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Alternate-Nostril Yoga Breathing Reduced Blood Pressure While Increasing Performance in a Vigilance Test

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Background: Reports suggest that vigilance or sustained attention increases sympathetic activity. A persistent increase in sympathetic activity can lead to an increase in blood pressure. Alternate-nostril yoga breathing has been shown to be useful to (i) improve attention and (ii) decrease the systolic and diastolic blood pressure. Earlier studies did not report simultaneous recordings of the blood pressure and performance in vigilance tests after alternate-nostril yoga breathing. With this background, the present study was planned to determine if 15 minutes of alternate nostril yoga breathing could improve the performance in a vigilance test without an increase in blood pressure.

Material/Methods: Fifteen healthy male volunteers participated in the study (group mean age ±SD, 22.4±2.4 years). Participants were assessed on 3 separate days in 3 different sessions. These were (i) alternate nostril yoga breathing, (ii) breath awareness, and (iii) sitting quietly as a control. Blood pressure and the digit vigilance test were simultaneously assessed before and after each session.

Results: Systolic blood pressure ($p<0.01$), mean arterial blood pressure ($p<0.05$), and the time taken to complete the digit vigilance test ($p<0.05$) significantly decreased following alternate-nostril yoga breathing. The time taken to complete the digit vigilance test differed significantly between sessions ($p<0.05$). The time taken to complete the digit vigilance test was also significantly decreased after sitting quietly ($p<0.01$).

Conclusions: Alternate-nostril yoga breathing appears to improve performance in the digit vigilance test, along with a reduction in systolic blood pressure. This is suggestive of better vigilance without sympathetic activation.

MeSH Keywords: Attention • Blood Pressure • Breathing Exercises

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Background

Cerebral cortical activation influences the ability to process information [1]. States of cortical activation include arousal, alertness, vigilance, and attention. Vigilance has been described differently by specialists in different areas; however, vigilance is most commonly used to describe sustained attention [2]. Sub-cortical monoaminergic projections such as those from the nor-epinephrine locus coeruleus and the serotonergic raphe system play an important part in cognitive functions, especially attention [3]. Sustained attention is associated with increased sympathetic nervous system activity [4], which can result in changes such as increased heart rate or blood pressure [5]. Hence, it would be ideal to focus attention without an increase in sympathetic nervous system activity.

Yoga practice includes voluntary breath regulation, which allows a practitioner to modify physiological functions and mental state within physiological limits [6]. There are several voluntarily regulated breathing techniques which include changes in the rate and depth of respiration and the nostril breathed through [7]. Previous studies have shown that high-frequency yoga breathing (HFYB, at the rate of 2.0 Hz) can influence performance in cancellation tasks [8]. Cancellation tasks require the ability to focus attention and to shift or re-direct attention, as well abilities related to visual scanning and repetitive motor activity. It was speculated that HFYB improves attention, which was further supported by an increase in the P3 amplitude and decrease in P3 latency after HFYB [9].

Apart from HFYB, breathing through a particular nostril or through both nostrils alternately has been studied extensively [10]. Breathing through a particular nostril is supposed to selectively activate the parasympathetic (left nostril) or sympathetic (right nostril) divisions of the autonomic nervous system through a pathway involving connections between the nasal meatus and different hypothalamic nuclei [11]. The possibilities of altering the autonomic nervous system by alternate-nostril yoga breathing (ANYB) has given rise to several detailed studies which have also sought to determine the periodicity of the natural rhythm, which is the nasal cycle [12].

