Effect of Volitional Modification of Breath Frequency on Attention and Mood States: An Exploratory Randomized Crossover Study

Abstract

Background: Previously, yoga breathing improved mood states and attention but the effect of varying breath frequency on mood and attention was not clear. **Objectives:** The objective of this study was to determine the effects of changes in breath frequency on attention, mood, vigor, and affect states. **Materials and Methods:** Thirty participants (mean age ± standard deviation, 27.3 ± 4.2 years) were assessed on 2 separate days practicing either high-frequency yoga breathing (HFYB, breath frequency 54.23/min) or bumblebee yoga breathing (BBYB, breath frequency 3.97/min) in random order. Assessments included blood pressure (BP), cancellation test scores, Nijmegen (to check for hyperventilation), respiration (rate, height of the breath wave [depth], and duration of inhalation relative to exhalation), mood states, vigor, and affect states. **Results:** Diastolic BP increased after HFYB, whereas systolic BP decreased after BBYB, after both sessions scores in a cancellation test increased (changes in cancellation test performance suggest alertness and test-directed attention), also global vigor (signifying mental energy) and global affect (related to being "happy" and "calm") scores increased, whereas negative mood decreased after HFYB session ($P < 0.05$, Wilcoxon signed-rank test). **Conclusion:** Both HFYB and BBYB increased attention test scores, possibly due to cortical activation (HFYB) or relaxation (BBYB). In HFYB, breath frequency and inspiration duration increased suggestive of increased sympathetic activity, accounting for increased vigor, positive affect, and diastolic BP. In contrast in BBYB, low breath frequency, higher breath amplitude, and prolonged expiration suggestive of parasympathetic activity may account for the decreased systolic BP after BBYB.

Keywords: *Affect, attention, blood pressure, mood, yoga breathing*

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Introduction

Volitional yoga breathing practices form the fourth stage in eight progressive steps intended to help a yoga participant (or seeker) achieve absolute mental control as an attribute of spiritual emancipation (i.e., the eight step in yoga practice called *Samadhi*.[1]

With this emphasis on mental control as an objective of yoga breathing, the practices have been studied in the context of attention regulation and mood modification. Since experienced yoga practitioners effortlessly practice volitional yoga breathing for several minutes, these techniques provide an opportunity to understand the psychophysiological effects of voluntarily changing the breath. These yoga breathing techniques involve volitional changes in the breath rate, the volume of air breathed, and the ratio of inspiration to expiration among other characteristics.[2]

Among commonly practiced yoga breathing practices, two of them change the breath rate in opposite directions, while high-frequency yoga breathing (called *kapalabhati* in Sanskrit, HFYB) increases the breath rate, in bumblebee yoga breathing (called *brahmari pranayama,* BBYB), the breath rate is reduced.[3] As mentioned above, yoga breathing practices are intended to help the practitioner attain control over their attention and mood states. When people focus attention or carry out a cognitively demanding test, their breathing changes.[4]

Mentally demanding tests are generally marked by involuntary faster breathing,[4] whereas intentional slower breathing has been reported to improve performance in attention tests.[5] Separate studies have reported the effects of HFYB and BBYB on attention. HFYB practice

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was found to improve the performance in attention assessed with a cancellation performance test to assess attention.[6-8] A single study on BBYB in participants with impaired vision documented improved cancellation test performance following BBYB.[9] To compare the effects of HFYB and BBYB, an exploratory study was designed with all participants practicing both HFYB and BBYB on separate occasions, indicating an increase in cancellation test scores after HFYB but not after BBYB.[6] However, this exploratory study was not supported by the recording of breathing during the practice of HFYB and BBYB to objectively confirm that participants were able to volitionally regulate breathing as required during the practices. Hence, the present study aims to record attention test performance related to BBYB and HFYB, both practiced in the same participants, with simultaneous recording of the respiration during the two practices.

