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Immediate autonomic changes during right nostril breathing and left nostril breathing in regular yoga practitioners

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Abstract:

BACKGROUND: The ancient Indian science of Yoga makes use of voluntary regulation of breathing to make respiration rhythmic and calm the mind. This practice is called pranayama. Nadisuddhi pranayama means “purification of subtle energy paths,” inhalation and exhalation are through alternative nostrils for successive respiratory cycles. Surya Anuloma-Viloma pranayama means “heat generating breathing particle” when the respiratory cycle of inhalation and exhalation is completed through the right nostril exclusively. When completed through the left nostril alone, the practice is called “Chandra Anuloma-Viloma pranayama,” which means a heat-dissipating or cooling liberating practice. We compared the effect of right nostril breathing (RNA) and left nostril breathing (LNB) pranayama on heart rate variability.

MATERIALS AND METHODS: The study was conducted at the Department of Physiology at an institute of national importance, after obtaining necessary ethical approvals from the Institutional Ethics Committee. Twenty healthy kriya yogi volunteers (mean age: 44 years), who are regular practitioners for the last 10–20 years, were inducted into the study. RNB pranayama starts with closing the right nostril with the thumb of the left hand followed by exhalation through the right nostril and inhaling slowly through the same nostril. This forms one round of RNB pranayama. In contrast, inhalation through the left nostril and exhalation through the right nostril exclusively is called chandrabhedana pranayama (chandrabhedana means moon-piercing breath in Sanskrit) with a similar variation called Chandra Anuloma-Viloma pranayama in which inhalation, as well as exhalation, is performed through the left nostril exclusively. The recording of electrocardiogram (ECG) for heart rate variability (HRV) analysis was taken by heart rate variability (Dinamika HRV-Advanced Heart Rate Variability Test System, Moscow, Russia). The resting and during readings of heart rate variability parameters were compared and post hoc analysis was done using Bonferroni and Holm multiple comparisons for repeated measures.

RESULTS: Time domain parameters: Standard deviation of normal to normal RR intervals (SDNN) and root mean square of successive NN interval differences (RMSSD) were increased at a high level of statistical significance during both pranayama manoeuvres. Frequency domain parameters: LF, LF/HF ratio increased significantly. Parasympathetic activity is represented by LF when the respiration rate is lower than 7 breaths per min or during taking a deep breath. Thus, when the subject is in a state of relaxation with slow and even breathing in both RNB—right nostril and Chandra—LNB, the LF values can be very high, indicating an increase in parasympathetic activity rather than an increase in sympathetic regulation.

CONCLUSION: Our study is an acute study, where changes in HRV were seen after 5 min of RNB and LNB. However, statistically, there is not much difference in the immediate effects of the two pranayamas on heart rate variability in regular yoga practitioners.

Keywords:

Heart rate variability, left nostril breathing, pranayama, right nostril breathing

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Introduction

Patanjali, the foremost exponent of Yoga, described pranayama as the gradual unforced cessation of breathing. Pranayama is derived from two Sanskrit words—prana (life) and yama (control). Pranayam or control of prana or life force yields heartbeat pulse and mind control. Yoga combines the scientific techniques of right behavior (Yama-Niyama), proper posture (asana), life force control (pranayama), interiorization of the mind (pratyahara), concentration (dhyana), developing intuition (dharma), and Samadhi (ultimate realization).

