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Original Research Article

Effect of Deep Breathing Exercise on Heart Rate Variability in Young Adults –Randomised Controlled Trial

Chauhan Nirupama[1], Sharma Meenakshi[2], Soni Ramesh[3], Rinki Hada[4], Gupta Chaya[5]

[1,2,3,4,5]**Department of Physiology, SMS Medical College, Jaipur, Rajasthan, India**

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Corresponding author: Dr. Chauhan Nirupama
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Abstract

Introduction: Breathing affects our respiratory, cardiovascular, neurological, gastrointestinal, muscular, and psychological wellbeing. Breathing also influences our sleep, memory, and concentration ability to and plays an important role in improving our energy level. To study the effect of deep breathing exercise on heart rate variability of Pranayama, most known as deep breathing exercises, is a compound word with Pran and Ayama. The increase in HRV may be since the reduction in breathing frequency caused by the breathing training allows the respiration to modulate the sympathetic cardiac outflow along with the vagal outflow which result in increased HRV. There are no known studies reported the heart rate variability (HRV) changes either during or after the practice of Bhramari Pranayama. Hence, this study aims at evaluating the HRV changes during and after the practice.

Materials and Methods: Thirty healthy volunteers with the mean ± standard deviation age of 23.50 ± 3.01 years was recruited. All the subjects performed Bhramari pranayama for the duration of 5 min. Thirty healthy volunteers were taken as controls without intervention. Assessments were taken before, during, and immediately after the practice of pranayama. Statistical analysis was performed using students paired samples *t*-test, Wilcoxon signed-ranks test and repeated measures of analysis of variance and *Post-hoc* analysis with Bonferroni adjustment for multiple comparisons.

Results: Results of this study showed a significant decrease in HR and low frequency spectrum of HRV and a significant increase in high frequency spectrum of HRV during the practice of Bhramari which revert to normal after the practice.

Conclusion: Results of this study suggests that there might be a parasympathetic dominance during the practice of Bhramari. However, further studies are required to warrant the findings of this study.

Keywords: Bhramari pranayama, blood pressure, heart rate variability

Introduction

Yoga is an ancient Indian science as well as the way of life, which includes the practice of specific posture (asana) and regulated breathing (pranayama). Pranayama is one of the most important yogic practices.[1] Different types of pranayama were reported to produce different cardiovascular [2] and autonomic responses [3] in healthy individuals.[2,3]

Bhramari pranayama (humming bee breath) is one of the common pranayama practice, which involves inhaling through both nostrils and while exhaling produce sound of humming bee. [1]

There are several methods available to measure cardiac autonomic nervous system, of which heart rate variability (HRV) has been established as a noninvasive tool. Classical spectral analysis of HRV signals distinguishes sympathetic from the parasympathetic activity. [5]

Heart rate variability (HRV) is a popular research tool for assessing cardiac autonomic nervous system (ANS).Heart rate variability (HRV), a non-invasive predictive and prognostic cardiac autonomic modulation marker, is extensively studied in exercise science for exploring the acute and training effects of exercise on cardiac autonomic modulation.[8] Initial parasympathetic withdrawal (indicated by decrease in HF component of HRV and tachycardia) and delayed sympathetic activation (indicated by increase in LF component (equivocal), blood pressure, cardiac output, heart rate, etc.) are fairly established observations of acute autonomic modulation

In general, the human system is not designed to always breathe deeply and in all situations. Though deep breathing is considered as an advantageous method, it can be practiced only as a regulated exercise. Pranayama, most known as deep breathing exercises, is a compound word with Pran and Ayama. Pran means breathing or respiration and Ayama means extension or expansion. Thus, Pranayama means extension of breath or life span. During pranayama the mind must concentrate on breathing process. Pranayama or cooling breath [14]. Sama Vritti or Equal Breathing [5] Ujjayi Pranayama or ocean breath [6] Skull Shining Breath or Kapalabhati Pranayama [7] Abdominal Breathing Technique [8] Bhramari Pranayama or breathing with humming sound [9]. Cardiovascular diseases are the leading cause of death globally. It also increases the morbidity. By early detection and treatment, we can prevent the progress of cardio vascular disorders.

Heart rate (HR) exhibits an oscillatory pattern in synchrony with the respiratory cycle, which is denominated respiratory sinus arrhythmia (RSA) [15-17]. During inspiration, the HR increase is largely due to withdrawal of the parasympathetic activity on the sinus node. During expiration, the parasympathetic resumes activity and HR decreases [15]. Heart rate variability (HRV) has come to be widely used as a noninvasive tool to assess autonomic function in a variety of physiologic as well as disease states. Heart rate variability (HRV), the beat-to-beat variation in either heart rate or the duration of the R-R interval, has become a popular clinical and investigational tool [18-20].

A reduced HRV is associated with a poorer prognosis for a wide range of clinical conditions while, conversely, robust periodic changes in R–R interval are often a hallmark of health [21]. Although HRV and RSA are not quite the same, these terms are often used interchangeably, and both are widely believed to reflect changes in cardiac autonomic regulation [22]. Heart rate variability is the analysis of the cardiac autonomic regulation through quantification of sinus rhythm variability.

