

Differential effects of uninostril and alternate nostril pranayamas on cardiovascular parameters and reaction time

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ABSTRACT

Background: Recent studies have reported the differential physiological and psychological effects of yogic uninostril breathing (UNB) and alternate nostril breathing (ANB) techniques. This study aims to determine differential effects of these techniques on reaction time (RT), heart rate (HR), and blood pressure (BP).

Materials and Methods: Twenty yoga-trained subjects came to the lab on six different days and RT, HR, and BP were recorded randomly before and after nine rounds of right UNB (surya nadi [SN]), left UNB (chandra nadi [CN]), right initiated ANB (surya bhedana [SB]), left initiated ANB (chandra bhedana [CB]), nadi shuddhi (NS), and normal breathing (NB).

Results: Overall comparison of Δ % changes showed statistically significant differences between groups for all parameters. There was an overall reduction in HR- and BP-based parameters following CB, CN, and NS with concurrent increases following SB and SN. The differential effects of right nostril initiated (SB and SN) and left nostril initiated (CB, CN, and NS) UNB and ANB techniques were clearly evidenced. Changes following NB were insignificant in all respects. The overall comparison of Δ % changes for RT showed statistically significant differences between groups that were significantly lowered following both SB and SN.

Discussion and Conclusion: Our study provides evidence of sympathomimetic effects of right nostril initiated pranayamas with sympatholytic/parasympathomimetic effect following left nostril initiated pranayamas. We suggest that the main effect of UNB and ANB techniques is determined by the nostril used for inspiration rather than that used for expiration. We conclude that right and left yogic UNB and ANB techniques have differential physiological effects that are in tune with the traditional swara yoga concept that air flow through right nostril (SN and pingala swara) is activatory in nature, whereas the flow through left nostril (CN and ida swara) is relaxatory.

Key words: Blood pressure; heart rate; pranayama; reaction time.

INTRODUCTION

Pranayama, the fourth limb of classical ashtanga yoga is an essential part of yogabhyasa and is increasingly being used as a tool of yoga chikitsa or the application of yoga as a therapy. There are a multitude of pranayama techniques and it is traditionally taught that each of them has different psycho-physiological benefits.^[1] The ancient rishis, the seers of India have intuitively analyzed all aspects of

human life and one such example is swarodaya vinyan, the ultradian nasal cycle as codified in the Shiva swarodaya, wherein differential effects of different phases of the nasal cycle are given in great detail.^[2]

A group of pranayama, namely chandra and surya nadi (CN and SN, respectively) and chandra bhedana and surya bhedana (CB and SB, respectively) have uninostril breathing (UNB) and alternate nostril breathing (ANB) patterns using left and/or right nostrils, respectively. This type of yogic nostril manipulation is also furthered in nadi shuddhi (NS), a specific technique involving alternate use of both nostrils in a specific pattern.

These yogic UNB and ANB techniques have captured the imagination of researchers worldwide and recent studies have reported their differential physiological and

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psychological effects including effects on O₂ consumption, metabolism and body weight,^[3] blood glucose,^[4] involuntary blink rates^[4] and intraocular pressure,^[5] heart rate (HR), stroke volume and end diastolic volume^[6] as well as skin resistance, digit pulse volume, and blood pressure (BP).^[7] ANB (as done in NS pattern) has been reported to rapidly alter cardiopulmonary responses and improve simple problem solving.^[8] Raghuraj and Telles have suggested that yogic breathing through the right, left, or through both nostrils alternately produces distinct autonomic changes.^[9] They reported that right UNB increased systolic pressure (SP) and diastolic pressure (DP), whereas left UNB resulted in significant reduction in SP and mean pressure (MP).