In addition to attention, modifying breathing is known to bidirectionally influence mood states,[10,11] with breathing often considered an index of emotional state.[12] Volitionally regulating breathing to be deeper and slower has been reported to increase positive emotions when negative emotions are prevalent. Conscious modulation of breathing toward a slower and deeper pattern may strengthen positive emotions when negative emotions are prevalent.[13] Furthermore, positive emotions influence respiration depending on the level of arousal created by the emotions, since arousing emotions increase the respiration rate.[14] A preliminary exploratory trial (cited above) reported reduced state anxiety following both HFYB and BBYB, although other emotional states were not assessed and there was no objective recording of respiration to associate the findings with the changes in respiration.[6]

With this background, the present self-controlled, randomized trial was planned to assess the effects of HFYB and BBYB in the same individuals on separate days with simultaneous monitoring of cancellation test performance, mood states, vigor affect, and respiration (to attempt to associate any changes in attention/affect with changes in breathing).

Materials and Methods

Participants

Thirty healthy student volunteers of both genders (male: female = 15:15; group mean age ± standard deviation [SD]: 27.3 ± 4.24 years) were recruited from a state private university located in North India. The *post hoc* power analysis showed that the present study, with sample size (n = 30), level of significance (α = 0.05), effect size = 0.42 (calculated using Cohen's formula for the change in global vigor (GV) following HFYB session), had power = 0.58 (G * power software University of Bonn, Bonn, Germany).[15] No incentive was given to the participants to take part in the study. Recruitment of the participants was by oral announcements in the lecture halls of the university. Participants (i) aged between 20 and 40 years, (ii) apparent normal health based on a semi-structured interview, and (iii) at least 6 months of experience of yoga breathing practices, including the practice of HFYB and BBYB were included in the study. The participants were to be excluded if they: (i) had recent abdominal surgery, (ii) had any contraindicated conditions associated with the yoga breathing techniques (e.g., tinnitus or active ear infection for BBYB and epilepsy or history of stroke for HFYB), none of the participants were excluded for any of the abovementioned exclusion criteria. The signed informed consent was obtained from each participant and the study was approved by the Institution's Ethics Committee (PRF/YRD/022/010). The baseline characteristics of the participants are given in Table 1.

Study design

The present randomized crossover study was carried out between June and August 2022. The participants were assessed for changes in (i) respiration, (ii) blood pressure (BP), (iii) performance in a letter cancellation test, and (iv) mood states before and after the two yoga breathing sessions (i.e. BBYB and HFYB). The Nijmegen Questionnaire was administered immediately after the two yoga breathing sessions to detect if there were any symptoms related to hyperventilation arising from the two yoga breathing practices.[16]

The two sessions were conducted in random order on 2 consecutive days at the same time of the day. Random assignment of the order of the two sessions was carried out using the following strategy: a person who was not involved in the trial prepared thirty identical slips of paper. The order of the sessions was randomized using 15 papers with the word "BBYB" and 15 with the word "HFYB" put in an

Table 1: The baseline characteristics of the participants

Characteristics	*n*=30
Age (years)	
Group mean age±SD	27.3±4.24
Age range	20–38
Gender	
Male:female	1:1
Actual values	15:15
Education (years) (%)	
13–15	10.00
16–17	90.00
Experience of yoga (months) (%)	
6–12	3.00
13–60	30.33
60 and above	66.66
Time spent in yoga practice per week (min) (%)	
<150	10.00
150–300	67.00
300 and above	23.33

SD: Standard deviation

envelope and each participant drew a paper to determine their order. The participants who had the word "HFYB" were assigned the HFYB session on Day 1, followed by the BBYB session on Day 2, whereas the participants who had the word "BBYB" were assigned the BBYB session on Day 1, followed by the HFYB session on Day 2.[17] The words (i.e. "HFYB" or "BBYB" written on the slips) were not decoded to the participants. The order of assessments of a session is shown in Figure 1. The duration of the active intervention session was 9 min (i.e., during 1, during 2, and during 3 each for 3 min) and the total duration of the session (which includes all the assessments as shown in the schematic) was 23.5 min. The assessments were conducted in a well-ventilated, dimly lit sound attenuated room.