Practical observations have shown that 18 minutes of alternate nostril yoga breathing (ANYB) are optimal [13]. A recent EEG study on 13 normal participants showed a significant decrease in theta activity at the vertex and occipital region during ANYB [14]. The effects of ANYB have also been studied on the heart rate variability (HRV) in experienced yoga practitioners [15,16] and in those with no experience in yoga [17], showing that yoga practice makes a difference in the effects of ANYB on the HRV, with a shift towards parasympathetic dominance. Eighteen minutes of alternate-nostril yoga breathing (ANYB) in 26 healthy volunteers was found to lower the systolic blood pressure by an average of 4.5 mmHg as an immediate effect [15]. The reduction in systolic blood pressure in normotensives after 18 minutes of ANYB led to the question of whether hypertensives could perform a task requiring focused attention and coordination with no rise in blood pressure. This was tested in 90 hypertensives on medication, who were asked to perform the Purdue pegboard task while their blood pressure was monitored non-invasively [18]. Immediately after ANYB participants significantly improved their performance in the Purdue pegboard task (effect size=0.61). Simultaneously, both their systolic and diastolic blood pressure were decreased by an average of 4.24 mmHg (effect size=0.45) and 1.56 mmHg (effect size=0.16), respectively. As mentioned above, the Purdue pegboard task involves eye-hand coordination, repetitive motor activity, and focused attention. However, the Purdue pegboard task is not a direct test of sustained attention and vigilance. Hence, the present study was planned to assess the effect of ANYB on the performance of normotensives in a digit vigilance task while the blood pressure was simultaneously monitored non-invasively. The study was carried out on normotensives to check whether sustained attention, which is a part of vigilance, would increase the blood pressure. This has not been done before using a test which exclusively assesses vigilance. A first-time evaluation of effects is most easy to understand under normal physiological conditions [19]. Bernard (1957) differentiated between the study of disease and the study of normal physiology [19], stating that physiology is the foundation of scientific medicine, as it yields explanations of morbid phenomena by showing their relationship to normal states. Based on this general principle that the true mechanism of an intervention is best understood in the normal physiological state, the present study was designed to test normotensives and their response to a vigilance-specific task while measuring the blood pressure in relation to ANYB. The objective was to determine if ANYB could prevent an increase in blood pressure while participants completed the vigilance task. ANYB was compared with breath awareness (BAW), since BAW is a part of yoga breathing which has been found to increase attention [18]. Both ANYB and BAW sessions were compared with sitting quietly as a control.

The aim of the present study was to assess whether 18 minutes of alternate-nostril breathing or 18 minutes of breath awareness would prevent an increase in blood pressure while normotensives performed a vigilance task specific for sustained attention and alertness.

Material and Methods

Participants

Fifteen healthy male participants with ages ranging between 18 and 27 years (group mean ±SD, 22.4±2.4 years) participated

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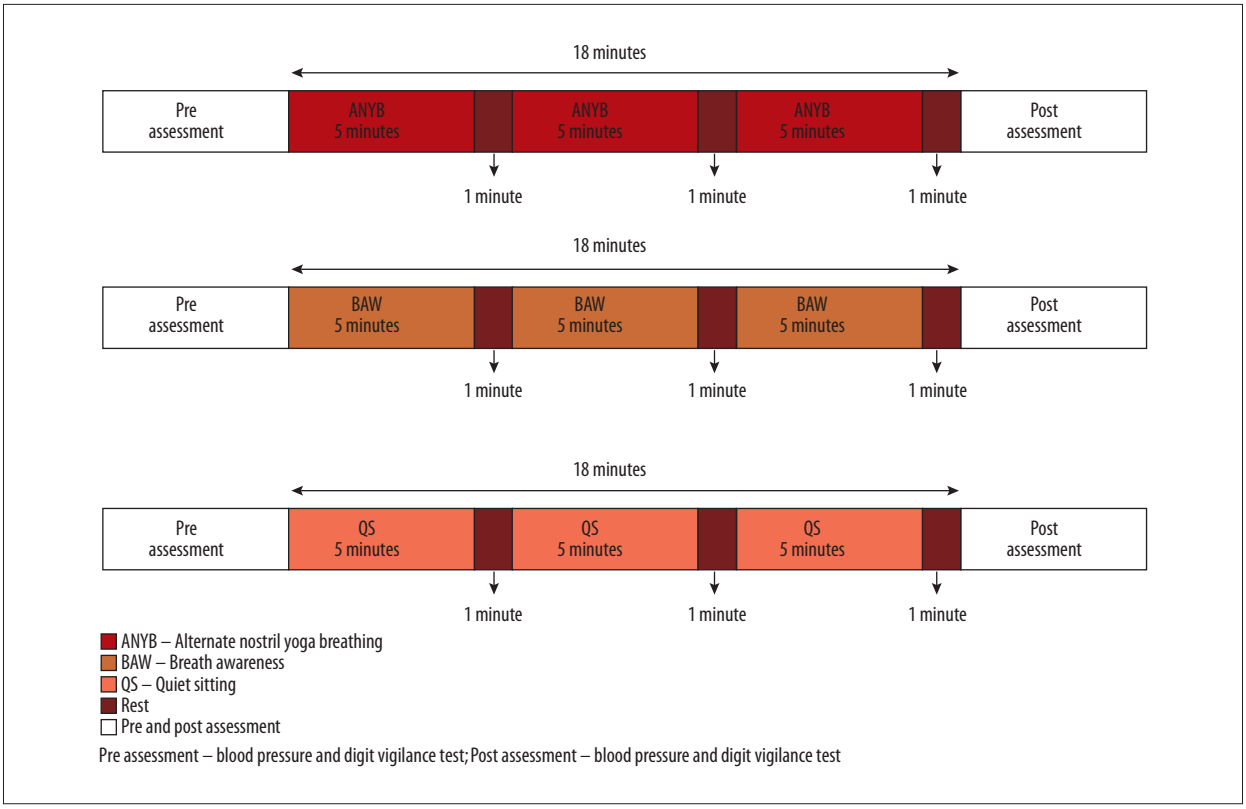

