated measures ANOVA and *post-hoc* analyses). There was a significant reduction ( $P<0.001$ ) in error (41% after *kapalabhati* and 21% after breath awareness) as well as time taken to complete the shape and size discrimination test (15% after *kapalabhati* and 15% after breath awareness;  $P<0.001$ ) was also observed. **Conclusion:** Both *kapalabhati* and breath awareness can improve fine motor skills and visual discrimination, with a greater magnitude of change after *kapalabhati*.

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Perception is often discussed with reference to cues as a separate source of information for the perceiver. [1] These cues are in turn correlated with the manner in which the sensory apparatus has physically and computationally evolved. Sensory perception and discrimination of shapes and sizes depends on haptic or tactile cues. [2] Tactile information relevant to the size discrimination is combined with proprioceptive inputs. [3] Hence shape and size detection requires specific stereotypical movements. [4] These movements often take the form of scanning movements of the fingers. [5] While not directly related to the kind of movements mentioned above, finger movements involved in performing a dexterity task are also required for haptic sensitivity; the two (i.e. size discrimination and dexterity) being influenced by similar factors. [6]

Yoga is an ancient science, originating in India which includes specific postures, voluntary breath regulation, meditation, and certain philosophical principles. [7] Practicing yoga has been shown to influence several motor functions. These include static motor performance, [8],[9] tweezer dexterity, [10],[11] maze learning, [12] as well as visuomotor speed. [13]

Early studies on experienced practitioners of Burmese Buddhist meditation showed that experienced meditation practitioners were more sensitive to various aspects of visual stimuli, such as size, shape, color and texture. [14] Apart from meditation alone, a combination of yoga practices was shown to improve the sensitivity to a flickering light stimulus, [15] to reduce visual geometric illusions, [16] as well as to improve visual contrast sensitivity. [17]

More recently Tai Chi, a Chinese slow-motion meditation was shown to enhance tactile acuity in long-term practitioners. [18] A blinded assessor compared the ability to discriminate between two different orientations (i.e., parallel and horizontal) of different cross-grating widths at the fingertips in Tai Chi practitioners and controls. This tactile spatial acuity was found to be better in more experienced Tai Chi practitioners, compared to those with less experience in meditation. The authors also speculated that related somatosensory attentional practices such as yoga mindfulness meditation, and qigong could have similar effects. However, there has been no study on the effect of yoga on tactile acuity based on the performance in a size and shape discrimination task. Hence the present study was planned to assess the short term (or immediate) effect of two yoga breathing practices on (i) finger dexterity and (ii) size and shape discrimination.

The yoga techniques studied were two breathing practices. One of them was a high frequency yoga breathing practice(s), called kapalabhati (where kapala=forehead, bhati=shining, in Sanskrit). [19] Immediately after this practice, university students, middle-aged adults and persons 60 years of age and older, performed better in a cancellation task. [20] The letter cancellation task assesses selective and sustained attention, shifting attention, as well as visual scanning. [21] There was no change when the same participants practiced breath awareness (as control) to assess re-test effects on another day. Breath awareness was chosen in the study cited above, as well as in the present study as a control as breath awareness is an important part of all yoga voluntary regulated breathing and in traditional yoga.

Hence, in summary the present study assessed the immediate effects of (i) high frequency yoga breathing (kapalabhati) and (ii) breath awareness, on (i) size and shape discrimination and (ii) finger dexterity.

## Materials and Methods

### Participants

The participants were attending an outpatient department to receive treatment in yoga and ayurveda at Patanjali yogpeeth, Haridwar, India. All participants were also given an opportunity to learn yoga in the outpatient facility area. A general announcement was made in the out-patient department and interested subjects who were seeking stress management enrolled and expressed their interest to volunteer. All of them gave their signed consent to participate in the study, which was approved by the Ethics Committee of Patanjali Research Foundation.