The schematic representation of the study design is given in Figure 1.

Assessments

Respiratory characteristics

Assessment of respiration rate was made using an MP 45 data acquisition system (Biopac Student Lab, BIOPAC System Inc., USA).[18] Respiration was recorded using a respiratory strain gauge transducer fixed at the abdominal region around 8 cm below the lower coastal margin when the participant sat down erect and steady.[19]

Noninvasive blood pressure

BP was recorded using the OMRON BP monitor, model: T9P (HEM-759P-c1) OMRON Healthcare Co., Ltd. Kyoto, Japan,[20] before and after the intervention. The BP cuff was placed on the left upper arm.

Six-letter cancellation test

A six-letter cancellation test (SLCT) was used to assess sustained attention, selective attention, and visual scanning.[7] This test has been used in earlier studies for the Indian population (test–retest reliability $r = 0.781$, $P = 0.002$). A standard method of assessment was used to administer the test on each participant.

Brief mood introspection scale

The mood at the moment of testing was assessed using the Brief Mood Introspection Scale (BMIS).[21] The BMIS is one of the widely used scales to measure mood states and has also been used to detect changes in mood states in the Indian population. The scale has been proven to have good reliability (Cronbach's α range from 0.76 to 0.83). A standard procedure was followed for the assessment and extraction of the BMIS.

Global vigor and affect scale

Each participant was assessed for the subjective feelings of GV and global affect (GA) using the GV and affect instrument (GVA-I).[22] The validity of the GV and GA scales has been confirmed by comparing the scores of healthy controls with those of depressed patients, where depressives showed about 0.6 SDs lower scores than controls in GV and about 1.5 SDs lower scores in GA. The scales have also been used in the Indian population to

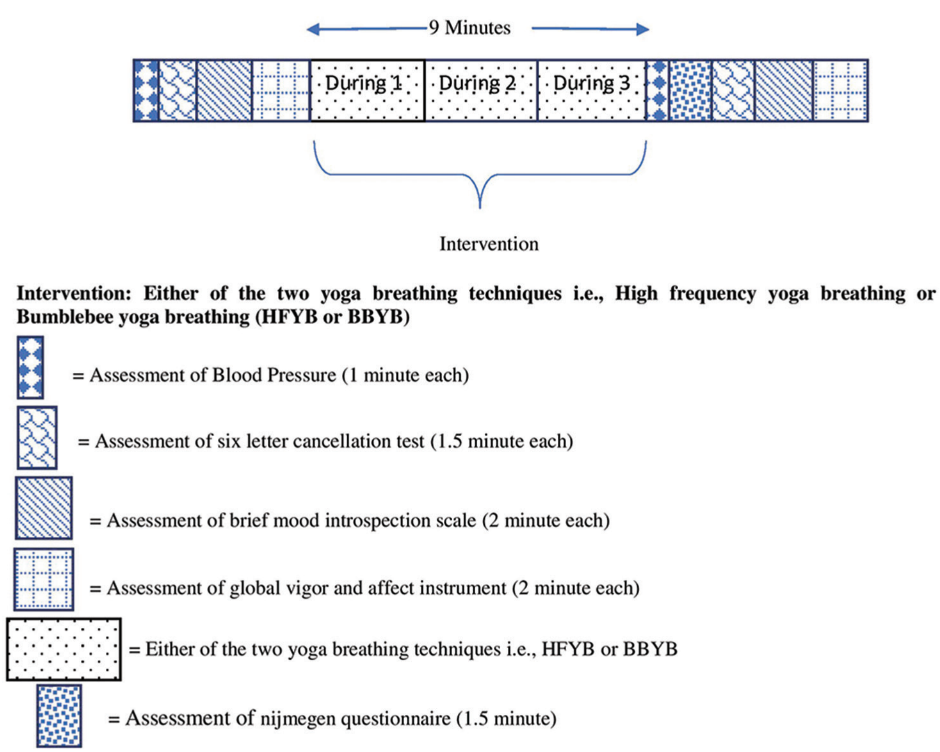


Figure 1: Schematic representation of the study design

detect changes in GV and GA. A standard procedure was followed for the assessment and extraction of the six-letter cancellation test.