Figure 1. Schematic presentation of the study design.

in the study. The study was limited to male participants as autonomic variables vary with the phases of the menstrual cycle [20]. For the present study, the sample size was not calculated prior to the study. *Post hoc* analysis carried out to determine the power of the study, showing that for the present study, with a sample size of 15 and with the effect size of 0.40 calculated from the mean and SD of systolic blood pressure values which changed significantly after alternate nostril yoga breathing, the power was 0.82869 [21]. The participants were students of a university located in the north of India. The inclusion criteria were: (i) a minimum of 12 months of experience in yoga practice (average yoga experience ±SD, 28.9±15.1 months), (ii) normal physical and mental health based on a clinical examination, (iii) right hand dominance based on a standard inventory [22], and (iv) willingness to take part in the study. The exclusion criteria were: (i) any disease, (ii) taking any medication, and (iii) impaired cognitive or motor functions. None of the participants were excluded for these reasons. Participation in the study was voluntarily with no remuneration. The variables to be assessed and the study design were explained to the participants and signed informed consent was obtained from each participant. The study had ethics clearance from the Ethics Committee of the Patanjali Research Foundation [approval number: PRF/16/0024] which was formed based on the guidelines of the Indian Council of Medical Research.

Design of the study

Each participant was assessed in 3 separate sessions: (i) alternate nostril yoga breathing or *anuloma-viloma pranayama* (ANYB), (ii) breath awareness (BAW), and (iii) sitting quietly as a control (QS). The sessions were on 3 separate days. The 3 sessions were randomly allocated to the participants using a standard randomizer (*www.randomizer.org*). The total duration of each intervention was 18 minutes, which was divided into 3 epochs of 5 minutes with 1 minute for rest between 2 epochs. Blood pressure and performance on the digit vigilance test were assessed simultaneously. The design of the sessions is schematically presented in Figure 1.

Assessments

Noninvasive blood pressure

Participants were asked to rest for 10 minutes before assessments. The noninvasive blood pressure was measured using a Schiller Truscope™ II Multiparameter monitor (Guangdong BiolightMeditech, China) with the transducer placed over the left brachial artery, while the participant was seated with the left arm extended on a table. The systolic and diastolic blood pressure values were noted. The mean arterial pressure was calculated using the formula [MAP=DBP+1/3(SBP–DBP)] [23].

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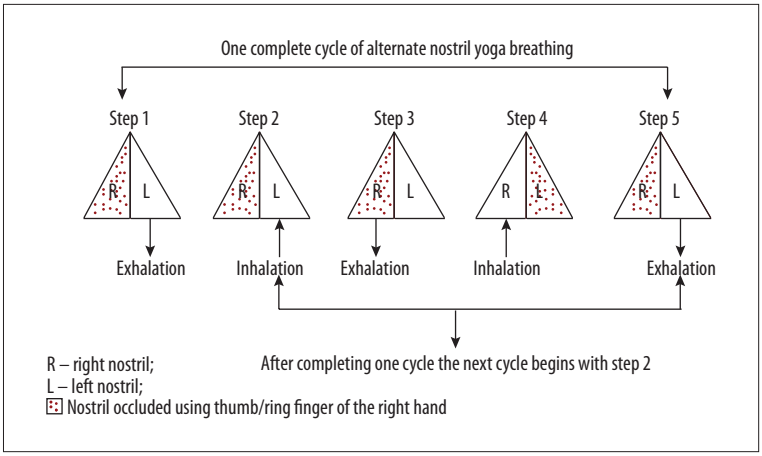

Figure 2. Schematic diagram for a typical cycle of alternate-nostril yoga breathing.