The ancient Indian science of Yoga makes use of voluntary regulation of breathing to make respiration rhythmic and calm the mind.^[1] This practice is called pranayama. Nadisuddhi pranayama means “purification of subtle energy paths,” inhalation and exhalation are through alternative nostrils for successive respiratory cycles. Right nostril breathing (RNB) Anuloma-Viloma pranayama means “heat generating breathing particle” when the respiratory cycle of inhalation and exhalation is completed through the right nostril exclusively. When completed through the left nostril alone the practice is called “Chandra Anuloma-Viloma pranayama,” which means a heat-dissipating or cooling liberating practice.^[2-5] The effects of breathing through the right nostril, the left nostril, or through both nostrils alternately have been described in a specific yoga text called Swara yoga.^[6] Swara yoga describes the effects of ida (left nostril patency), pingla (right nostril patency), and sushumna (both nostrils patent) on one’s body, mind, and behavior. The text describes favorable acts to be performed when the breath flows through a particular swara or nostril. For example, breathing through the left nostril is believed to have cooling effects and it is mentioned that one should perform acts, which are not vigorous but are spiritually inclined when the left nostril is patent. These include stationary work, construction of a temple or well, consecration of a deity, charity, entry into a newly constructed house, and seed sowing.^[7] It is also mentioned that a person should carry out activities requiring energy when the right nostril is patent because breathing through the right nostril is believed to be heat-generating. The texts mention to carry out activities such as chanting of *vira* mantra (mantra for obtaining vigor and energy), journey, hunting, taming a horse, driving a chariot, and holding a sword.^[7] When prana (breath) flows through both nostrils equally, it is advised to remain silent, become introspective, concentrate the mind on *Iswara* (God), and perform yoga practices.^[7] The effects of these breathing practices as described in Swara yoga texts have only been partially studied in scientific papers and their effects on HRV are scanty. We, therefore, intended to compare the effect of RNB

and left nostril breathing (LNB) pranayama on heart rate variability.

Following are the objective of the study:

- To study and compare the effect of pranayama on time domain and frequency domain parameters of HRV among healthy adults in the three phases of before during and after RNB.
- To study and compare the effect of pranayama on time domain and frequency domain parameters of HRV among healthy adults in the three phases of before during and after LNB.
- To compare the HRV parameters among the adults practicing RNB vs. LNB pranayama.

Materials and Methods

Study design and setting: This is an observational study that was conducted at the Department of Physiology at an institute of national importance. Study participants and samples included 20 healthy Kriya yogi volunteers (male-10, female-10), age- 44 ± 6 years, height- 150 ± 20 cm, and weight- 60 ± 15 kg, who are regular practitioners for the last 10–20 years. The volunteers were allowed to rest for at least 10 min before data acquisition. They were in comfortable clothing. The room temperature was kept in a thermo-neutral zone and silence was maintained during recordings. The pranayama was performed on an empty stomach. The subjects were advised not to hold their breath for uncomfortably long periods, as this causes harmful pressure on the heart, lungs, diaphragm, and arteries. The person with lung diseases, for example, pulmonary TB, interstitial lung disease, lung fibrosis, vertebral deformities such as kyphosis, and scoliosis that cannot hold their breath comfortably for long periods were excluded from the study. *Sample Size:*

We calculated the sample size using the G-power software. Our objective was to compare the effect of two different types of breathing techniques (LNB and RNB) on AFT parameters at three different levels (pre, during, and post) of breathing practice and detect the interaction between them. Time was within the factor variable and breathing techniques were between the factor variable.

Partial eta squared (η^2) is the effect size measure used for the interaction between the within and between variables. We assumed the conventional medium effect size of ($\eta^2 = 0.06$); so, the calculated effect size was ($f = 0.252$).

Therefore, the sample size was calculated with a type-1 error of 5%, power of 90%, and an effect size of 0.252 (medium effect size). The calculated sample size

was 18 and considering non-response and attrition rate of 10%, the final sample size was 20 in each group.

Data collection tools and technique

Procedure for right nostril breathing and left nostril breathing pranayama

RNB pranayama starts with closing the left nostril with the thumb of the left hand, followed by exhalation through the right nostril and inhaling slowly through the same nostril. This forms one round of RNB pranayama. Inhalation was for a count of 25, holding to a count of 12, and exhalation to a count of 25. The rate of counting was 2 per second. So, one round was about 30 s. Heart rate variability was recorded before, during, and after pranayama for 5 min each. Inhalation through the right nostril and exhalation through the left nostril exclusively is called suryabhedana pranayama (suryabhedana means sun-piercing breath in Sanskrit) with a variation called Surya Anuloma-Viloma pranayama, in which inhalation, as well as exhalation, is performed through the right nostril exclusively.