Materials and Methods

Randomized interventional study group includes undergraduate students, post graduate students, staff members of SMS Medical College.

Inclusion criteria

- Healthy volunteers.
- Both males & females.

- In the age group of 18 to 30 years.

Exclusion criteria

- Smokers, alcoholics, obese persons.
- Known case of Diabetes Mellitus, Hypertension, Cardiovascular disorders, Respiratory problems, psychological disorders, Neurological diseases & Cerebro vascular illness.
- Subjects practicing regular Exercise, Yoga, Meditation.
- Taking medications affecting Autonomic Function Tests.

Study group

This study was performed in Department of Physiology, SMS Medical College Jaipur sixty healthy volunteers were included. They were divided into 2 groups.

Group I

Thirty normal healthy volunteers in the age group of 18 to 30 years includes both Males & Females doing practising pranayama

Group II

Thirty normal healthy volunteers in the age group of 18 to 30 years includes both Males & Females not practising pranayama

Study protocol

Ethical committee clearance was obtained from Institutional ethical committee. Written informed consent was taken from the subjects after explaining them about the whole procedure and the tests involved. Bhramari Pranayama or slow deep breathing exercise was taught to 30 volunteers.

Prerequisites

The subjects were asked to avoid exercise, heavy physical activity (running, playing outdoor games, weightlifting) the previous day & on the day of the test. They were asked to come the previous day of the test to the department & they were given clear instructions. They were asked to have a light meal and come to lab 2 hours after light meal. They were asked to report to the Research Laboratory in the department of Physiology at 8.30am.

Methodology

Questionnaire was given to all the subjects. Family history (parental H/O DM, HT, CAD), Personal H/O (Smoker, Alcoholics), H/O Drug intake were recorded through questionaire. Anthropometric measurements namely Height and Weight was measured followed by resting HR and BP. The BMI was calculated as the weight in kilograms divided by the square of the height in meters (weight (kg) /height (m^2)). The subjects were asked to empty the urinary bladder. They were asked to lie down on the couch and adviced to rest and relax; Watch, bracelets, metallic objects& mobile phones were removed from their body to prevent interference with the datas. Heart Rate Variability was measured by using POWERLAB PRO.

Sample size

The sample size for this study was calculated based on the anticipatory mean difference of 3 with standard deviation 9, alpha error of 0.05, power of 0.8 and the effect size of 0.3, which makes up 30 (each group).

Statistical analysis

Data is expressed as mean ± standard deviation (SD). Comparison of mean difference in between the group was done using independent t test and intra-group comparison was done using paired t-test. Significant level was set at $P < 0.05$.

Table 1: Indicates baseline parameters among two groups. Equal distribution of Height, Weight, BMI, Heart rate, Systolic blood pressure, Diastolic blood pressure seen between two age groups.

Parameters	Group I	Group II
Age(years)	23 ± 0.78	24.40 ± 2.92
Height (cm)	162 ± 10.20	162.84 ± 8.16
Weight (kg)	62 ± 13.78	66.76 ± 10.99
BMI	24.18 ± 3.76	25.17 ± 3.82
HR (beats/min)	87.04 ± 12.40	84.44 ± 13.52
SBP (mmHg)	110.04 ± 13.10	109.92 ± 13.83
DBP (mmHg)	72.48 ± 10.14	74.04 ± 8.51

Table 2: Comparison of time domain and frequency domain parameters between yoga breathing group and no intervention control group.

	Group with intervention			**Group without intervention**	
	Before	**After 3 months**	**Δ Value**	**Before**	**After 3 months**
Time domain variable					
HR (bpm)	75.28 ± 4.26	70.73 ± 5.29***	−4.55 ± 1.40	74.22 ± 6.05	75.18 ± 5.65
R-R (msec)	740.05 ± 53.19	779.98 ± 61.55***	39.93 ± 8.34	763.79 ± 48.98	750.57 ± 57.53
SDNN (sec)	81.03 ± 10.14	89.06 ± 14.83**	8.03 ± 1.90	80.05 ± 12.71	77.82 ± 12.32
RMSDD (sec)	60.91 ± 13.50	63.05 ± 16.93***	2.13 ± 0.34	59.78 ± 14.27	57.06 ± 13.03
NN 50 (count)	27.29 ± 10.16	30.68 ± 11.02***	3.38 ± 0.45	27.33 ± 10.58	25.70 ± 11.06
pNN 50 (%)	12.20 ± 4.17	14.59 ± 7.08***	2.39 ± 0.93	12.77 ± 4.21	11.68 ± 4.08**
Frequency domain variable					
LF (n.u)	66.06 ± 11.67	58.02 ± 12.29***	−4.87 ± 0.91	64.95 ± 11.66	63.86 ± 11.37***
HF (n.u)	41.08 ± 9.01	46.87 ± 11.22**	6.14 ± 1.20	41.05 ± 8.88	40.72 ± 8.95

		*			
LF/HF Ratio	1.63 ± 0.42	1.33 ± 0.40***	−0.21 ± 0.02	1.71 ± 0.44	2.26 ± 0.55***

Data are represented in the mean ± SD (standard deviation). Δ (Delta), changes between before and 3-months after treatment.