There were ninety-six subjects ranging in age between 20 and 55 years. The participants had enrolled for the yoga program from stress management. They were randomly allocated to two groups namely, high frequency yoga breathing HFYB (kapalabhati) group and the breath awareness group, using a random number table. Hand dominance of all the participants was checked using the Edinburgh handedness inventory. [22] During handedness testing, it was found that one person from the high frequency yoga breathing group was left hand dominant, and this person was exempted from the study. For ease of analysis and to make the groups equal in number, one more person (selected at random) who was allocated to the breath awareness group was excluded from the study. Hence the number of participants was ninety-four. Out of ninety-four patients, forty-seven patients, (28 females and 19 males) were taken

as the high frequency yoga breathing group (group average age $\pm$ S.D., 39.3  $\pm$  10.5 years). The remaining forty-seven participants, (26 females and 21 males) were assigned to the breath awareness group (group average age $\pm$ S.D., 39.8  $\pm$  10.7). None of the participants had any active form of disease nor did they have any physical disability which would have interfered with their performance on the task. All of them had seven days of experience for both high frequency yoga breathing and breath awareness exercises, which they practiced every day (during the seven days).

### Design

The ninety-four participants were randomized as two groups, with forty seven participants in each group. The sample size (i.e., 47 in each group) was not calculated prior to the test. However, the G\*Power (a general power analysis program) 3.1 [23] software was used to calculate the power of the test as a post-hoc analysis. The power was found to be adequate i.e., 0.9997 (for the finger dexterity task) and 0.9998 (for the shape and size discrimination task). One group practiced high frequency yoga breathing while the other group practiced breath awareness. The two groups were comparable for age and gender. The detailed characteristics of the two groups are given in [Table 1].{Table 1}

### Assessments

All participants were assessed using two tasks. These are described below:

#### O'Connor finger dexterity task

Finger dexterity was measured using the O'Connor finger dexterity apparatus, which consists of a shallow tray beside a metal plate which has 100 holes arranged in ten rows of ten holes each. The participants had to place three cylindrical metal pins 2.5 cm long and 0.2 cm in diameter in each hole. [24] The number of pins placed in 4 min was counted.

#### Shape and size discrimination test

The shape and size discrimination task (Takei Scientific Instruments Co., Ltd., T.K.K.117 Coin Sorting Model, Japan) assesses a participant's ability to discriminate between coins of different sizes depending on their visual and tactile sensations as well as their speed of sorting. The participant has to insert fifty small coins, which are different in size and thickness into one of the five slits, where each slit is designed to allow a specific coin to pass through. The time taken to complete the task was recorded with a stopwatch.

### Intervention

The high frequency yoga breathing (HFYB) group was asked to practice 10 min of high frequency yoga breathing (kapalabhati) where the person had to breathe with a frequency of approximately 1.0 Hz, during which the exhalation is an intentionally active process. The other group practiced breath awareness for the same period. During breath awareness, the participants maintained awareness of spontaneous breathing without any intentional manipulation of the nostrils, throat or chest. The participants' attention was directed to the natural movement of air into and out of their nostrils. They also attempted to be aware of the air flow and its' temperature as it moved through their nasal passages.

### Data analysis

(i) Finger dexterity and (ii) shape and size discrimination scores obtained before and after high frequency yoga breathing (kapalabhati) practice and before and after breath awareness were compared using repeated measures analyses of variance (ANOVA), with one between-subjects factor (i.e. Groups, with two levels, high frequency yoga breathing (kapalabhati) group and breath awareness group), and one within-subjects factor (i.e., states, with two levels, before and after).

Post-hoc analyses with multiple comparisons and Bonferroni adjustment (When multiple comparisons are carried out statistically, there is an increase in the risk of false positives, the Bonferroni corrections reduced this risk) was carried out to compare values recorded before and after high frequency yoga breathing (kapalabhati), as well as before and after breath awareness.

## Results

### Repeated measures analysis of variance

The finger dexterity scores showed a significant difference between states (i.e. before and after, with  $F=138.37$ ,  $df=1$ ,  $46.0$ ,  $P<0.001$ ) and between Groups (i.e. high frequency yoga breathing and breath awareness with  $F=5.13$ ,  $df=1$ ,  $46.0$ ,  $P<0.001$ ).

The error scores in the shape and size discrimination test also showed a significant difference in the interaction between Groups and states ( $F=51.25$ ,  $df=1$ ,  $46.0$ ,  $P<0.001$ ). This suggests that the two are interrelated. There was no significant difference between groups (i.e. high frequency yoga breathing and breath awareness). The time taken to complete the test also showed a significant difference between states (i.e. before and after with  $F=88.84$ ,  $df=1$ ,  $46.0$ ,  $P<0.001$ ) and no significant difference was found between groups. In all cases, the Huynh-Feldt epsilon was equal to 1 (Symmetry is an assumption that the numbers in the analysis of variance (ANOVA) matrix are homogenous, or almost nearly so. If the data do not meet the criteria for sphericity correction factors have to be used. An example of such a correction factor is the Huynh-Feldt Epsilon).