In contrast, inhalation through the left nostril and exhalation through the right nostril exclusively is called chandrabhedana pranayama (chandrabhedana means moon-piercing breath in Sanskrit) with a similar variation called Chandra Anuloma-Viloma pranayama in which inhalation, as well as exhalation, is performed through the left nostril exclusively. LNB pranayama starts with closing the right nostril with the thumb of the right hand, followed by exhalation through the left nostril and inhaling slowly through the same nostril. This forms one round of Chandra nadisuddhi pranayama. Inhalation was for a count of 25, holding to a count of 12, and exhalation to a count of 25. The rate of counting was 2 per second. So, one round was about 30 s. Heart rate variability was recorded before, during, and after pranayama for 5 min each.^[6-8]

Posture: All recordings were done in a sitting position either on a chair or cross-legged on a cushion or mat with spine straight, shoulders back, abdomen drawn comfortably in, chin parallel to the ground.^[1] The eyes were directed to the point between the eyebrows.

Recordings: The deep breathing was done for about 5 min and the recording of ECG was taken and HRV was analyzed by heart rate variability (Dinamika HRV-Advanced Heart Rate Variability Test System, Moscow, Russia). The Dinamika HRV is a novel digital analyzer used to measure HRV by neurodynamic analysis. It measures an electrocardiogram recording with real-time monitoring of functional state indices. The physiological parameters can be assessed within 5 min. The total duration of the recording was 10 min. The subjects who performed RNB performed the same

maneuver after a couple of weeks. The recordings were taken at resting or baseline, during, and after the maneuvers.

The devices used were two electrodes for the wrist and a laptop with the software "Dinamika" mobile HRV unit that is available at the Department of Physiology. The electrodes were placed on the wrist with water or jelly. The baseline record of the subject was taken for 5 min. The following parameters were recorded again after the yogi practitioner completed the meditation session.

Statistical analysis: We used the IBM SPSS-26 software for data analysis. Numerical variables are summarized as mean and standard deviation and relative percentages depending upon distribution. Mixed factor analysis of variance (ANOVA) was used with two independent variables (factors), factor 1 was a type of pranayama (LNB and RNB) and factor 2 was the time or condition of pranayama (pre, during, and post). The various autonomic function and heart rate variability parameters (mean heart rate, SDNN, pNN50, RMSSD, LF, HF, VLF, total power, and LF/HF ratio) were dependent variables. The two main effects were tested, the first being the within subjects' effect, that is, the effect of the condition of pranayama (pre, during, and post), and the other being the between-subjects effect, that is, type of pranayama (LNB vs RNB). An interaction between the type of pranayama and condition was also tested. Post hoc analysis was done using Bonferroni and Holm multiple comparisons for repeated measures. *P* value less than 0.05 was considered a level of significance.

Ethical consideration

The study was conducted after obtaining necessary ethical approvals from Institutional Ethics Committee (IM0247). Informed consent was taken from the participants. Their confidentiality and anonymity were maintained and they were assured that no harm will come to them during RNB/LNB or during the HRV recordings. They also had the free choice to pull out of the study at any time they desired.

Results

As analyzed statistically, there was not much difference between the two pranayamas in their effects on heart rate variability. However, SDNN decreases during RNB pranayama and SDNN increases during LNB pranayama. SDNN reflects all the cyclic components responsible for variability in the period of recording, therefore it represents total variability. RMSSD reflects a parasympathetic system, that is, not affected by respiration increased during both RNB and LNB

pranayamas. The increase however was more during LNB pranayama [Table 1].

Discussion

Pranayamic breathing is a process of continuous, regularity of inhalation, holding of breath, and exhalation. All venous blood is converted to oxygenated blood, giving extraordinary rest to the heart, which is reflected by a decrease in heart rate during both RNB and LNB pranayama from 71.6 to 68.8 and 72.1 to 69.15, respectively [Table 1].

