

## Performance in a Corsi Block-tapping Task following High-frequency Yoga Breathing or Breath Awareness

### Abstract

**Background:** Uninostil yoga breathing practices have improved spatial memory scores. There has been no assessment on the effect of high-frequency yoga breathing (HFYB) on working memory and spatial memory scores using the Corsi block-tapping task (CBTT). **Objectives:** The present study was planned to assess the immediate effects of HFYB and breath awareness (BAW) compared to a control session on performance in a CBTT. **Methods:** Fifteen participants of both sexes with ages between 18 and 24 years (group mean age  $\pm$  standard deviation, 20.0  $\pm$  1.6 years; 10 females) were recruited for the trial from a university in North India. Each participant was assessed in three sessions conducted on 3 separate days at the same time of the day. The three sessions were (i) HFYB, (ii) BAW, and (iii) quiet sitting (QS). The duration of the intervention was 18 min. The participants were assessed before and after all the three sessions. Repeated-measures-analyses of variance followed by *post hoc* tests with Bonferroni adjustment were performed to compare data before and after all the three sessions. **Results:** BAW resulted in an improvement in backward total scores ( $P < 0.05$ ) and the backward Corsi span ( $P < 0.05$ ; one tailed). **Conclusions:** The results suggest that BAW improves primary working memory, spatial memory, and spatial attention. HFYB did not cause any change.

**Keywords:** Breath awareness, Corsi block-tapping task, high-frequency yoga breathing

### Introduction

Voluntary breath regulation (*pranayama* in Sanskrit) consists of yoga practices which modify the depth, rate, and the other dimensions of respiration.<sup>[1]</sup> The breath rate can be voluntarily increased as high as 2.0 Hz in a practice called *kapalabhati* (*kapala* = forehead; *bhati* = shining in Sanskrit), described as high-frequency yoga breathing (HFYB). HFYB is a yoga breathing technique which is practiced by increasing the breath rate and forceful exhalation.

All *pranayama* practices include breath awareness (BAW) as an important component to direct the attention inward and ultimately reduce awareness of all other stimuli and sensations.<sup>[2]</sup> Both HFYB and BAW have been shown to influence attention. The performance in a cancellation task on 110 participants (Cohen's  $d = 0.99$ ) whose age ranging from 18 years to over 60 years was improved after 1 min of practice of HFYB at 2.0 Hz. The results suggest an improvement in ability to shift

attention and in selective and sustained attention.<sup>[3]</sup> Similarly, in another study, on assessments with the P300 event-related potential task, there was a decrease in P300 peak latency in thirty practitioners (Cohen's  $d = 0.61$ ) after 1 min of the practice of HFYB at 2.0 Hz.<sup>[4]</sup> These results suggested that HFYB reduced the time taken to complete the P300 task which measures selective attention. In the similar study, the practice of BAW showed an increase in the P300 peak amplitude which indicates an increase in neurons recruited to perform the task.<sup>[4]</sup> The results suggested beneficial effects of these practices (i.e., HFYB and BAW) on conscious arousal and attention.

Mindfulness does bear some resemblance with BAW. In a study, 18 long-term practitioners showed an improvement in attention, working memory, and cognitive flexibility,<sup>[5]</sup> when they were compared to age-matched control group.

One dimension of attention is visuospatial attention which involves directing the attention to the location of an object in

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space. After directing attention to a specific spatial location, further cognitive processing may be required, which may involve working memory.<sup>[6]</sup>

The Corsi block-tapping task (CBTT) is a nonverbal test<sup>[7]</sup> to measure executive functions such as visuospatial short-term memory, working memory,<sup>[8]</sup> and spatial attention.<sup>[9]</sup>

Yoga practice including *pranayamas* improved spatial memory scores by 43% when thirty schoolchildren (Cohen's  $d = 0.89$ ) with ages between 11 and 16 years were assessed using verbal and spatial memory tests.<sup>[10]</sup> Similar effects were found when four specific types of *pranayamas* improved spatial memory scores by 84% in schoolchildren.<sup>[11]</sup>

However, to the knowledge of the authors, no study has attempted to study the effects of an individual *pranayama* on visuospatial memory using CBTT, which is a more objective way of assessing primary working memory. Hence, the present study was designed to assess the immediate effects of HFYB and BAW on performance in CBTT in comparison with a control session.

