Original Article

Slow Yogic Breathing Through Right and Left Nostril Influences Sympathovagal Balance, Heart Rate Variability, and Cardiovascular Risks in Young Adults

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Abstract

Background: Specific nostril breathing is known to influence autonomic functions. **Aim:** The study was to assess the effects of right nostril breathing (RNB) and left nostril breathing (LNB) on heart rate variability (HRV) and cardiovascular functions. **Material and Methods:** Eighty-five student volunteers were divided into three groups: RNB group (n = 30), LNB group (n = 30), and control group (n = 25). RNB and LNB group subjects practiced right and left nostril breathing, respectively, every day 1 h for 6 weeks. The control group did not practice nostril breathing. Cardiovascular parameters and spectral indices of HRV were recorded before and after 6-week practice of nostril breathing. In RNB and LNB groups, prediction of rate-pressure product (RPP) by low-frequency to high-frequency ratio (LF-HF) of HRV was assessed by bivariate logistic regression. **Results:** HRV indices representing sympathetic activity were increased in the RNB group and indices representing parasympathetic activity were increased in LNB group following 6-week nostril breathing. Prediction of LF-HF to RPP, the marker of cardiovascular risks, was more significant (OR 2.65, P = 0.005) in the LNB group compared to the RNB group (OR 1.452, P = 0.016). **Conclusions:** Short-term practice of LNB improves vagal tone, increases HRV, and promotes cardiovascular health of medical students. Practice of RNB increases sympathetic tone and could jeopardize cardiovascular health.

Keywords: Autonomic functions, Cardiovascular risk, Heart rate variability, Nostril breathing, Sympathovagal balance

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Introduction

Yogic breathing or pranayama has long been reported to improve health and reduce the effects of stress and strain on the body.[1-3] It has been observed that health promotion effects of pranayama are mediated mainly through improvement of autonomic functions.[1,4,5] Recently, it has been observed that the level of stress has increased profoundly in the society due to the increased demand of the modern life. Such chronic stress affects health and produces various types of bodily dysfunction.[6] Therefore, the incidence of stress-induced disorders has increased considerably in the past few years that particularly increases the cardiovascular (CV) risks.[7] It has been reported that many stress-induced disorders occur due to autonomic imbalance, the imbalance between sympathetic and parasympathetic functions.[8] Due to abrupt change in lifestyle, the prevalence of stress disorders such as obesity, diabetes, hypertension, and heart disease has increased enormously in adolescents, school children, and young adults.[9,10] However, no study has been conducted till date to assess the effects of autonomic balance achieved by practice of breathing exercises on reduction of prevalence of such metabolic disorders. Though the McEwen theory of 'allostatic load' explains the long-term effects of stress on autonomic, endocrine, and cardiovascular functions,[11] the exact pathophysiology of stress-induced dysfunctions are not known.

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Reports from our laboratory and others have demonstrated that slow pranayamic breathing is more effective in improving autonomic functions than the first pranayamic breathing.[12-14] Further, it was observed that *kapalabhati* yogic breathing (breathing at high frequency) increases sympathetic activity and *nadisudhi* yogic breathing (slow alternate nostril breathing) decreases the sympathetic activity.[15] Though an earlier study reported some degree of vagal dominance in autonomic functions without significant difference in cardiorespiratory functions in the groups practicing left nostril breathing (LNB) and right nostril breathing (RNB) exercises,[16] a recent study has reported decreased sympathetic activity and blood pressure (BP) following practice of LNB.[17] Moreover, another report has indicated increase in the sympathetic activity and BP following right nostril yoga breathing and decrease in the sympathetic activity and BP following left nostril yoga breathing.[18] We have also observed improvement in cardiac systolic time intervals following 6-week practice of LNB, compared to right RNB.[19] However, till date no study has been conducted to assess the alteration in sympathovagal balance, heart rate variability, and CV risks following specific nostril breathing.