Right nostril yoga breathing has been shown to increase oxygen consumption immediately after 45 min of practice as well as after 1 month.^[9,10] Along with this, RNB also caused an increase in peripheral vasoconstriction, increased systolic blood pressure, and heart rate suggesting sympathetic activation.^[9,10] Similar findings were later reported when the practice of RNB pranayama increased systolic, diastolic, and mean blood pressure.^[11] Chandrabhedana pranayama caused a reduction in systolic and mean blood pressure, whereas Anuloma-Viloma pranayama decreased the systolic and diastolic blood pressure in 20 yoga-experienced individuals.^[12] These findings support the energizing and heat-generating effects of suryabhedana pranayama and the relaxing effects of chandrabhedana pranayama and Anulom Viloma pranayam described in the yoga text. However, in our study as analyzed statistically, there was not much difference between the two pranayamas in their effects on heart rate variability [Table 1]. This may be due to the mechanical effects of breathing rather than the neural reflex activation. All venous blood is converted to oxygenated blood, giving extraordinary rest to the heart, and also due to slow deep breathing, the parasympathetic component of the autonomic nervous system is activated in both pranayamas. RMSSD reflects a parasympathetic system, that is not affected by respiration increased during both RNB and LNB pranayamas [Table 1]. The increase however was more during LNB pranayama supporting partially the old scriptures of Shiva Swarodaya that LNB is more cooling than RNB pranayama.^[7]

Parasympathetic activity is represented by LF when the respiration rate is lower than 7 breaths per min or during taking a deep breath. When the subject is in a state of relaxation during slow and even RNB and LNB, the LF values can be very high indicating an increase in parasympathetic activity rather than an increase in sympathetic regulation [Table 1]. McCraty and Shaffer^[8] have advocated that below 0.1 Hz rhythm (6 breaths in 60 s or $6/60 = 0.1$ Hz), the sympathetic nervous system does not appear to be involved as heart rhythms are

affected by the parasympathetic nervous system. During slow breathing below 8.5 breaths per min, vagal activity can generate oscillations in the LF band. This is related to a link between respiration and heart rate variability. Breathing is slowed to a point, at which resonance occurs between respiration-induced oscillations and heart rate oscillations that naturally occur at this rate. It has been shown that any changes in breathing frequency that almost coincide with spontaneous Mayers wave frequency (6 breaths per min) such as regulated slow breathing or chanting Ave Maria or yoga mantra enhances heart rate variability and Baroreflex sensitivity by synchronizing inherent cardiovascular rhythms.^[13] This may explain the changes such as an increase in heart rate variability components, which occurred during the practice of LNB pranayama when the rate of breathing was slower as reflected by an increase in SDNN from 41.59 to 77.67 [Table 1]. SDNN reflects all the cyclic components responsible for variability during recording; therefore, it represents total variability. In the present study, the LF/HF ratio increased significantly during both RNB and LNB pranayamas, LF, HF power, and their ratios were significantly different during versus pre-states of both types of pranayama, indicating the lasting effect of slow yogic left and RNB maneuver on the cardiovascular autonomic system [Tables 1 and 2].^[14,15]

Apart from the effects on vagal modulation, uninostril breathing practices have been shown to have lateralized effects on the cerebral hemispheres. Earlier studies that were based on electroencephalogram recordings as well as on performance in hemisphere-specific tasks suggested that forced uninostril breathing activates the contralateral cerebral hemisphere.^[16,17] A recent study supported this result with changes in brain hemodynamics that showed brain oxy-hemoglobin levels increased in the left prefrontal cortex during the practice of RNB.^[18] The study also reported a trend of increased oxy-hemoglobin levels in the right prefrontal cortex after the practice of LNB. In another study, RNB and alternate nostril breathing but not LNB improved scores in an attention-related task.^[19] When yoga-based uninostril breathing practices were compared for performance in verbal and spatial tasks in 108 school children, the spatial memory task scores increased after LNB, RNB as well as alternate nostril breathing.^[20] The lateralized effects of suryabhedana pranayam were shown by the recordings of middle latency auditory-evoked potentials. There was an increase in the peak amplitudes of Na wave and Nb wave on the right cerebral hemisphere during suryabhedana pranayama, suggesting better neural allocation at the right cerebral hemisphere.^[21] The increase in the peak amplitude suggested increased recruitment of neural resources at the thalamic medial geniculate and Heschl's gyrus on the right hemisphere during the practice of suryabhedana.^[22]