## Methods

### Participants

Fifteen volunteers of both sexes with ages between 18 and 24 years (group mean age  $\pm$  standard deviation (SD),  $20.0 \pm 1.6$  years; 10 females) were recruited as participants. Because menstrual cycle affects different aspects of attention,<sup>[12]</sup> female participants were assessed after 7 days of their period of menstrual cycle. The sample size was based on changes in backward total scores after BAW gave an effect size = 0.52 (medium) and power = 0.95 using G Power software version 3.1, Germany.<sup>[13]</sup> The inclusion criteria were (i) minimum 3 months of experience in the yoga breathing practices, (ii) ability to practice HFYB at the rate of 1.0 Hz (range, 0.83–1.17 Hz); their breath rate was checked using Quark cardio pulmonary exercise test, and (iii) normal health based on a routine clinical examination. The exclusion criteria were (i) any history of epilepsy, (ii) recent chest or abdominal surgery (because the intervention was high-frequency breathing), (iii) taking medication or using other wellness strategies, and (iv) use of stimulants or intoxicating substances. The study conditions were explained to the participants. Their signed informed consent was written in English and explained in both English and Hindi for those who were not able to understand English adequately. The study was approved by the institutional ethics committee (approval number YRD/017/032).

### Study design

Each participant was assessed in all the three sessions on 3 separate days at the same time of the day. These sessions were (i) HFYB, (ii) BAW, and (iii) quiet sitting (QS)

as a control group. The sequence of the practices was randomized for 15 participants using a randomizer (www.randomizer.org). The total duration of each session was 18 min, with 1 min of rest after each 5 min of practice. During the sessions, participants were asked to sit erect and keep their eyes closed.

## Assessment

### Corsi block-tapping task

The CBTT is an individual test which measures visuospatial short-term and working memory.<sup>[8]</sup> Nine blue squares appear on the screen. For each trial, the squares “light up” as yellow one by one in a varying sequence. After the presentation, the participants had to click each of the boxes in the similar order in which they had “lit up” the first part of the task, i.e. forward tapping. In the second part of the task, they maintained the reverse order, i.e., backward tapping. The task begins with a two-box sequence to a maximum of nine. The test gets terminated when the participant is not able to remember the sequence for two consecutive trials at any one level. Hence, the test assesses the following four variables: (i) forward Corsi span, (ii) forward total score, (iii) backward Corsi span, and (iv) the backward total score. The sample of the square presentation along with forward and backward tapping is shown in Figure 1.

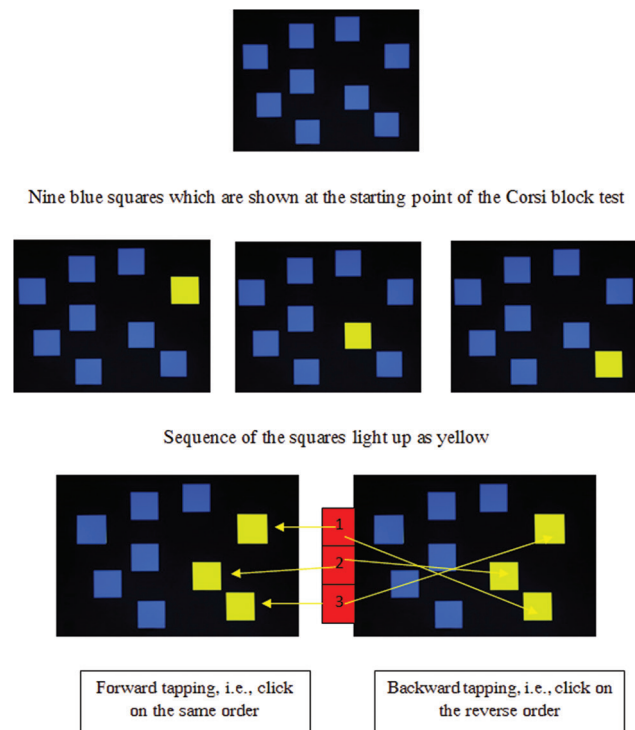


Figure 1: Sequence of the square presentation along with forward and backward tapping