Vigilance or sustained attention

Sustained attention was measured using a digit vigilance test (DVT) of proven validity and reliability [24], which consisted of the numbers 1 to 9 arranged randomly in rows [25]. Each sheet had 50 rows with 30 digits per row. The participants were instructed to cancel only 2 digits (6 and 9) as quickly as they could. They were asked not to: (i) cancel other digits or (ii) miss any of the target digits (6 and 9). The total time taken to complete the test and the number of errors made were noted.

Interventions

Each participant was assigned to the following sessions: (i) alternate-nostril yoga breathing (ANYB), (ii) breath awareness (BAW), and (iii) quiet sitting (QS). The total time for each intervention was 18 minutes. The interventions were preceded and followed by assessments of the digit vigilance test and noninvasive blood pressure. The participants were instructed to sit erect with eyes closed during each session.

Alternate-nostril yoga breathing (ANYB)

ANYB involves breathing through both left and right nostrils alternately. The thumb and the ring finger of the right hand are used to manipulate the nostrils. The breathing practice begins by occluding the right nostril with the right thumb and exhaling through the left nostril, then inhaling through the left nostril with right nostril occluded, then exhaling through the right nostril with the left nostril occluded with the right ring and little fingers. After this, the practitioner inhales through the right nostril with the left nostril occluded, then exhales through the left nostril with right nostril occluded. This is 1 cycle of ANYB and is shown schematically in Figure 2.

Breath awareness (BAW)

The participants were seated erect with their eyes closed, and during this time participants maintained their awareness of the flow of the breath through the nasal passages, without manipulation of the breath.

Quiet sitting (control session; QS)

Participants were seated erect, as they were during the ANYB and BAW sessions. Participants were instructed to keep their eyes closed and allowed their thoughts to wander freely. There was no other activity.

Data extraction

Blood pressure

The systolic and diastolic blood pressure values of each participant were noted in mmHg, and the mean arterial pressure was calculated using the standard formula [MAP=DBP+1/3(SBP–DBP)] [23].

Vigilance or Sustained attention

The digit vigilance task was scored using the standard method [24]. The total time taken to complete the test (in minutes) and number of errors made were noted for analysis.

Data analysis

Statistical analysis was carried out using SPSS (Version 18.0). The data obtained before and after the 3 sessions were compared using a repeated-measures analysis of variance (RM-ANOVA) followed by *post hoc* analyses with Bonferroni adjustment. For the RM-ANOVA, there were 2 within-subject factors. These were sessions with 3 levels (alternate nostril yoga breathing, breath awareness, and quiet sitting) and states with 2 levels (before and after).

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Table 1. Changes in BP and DVT task performance before and after ANYB, BAW and QS.

Variables	ANYB			BAW			QS		
	Pre Mean ±SD	Post Mean ±SD	Cohen's d	Pre Mean ±SD	Post Mean ±SD	Cohen's d	Pre Mean ±SD	Post Mean ±SD	Cohen's d
Systolic BP (mmHg)	122.30 ±9.45	118.23* ±10.62	0.404	118.97 ±9.98	116.73 ±8.93	0.236	119.48 ±11.66	117.02 ±14.46	0.187
Diastolic BP (mmHg)	76.79 ±6.79	74.65 ±8.10	0.286	73.75 ±6.66	73.41 ±7.26	0.048	74.38 ±9.84	74.93 ±9.84	0.350
Arterial mean pressure (mmHg)	91.97 ±7.54	89.19* ±8.79	0.339	88.82 ±7.18	87.86 ±7.50	0.132	89.41 ±10.19	88.97 ±13.01	0.037
DVT task: Time Taken (in minutes)	6.54 ±1.09	5.98* ±1.15	0.499	5.95 ±1.22	5.69 ±1.58	0.184	5.96 ±1.60	5.27** ±1.03	0.512
DVT task: No. of errors	19.53 ±28.82	12.53 ±15.38	0.303	13.80 ±12.66	8.47 ±6.27	0.533	14.87 ±15.27	9.20 ±11.88	0.414

* p<0.05; ** p<0.01; RMANOVA with Bonferroni adjustment when pre values were compared with post values of the respective session. ANYB – alternate nostril yoga breathing; BAW – breath awareness; QS – quiet sitting; BP – blood pressure; DVT – digit vigilance test.