The Nijmegen Questionnaire

The Nijmegen Questionnaire was used to detect the signs of hyperventilation immediately following the two yoga breathing sessions.[16] The Nijmegan Questionnaire is one of the widely used measures to determine the symptoms of hyperventilation with high reliability (Cronbach alpha = 0.92).

Intervention

For both interventions, participants were instructed to sit in the cross-legged posture (*sukhasan*) comfortably with their spine erect and eyes closed, hands resting on their knees throughout the session.

Bumblebee yoga breathing

Participants were asked to breathe slowly (as per the capacity) and to exhale with the humming sound of a bumblebee, while exhaling through both nostrils. There were no specific instructions for inhalation and exhalation regarding the time duration. The BBYB practice was for 9 min.

High-frequency yoga breathing

Participants were instructed to breathe rapidly (as per the capacity) performing forceful exhalation, followed by passive inhalation through both nostrils. The frequency of the practice was 1.0 Hz (nearly 1 stroke per second) and the total duration of the practice was 9 min.

Data analysis

The data of (i) six-letter cancellation test, (ii) BMIS, (iii) GVA-I (iv) BP (v) Nijmegen Questionnaire, and (vi) respiration were analyzed using Wilcoxon signed-rank test using SPSS version 24.0, IBM SPSS, New York, USA. The statistical significance (α) was set at 0.05. There are two reasons for selecting the Wilcoxon signed-rank test as follows:

1. All the data were checked, i.e., pre and post for both BBYB and HFYB sessions at least some of these data for all variables were not normally distributed based on Shapiro–Wilk test
2. For the psychological scales, i.e., GVA, BMIS, Nijmegen, and SLCT, the data are ordinal, so for these two reasons, we have selected nonparametric tests.

Results

Thirty participants (15 males and 15 females) aged between 20 and 38 years (group average age ± SD; 27.3 ± 4.24 years) completed the study. All the participants attended the two sessions. None of the participants reported any sign of hyperventilation following the two breathing sessions based on the scores of the Nijmegen Questionnaire (group average score ± SD; 5.1 ± 5.3 for BBYB and 3.8 ± 3.8 for HFYB).

Wilcoxon signed-rank test

BBYB and HFYB increased total attempted scores ($P < 0.031$, $P < 0.009$) and net attempted scores ($P < 0.007$, $P < 0.002$) of the SLCT, respectively. HFYB reduced the negative relaxed scores ($P < 0.038$) of the BMIS. HFYB increased GV and GA scores ($P < 0.001$, $P < 0.023$) of the GVA, respectively. BBYB decreased systolic BP ($P < 0.002$) whereas HFYB increased the diastolic BP ($P < 0.003$), respectively. BBYB and HFYB increased respiration depth at (a) during 1 ($P < 0.001$), (b) during 2 ($P < 0.001$), and (c) during 3 ($P < 0.001$), respectively. BBYB decreased respiration (duration of inhalation relative to exhalation) ratio at (a) during 1 ($P < 0.001$), (b) during 2 ($P < 0.001$), and (c) during 3 ($P < 0.001$) whereas HFYB increased respiration (duration of inhalation relative to exhalation) ratio at (a) during 1 ($P < 0.001$), (b) during 2 ($P < 0.001$), and (c) during 3 ($P < 0.001$), respectively. BBYB decreased respiration rate at (a) during 1 ($P < 0.001$), (b) during 2 ($P < 0.001$), and (c) during 3 ($P < 0.001$) whereas HFYB increased respiration rate at (a) during 1 ($P < 0.001$), (b) during 2 ($P < 0.001$), and (c) during 3 ($P < 0.001$), respectively. The group mean ± SD; median (interquartile range), effect size, *post hoc* power, level of significance, confidence interval values for (i) SLCT, (ii) BMIS, (iii) GV and GA, (iv) Nijmegen, and (v) BP are given in Table 2 and for respiration in Table 3. The respiration tracing is given in Figure 2.