## Intervention

Each participant performed three yoga techniques namely (1) HFYB, (2) BAW, and (3) QS. The total time for each intervention session was 18 min, with 1 min of rest after each 5 min of all the sessions.

### High-frequency yoga breathing

The participants were asked to sit in a comfortable posture (*sukhasana*), keeping their spine erect, neck aligned, and eyes closed. They practiced HFYB at approximately 1.0 Hz with forceful exhalation, for 3 periods of 5 min each.

### Breath awareness

The participants were asked to be aware of the flow of the air as it enters and passes through the nasal passages without modifying their breathing. The participants were asked to maintain similar posture in all the three sessions, seated with spine erect and eyes closed.

### Quiet sitting

In the QS as a control session, the participants allowed their thoughts to wander at random without modifying them or being aware of their breathing. They were asked to sit with their spine erect and eyes closed. No other activity was given to them.

## Data analysis

Repeated-measures-analyses of variance was performed for (i) forward Corsi span, (ii) forward total score, (iii) backward Corsi span, and (iv) backward total score in which the three sessions (HFYB, BAW, and QS) and two states (before and after sessions) were compared. *Post hoc* analysis was performed to compare data before and after all the three sessions which were Bonferroni adjusted.

## Results

BAW improved total scores in backward tapping ( $P < 0.05$ ) and backward Corsi span ( $P < 0.05$ ; one tailed). HFYB did not show any changes in Corsi span and total scores of backward as well as forward tapping. Changes in mean, SD, and Cohen's  $d$  for both forward and backward Corsi span with total scores are summarized in Table 1. The  $df$ , mean square,  $F$ , and partial  $\eta$  squared values are summarized in Table 2.

## Discussion

Fifteen minutes of BAW resulted in an improvement in the backward total scores and backward Corsi span using the CBTT. This suggested an improvement in executive functions in terms of increased visuospatial short-term memory, primary working memory,<sup>[8]</sup> and specific spatial processes.<sup>[14]</sup>

The forward digit span test measures material-specific slave systems while the backward test measures primarily tax central executive resources.<sup>[15]</sup>

Previously, attention was improved during and after HFYB and BAW using the P300 event-related potential task in thirty male adult volunteers<sup>[4]</sup> who had experience in yoga breathing practices for at least 3 months. Similar improvement after BAW occurred when performance in a letter cancellation task was assessed in twenty male volunteers whose ages ranged from 20 to 45 years.<sup>[16]</sup> The findings suggested that BAW can improve performance in attention tasks.<sup>[16]</sup>

In the studies cited above, attention was measured using the P300 event-related potential task and a letter cancellation task, whereas in the present study, visuospatial attention was measured using the CBTT. As described below, yoga breathing practices or *pranayamas* were found to improve performance in recall in the digit span test.

**Table 1: Mean, SD, and Cohen's d for forward and backward Corsi span with total scores**

Variables	HFYB		BAW		QS	
	Pre	Post	Pre	Post	Pre	Post
Forward Corsi span	6.0±1.00	5.93±0.88	6.07±1.10	6.27±1.22	6.13±0.92	6.0±0.93
<i>P</i>		0.827		0.531		0.582
Cohen's <i>d</i>		0.074		0.17		0.14
Forward total score	51.27±15.99	54.07±17.80	53.53±17.62	58.33±24.82	53.2±15.32	51.13±16.94
<i>P</i>		0.629		0.407		0.630
Cohen's <i>d</i>		0.17		0.22		0.13
Backward Corsi span	5.93±0.46	6.13±0.74	6.13±0.64	6.47±0.83	5.8±0.68	6.00±0.76
<i>P</i>		0.271		(0.048, one-tailed)		0.334
Cohen's <i>d</i>		0.32		0.460		0.28
Backward total score	55±11.23	54.47±15.39	52.67±15.99	61.53±18.61	48.87±14.93	54.07±15.89
<i>P</i>		0.875		0.027*		0.104
Cohen's <i>d</i>		0.04		0.51		0.34