### Post-hoc comparisons

Multiple post-hoc comparisons were carried out with Bonferroni adjustment. The scores of finger dexterity were significantly higher following high frequency yoga breathing (kapalabhati) as well as breath awareness compared to before ( $P<0.001$ , two tailed).

The percentage change after high frequency yoga breathing (kapalabhati) practice was 19.0% whereas in the case of breath awareness the increase was 9.0% after the practice.

There was a significant reduction in the error rate as well as time taken to complete the shape and size discrimination test after both practices i.e. high frequency yoga breathing (kapalabhati) and breath awareness ( $P<0.001$ , two tailed). Errors were reduced by 41% after high frequency yoga breathing (kapalabhati) practice whereas after practicing breath awareness the errors were reduced by 22%. The difference between the two groups, namely, kapalabhati (41% change) and breath awareness (22% change) can be explained based on studies which have shown that kapalabhati compared to breath awareness increases attention more [25] and increases visual perceptual activity more as well. [26] Apart from this while breath awareness appears to increase sympathetic tone based on the LF/HF ratio of the heart rate variability spectrum, kapalabhati does not have this effect. [27] This may be due to the fact that breath awareness involves a certain degree of focusing which is known to increase sympathetic tone. The time taken was reduced by 15% after high frequency yoga breathing (kapalabhati) as well as after practicing breath awareness (it reduced by 15%). The mean values $\pm$ S.D. of finger dexterity test and shape and size discrimination tasks before and after kapalabhati and breath awareness are given in [Table 2].{Table 2}

## Discussion

In the present study, there was a significant improvement in finger dexterity following kapalabhati and breath awareness. The O'Connor finger dexterity task is a fine motor skill task which measures fingertip dexterity and eye-hand co-ordination. The improvement observed in the present study might have resulted due to the beneficial effect of kapalabhati on conscious arousal, attention [28] and anxiety based on changes in electroencephalography. [29] The present group of subjects were possibly anxious as they had joined for stress relief. However, their level of anxiety was not measured. Kapalabhati has been shown to improve attention in a study which assessed the effect of the practice on the P300 event related potential. [28] Attention has been shown to be a predictor of fine motor skills particularly in children suffering from attention deficit hyperactivity disorder. [30] Anxiety is also considered to influence motor skills. [31] Hence the improvements in attention and anxiety relief following kapalabhati practice as seen above might explain the increase in finger dexterity in the present study. This explanation is also applicable to the change seen after breath awareness as mindfulness meditation (which breath awareness resembles) is reported to improve attention [32] and reduce anxiety. [33]

The improvement in shape and size discrimination following kapalabhati found in the present study is in line with an earlier study which showed improvement in selective and sustained attention, as well as visual scanning following yoga breathing other than kapalabhati. [20] In a study on the effect of kapalabhati on spontaneous electrical activity in the brain, there was an increase in alpha, theta and beta 1 activity during the practice in the occipital region. [29] This change might have influenced the functioning of the extrastriate cortex in the occipital region which helps in visuospatial processing. [34] As the shape and size discrimination task involves visuospatial processing, the change in extrastriate cortical functioning may underlie

the improvement following kapalabhati. Closely related to this, is the finding that 15 min of kapalabhati practice reduced error in visual optical illusion, when the Müller-Lyer lines were used for the assessments. [26] However, these explanations are merely a speculation at this stage as the exact mechanism of kapalabhati influencing tactile discrimination was not studied. The effect of kapalabhati on attention-arousal as mentioned earlier might also contribute to the improvement. Like kapalabhati, breath awareness has also been shown to improve the performance in an attention task for sustained, selective attention and visual scanning. [21] Interestingly, both kapalabhati and breath awareness did not appear to increase sympathetic tone, based on the LF/HF ratio in a frequency domain analysis of the heart rate variability spectrum in an earlier study [27] a change normally associated with increased attention-arousal. This was confirmed by studies on breath awareness [35] and kapalabhati. [27]

## Conclusion

In summary, both kapalabhati and breath awareness improved fine motor skills measured by finger dexterity and visual discrimination assessed by the shape and size discrimination task. While this may be related to earlier demonstrated effects on attention-arousal, the exact neural mechanisms are not yet known.

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