However, none have studied the immediate effect of these UNB and ANB techniques on reaction time (RT), a sensitive and simple indicator of central neuronal processing. RT is the interval between the onset of a signal (stimulus) and the initiation of a movement response and is an indirect index of central neuronal processing as well as a simple means of determining sensory-motor association, performance, and cortical arousal. Though RT shortening effects of pranayama as well as comprehensive yoga training of different durations have been reported,^[10-12] earlier none have studied the immediate effects. Previous studies by Bhavanani *et al.* have reported significant and immediate decrease in auditory reaction time and visual reaction time (ART and VRT, respectively) following nine rounds of mukha bhastrika, a bellows type of pranayama in normal school children as well as mentally challenged adolescents.^[13,14]

With the above in mind, we have studied the immediate effects of UNB and ANB on cardiovascular (CV) parameters and RT. The aim of the study is to determine the differential effects of these techniques if any and understand the mechanisms behind their physiological effects. It is hypothesized that right/left UNB, ANB performed by right in and left out/left in and right out methods as well as NS will have different effects. Keeping all of this in mind, this study was planned to investigate the acute effects of different UNB and ANB pranayamas on resting CV parameters and RT.

MATERIALS AND METHODS

Twenty subjects (13 females and 7 males) regularly attending yoga sessions at the Centre for Yoga Therapy, Education, and Research (CYTER) thrice weekly for more than 3 months were recruited for the study by convenience sampling. Their mean age and Body mass index (BMI) were 34.10 ± 13.62 standard deviation (SD) and 25.28 ± 7.65 (SD), respectively. All of them were right handed. Eight of them reported normal health status, whereas the other 12 reported that they

were undergoing regular treatment for one or more medical conditions such as hypertension,^[6] hypothyroidism,^[3] type 2 diabetes mellitus,^[2] polycystic ovary syndrome,^[2] bipolar affective disorder,^[1] sinusitis,^[1] psoriasis,^[1] and uterine prolapse.^[1] None were receiving autonomic modifying agents like α - or β -blocking drugs.

Each subject came to the CYTER lab on six different days. They were instructed to have a light breakfast before 8 a.m. and report for the study between 10 a.m. and 12 noon. On each of the 6 days, they performed nine rounds of any one of the six techniques selected by random selection of both subject and technique so as to avoid any bias or influence of different days on the group.

The subjects were instructed to sit in any comfortable posture and relax for 5 min before the pre-intervention recordings of resting HR, BP, and RT were taken. They then performed nine rounds of the following techniques after which the post-recordings of HR, BP, and RT were repeated.

- Right UNB (SN) using nasika mudra wherein the ring finger was used to occlude left nostril by pressing on the outside of the nostril
- Left UNB (CN) using nasika mudra wherein the thumb was used to occlude right nostril by pressing on the outside of the nostril
- Breathing in through right nostril and out through the left (SB) using nasika mudra to regulate flow through respective nostrils
- Breathing in through left nostril and out through the right (CB) using nasika mudra to regulate flow through respective nostrils
- Breathing in through left nostril and out through right followed by breathing in through right and out through left (NS) using nasika mudra to regulate flow through respective nostrils
- Performance of normal breathing (NB) through both nostrils with nasika mudra (just performed as a placebo but not closing either nostril).

Participants were instructed to focus their mind on their breath and ensure it was slow, deep, and regular while attempting to utilize all sections of their lungs. Respiratory rate for all techniques was maintained at 5-6 breaths per min (BPM) and this was regulated by one of the investigators providing an audible count of six for both inspiration and expiration. As they were all attending regular yoga sessions, none reported any difficulty in doing the techniques in this manner.

To ensure objectivity in measuring HR and BP, the recordings were done using non-invasive semi-automatic BP monitor (CH – 432, Citizen Systems, Tokyo, Japan) with an instrumental accuracy of $\pm 5\%$ for HR and ± 3 mm Hg for BP. Pulse pressure (PP) was calculated as SP-DP, MP as

DP + 1/3 PP, rate-pressure product (RPP) as HR × SP/100, and double product as HR × MP/100.