Table 1: Parameters show heart rate variability before, during, and after right nostril breathing (RNB) vs. left nostril breathing (LNB)

Parameters	Right nostril breathing (n=20)			Left nostril breathing (n=20)			Repeated measures ANOVA			Effect size η ² / Interpretation
	Pre (A)	During (B)	Post (C)	Pre (D)	During (E)	Post (F)	RNB F-value (df 2,57) (P1 value)	LNB F-value (df 2,57) (P2 value)	F-value (Interaction) (df 2,114) (P3 value)	
Mean heart rate (bpm)	71.6±5.04	68.8±5.16	74.15±5.74	72.1±6.33	69.15±5.14	73.85±7.23	23.37 (0.00001)***	23.61 (0.00001)***	0.053 (0.95)	0.00093 (Very small)
SDNN (ms)	50.61±17.06	17.06±15.55	45.82±13.31	41.59±13.66	77.67±17.15	44.25±12.38	42.53 (0.00001)***	46.86 (0.00001)***	0.74 (0.48)	0.013 (small)
pNN50 (%)	19.15±11.42	26.6±11.16	13.9±10.32	17.51±11.41	26.85±10.82	14.4±10.97	21.97 (0.00001)***	14.86 (0.00002)***	0.113 (0.89)	0.002 (very small)
RMSSD (ms)	39.3±10.68	47.38±10.48	34.06±10.60	34.03±12.61	47.28±10.60	33.11±10.71	23.73 (0.00001)***	24.64 (0.00001)***	0.64 (0.53)	0.011 (small)
Total power (ms ²)	2569.7±1716.36	6500±2512.56	1924.9±1028.98	1814.25±1146.02	6172.1±2739.45	1877.35±1380.65	53.81 (0.00001)***	36.38 (0.00001)***	0.36 (0.69)	0.0063 (very small)
HF (ms ²)	605.8±355.55	393.25±257.96	469.9±297.38	474.7±238.65	397.9±173.83	457.05±304.71	5.65 (0.007)**	1.21 (0.31)	0.71 (0.49)	0.012 (small)
LF (ms ²)	826.05±775.66	5191.75±2177.2	612.9±384.84	570.4±669.05	4983.3±2624.02	731.95±1319.46	82.24 (0.00001)***	37.02 (0.00001)***	0.17 (0.84)	0.003 (very small)
VLF (ms ²)	1137.8±1026.5	914.7±709.3	842.3±498.86	769±644.79	790.9±431.02	706.15±403.45	1.07 (0.35)	0.17 (0.84)	0.44 (0.642)	0.0077 (very small)
HF power (nu%)	45.29±18.24	6.74±3.08	42.65±3.08	49.54±17.07	9.02±6.58	46.17±17.34	55.85 (0.00001)***	55.16 (0.00001)***	0.05 (0.9483)	0.00093 (very small)
LF power (nu%)	52.06±16.14	93.18±3.11	56.23±11.94	50.46±17.07	90.38±6.96	74.39±87.66	70.25 (0.00001)***	2.99 (0.062)	0.98 (0.3763)	0.017 (small)
LF/HF ratio	1.78±2.74	16.22±6.66	1.47±0.75	1.45±1.64	14.70±8.55	2.53±4.9107	79.75 (0.00001)***	29.27 (0.00001)***	0.65 (0.5205)	0.011 (small)

Legend - Values are mean±SD (n=20). Abbreviations: SDNN, Standard Deviation of all NN intervals; pNN50, NN50 count divided by the total number of all NN intervals; RMSSD, the square root of the mean of the squares of differences between adjacent NN intervals; HF, High frequency in normalized units; LF, Low frequency in normalized units. P-value: P1 compares - pre and during right nostril breathing values, P2 compares - Pre and post parameters and P3 compares - during and post values. Statistically significant***P<0.001, ** P<0.01, * P<0.05