Discussion

Both HFYB and BBYB improved their performance in the cancellation test by 4.74% and 5.0%, respectively, scores suggesting improved ability to focus and shift attention.[23] These results are a contrast to a previous report of improved cancellation test performance after HFYB, but not after BBYB.[6] The previous study did not include an objective recording of respiration, hence comparisons between the two studies cannot be made. In the present study, during BBYB, respiration was slower than the preceding baseline, with prolonged expiration and an increase in depth (based on the height of the respiratory wave). In contrast, during HFYB, breathing frequency was higher, with inspiration longer than expiration. Given these differences in breath characteristics, the ways, in which the two breathing practices may be influencing attention may be different. Slow, deep breathing has already been shown to improve attention test performance which was attributed to better relaxation.[5] In the case of HFYB, breath frequency is increased considerably (average 54.23 breaths per minute), this practice may be expected to increase “respiration-driven cortical activation” with increased afferent discharge from muscles of respiration during breathing.[24]

Table 2: Qualitative assessment of psychological measurements, performance in letter cancellation test, blood pressure using Wilcoxon signed-rank test. "Values are group mean±SD; median (IQR). Total number of participants are (n=30)"

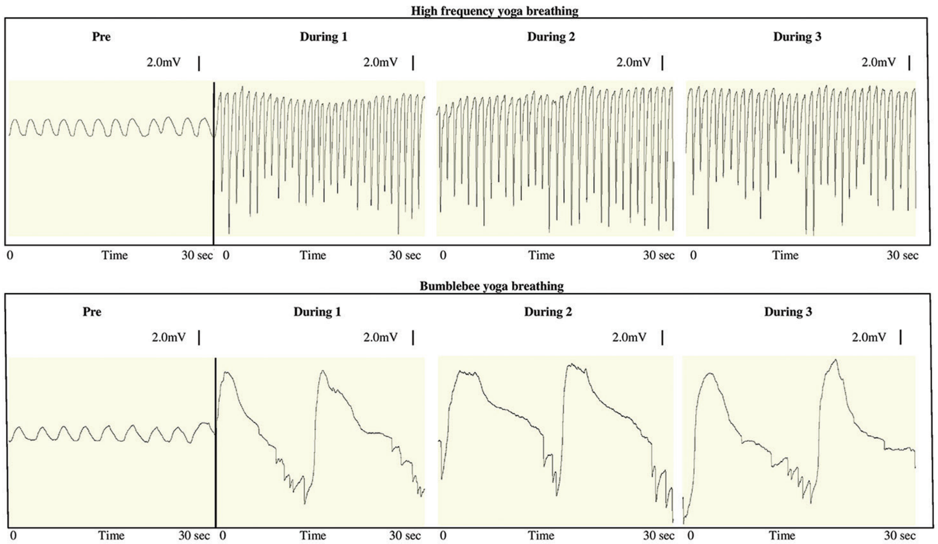
Measurements	Subscale	BBYB			HFYB			Pre BBYB versus pre HFYB comparison (*P*)
		Pre	Post	*P*	Pre	Post	*P*	
Six letter cancellation-test (scores)	Total attempt	41.07±8.37; 41 (10.25)	42.3±7.39*; 42.5 (10) Cohen's *d*=0.16, *post hoc* power=0.13 CI (LB=39.54–UB=45.06)	0.031	41.23±9.55; 41.5 (12.5)	42.93±8.46**; 44 (11.25) Cohen's *d*=0.19, *post hoc* power=0.17 CI (LB=39.77–UB=46.09)	0.009	0.90
	Wrong attempt	0.83±2.38; 0 (0)	0.37±1.16; 0 (0)	0.389	0.57±1.91; 0 (0)	0.33±1.03; 0 (0)	0.765	0.30