RT apparatus manufactured by Anand Agencies, Pune was used for the study. The instrument has a built in 4-digit chronoscope with a display accuracy of 1 ms. It features four stimuli, two response keys, and a ready signal. Switches for selecting right or left response key for any stimulus are provided. In this study, simple ART was recorded for auditory beep sound stimulus and simple VRT for red light stimulus. The subjects were instructed to release the response key as soon as they perceived the stimulus. The signals were given from the front of the subjects to avoid the effect of lateralized stimulus and they used their dominant hand while responding to the signal. All subjects were given adequate exposure to the equipment on two different occasions to familiarize them with the procedure of RT measurement as this is found to be more consistent when subjects have had adequate practice. For statistical analysis of RT, more than 8-10 trials were recorded and the average of the lowest three similar observations was taken as a single value.^[11-14]

Data were assessed for normality using GraphPad InStat and passed normality testing by Kolmogorov-Smirnov

Test. Statistical analysis was done using analysis of variance (ANOVA) with Tukey-Kramer Multiple Comparisons Test for data with identical SDs and Kruskal-Wallis (non-parametric ANOVA) with Dunn's Multiple Comparisons Test for data with non-identical SDs. Students *t* (paired) test was done and *P* values less than 0.05 were accepted as significant differences in pre-post, intra-group comparisons.

RESULTS

The overall comparison of Δ % changes showed statistically significant differences between groups for all parameters [Tables 1 and 2]. As seen in Table 1, HR reduced significantly following both CB and CN, whereas SP fell significantly following CB and NS and a significant rise was seen in DP following SB. PP fell significantly following NS, MP reduced significantly following CB, while it increased following SB and there was significant reduction in RPP and Double product (DoP) following CB and CN, while only RPP decreased significantly following NS. Inter-group differences were statistically significant for HR, DP, MP, RPP, and DoP comparisons between CB and SB, as well as SB and CN. The comparisons were significant for RPP and DoP between CN and SN as well as CB and SN. The inter-group differences were statistically significant

Table 1: Overall comparison of Δ % changes in heart rate, systolic pressure, diastolic pressure, pulse pressure, mean pressure, rate-pressure product, and double product in 20 subjects following a control period of nine rounds of normal breathing as well as nine rounds of chandra bhedana, surya bhedana, chandra, surya nadi and nadi shuddhi pranayamas

(%)	Δ % after NB	Δ % after CB	Δ % after SB	Δ % after CN	Δ % after SN	Δ % after NS	<i>P</i> value
HR	0.19±4.79	-4.61±5.99	2.22±6.42*	-4.78±7.17 [▲]	1.13±8.05	0.30±8.41	0.0017
SP	-0.90±5.05 [†]	-2.29±5.58	1.23±5.33 ^{PPP}	-1.28±5.13	1.49±5.17 ^{UUU}	-5.04±4.97	<0.0001
DP	0.36±5.91	-2.42±6.94	4.17±6.46 ^{**}	-2.05±7.59 [▲]	-0.50±6.36	0.59±6.98	0.0089
PP	-0.57±18.84 [†]	-1.26±13.14	-2.70±13.95	-1.16±13.42 [▲]	6.12±11.70 ^{UUU}	-12.83±15.04	0.0008
MP	0.34±3.85	-2.40±5.62	2.80±4.98 ^{**}	-1.76±5.70 [▲]	0.33±5.36	-2.02±4.86 [‡]	0.0027
RPP	-1.03±7.83	-6.84±7.25	3.64±10.25 ^{**}	-5.90±9.74 ^{▲▲}	2.74±10.65 ^{UUUΩ}	-4.82±8.70 ^{UU}	<0.0001
DoP	0.47±7.11	-6.93 ^{***} ±7.52	5.20±9.77	-6.33±10.15 ^{▲▲▲}	1.56±10.70 ^{UUΩ}	-1.82±8.46	<0.0001