Variables in the Corsi block-tapping test pre- and post-HFYB, BAW and QS session. Postvalues were compared with the prevalues for three sessions, i.e., HFYB, BAW, and QS. \* $P < 0.05$ , RM-ANOVA, with Bonferroni adjustment. HFYB=High-frequency yoga breathing, BAW=Breath awareness, QS=Quiet sitting, RM-ANOVA=Repeated-measures-analyses of variance

**Table 2: Details of four repeated-measures-analyses of variance**

Variables	Sources	df	MS	F	Partial $\eta^2$
Forward Corsi span	Sessions	2, 28	0.300	0.340	0.010
	States	1, 14	0.000	0.000	0.000
	Sessions $\times$ states	2	0.233	0.403	0.002
Forward total score	Sessions	2, 28	125.544	0.567	0.001
	States	1, 14	76.544	0.463	0.032
	Sessions $\times$ states	2	93.544	0.421	0.022
Backward Corsi span	Sessions	2, 28	1.244	3.664	0.044
	States	1, 14	1.344	3.651	0.207
	Sessions $\times$ states	1.362, 19.069	0.065	0.211	0.000
Backward total score	Sessions	2, 28	240.033	1.361	0.055
	States	1, 14	457.878	3.239	0.188
	Sessions $\times$ states	1.900	177.212	3.173	0.125

Details of four repeated-measures-analyses of variance of forward Corsi span, forward total score, backward Corsi span, and backward total score. MS=Mean square

Eighty-four participants with an age range between 18 and 25 years showed an improvement in both forward and backward digit span tests suggestive of an improvement in executive functions after practicing a combination of yoga breathing practices.<sup>[17]</sup> In another study, 67 healthy medical students (37 females) with an age range of 18–25 years showed an improvement in both forward and backward digit span tests after 4 weeks of practicing a combination of *bhramari*, *anulom-vilom*, *kapalabhati*, and *bhastrika* for 30 min per day.<sup>[18]</sup> Digit span test differs from the CBTT in the brain regions involved<sup>[19]</sup> and cognitive activities.<sup>[8]</sup>

BAW does bear some resemblance to mindfulness. Tomasino and Fabbro showed that 8 weeks of mindfulness meditation increased activity in the right dorsolateral prefrontal cortex (PFC) and in the left caudate/anterior insula, while activation in the rostral PFC and right parietal area 3b (subdivision of the brodmann area) reduced.<sup>[20]</sup>

The dorsolateral PFC was found to be associated with processing of information such as integrating different dimensions of cognition and behavior,<sup>[21]</sup> ability to maintain and shift set, planning and working memory.<sup>[22,23]</sup>

Another possible mechanism for the improvement in attention after BAW could be increased sympathetic and decreased parasympathetic activities.<sup>[24]</sup> This is relevant because attention and vigilance are associated with higher sympathetic modulation in human volunteers.<sup>[25]</sup>

The findings were limited by (i) the small sample size ( $n = 15$ ) though the power was 0.95 which is high compared to an earlier study, (ii) recruitment of both sexes, and (iii) the levels of significance in all cases were low ( $P < 0.05$ ; one tailed) and Cohen's  $d$  values were small. Unlike earlier studies, the participants in the

present study were not assessed using the standard digit span task, which is a limitation when attempting to view these findings based on the CBTT in light of earlier studies which used the digit span task. A possible future direction of research could be simultaneous assessment of the CBTT performance with the digit span test.

## Conclusions

BAW significantly improved backward total scores and backward Corsi span, suggesting an improvement in primary working memory, spatial memory, and spatial attention.

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## Conflicts of interest

There are no conflicts of interest.

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