A strong sympathovagal balance ensures stable CV functions as cardiovascular system is primarily under the control of autonomic nervous system (ANS).[20,21] Therefore, effective sympathovagal homeostasis is the objective of various physical exercises and yogic therapies that aim at providing healthy psychological, physical, and spiritual life.[22,23] Recently, spectral analysis of heart rate variability (HRV) has been documented as a sensitive measure of autonomic function and dysfunction in health and clinical disorders.[24] Though the effects of right and left nostril breathing on sympathetic activity and BP are known,[16,17] the effects on HRV and CV risks are not yet investigated. Therefore, in this study we have assessed the difference in the effects of RNB and LNB practice on sympathovagal balance, HRV and CV risks assessed by spectral analysis of HRV in young adults.

Materials and Methods

This study was conducted at the Department of Physiology, Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry, India. Prior to the commencement of the study, the permissions of Institute Research Council and Institute Ethics committee were obtained. This study was conducted as part of Indian Council of Medical Research (ICMR) short-term student research project for 2007-2008.

This case-control study was carried out on 85 young (17-21 years), apparently healthy first year medical and paramedical students. The sample size was estimated for low-frequency to high-frequency (LF-HF) ratio of HRV that yielded the highest sample size of 25, with an expected mean difference of 11 from the previous study,[16] done for a power of 0.8 and type I error of 0.05.

The study procedure was explained to all the subjects and written informed consent was obtained. Subjects were randomly divided into three groups, using the constructed Random Table method.[25]

1. Right nostril breathing (RNB) group (n = 30): Practiced RNB exercise
2. Left nostril breathing (LNB) group (n = 30): Practiced LNB exercise.
3. Control group (n = 25): Performed normal breathing

Inclusion criteria

Healthy subjects having body mass index (BMI) in the normal range as per world health organization (WHO) criteria of BMI for Asian population,[26] were included for the study.

Exclusion criteria

Subjects receiving any medication, with history of smoking or alcoholism, with acute or chronic ailments, having BMI in the obesity range, and known cases of diabetes and hypertension were excluded from the study. As physical training influences sympathovagal balance,[27,28] subjects performing regular exercises were excluded from the study.

Procedure

All subjects reported to the autonomic function testing laboratory (AFT Lab) between 8 to 10 AM for recording of various parameters. Age, height, body weight, and BMI were recorded. Following 10 min of supine rest, basal heart rate (BHR), and blood pressures (diastolic and systolic) were recorded. Mean arterial pressure (MAP) was calculated. Rate pressure product (RPP), the indirect measure of myocardial workload and oxygen consumption was calculated using the formula, RPP = systolic pressure × heart rate × 10^{-2}.[29]

Recording of HRV parameters

For recording HRV, recommendation of the task force on HRV was followed.[30] Electrocardiogram (ECG) electrodes were connected and Lead II ECG was acquired at a rate of 1000 samples/second during supine rest using BIOPAC MP 100 data acquisition system (BIOPAC Inc., Goleta, CA, USA). Data were transferred from BIOPAC to a windows-based PC with AcqKnowledge software version 3.8.2. HRV analysis was done using the HRV analysis software version 1.1 (Bio-signal Analysis group, Kuopio, Finland). Different frequency domain indices such as total power (TP), low frequency component expressed as normalized unit (LFnu), high frequency component expressed as normalized unit (HFnu) and ratio of low-frequency to high-frequency power (LF-HF ratio), and time-domain indices such as square root of the mean squared differences of successive normal to normal RR intervals (RMSSD), standard deviation of normal to normal RR interval (SDNN), the number of interval differences of successive normal to normal RR (NN) intervals greater than 50 ms (NN50), and the proportion derived by dividing NN50 by the total number of NN intervals (pNN50) were calculated.

Nostril breathing exercise

The procedure of nostril breathing as described earlier was followed.[16,18,19] For RNB and LNB groups, the subjects were allowed to be seated in a well-ventilated room of Physiology department and were taught to practice right or left nostril breathing, for 1 h every day between 5 and 6 PM for 6 weeks. For the purpose, they were asked to sit in an easy and steady posture with the head, neck, and trunk erect. They were instructed to bring the right hand up to the nose and close the left nostril (for RNB) or right nostril (for LNB) with the finger and then breathe through one nostril only. During this unilateral breathing the exhalation and inhalation were of equal duration and without any pause. Breathing was diaphragmatic and slow and controlled with no sense of exertion. For both inspiration and expiration, they were asked to count 1 to 5 in their mind (each count was roughly one second) for each phase, so that each respiratory cycle lasted for about 10 s. Thus, about six breathing cycles occurred during 1 min. The breathing exercise (LNB or RNB) training was imparted and monitored during 1 h breathing intervention by the principal investigator who has been trained in practice of pranayamic breathings, as mentioned earlier.[12,19] All the physiological parameters described earlier were recorded before and after 6-week nostril breathing practice.