Values are given as mean±SD. *P* values are given for intergroup comparisons done by repeated measures of analysis of variance with Tukey-Kramer Multiple Comparisons Test. For HR: **P*<0.05 for CB versus SB; [▲]*P*<0.05 for SB versus CN; For SP: ^{PPP}*P*<0.001 for SB versus NS; ^{UUU}*P*<0.001 for SN versus NS; [†]*P*<0.05 for NB versus NS; For DP: ^{**}*P*<0.01 for CB versus SB; [▲]*P*<0.05 for SB versus CN; For PP: [‡]*P*<0.05 for CN versus NS; ^{UUU}*P*<0.001 for SN versus NS; [‡]*P*<0.05 for NB versus NS; For MP: ^{**}*P*<0.01 for CB versus SB; [▲]*P*<0.05 for SB versus CN; [‡]*P*<0.05 for SB versus NS; For RPP: ^{**}*P*<0.01 for CB versus SB; ^{UU}*P*<0.01 for CB versus SN; ^{▲▲}*P*<0.01 for SB versus CN; ^Ω*P*<0.05 for CN versus SN; ^Ω*P*<0.05 for SB versus NS; [‡]*P*<0.05 for SN versus NS; For DoP: ^{***}*P*<0.001 for CB versus SB; [‡]*P*<0.05 for CB versus SN; ^{▲▲▲}*P*<0.001 for SB versus CN; ^Ω*P*<0.05 for CN versus SN; For all other comparisons, *P*>0.05. HR = Heart rate; SP = Systolic pressure; DP = Diastolic pressure; PP = Pulse pressure; MP = Mean pressure; RPP = Rate-pressure product; DoP = Double product; NB = Normal breathing; CB = Chandra bhedana; SB = Surya bhedana; CN = Chandra nadi; SN = Surya nadi; NS = Nadi shuddhi

Table 2: Overall comparison of Δ % changes in auditory reaction time and visual reaction time in 20 subjects following a control period of nine rounds of normal breathing as well as nine rounds of chandra bhedana, surya bhedana, chandra nadi, Surya nadi, nadi shuddhi pranayamas

(%)	Δ % after NB	Δ % after CB	Δ % after SB	Δ % after CN	Δ % after SN	Δ % after NS	<i>P</i> value
ART	-2.62 (-7.35,7.23)	4.73 (-6.88, 7.43)	-4.84 (-12.75,8.40) ^{***}	3.95 (-9.42,10.67) ^{▲▲}	6.596 (-15.05,4.82) ^{UUUUΩΩΩΩ}	1.09 (-8.38,8.97) ^{UU}	<0.0001
VRT	1.40 (-4.09, 5.18)	2.02 (-6.86,9.89)	-6.05 (-13.04,6.64) ^{**U}	2.83 (-9.31,10.17) ^{▲▲}	-6.67 (-0.89,-10.94) ^{UUUUΩΩΩΩPPP}	1.28 (-7.58,10.66) ^{UUU▲▲}	<0.0001

Values are given as median (range). *P* values are given for intergroup comparisons done by Kruskal Wallis (nonparametric analysis of variance) with Dunn's Multiple Comparisons Test. For ART: ^{***}*P*<0.001 for CB versus SB; ^{UUUU}*P*<0.001 for CB versus SN; ^{▲▲}*P*<0.01 for SB versus CN; ^{ΩΩΩΩ}*P*<0.001 for CN versus SN; [‡]*P*<0.05 for SN versus NB; ^{UU}*P*<0.01 for SN versus NS; For VRT: ^{**}*P*<0.01 for CB versus SB; ^{UUUU}*P*<0.001 for CB versus SN; ^{▲▲}*P*<0.01 for SB versus CN; [‡]*P*<0.05 for SB versus NB; ^{▲▲}*P*<0.01 for SB versus NS; ^{ΩΩΩΩ}*P*<0.001 for CN versus SN; ^{PPP}*P*<0.001 for SN versus NB; ^{UUU}*P*<0.001 for SN versus NS; For all other comparisons, *P*>0.05. ART = Auditory reaction time; VRT = Visual reaction time; NB = Normal breathing CB = Chandra bhedana; SB = Surya bhedana; CN = Chandra nadi; SN = Surya nadi; NS = Nadi shuddhi

for comparisons between NS and SB, SN and NB for SP; between NS and CN, SN and NB for PP; between NS and SB for MP; and between NS and SB and SN for RPP. In contrast to all of this, there were no significant changes following NB.