	Net attempt	40.3±7.46; 40.5 (9.25)	42±7.06**; 42.5 (10) Cohen's *d*=0.23, *post hoc* power=0.22 CI (LB=39.36–UB=44.64)	0.007	40.67±8.81; 41.5 (13)	42.6±8.35**; 44 (11.25) Cohen's *d*=0.22, *post hoc* power=0.21 CI (LB=39.48–UB=45.72)	0.002	0.78
BMIS (scores)	Pleasant-unpleasant	53.6±7.64; 54.5 (10.5)	55.7±7.55; 58.5 (14.25)	0.13	54.27±6.1; 53.5 (11.25)	55.93±6.75; 57.5 (9.5)	0.165	0.67
	Arousal-calm	29.8±2.73; 29 (3)	30.27±2.94; 30 (3.25)	0.294	30.83±3.68; 30 (5)	29.73±3.28; 29.5 (3.25)	0.058	0.11
	Positive-tired	23.4±3.29; 23.5 (4.25)	24.27±2.88; 25 (4.25)	0.134	23.9±2.72; 24 (4.25)	24.17±2.77; 25 (3.5)	0.73	0.49
	Negative-relaxed	9.67±3.66; 9 (6)	9.03±3.63; 7 (6.25)	0.282	10.03±3.35; 9.5 (6)	8.93±3.34*; 7 (5.25) Cohen's *d*=0.33, *post hoc* power=0.40 CI (LB=7.69–UB=10.18)	0.038	0.62
GVA (scores)	GV	74.29±1.44; 74.07 (2.45)	74.66±1.75; 74.66 (3.14)	0.380	73.73±4; 74.23 (2.36)	75.19±1.55***; 75.25 (2.18) (Cohen's *d*=0.42, *post hoc* power=0.58) CI (LB=74.61–UB=75.77)	<0.001	0.46
	GA	52.68±1.74; 52.53 (2.36)	53.22±1.6; 53.74 (2.63)	0.041	52.83±1.6; 52.95 (2.63)	53.44±1.66*; 54.14 (2.03) Cohen's *d*=0.37, *post hoc* power=0.48 CI (LB=52.82–UB=54.06)	0.023	0.60
Nijmegen (scores)			5.07±5.32; 4 (10)			3.77±3.85; 2.5 (7.25)		0.09
BP (mmHg)	Systolic	115.97±12.53; 115.5 (16.25)	110.67±12.11**; 110.5 (20.5) Cohen's *d*=0.43, *post hoc* power=0.60 CI (LB=106.14–UB=115.19)	0.002	115.4±12.46; 115.5 (19.25)	116.86±12.14; 115.5 (17.75)	0.338	0.75
	Diastolic	73.67±7.26; 74 (12.25)	74.3±8.06; 75 (13.25)	0.561	72.2±8.53; 73 (13.5)	77.17±8.96**; 76.5 (11.5) Cohen's *d*=0.57, *post hoc* power=0.84 CI (LB=73.82–UB=80.51)	0.003	0.21

*P<0.05, **P<0.01, ***P<0.001. Wilcoxon signed--rank test comparing pre and post. I/E: Inhale/exhale, GV: Global vigor, GA: Global affect, Cohen's d: Effect size, CI: Confidence interval, LB: Lower bound, UB: Upper bound, BBYB: Bumblebee yoga breathing, HFYB: High-frequency yoga breathing, BMIS: Brief Mood Introspection Scale, BP: Blood pressure, GVA: GV and affect, IQR: Interquartile range, SD: Standard deviation