The control subjects were neither trained, nor allowed to practice nostril breathing. However, they were allowed to sit in the same room and breathe normally for the same amount of time. The recordings of all control subject parameters were obtained before and after the 6-week period.

Statistical analysis

All analysis of the data was performed blindly. The investigators involved in recording of data were not involved in data analysis. Data were expressed as mean ± SD. The *t* test was used for comparison of data before and after 6-week practice of breathing exercise in each group. One-way analysis of variance (ANOVA) was used for data analysis across the three groups. The association of LF-HF ratio with BMI and CV parameters before and after practice of RNB and LNB groups was assessed by Pearson's partial correlation analysis. Bivariate logistic regression was used to predict rate-pressure product by the LF-HF ratio in RNB and LNB groups after 6-week nostril breathing practice. A *P* value less than 0.05 was considered statistically significant.

Results

There was no significant difference in age and BMI between subjects of all the groups [Table 1]. Also, there was no significant difference in BMI between before-practice and after-practice values of all the groups. Further, before the practice of nostril breathing exercise, there was no significant difference in CV parameters (BHR, SBP, DBP, MAP, and RPP) among all the three groups. Though in the control group there was no significant difference in these parameters after 6 weeks of practice period, in the RNB group there was significant increase and in the LNB group there was significant decrease in the CV parameters [Table 1]. Therefore, CV parameters (BHR, SBP, DBP,

Table 1: Age, BMI, and basal cardiovascular parameters of the control group, right nostril breathing (RNB) group, and left nostril breathing (LNB) group, before and after practice of 6-week nostril breathing

Parameters	Control group (n = 25)	RNB group (n = 30)	LNB group (n = 30)
Age (years)	19.32±1.20	19.45±1.58	19.50±1.24
BMI (Kg/m^2)			
Before	22.34±2.84	22.62±3.10	22.45±3.28
After	22.50±2.74	21.54±3.24	23.10±3.15
P values	0.8402	0.1923	0.6749
BHR (per min)			
Before	73.80±10.52	72.35±9.26	74.12±9.70
After	75.10±9.86	82.60±8.50**	67.40±5.64$^{**,###}$
P values	0.6542	< 0.0001	0.0018
SBP (mmHg)			
Before	108.20±8.94	107.68±8.35	110.16±7.78
After	110.56±7.28	115.20±6.38*	102.86±4.78$^{***, ###}$
P values	0.3112	0.0002	<0.0001
DBP (mmHg)			
Before	71.90±8.42	73.62±7.38	74.10±8.70
After	73.38±6.80	80.50±5.34***	68.68±6.20$^{*, ###}$
P values	0.4974	0.0001	0.0073
MAP (mmHg)			
Before	84.05±9.30	84.97±8.65	86.12±7.84
After	86.35±8.15	90.06±7.70	80.07±7.10$^{**, ###}$
P values	0.3570	0.0193	0.0027
RPP			
Before	79.85±10.30	77.90±7.46	80.65±8.76
After	82.43±9.18	95.15±6.35***	71.38±7.20$^{***, ###}$
P values	0.3545	<0.0001	<0.0001

Data presented are mean ± SD, The * mark indicates comparison with control group and the $^{\#}$ mark indicates comparison with right nostril group. $^{*}P$ < 0.05, $^{**}P$ < 0.01, $^{***}P$ < 0.001, $^{###}P$ < 0.001, BMI = Body mass index, BHR = Basal heart rate, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, MAP = Mean arterial pressure, RPP = Rate-pressure product

MAP, and RPP) after 6-week practice of nostril breathing in the RNB group were significantly more and in the LNB group were significantly less compared to their own before practice values [Table 1].