Table 2: Comparison within groups of RNB and LNB (Pre, during, and post)

Parameters	RNB (n=20)			LNB (n=20)			
	Post hoc test (Bonferroni and Holm multiple comparison)			Post hoc test (Bonferroni and Holm multiple comparison)			
	Difference within groups Bonferroni and Holm T-statistic (P- Bonferroni and Holm)	Pre vs. Post	During vs. Post	Difference between groups F (P)	Pre vs. During	Pre vs. Post	During vs. Post
Mean heart rate (bpm)	5.43 (0.007)**	1.66 (0.31, 0.20)	3.30 (0.01,0.01)**	2.78 (0.07)	1.48 (0.43,0.29)	0.85 (1.19,0.40)	2.33 (0.07,0.07)
SDNN (ms)	29.17 (0.05)*	6.067 (0.01,0.01)**	7.05 (0.01,0.01)**	38.24 (0.05)*	7.84 (0.01,0.01)**	0.57 (1.72,0.57)	7.27 (0.01,0.01)**
pNN50 (%)	6.76 (0.002)**	2.15 (0.11,0.07)	3.66 (0.01,0.01)**	6.72 (0.002)**	2.67 (0.05,0.05)*	0.84 (1.21,0.40)	3.51 (0.01,0.01)**
RMSSD (ms)	8.02 (0.0009)***	2.41 (0.05,0.05)*	3.97 (0.01,0.01)**	9.75 (0.0002)***	3.69 (0.01,0.01)**	0.25 (2.42,0.81)	3.94 (0.01,0.01)**
Total power (ms ²)	35.66 (0.05)*	6.70 (0.01,0.01)**	7.80 (0.01,0.01)**	34.93 (0.05)*	7.29 (0.01,0.01)**	0.10 (2.77,0.92)	7.19 (0.01,0.01)**
HF (ms ²)	2.47 (0.09)	1.19 (0.10,0.10)	0.79 (1.29,0.43)	0.54 (0.59)	0.99 (0.98,0.98)	0.23 (2.45,0.82)	0.76 (1.35,0.90)
LF (ms ²)	72.99 (0.05)*	10.21 (0.01,0.01)**	10.70 (0.01,0.01)**	41.51 (0.05)*	8.02 (0.01,0.01)**	0.26 (2.38,0.79)	7.76 (0.01,0.01)**
VLF (ms ²)	0.79 (0.46)	0.91 (1.10,0.73)	0.29 (2.30,0.76)	0.15 (0.86)	0.14 (2.67,0.89)	0.39 (2.09,1.39)	0.53 (1.80,1.80)
HF Power (nu%)	57.58 (0.05)*	9.61 (0.01,0.01)**	8.95 (0.010,0.01)**	47.67 (0.05)*	8.79 (0.01,0.01)**	0.72 (1.43,0.48)	8.07 (0.01,0.01)**
LF power (nu%)	74.47 (0.05)*	11.08 (0.01,0.01)**	9.96 (0.01,0.01)**	3.03 (0.06)	2.44 (0.05,0.05)*	1.48 (0.43,0.29)	0.96 (1.03,0.34)
LF/HF ratio	81.29 (0.05)*	10.92 (0.01,0.01)**	11.16 (0.01,0.01)**	32.51 (0.05)*	7.26 (0.01,0.01)**	0.60 (1.66,0.55)	6.67 (0.01,0.01)**
LF%	31.59 (0.05)*	22.66 (0.01,0.01)**	20.75 (0.01,0.01)**	258.02 (0.05)*	19.81 (0.01,0.01)**	0.28 (2.35,0.78)	19.53 (0.01,0.01)**
HF%	36.83 (0.05)*	8.25 (0.01,0.01)**	6.17 (0.01,0.01)**	25.22 (0.05)*	6.43 (0.01,0.01)**	0.60 (1.66,0.55)	5.83 (0.01,0.01)**
VLF%	39.94 (0.05)*	7.56 (0.01,0.01)**	7.91 (0.01,0.01)**	46.16 (0.05)*	8.15 (0.01,0.01)**	0.34 (2.21,0.74)	8.49 (0.01,0.01)**