Table 2. Details of the repeated measures analyses of variance for BP and DVT task performance.

Variables	Sources	df	Mean square	F	Partial eta square
Systolic BP (mmHg)	Sessions	1.77, 22.41	56.51	1.240	0.082
	States	1, 14	192.41	8.580	0.380
	Sessions*States	2, 28	7.6	0.436	0.030
Diastolic BP (mmHg)	Sessions	1.51, 21.08	45.71	0.804	0.054
	States	1, 14	9.3	0.542	0.037
	Sessions*States	1.89, 28	14.9	1.009	0.067
Arterial mean pressure (mmHg)	Sessions	1.514, 21.19	50.32	0.952	0.064
	States	1, 14	44.33	2.564	0.155
	Sessions*States	2, 28	11.23	0.812	0.055
Time taken (in minutes)	Sessions	1.95, 27.34	3.3	6.260	0.309
	States	1, 14	5.8	25.810	0.648
	Sessions*States	2, 28	0.358	0.929	0.062
No. of errors	Sessions	1.63, 22.86	249.97	0.723	0.049
	States	1, 14	810	7.550	0.350
	Sessions*States	1.97, 27.64	5.9	0.049	0.003

Results

The group mean values ±SD for the different variables are given in Table 1. ANOVA values for blood pressure and digit vigilance test are given in Table 2.

Repeated-measures analyses of variance (RM-ANOVA)

The systolic blood pressure differed significantly between states (F=8.589, df=1, 14, Huynh-Feldt epsilon=1.000, p<0.05). A significant interaction between sessions x states (F=0.846, df=2, 13, p<0.05, Huynh-Feldt epsilon=1.000) was noted in mean

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arterial blood pressure, suggesting interdependence of the 2 factors. The time taken to complete the digit vigilance test differed significantly between states (F=25.814, df =1, 14, Huynh-Feldt epsilon=1.000, p<0.001) and sessions (F=4.201, df=2, 13, Huynh-Feldt epsilon=0.976, p<0.05).

Post hoc analyses

Systolic blood pressure decreased significantly (p<0.05) after ANYB with a 95% confidence interval (CI) of [6.779, 1.379]. The mean arterial blood pressure also reduced significantly (p<0.05) following ANYB with 95% CI of [5.145, 0.425]. The time taken to complete the digit vigilance test decreased significantly: (i) following ANYB (p<0.05) with 95% CI of [1.096, 0.036], and (ii) after quiet sitting (p<0.01) with 95% CI of [1.133, 0.250].

Discussion

Fifteen healthy volunteers performed a digit vigilance task with significantly less time, along with a decrease in systolic and mean blood pressure, after 18-minute practice of alternate-nostril yoga breathing (ANYB).

Previously, alternate-nostril yoga breathing was shown to reduce both systolic and diastolic blood pressure [26] and systolic blood pressure alone [15,27,28]. In hypertensives after 18 minutes of ANYB practice, the performance in a Purdue pegboard task which requires eye-hand coordination was better, while both systolic and diastolic blood pressure values reduced [18].

The mechanism by which ANYB alters the blood pressure is complex. ANYB acts on an inherent rhythm that influences autonomic functions, which is the nasal cycle. The nasal cycle is an ultradian rhythm which results in a variation in the patency and efficiency of the right and left nostrils [29,30]. Time-series analysis demonstrated that the time periods for 10 variables including the nasal cycle in healthy adults was 115–145 minutes, 70–100 minutes, and 40–65 minutes.

Hence, the concept of spontaneous variations occurring in nostril dominance in human appears a distinct possibility, most probably mediated by autonomic and central regulation of nasal blood vessels [11]. ANYB hence is voluntarily superimposed on this existing rhythm of fluctuation in nostril dominance. Earlier studies have found no correlation between nostril patency at baseline and the effects of voluntary regulation of the nostril in yoga breathing [26]. However, it is worth noting that the basic rhythm is based on complex regulation of the nasal vasculature.