Before practice of nostril breathing, there was no significant difference in HRV indices between the three groups [Table 2]. In the control group, after 6-week practice period, the HRV indices were not significantly different compared to their before practice values. In the RNB group, among frequency-domain indices (TP, LFnu, HFnu, LF-HF ratio), though the decrease in TP was not significant (P = 0.3534), the decrease in HFnu (P = 0.0159) and the increase in LFnu (P = 0.0227), and LF-HF ratio (P = 0.0001) was significant compared to their before practice values. In the LNB group, there was significant increase in TP (P = 0.0110) and HFnu (P = 0.0254) and the decrease in LFnu (P = 0.0054) and LF-HF ratio (P = 0.0002) after 6-week practice of breathing exercise compared to their before practice values. Thus, after 6-week nostril breathing practice, TP in the LNB group was significantly more compared to the control group ($P < 0.05$) and the RNB group ($P < 0.01$). Also, after 6-week practice, in the LNB group HFnu ($P < 0.05$) was significantly increased and LFnu (P < 0.05) and LF-HF ratio ($P < 0.001$) were significantly decreased compared to the control group and RNB group ($P < 0.001$). The time-domain indices (RMSSD, SDNN, NN50, pNN50) in LNB group were significantly more compared to the control group ($P < 0.05$) and RNB group following 6-week practice of nostril breathing [Table 2].

Table 2: HRV indices of the control group, right nostril breathing (RNB) group, and left nostril breathing (LNB) group, before and after practice of 6-week nostril breathing

Parameters	Control group (n = 25)	RNB group (n = 30)	LNB group (n = 30)
TP (ms²)			
Before	910.80±320.32	945.40±352.18	930.10±305.46
After	926.30±316.84	870.57±260.64	1174.80±408.39*, ##
P values	0.8658	0.3534	0.0110
LFnu			
Before	40.62±19.46	41.84±18.35	42.65±17.50
After	41.25±17.30	53.50±20.20*	30.25±15.17*, ###
P values	0.9042	0.0227	0.0054
HFnu			
Before	59.20±21.28	58.20±20.60	57.42±19.34
After	58.05±22.50	45.70±18.32	69.68±21.96*, ###
P values	0.8535	0.0159	0.0254
LF:HF ratio			
Before	0.72±0.30	0.69±0.31	0.73±0.30
After	0.75±0.32	1.20±0.58 ***	0.43±0.20***,###
P values	0.7339	0.0001	0.0002
RMSSD (ms)			
Before	47.20±20.30	45.84±19.60	43.96±20.34
After	45.50±18.60	36.26±12.50	62.30±23.12**, ###
P values	0.7589	0.0285	0.0019
SDNN (ms)			
Before	55.70±22.46	57.38±20.60	54.75±21.20
After	56.40±20.34	45.15±16.42	72.10±24.46*, ###
P values	0.9085	0.0138	0.0048
NN50			
Before	33.10±13.40	32.62±12.24	30.86 ±12.10
After	32.80±12.18	25.58±10.17	41.80 ±15.86*, ###
P values	0.9343	0.0186	0.0040
pNN50			
Before	20.30±7.34	22.75±6.48	20.46±7.90
After	21.35±6.50	17.14±5.36*	28.65±7.26***, ###
P values	0.5948	0.0006	0.0001

Data presented are mean ± SD, The * mark indicates comparison with control group and the # mark indicates comparison with right nostril group. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, ##$P < 0.01$, ###$P < 0.001$. TP = Total power of HRV, LFnu = Low-frequency normalized power, HFnu = High-frequency normalized power, LF-HF = Ratio of low-frequency to high-frequency power, mean RR = Mean heart rate, SDNN = Standard deviation of normal to normal RR interval, RMSSD = Square root of the mean squared differences of successive normal to normal RR intervals, NN50 = The number of interval differences of successive NN intervals greater than 50 ms, pNN50 = The proportion derived by dividing NN50 by the total number of NN intervals

Before practice of 6-week breathing exercise, there was no significant correlation of LF-HF ratio with cardiovascular parameters in both RNB and LNB groups [Table 3]. However, after the practice period, the correlation was significant in both the groups, in which the degree of correlation was more significant in the LNB group for all the parameters [Table 3]. The bivariate logistic regression demonstrated significant prediction of RPP by the LF-HF ratio in both RNB and LNB groups after 6-week practice [Table 4]. However, the degree of prediction was more significant in the LNB group (OR 2.65, CI 1.132-7.657, P = 0.005) compared to the RNB group (OR 1.452, CI 1.095-3.728, P = 0.016).