HF, high-frequency power; HR, heart rate; LF, low-frequency power; LF/HF, ratio of low frequency to high-frequency power; NN50, number of pairs of adjacent NN intervals differing by more than 50 ms in the entire recording; n.u, normalized unit; pNN50, percentage of absolute differences between successive normal RR intervals that exceed 50 ms; RR, normal-to-normal interval; RMSSD, root-mean-square of the successive normal sinus RR interval difference; SDNN, the standard deviation of the normal-normal interval. *$p < 0.05$, **$P < 0.01$, ***$p < 0.001$ compared with before and after 3 months.

Discussion

In our study, though not statistically significant we observed a decrease in SBP, DBP and basal HR, in both the groups after practicing deep breathing exercise for 3 months indicating sympathetic inhibition. This is in par with the study done by Roberts et al. where they have observed a reduction in systolic and diastolic BP after practicing slow deep breathing exercise at the rate of 6 BPM for 4 weeks [23-24]. In a study done by Cuttle et al. it was found that deep breathing exercise when practiced for 10 minutes daily for 3 months reduces stress and promotes calmness thereby decreasing sympathetic activity and increasing para sympathetic activity. Also, deep breathing at rate of 6 breaths per minute increases baro reflex sensitivity and reduces sympathetic activity and chemo reflex activation which produces reduction in SBP and DBP [25]. It is possible that Deep breathing bring about withdrawal of sympathetic tone in skeletal muscle blood vessels exercise when practiced, this may lead to widespread vasodilatation, thus causing decrease in peripheral resistance in turn decreases the DBP. The decrease in SBP may be due to increased vagal tone and decreased sympathetic activity as suggested by Westbrook et al. [30]. In our study, we measured both time domain and frequency domain parameters. However, for short term HRV, Frequency domain parameters reflect autonomic functions. Time domain parameters are better commented on long term or 24 hours ECG acquisition.

The HF value was significantly increased in group1 after 3 months of practicing deep breathing exercise indicating an increase in the parasympathetic activity. LF/HF Ratio value was significantly decreased in group 1 after 3 months of practicing deep breathing exercise. This is in par with the study done by Siegelbaum et al. where they found that simple deep slow breathing exercise, without any associated yogic practices, when practised for short term of one month duration, increased the HF and decreased the LF values [26].

In a study done by Westbrook et al. [27] again it was reported that slow deep breathing exercise when practiced for a month reduces blood pressure and increases heart rate variability in young healthy adults. The increase in HRV may be since the reduction in breathing frequency caused by the breathing training allows the respiration to modulate the sympathetic cardiac outflow along with the vagal outflow which result in increased HRV. In a study done by Pal et al, it was found that practicing slow deep breathing exercise for 3 months increases the parasympathetic dominance whereas practicing fast deep breathing exercise for same duration does not have this effect on HRV. This supports the fact that slow deep breathing exercise modulates the sympathetic and vagal outflow which results in increase in HRV [28].

It was also postulated by Matsumoto et al that voluntary slow deep breathing functionally resets the autonomic nervous system by means of two ways. (i) Pranayama increases frequency and duration of inhibitory neural impulses by activating stretch receptors of the lungs during above tidal volume inhalation (as seen in the Hering Breuer's reflex). Further Pranayama improves the generation of hyperpolarization current by stretch of connective tissue (fibroblasts) localized around the lungs. It is found that an inhibitory impulse, which is produced by slowly adapting receptors (SARs) in the lungs during inflation [29], play a role in controlling autonomic functions such as breathing pattern, airway smooth muscle tone, systemic vascular resistance, and heart rate . Stretches of connective tissue fibroblasts are capable to affect the membrane potential of nervous tissue. Both hyperpolarization and inhibitory impulses which is produced by stretch of neural and non-neural tissue of the lungs are the likely agents of autonomic shift during pranayamic breathing. Inhibitory current synchronizes rhythmic cellular activity between the cardiopulmonary center and the central nervous systems. Inhibitory current regulates excitability of nervous tissues. It is known to elicit synchronization of neural elements which typically is indicative of a state of relaxation [29]. Synchronization which occurs within the hypothalamus and the brainstem is responsible for inducing the parasympathetic response during breathing exercises.[31]

In our study we have asked the subject to practice deep breathing for 6 months which is a long duration. In our study we found that improvement in parasympathetic activity as indicated by an increase in HF value and increase in HRV This change may be due to increase in the elasticity of the lungs. Because deep breathing exercise reduces the respiratory rate and increases the inspiratory flow rate. It may result in increase in gas exchange. Hence there is reduction oxygen consumption and workload done by heart [32].

Conclusion

Therefore, we can conclude that, there was increase in HRV, that is predominance of parasympathetic tone at the end of three months, after practicing of slow deep breathing exercise for ten minutes daily for the duration of three months.

Ethical Approval

The study was approved by the Institutional Ethics Committee.

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