ART and VRT shortened significantly following SB and SN [Table 2]. There was a significant prolongation of ART and VRT following CB while only ART was prolonged following CN. The overall comparison of Δ % changes for RT showed statistically significant differences between groups for ART and VRT that were significantly lowered following both SB and SN with no apparent differences between SB and SN or CB and CN and no significant changes following NB and NS.

DISCUSSION

Resting CV parameters

There was an overall reduction in majority of CV parameters following CB, CN, and NS with concurrent increases following SB and SN [Table 1]. The differential effects of right nostril initiated (SB and SN) and left nostril initiated (CB, CN, and NS) UNB and ANB techniques were clearly evidenced by statistically significant differences between them. The changes following NB were insignificant in all respects.

The significant reductions in HR, RPP, and DoP following CB and CN as well as the significant fall in SP following CB and the same coupled with decrease of RPP following NS may be attributed to reduction in sympathetic activity and/improvement of vagal tone as supported by previous studies.^[3,6,9,15] The significant decrease in PP following NS may be attributed to the combination of the significant fall in SP coupled with a small and insignificant rise in DP. Interestingly, there was a significant rise in DP and MP and a small insignificant rise in SP following SB. There was also a small but insignificant rise in HR, RPP, and DoP following SB and all of these changes may be attributed to an enhanced sympathetic activity as reported by previous studies.^[3,7,9,16]

RPP and DoP are indirect indicators of myocardial O₂ consumption and load on the heart, thereby signifying a lowering of strain on the heart.^[15,17] Sympathetic activation is known to increase HR and RPP and decrease overall heart rate variability (HRV). RPP provides a simple measure of HRV in hypertensive patients and is a surrogate marker in situations where HRV analysis is not available. It has also been shown that standard deviation of normal to normal beats and total power of HRV are inversely correlated with mean HR and RPP.^[17] Hence, the reduction in HR and RPP following CB, CN, and NS implies better autonomic regulation of the heart in our subjects with decreased O₂

consumption and load. This can be attributed to either an overall increase of parasympathetic tone and/or a reduction in sympathetic tone as it has also been previously reported that sympathetic activity is lower during left UNB.^[18]

Raghuraj and Telles^[9] reported significant decreases in SP and MP following 30 min of left UNB, while the small reduction in DP in that study also missed significance as in this study. Though they reported a significant increase in HR, we have found a significant decrease in HR following both CB and CN in this study where the fall in SP was significant only following CB and NS and not after CN. These changes may be attributed to changes in cardiac output (CO), peripheral vascular resistance, and humoral factors.^[9] As the HR reduced significantly following CB and CN in this study, it is plausible that the coexisting fall in SP is related to CO. It has been recently suggested that there is an immediate increase in cardiac autonomic modulation following ANB and paced breathing at five BPM without a shift in autonomic balance in individuals inexperienced with yogic breathing.^[19]

Breathing at the rate of six BPM is known to increase vagal modulation of sinoatrial (SA) and atrioventricular nodes and enhances baroreceptor sensitivity.^[15] This may be responsible for reduction in HR and the BP indices following CB, CN, and NS in this study as it may have harmonized respiratory and CV Meyer rhythms. This may have potentially limited the otherwise influential sympathomimetic effects of SB and SN; it has been earlier suggested that sympathetic activation produced by right UNB may be masked by vagally mediated lung baroreceptor activity due to voluntary breathing efforts.^[20]

Srivastava *et al.* have earlier reported a tilt toward parasympathetic dominance after just 15 min of ANB.^[21] It is to be noted that this type of ANB (NS) involves a two breath cycles for each round of the practice as opposed to the one breath cycle as done in SB and CB. It is possible that the significant changes seen in SP, PP, and RPP following NS are a result of the longer duration and double the number of breaths compared to the other techniques.