Discussion

In this study, following 6-week practice of slow nostril breathing, the LF-HF ratio of LNB group was significantly less and of RNB group was significantly more compared to the control group [Table 2] suggesting that there was sympathetic activation in subjects those who practiced right nostril breathing and parasympathetic activation in those who practiced left nostril breathing, as increase in the LF-HF ratio indicates increased sympathetic and decrease in this ratio indicates the increased vagal activity.[24,30] The increased sympathetic activity in the RNB group was further evidenced by increase in LFnu in these subjects compared to the control group and to their own before the practice value, as LFnu represents sympathetic drive to the heart.[24,30] The increased vagal tone in the LNB group was supported by increase in HFnu in these subjects compared to the control group

Table 3: Correlation of LF-HF ratio with basal heart rate (BHR), systolic blood pressure (SBP) and diastolic blood pressure (DBP), mean arterial pressure (MAP) and rate-pressure product (RPP) in subjects of right nostril and left nostril breathing before and after practice of breathing exercises for 6 weeks

	Right nostril breathing group				Left nostril breathing group			
	Before practice		After practice		Before practice		After practice	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
BHR	0.210	0.116	0.278	0.040	0.198	0.120	−0.315	0.012
SBP	0.282	0.062	0.334	0.009	0.266	0.072	−0.382	0.004
DBP	0.258	0.081	0.312	0.018	0.270	0.070	−0.410	0.000
MAP	0.250	0.084	0.320	0.010	0.246	0.088	−0.336	0.009
RPP	0.195	0.128	0.370	0.005	0.184	0.132	−0.456	0.000

The *P* values less than 0.05 was considered significant

Table 4: Logistic regression analysis of rate pressure product (as dependent variable) with LF-HF ratio (as independent variable) in right nostril breathing and left nostril breathing group after 6-week practice of nostril breathing.

	Right nostril breathing group		Left nostril breathing group	
	OR (95% C.I.)	*P* value	OR (95% C.I.)	*P* value
LF-HF ratio	1.452 (1.095 to 3.728)	0.016	2.65 (1.132 to 7.657)	0.005

OR = Odds ratio, $P < 0.05$ considered significant

and to their own before practice value, as HFnu indicates parasympathetic drive of cardiac autonomic control.[24,30] The improvement in vagal tone in the LNB group was further demonstrated by increase in TP and time-domain indices (RMSSD, SDNN, NN50, pNN50) of HRV as TP and time-domain indices in general represent vagal modulation of cardiac functions.[24,30] Further, the BHR of LNB group was significantly decreased compared to their own before practice value and to the values of the control group [Table 1] indicating improvement in vagal tone as resting heart rate is an index of the parasympathetic activity and decrease in the heart rate reflects increased vagal tone.[31] In the RNB group, decrease in TP, HFnu, time-domain indices of HRV and increase in BHR following 6 week-practice of nostril breathing indicate decreased vagal modulation of cardiac activities in subjects those who practiced right nostril breathing.