There was no significant difference between before and after (pre-post) of all parameters of heart rate variability but a significant difference exists in effects on HRV before and during (pre-during) and during and after (during-post) in both RNB and LNB pranayamas

Nostril manipulative breathing has also been shown to improve performance in several psychomotor tasks. In 15 yoga practitioners, alternate nostril yoga breathing reduced the time taken to complete a vigilance-related task as an immediate effect along with a simultaneous reduction in systolic and mean arterial blood pressure.^[23] Another study on 50 male volunteers showed improved scores in shape and size discrimination tasks after alternate nostril yoga breathing and decreased state anxiety after breath awareness and quiet sitting.^[24] Similarly, studies reported improved performance in a letter cancellation task after Anuloma-Viloma pranayama as well as increased verbal and spatial memory scores after Anuloma-Viloma pranayama, suryabhedana pranayama, and chandrabhedana pranayama.^[19,25]

The results of another study show that unilateral nostril breathing causes significant changes in autonomic processes. Chronic unilateral nostril breathing secondary to nasal blockage has been linked to a variety of chronic SVI-related diseases, including migraine, hyperthyroidism, asthma, and cardiac dysfunctions. As a result, future research should look at whether improving autonomic functions through specialized nostril breathing might help with chronic conditions, as other kinds of yoga have shown.^[26] The significant rise in sympathovagal balance seen in this study after 6 weeks of slow LNB suggests that this breathing pattern has a substantial impact on cardiovascular (CV) functioning. Medical students have recently been found to be experiencing study stress as a result of the increased demand for learning in the medical curriculum,^[27,28] which has a negative impact on their health. CV diseases are linked to sympathovagal imbalance, which is induced by a high amount of stress.^[29] The findings of this study show that practicing LNB might help medical students feel less stressed and lessen their CV risk. Furthermore, they should not be encouraged to practice RNB because the RNB group had higher sympathetic activity, blood pressure, and RPP.

Normally, the heart pumps, on average, 12 tons or more of blood a day. If a person indulges in restlessness, or worry, or other emotions, he agitates the heart and it beats faster to prepare the individual to face the threat ahead. The heart of a mouse caught in a mousetrap beats at twice its normal rate because of intense fear. The hearts of the calm Napoleon and Duke of Wellington are said to have been beaten only 50 times per min.^[15] The practice of pranayama naturally slows the breathing, which in turn makes the heart calmer and calmer as demonstrated by a statistically significant decrease in heart rate after 5 min of RNB/LNB. The present study explored the acute effect of RNB/LNB on cardiac oscillations; we observed

that slow deep breathing with a frequency of less than 6 BPM increases the variability in heart rate, which is reflected in both the time domain and frequency domain parameters of HRV. SDNN is the most representative parameter of HRV. During yogic breathing, the SDNN increased to a high normal of 99.^[15] This is an indicator that ANS regulating function and stress-coping ability is good. In our study, breath-holding leads to activation of both cardiac sympathetic and parasympathetic simultaneously.^[15] RMSSD, an index of activity of the parasympathetic arm of autonomic regulation, increased at a high level of statistical significance. Though with resting spontaneous breathing, HF power represents the parasympathetic influence, if the breathing rate is below 8.5 BPM these can generate oscillations in the LF band thereby increasing the LF power. Low frequency is a band of power spectrum between 0.04 and 0.15 Hz. This measure is a strong indicator of sympathetic activity but reflects both parasympathetic and sympathetic activity. As the respiratory rate achieved was less than 5 BPM in all volunteers, we found a more than a 10-time increase in LF power as compared to the insignificant increase in LF power, indicating an increase in parasympathetic activity rather than an increase in sympathetic regulation. The RNB/LNB maneuver in the present study involved breath-holding after deep inspiration, which can have a mechanical effect on the heart via direct influence on SA node activity. Also, breath holding may have increased the end-tidal CO₂ levels, thereby influencing the central command to the heart. In five patients, the resting HF value was very high and their values dropped during RNB/LNB. The possible underlying mechanism could be, initially, decreased vagal tone with increased heart rate, and sympathovagal balance during RNB/LNB may be due to conscious efforts to keep the count of breathing the same during inhalation, holding, and exhalation.^[15] During yoga, up-regulation of both autonomic activities may occur. This notion is supported by the view that sympathetic and parasympathetic branches do not always act reciprocally but may act synergistically and complementarily.^[15]