Our study provides evidence of sympathomimetic effects as manifested by increases in all resting CV parameters following the right nostril pranayamas. This is in agreement with previous studies suggesting that right UNB has sympathomimetic effects including increase in metabolism, baseline O₂ consumption, and enhanced cardio-sympathetic activity.^[6,3,7,9,16] These effects have been demonstrated after a month-long training^[3] as well as immediately after 45 min of the practice.^[7] A recent study also has reported significant increase in SP, DP, and MP after 30 min of the practice.^[9] Earlier studies in normal subjects^[3,6,7,16] have reported significant increases

in HR and/or BP following right UNB though Jain *et al.* conversely reported no significant change in HR and a significant reduction in BP in healthy male subjects with no significant changes in female subjects after 15 min of SN.^[20] A month of right UNB practice compared to ANB resulted in a significant increase in the HR and O₂ consumption and a decrease in the body weight.^[3] Another study, which compared the immediate effects of right UNB with NB, both practiced for 45 min, showed a reduction in skin resistance, digit pulse volume with an increase in SP following right UNB.^[17]

Studies on the dog by Levi *et al.* have reported considerable right left asymmetry in the distribution of sympathetic fibers to the heart with right-sided stellate ganglion stimulation having greater chronotropic effects while the left produced greater inotropic effects.^[4] It is to be noted that there are differences between the right and left vagus nerves too with the right vagus having greater cardiac deceleratory effect compared to the left and the right vagus exerting greater restraint on the SA node than the left.^[4] Shannahoff-Khalsa and Kennedy have suggested that ultradian rhythms of HR may be also governed by alternating rhythmic influences of the right and left branches of the autonomic nervous system with increased HR resulting from right sympathetic with left parasympathetic dominance.^[6]

Despite the above findings, it is to be noted that there are no significant differences between right nostril initiated UNB and ANB techniques (SB and SN). Similarly, there are no significant differences between left nostril initiated UNB and ANB techniques (CB and CN). Most of the significant changes seemed to be following SB rather than SN where the changes were on the similar lines but statistically insignificant. The picture was not so demarcated with regard to CN and CB as both seemed to be producing equivalent changes in all parameters. The changes in NS were more on the lines similar to left nostril initiated techniques. On the basis of these findings, we suggest that the main effect of the various UNB and ANB techniques is determined more by the nostril used for inspiration rather than that used for expiration.

Reaction time

Both ART and VRT shortened significantly following SB and SN [Table 2]. There was a significant prolongation of ART following both CB and CN, while VRT was prolonged following CB. These changes were significantly lower following both SB and SN as compared to NB, NS, CN, and CB but there were no apparent differences between SB and SN or CB and CN and no significant changes following NB and NS. All the ART values were significantly shorter than respective VRT values, and this is in agreement with previous reports.^[10-14]

It has been previously suggested that the faster reactivity seen post-pranayama may be due to a modulation of activity at ascending reticular activating system and generalized alteration in information processing at the primary thalamo-cortical level occurring during pranayama.^[13,14] Changes in breathing period produced by voluntary control of inspiration have been reported to be significantly correlated to changes in RT.^[22] According to the traditional wisdom of yoga, pranayama is the key to bringing about psychosomatic integration and harmony. It may be easily understood that a calm mind will be able to process information much better and react appropriately than an agitated one. A previous study from JIPMER reported a reduction in RT following 3 weeks of training in both slow and fast pranayamas.^[12]