Systolic blood pressure is understood to be determined by the cardiac output, whereas diastolic blood pressure is influenced more by peripheral vascular resistance [31].

In the present study, unlike in a previous study on hypertensives who practiced ANYB for the same duration [18], there was no change in systolic blood pressure following breath awareness. This is most probably related to differences in the regulatory mechanism in hypertensive and normotensive individuals.

The participants in the present study performed better after ANYB in a digit vigilance test taking significantly less time and with a trend of fewer errors. The vigilance test is specifically designed to evaluate sustained attention and focusing. In this task both the time taken as well as the number of errors made are of importance. After all 3 sessions (ANYB, BAW, and QS) there was a non-significant decrease in errors as follows: After ANYB (35.9% decrease, effect size=0.5), breath awareness (BAW) (38.6% decrease, effect size=0.5) and quiet sitting (QS) (38.1% decrease, effect size=0.4). There were no significant before/after differences in the number of errors, possibly due to the high levels of dispersion i.e., the high standard deviations. However, the degree of change was comparable in the 3 sessions, but after the ANYB session participants took significantly less time to complete the task. This suggests better efficiency.

An EEG study on 13 normal healthy participants after ANYB, BAW, and QS showed a decrease in theta activity at the vertex and occipital regions during ANYB [14]. These results suggest that the sustained attention required for DVT did not activate the mechanisms associated with mental effort. Memory tasks are known to result in increased frontal mid-line theta. It is possible that the effort involved in completing the DVT after ANYB was less than that after BAW and QS, as suggested by the decrease in systolic blood pressure (4.1 mmHg) and mean arterial pressure (2.8 mmHg). However, this is only a speculation.

The mechanism underlying the benefits of ANYB with improved efficiency in a vigilance task has not been studied. However, a study in army personnel who practiced a combination of yoga techniques including ANYB showed improved performance in a cancellation task requiring focusing and shifting attention, while their state anxiety decreased [30]. It is known that vigilance is influenced by psychological factors such as motivation [31] (a positive influence) and stress (a negative effect) [1]. In the present study, ANYB may have reduced stress and anxiety and hence improved performance. However, this remains to be studied. Not knowing the mechanism is a definite limitation of the study. It also provides direction for future research.

The mechanism by which breathing through one or both nostrils alternately influences the autonomic nervous system is complex. It appears to be mediated by mechanical receptors in the nasal mucosa, which are activated by air flow into the nostril from where the signal is unilaterally transmitted to specific regions within the hypothalamus regulating the autonomic nervous system [32].

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Conclusions

Hence, the results of the present study suggest that ANYB can help participants maintain a state of sustained attention without the usual increase in blood pressure. These findings are limited by the small sample size as well as by the fact that the participants were all male. A larger sample size with subjects of both sexes would allow the findings to be generalized.

References:

1. Oken BS, Salinsky MC, Elsas SM: Vigilance, alertness, or sustained attention: Physiological basis and measurement. Clin Neurophysiol, 2006; 117(9): 1885–901
2. Bonnet MH, Arand DL: We are chronically sleep deprived. Sleep, 1995; 18(10): 908–11
3. Berridge CW, Waterhouse BD: The locus coeruleus-noradrenergic system: Modulation of behavioral state and state-dependent cognitive processes. Brain Res Brain Res Rev, 2003; 42(1): 33–84
4. Aston-Jones G, Chiang C, Alexinsky T: Discharge of noradrenergic locus coeruleus neurons in behaving rats and monkeys suggests a role in vigilance. Prog Brain Res, 1991; 88: 501–20
5. Grassi G, Mark A, Esler M: The sympathetic nervous system alterations in human hypertension. Circ Res, 2015; 116(6): 976–90
6. Ramdev S: Pranayama rahasya with scientific factual evidence (Rev. ed.). Haridwar, India: Divya Prakashan; 2009
7. Iyengar BKS: Bks Iyengar Light on Yoga HB. United Kingdom: HarperCollins Publishers Ltd., 1988
8. Pradhan B: Effect of kapalabhati on performance of six-letter cancellation and digit letter substitution task in adults. Int J Yoga, 2013; 6(2): 128–30
9. Joshi M, Telles S: A nonrandomized non-naive comparative study of the effects of kapalabhati and breath awareness on event-related potentials in trained yoga practitioners. J Altern Complement Med, 2009; 15(3): 281–85
10. Shannahoff-Khalsa DS, Boyle MR, Buebel ME: The effects of unilateral forced nostril breathing on cognition. Int J Neurosci, 1991; 57(3–4): 239–49
11. Eccles R: Nasal airflow in health and disease. Actaoto-laryngologic, 2000: 12(5): 580–95
12. Shannahoff-Khalsa D, Golshan S: Nasal cycle dominance and hallucinations in an adult schizophrenic female. Psychres, 2015; 226(1): 289–94
13. Telles S, Singh N, Bhardwaj A: Science studies pranayama (first ed.). Haridwar, India: Divya Prakashan, 2011
14. Telles S, Gupta RK, Yadav A et al: Hemisphere specific EEG related to alternate nostril yoga breathing. BMC Res Notes. 2017; 10(1): 306
15. Telles S, Sharma SK, Balkrishna A: Blood pressure and heart rate variability during yoga-based alternate nostril breathing practice and breath awareness. Med Sci Monit Basic Res, 2014; 20: 184–93
16. Raghuraj P, Ramakrishnan AG, Nagendra HR, Telles S: Effect of two selected yogic breathing techniques of heart rate variability. Indian J Physiol Pharmacol, 1998; 42(4): 467–72
17. Subramanian RK, P R D, P S: Alternate nostril breathing at different rates and its influence on heart rate variability in non practitioners of yoga. J Clin Diagn Res, 2016; 10(1): CM01–2.
18. Telles S, Yadav A, Kumar N et al: Blood pressure and Purdue pegboard scores in individuals with hypertension after alternate nostril breathing, breath awareness, and no intervention. Med Sci Monit, 2013; 19: 61–66
19. Bernard C: An introduction to the study of experimental medicine. New York, Dover publications, 1957
20. Yildirir A, Kabakci G, Akgul E et al: Effects of menstrual cycle on cardiac autonomic innervation as assessed by heart rate variability. Ann Noninvasive Electrocardiol, 2001; 7(1): 60–63
21. Erdfelder E, Faul F, Buchner A: GPOWER: A general power analysis program. Behav Res Methods, 1996; 28(1): 1–11
22. Oldfield RC: The assessment and analysis of handedness: The Edinburgh inventory. Neuropsychologia, 1971; 9(1): 97–113
23. Glasser SP, Halberg DL, Sands CD et al: Is pulse pressure an independent risk factor for incident stroke, reasons for geographic and racial differences in stroke. Am J Hypertens, 2015; 28(8): 987–94
24. Kelland DZ, Lewis RF: The Digit Vigilance Test: Reliability, validity, and sensitivity to diazepam. Arch Clin Neuropsychol, 1996; 11(4): 339–44
25. Dixit A, Thawani R, Goyal A, Vaney N: Psychomotor performance of medical students: Effect of 24 hours of sleep deprivation. Indian J Psychol Med, 2012; 34(2): 129–32
26. Raghuraj P, Telles S: Immediate effect of specific nostril manipulating yoga breathing practices on autonomic and respiratory variables. Appl Psychophysiol Biofeedback, 2008; 33(2): 65–75
27. Srivastava RD, Jain N, Singhal A: Influence on alternate nostril breathing on cardiorespiratory and autonomic functions in healthy young adults. Indian J Physiol Pharmacol, 2005; 49(4): 475–83
28. Subbalakshmi NK, Saxena SK, Urmimala, D'Souza UJA: Immediate effect of 'nadishodhana pranayama' on some selected parameters of cardiovascular, pulmonary, and higher functions of brain. J Physiol Sci, 2005; 18(2): 10–16
29. Stoksted P: Rhinometric measurements for determination of the nasal cycle. Acta Otolaryngol Suppl, 1953; 109: 159–75
30. Telles S, Bhardwaj AK, Kumar S et al: Performance in a substitution task and state anxiety following yoga in army recruits. Psychol Rep, 2012; 110(3): 963–76
31. Begleiter H, Porjesz B, Chou CL, Aunon JI: P3 and stimulus incentive value. Psychophysiology, 1983; 20(1): 95–101
32. Shannahoff-Khalsa D: Lateralized rhythms of the central and autonomic nervous systems. Int J Psychophysiol, 1991; 11(3): 225–51

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