Slow breathing during RNB and LNB increases the baroreceptor sensitivity. When BP tends to increase, the baroreceptor reflex increases vagal and decreases sympathetic outflow to the SA and AV node. These help to decrease heart rate as were seen in our study. The increased LF power during RNB/LNB may be because of the mechanical effect of breathing, which gives a false rise in the sympathetic tone. Various studies have found an increase in amplitudes of blood pressure oscillations and HRV during slow breathing. This is particularly significant at a respiration rate of 6 breaths per min (0.1 Hz). This may explain the changes in the increase in heart rate and heart rate variability components, which occurred during the practice of

RNB/LNB practice when the rate of breathing was slower. In the present study, the LF/HF ratio increased significantly during RNB/LNB, LF, HF power, and their ratios were significantly different during RNB/LNB versus pre-RNB/LNB, indicating the lasting effect of slow yogic breathing maneuver on the cardiovascular autonomic system.^[15]

Limitations and recommendations

Ours is an acute study, where changes in HRV were seen after 5 min of RNB and LNB. The changes were not different regarding whether left or right nostril was used exclusively for breathing. However, ancient texts and scientists have seen a predominant vagal effect in parasympathetic dominance in LNB and sympathetic dominance in RNB for 6 weeks. For example, breathing through the left nostril is believed to have cooling effects and it is mentioned that one should perform acts, which are not vigorous; however, are spiritually inclined when the left nostril is patent. These include stationary work, construction of a temple or well, consecration of a deity, charity, entry into a newly constructed house, and seed sowing. It is also mentioned that a person should carry out activities requiring energy when the right nostril is patent because breathing through the right nostril is believed to be heat-generating. The texts mention to carry out activities such as chanting of vira mantra (mantra for obtaining vigor and energy), journey, hunting, taming a horse, driving a chariot, and holding a sword. When prana (breath) flows through both the nostrils equally, it is advised to remain silent, become introspective, concentrate the mind on Iswara (God), and perform yoga practices. Both RNB and LNB may be used to give extraordinary rest to the heart and is conducive to longevity.

The need for doing an extended study for at least 6 weeks is essential and recommended in the future to validate the ancient texts on the long-term effects of RNB and LNB. Our limitation is also that other autonomic functions such as cold pressor test, handgrip dynamometer, and 30:15 ratio of RR interval during RNB/LNB be measured in non-yoga practitioners and patients with hypertension. It is recommended that RNB and LNB be practiced regularly as it is conducive for longevity.

Conclusion

The practice of pranayama naturally slows the breathing, which in turn makes the heart calmer and calmer as demonstrated by a statistically significant decrease in the heart rate during 5 min of both RNB and LNB. In healthy individuals, the respiratory frequency is resonant with cardiac oscillations. The present research found an increased LF power of HRV during RNB and LNB, which might be due to the mechanical effect of

respiration. Simultaneously, the increased time-domain parameters and diminished HF power produce transient, rapid excitation of cardiovascular autonomic centers due to respiratory modulation. These may be vagally mediated and predominantly brought about by central non-baroreflex mechanisms. Transient and rapid excitation of the cardiovascular system during RNB and LNB suggests that slow yogic breathing may serve as a physiologic method to draw upon cardiovagal reserve. This shows that this may beneficially affect cardiovascular autonomic regulation in health and various cardiovascular diseases.^[15]

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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