Decrease in RT signifies an improvement in central neuronal processing ability of the special children. This may be due to (1) greater arousal and faster rate of information processing; (2) improved concentration; and/or (3) ability to ignore or inhibit extraneous stimuli. RT tends to improve as arousal increased and it has been reported that RT is fastest with an intermediate level of arousal and deteriorates when the subject is either too relaxed or too tensed. An enhancement of contralateral hemisphere function has been reported with selective nostril breathing,^[23] while Werntz *et al.* reported relatively greater integrated electroencephalogram (EEG) value in one hemisphere that correlated with predominant airflow in the contralateral nostril, defining a new inter-relationship between cerebral dominance and peripheral autonomic nervous function.^[24] It has also been suggested that forced ANB has a balancing effect on functional activity of left and right hemispheres.^[4]

It has been previously suggested that right nostril dominance in the nasal cycle as well as right UNB may be correlated with the “activity phase” of the basic rest-activity cycle, the time during which sympathetic activity in general exceeds parasympathetic activity throughout the body.^[4] Another study suggested that the lowering of intraocular pressure by right UNB indicated sympathetic stimulation.^[6] Various mechanisms have been postulated to explain differential physiological and psychological changes due to right and left nostril breathing. Shannahoff-Khalsa suggested that mechanical receptors in the nasal mucosa register flow of air across membranes (unilaterally) and transmit this signal ipsilaterally to the hypothalamus, the highest center for autonomic regulation.^[4] Even alternating left-right levels of catecholamines have been found to occur in peripheral circulation of resting humans with rhythms coupled to the nasal cycle.^[25] It is possible that the right nostril initiated techniques are producing such a state of autonomic arousal, whereas left nostril initiated techniques are inducing autonomic relaxation/balance in our subjects.

A major limitation of this study as well as the past studies in UNB and ANB is that most researchers have not taken into account the pre-intervention nasal dominance pattern of the subjects before initiating their study protocol. As the flow of air in the subjects' dominant/non-dominant nostril will already be having its own effects on autonomic function, this is a major lacuna that needs to be addressed in future studies.

CONCLUSION

We conclude that right and left yogic UNB and ANB techniques have differential physiological effects. Right nostril initiated UNB and ANB techniques (SB and SN) induce a state of arousal through sympathetic activation and/or through increased ascending reticular activity and/or by central action at the primary thalamo-cortical level. On the other hand, left nostril initiated UNB and ANB techniques (CB, CN, NS) delay reactivity of the subjects by inducing a sense of inert lethargy and may induce a state of parasympathetic dominance as seen in CV parameters. This finding is in tune with the traditional swara yoga concept that air flow through right nostril (SN and pingala swara) is activatory in nature, whereas the flow through left nostril (chandra nadi and ida swara) is relaxatory.^[2] Further studies in different populations and in patients of different conditions, as well as over different periods of time, may provide a more detailed understanding of the therapeutic potential of these simple and effective pranayama techniques.

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REFERENCES

1. Gitananda Swami. Pranayama: The fourth limb of Ashtanga Yoga. Pondicherry, India: Satya Press; 2008.
2. Bhavanani AB. Swarodaya vijnan A scientific study of the nasal cycle. *Yoga Mimamsa* 2007;39:32-8.
3. Telles S, Nagarathna R, Nagendra HR. Breathing through a particular nostril can alter metabolism and autonomic activities. *Indian J Physiol Pharmacol* 1994;38:133-7.
4. Shannahoff-Khalsa DS. Unilateral forced nostril breathing: Basic science, clinical trials, and selected advanced techniques. *Subtle Energies and Energy Med J* 2002;12:79-106.
5. Mohan SM, Reddy SC, Wei LY. Modulation of intraocular pressure by