The exact mechanism of improvement of the vagal activity in the LNB group and sympathetic activity in the RNB group cannot be fully ascertained from this study. It was reported by us earlier that slow breathing exercise increases vagal tone, which was proposed to be due to increased vagal discharge during prolongation of expiration in slow breathing.[12] Normally, the heart rate is more during inspiration due to decreased vagal activity and less during expiration due to increased vagal activity, the phenomenon called physiological sinus arrhythmia.[32] The mechanisms of increased sympathetic activity in RNB subject and increased vagal activity in LNB subjects have not been properly elucidated in previous studies.[16-18] In the yogic system of breathing, the right nostril dominance corresponds to activation of '*Pingala*', the subtle energy channel of yoga, which is related to sympathetic arousal; the left nostril dominance to '*Ida*', which is the representative of parasympathetic activation.[33] The nostril dominance at rest is the natural phenomenon of nasal cycle, which is an ultradian rhythm characterized by alternating patency of the left and right nostrils, with a periodicity of 2-8 h.[34] The variation in cognitive functions has been reported to be associated with nostril dominance.[34] Whereas, yoga one-nostril breathing is the practice of breathing through a particular nostril with other nostril closed,[35] which has been reported to be associated with alteration in autonomic functions.[4] Nevertheless, the scientific mechanisms of difference in autonomic balance in specific nostril breathing need to be evaluated.

The SBP, DBP, and MAP were increased in the RNB group and decreased in the LNB group [Table 1] following 6-week practice of nostril breathing, further suggesting increased sympathetic activity in RNB subjects and decreased sympathetic activity in LNB subjects, as BP control is primarily under the vasoconstrictor tone of sympathetic system.[32] Moreover, BHR and all BP parameters were significantly correlated with the LF-HF ratio after 6-week nostril breathing practice, indicating that alteration in these CV parameters are associated with change in autonomic tone, as the LF-HF ratio is a sensitive measure of sympathovagal balance.[24,30] As the degree of correlation was more significant in the LNB group compared to that of the RNB group, it appears that autonomic control of CV functions through left nostril breathing is stronger than that of right nostril breathing.

Significant decrease in rate-pressure product (RPP) in the LNB group subjects following practice of breathing techniques compared to their own pre-practice value and value of control group and RNB group indicates improvement in resting myocardial performance, as RPP is an indirect measure of myocardial work load and myocardial oxygen utilization.[29] Whereas in the RNB group, the RPP was high indicating that the myocardial work load could be more in subjects practicing RNB. Thus, findings of this study suggests that myocardial performance for the desired cardiac output can be achieved with less oxygen consumption in subjects practicing LNB. Increased resting heart rate and RPP are established markers of CV risks.[29] Therefore, subjects practicing RNB could be at risk of future CV disease. Nevertheless, decreased heart rate and RPP in the LNB group indicates improvement of cardiac function in these subjects. In addition, bivariate logistic regression analysis of RPP with LF-HF ratio demonstrated higher odds ratio and more significant relationship between these two variables after the practice of nostril breathing in the LNB group compared to that of the RNB group [Table 4]. This establishes the direct link of the LF-HF ratio with RPP following practice of nostril breathing. This means, following 6-week practice of nostril breathing, the LF-HF ratio could predict myocardial performance and workload more in the left-nostril group compared to the right-nostril group. In other words, decrease in the LF-HF ratio had direct contribution to decrease in RPP (myocardial stress) in LNB subjects after 6-week practice of breathing exercise. Thus, findings of this study demonstrate improvement of sympathovagal balance with lowering of myocardial workload and oxygen utilization following short-term practice of LNB.

Findings of this study indicate significant alteration in autonomic functions following unilateral nostril breathing. Persistent unilateral nostril breathing due to nasal obstruction is reported to be associated with a number of chronic disorders that occur due to SVI such as migraine, hyperthyroidism, asthma, and cardiac dysfunctions.[36-38] Therefore, future studies should evaluate if improvement in autonomic functions by specific nostril breathing can alleviate such chronic problems, as established by practice of other forms of yoga.[39] In this study, considerable increase in sympathovagal balance following 6-week practice of slow left nostril breathing indicates the profound effects of this breathing pattern on CV functions. Recently, medical students have been reported to have stress of study due to increased demand of learning in medical curriculum,[40,41] which affects their health.[42] CV disorders are associated with sympathovagal imbalance caused by increased level of stress.[8,43] Findings of this study provide evidence that the practice of left nostril breathing may alleviate stress in medical students and reduce their CV risks. Moreover, the students should not be encouraged to practice right nostril breathing as in this study there was increase in sympathetic activity, BP, and RPP in the RNB group.

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