Table 3: Respiratory characteristics using Wilcoxon signed-rank test. "Values are group mean±SD; median (IQR). Total number of participants are (n=30)"

Measurements	BBYB				HFYB			
	Pre	D1	D2	D3	Pre	D1	D2	D3
Respiration depth (mV)	0.47±0.3; 0.39 (0.36)	3.83±3.87***; 2.42 (4.45)	3.76±3.74***; 2.59 (3.96)	4.09±4.09***; 2.2 (5.51)	0.67±0.55; 0.5 (0.59)	4.19±4.44***; 2.39 (5.73)	4.13±4.05***; 2.58 (5.21)	4.06±4.49***; 2.5 (4.86)
		Cohen's *d*=0.90, *post hoc* power=1.00 (*P*<0.001)	Cohen's *d*=0.91, *post hoc* power=1.00 (*P*<0.001)	Cohen's *d*=0.91, *post hoc* power=1.00 (*P*<0.001)		Cohen's *d*=0.84, *post hoc* power=1.00 (*P*<0.001)	Cohen's *d*=0.91, *post hoc* power=1.00 (*P*<0.001)	Cohen's *d*=0.80, *post hoc* power=0.98 (*P*<0.001)
		CI (LB=2.39–UB=5.27)	CI (LB=2.36–UB=5.15)	CI (LB=2.56–UB=5.62)		CI (LB=2.53–UB=5.85)	CI (LB=2.62–UB=5.64)	CI (LB=2.38–UB=5.74)
Duration of inhalation relative to exhalation (I/E)	0.88±0.29; 0.86 (0.21)	0.19±0.08***; 0.18 (0.08)	0.18±0.08***; 0.18 (0.12)	0.22±0.13***; 0.2 (0.15)	0.92±0.38; 0.84 (0.26)	2.89±1.35***; 2.61 (1.45)	3.29±2.96***; 2.56 (1.63)	2.72±1.01***; 2.75 (1.42)
		Cohen's *d*=2.67, *post hoc* power=1.00 (*P*<0.001)	Cohen's *d*=2.70, *post hoc* power=1.00 (*P*<0.001)	Cohen's *d*=2.62, *post hoc* power=1.00 (*P*<0.001)		Cohen's *d*=1.63, *post hoc* power=1.00 (*P*<0.001)	Cohen's *d*=0.85, *post hoc* power=0.99 (*P*<0.001)	Cohen's *d*=2.04, *post hoc* power=1.00 (*P*<0.001)
		CI (LB=0.16–UB=0.22)	CI (LB=0.15–UB=0.21)	CI (LB=0.17–UB=0.27)		CI (LB=2.38–UB=3.39)	CI (LB=2.18–UB=4.40)	CI (LB=2.34–UB=3.10)
Respiration rate (cycles/min)	18.39±2.84; 19 (4)	3.82±1.02***; 4 (2)	3.75±0.77***; 4 (1)	3.93±0.87***; 4 (2)	18.25±2.58; 18 (3.34)	53.23±7.48***; 53.52 (9.84)	54.58±8.57***; 54.7 (14.4)	54.89±9.49***; 57.54 (11.91)
		Cohen's *d*=5.84, *post hoc* power=1.00 (*P*<0.001)	Cohen's *d*=5.75, *post hoc* power=1.00 (*P*<0.001)	Cohen's *d*=5.74, *post hoc* power=1.00 (*P*<0.001)		Cohen's *d*=5.31, *post hoc* power=1.00 (*P*<0.001)	Cohen's *d*=4.77, *post hoc* power=1.00 (*P*<0.001)	Cohen's *d*=4.31, *post hoc* power=1.00 (*P*=<0.001)
		CI (LB=3.65–UB=4.28)	CI (LB=3.58–UB=4.16)	CI (LB=3.74–UB=4.395)		CI (LB=50.43–UB=56.02)	CI (LB=51.38–UB=57.78)	CI (LB=51.35–UB=58.43)