- unilateral and forced unilateral nostril breathing in young healthy human subjects. *Int Ophthalmol* 2001;24:305-11.
6. Shannahoff-Khalsa DS, Kennedy B. The effects of unilateral forced nostril breathing on the heart. *Int J Neurosci* 1993;73:47-60.
7. Telles S, Nagarathna R, Nagendra HR. Physiological measures of right nostril breathing. *J Altern Complement Med* 1996;2:479-84.
8. Subbalakshmi NK, Saxena SK, Urmimala, D'Souza UJ. Immediate effect of 'Nadi-shodhana Pranayama' on selected parameters of cardiovascular, pulmonary, and higher functions of brain. *Thai J Physiol Sci* 2005;18:10-6.
9. Raghuraj P, Telles S. Immediate effect of specific nostril manipulating yoga breathing practices on autonomic and respiratory variables. *Appl Psychophysiol Biofeedback* 2008;33:65-75.
10. Malathi A, Parulkar VG. Effect of yogasanas on the visual and auditory reaction time. *Indian J Physiol Pharmacol* 1989;33:110-2.
11. Madanmohan, Thombre DP, Balakumar B, Nambinarayanan TK, Thakur S, Krishnamurthy N, *et al.* Effect of yoga training on reaction time, respiratory endurance and muscle strength. *Indian J Physiol Pharmacol* 1992;36:229-33.
12. Madanmohan, Udupa K, Bhavanani AB, Vijayalakshmi P, Surendiran A. Effect of slow and fast pranayams on reaction time and cardiorespiratory variables. *Indian J Physiol Pharmacol* 2005;49:313-8.
13. Bhavanani AB, Madanmohan, Udupa K. Acute effect of Mukh bhastrika (a yogic bellows type breathing) on reaction time. *Indian J Physiol Pharmacol* 2003;47:297-300.
14. Bhavanani AB, Ramanathan M, Harichandrakumar KT. Immediate effect of mukha bhastrika (a bellows type pranayama) on reaction time in mentally challenged adolescents. *Indian J Physiol Pharmacol* 2012;56:174-80.
15. Bhavanani AB, Sanjay Z, Madanmohan. Immediate effect of sukha pranayama on cardiovascular variables in patients of hypertension. *Int J Yoga Therap* 2011;21:73-6.
16. Raghuraj P, Telles S. Effect of yoga-based and forced uninostri breathing on the autonomic nervous system. *Percept Mot Skills* 2003;96:79-80.
17. Madanmohan, Prakash ES, Bhavanani AB. Correlation between short-term heart rate variability indices and heart rate, blood pressure indices, pressor reactivity to isometric handgrip in healthy young male subjects. *Indian J Physiol Pharmacol* 2005;49:132-8.
18. Mohan SM. Svava (nostril dominance) and bilateral volar GSR. *Indian J Physiol Pharmacol* 1996;40:58-64.
19. Ghiya S, Lee CM. Influence of alternate nostril breathing on heart rate variability in non-practitioners of yogic breathing. *Int J Yoga* 2012;5:66-9.
20. Jain N, Srivastava RD, Singhal A. The effects of right and left nostril breathing on cardiorespiratory and autonomic parameters. *Indian J Physiol Pharmacol* 2005;49:469-74.
21. Srivastava RD, Jain N, Singhal A. Influence of alternate nostril breathing on cardiorespiratory and autonomic functions in healthy young adults. *Indian J Physiol Pharmacol* 2005;49:475-83.
22. Gallego J, Perruchet P. The effect of voluntary breathing on reaction time. *J Psychosom Res* 1993;37:63-70.
23. Telles S, Raghuraj P, Maharana S, Nagendra HR. Immediate effect of three yoga breathing techniques on performance on a letter-cancellation task. *Percept Mot Skills* 2007;104:1289-96.
24. Wertz DA, Bickford RG, Bloom FE, Shannahoff-Khalsa DS. Alternating cerebral hemispheric activity and the lateralization of autonomic nervous function. *Hum Neurobiol* 1983;2:39-43.
25. Kennedy B, Ziegler MG, Shannahoff-Khalsa DS. Alternating lateralization of plasma catecholamines and nasal patency in humans. *Life Sci* 1986;38:1203-14.

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