*$P<0.05$, **$P<0.01$, ***$P<0.001$. Wilcoxon signed-rank test comparing pre and D1, D2, D3. D1: During1, D2: During2, D3: During3, Cohen's d: Effect size, CI: Confidence interval, LB: Lower bound, UB: Upper bound, BBYB: Bumblebee yoga breathing, HFYB: High-frequency yoga breathing, IQR: Interquartile range, SD: Standard deviation



mV=millivolts

Vertical direction of wave form represents vertical displacement of the respiration strain gauge (SS5LB of MP45 acquisition system [BIOPAC System Inc., U.S.A]) during thoracic abdominal movements and the horizontal scale shows time.

Figure 2: The respiration tracing of the breath waveform

The differences in breathing between BBYB and HFYB may also have influenced the participants' affect. Based on participants' self-reports, negative mood states decreased, whereas vigor and positive affect increased after HFYB alone. Systolic BP decreased after BBYB whereas diastolic BP increased after HFYB. These results support HFYB as an invigorating practice. Furthermore, the decrease in negative emotions, with increased positive emotions after HFYB is comparable with a previous report of reduced depression and anxiety following fast-paced yoga breathing.[25] This effect may also be attributed to increased cortical activation during HFYB, in contrast to BBYB.

However, the findings are difficult to explain in light of the difference in relative duration of inspiration and expiration in BBYB and HFYB. Prolonged expiration (as in BBYB) has been previously reported to be associated with increased positive emotions,[23,26] whereas prolonged inspiration (as in HFYB) was previously reported to not reduce negative emotions in contrast to breathing with prolonged expiration.[23] The difference between the present findings and previous reports may be due to the fact that previous reports on the ratio of inspiration to expiration were based on paced breathing with specific cues, whereas BBYB and HFYB are yoga breathing practices, in which participants regulate their breathing based on their training.

The difference in breath frequencies and differences in inspiration relative to expiration in HFYB and BBYB may also explain the changes in BP after the practices. Slow, deep breathing has been associated with increased cardiac vagal activity and a decrease in heart rate,[5] whereas rapid breathing is associated with a decrease in cardiac vagal activity and increased sympathetic activity.[27] Furthermore, prolonged expiration is known to increase cardiac vagal activity inferred from increased HRV,[26,28] whereas breathing with prolonged inspiration has been found to reduce HRV.[29]

The present preliminary results would be improved by additional controls such as breathing without any volitional change, as well as objective assessments of psychophysiological measures to complement self-reported affect.

The generalizability of the findings of the present study is limited by (1). Small sample size, (2). Requiring a minimum of 6 months of experience for inclusion in the study, and (3). inclusion of student volunteers exclusively. Future studies should address these limitations of the present study.

Conclusion

In summary, both HFYB and BBYB have comparable effects on attention test performance, although possibly through different mechanisms. However, HFYB alone showed improved mood states and increased vigor. This appears to be related to the greater breath frequency in HFYB associated with an increased amplitude of the breath wave and a longer duration of inspiration relative to expiration, all of which are often associated with greater sympathetic activity. In contrast, slow BBYB is associated with a low breath frequency, an increased amplitude of the breath wave, and a longer duration of expiration relative to inspiration, all suggestive of increased parasympathetic activity. This may account for reduced systolic BP after BBYB, whereas increased sympathetic activity after HFYB may explain increased diastolic BP.

Author's contribution

All authors contributed to the study conception and design. Data collection was performed by CA, research problem was defined by ST, SS. Data analysis done by CA. Manuscript compilation was done by ST, CA, SS. All authors read and approved the final manuscript.

Ethical approval

The study is approved by the institutional ethics committee (approval number: PRF/YRD/022/010).

Consent

Consent for Publication All authors gave written consent for submission of the manuscript. Informed Consent Informed consent has been obtained from the participants.

Financial support and sponsorship

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Conflicts of interest

There are no conflicts of interest.

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