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Physiology Section

# Effect of Different Pranayamas on Respiratory Sinus Arrhythmia

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## ABSTRACT

**Introduction:** Respiratory Sinus Arrhythmia (RSA) is the differential change of Heart Rate (HR) in response to inspiration and expiration. This is a noninvasive sensitive index of parasympathetic cardiac control.

**Aim:** To evaluate changes in RSA by utilizing a simple and cost-effective analysis of electrocardiographic (ECG) tracings obtained during performance of four pranayama techniques.

**Materials and Methods:** Fifty two trained volunteers performed the following pranayamas with different ratios for inspiration and expiration: sukha (1:1), traditional (1:2), pranava (1:3) and savitri (2:1:2:1) and ECG was recorded while performing the techniques with rest period of 5 minutes in-between. HR was calculated and maximum HR during inspiration ($I_{max}$), minimum HR during expiration ($E_{min}$), differences between $I_{max}$ and Emin (Δ), percentage differences between $I^{max}$ and $E_{min}$ (Δ%) and expiration: inspiration ratio (E:I) calculated by respective formulae. Statistical analysis was carried out using repeated measures of ANOVA with Tukey-Kramer multiple comparisons test.

**Results:** There were significant differences between groups in all five aspects namely: p= 0.0093 for mean $I_{max}$, p = 0.0009 for mean $E_{min}$, and p < 0.0001 for Δ HR (I-E), Δ% HR (I-E) and E:I ratio. Pranava pranayama produced the greatest changes in all five comparisons.

**Conclusion:** We suggest that further short and long term studies be undertaken with pranava pranayama in patients to further qualitatively and quantitatively evaluate inherent mechanisms of this simple technique. Addition of these cost-effective techniques to the medical armory will help patients of rhythm disorders and other cardiovascular conditions.

**Keywords:** Yoga, ECG, Cardiovascular, Heart rate

## INTRODUCTION

One of the discernable benefits of repeated regular yoga practice is the attainment of healthy life. It has been observed that yoga practitioners are physically and mentally healthier and have better coping skills in comparison to normal population [1]. It is the responsibility of researchers to explore various techniques of yoga in a scientific manner as they are inexpensive, effective and easily administrable. Such an approach will enhance the possibilities of our achieving best possible states of physical, mental, spiritual and social health. Yoga has been documented to facilitate better neuro-effector communication, improve strength, and enhance optimum functioning of all organ-systems while increasing resistance against stress and diseases with resultant tranquility, balance, positive attitude and equanimity [2-4].

Jerath et al., have suggested that practice of yogic breathing techniques (pranayama) can help reduce the oxygen consumption as well as the heart rate (HR) and blood pressure (BP) [5]. They postulated that slow deep breathing may rest the autonomic nervous system while synchronizing peripheral (heart and lungs) and central neuronal connections (limbic system and cortex).

Slow deep breathing is known to have harmonizing effect on autonomic tone and studies have reported that it evokes short-term plasticity of cardiorespiratory coupling [6]. In an earlier work we found that sukha pranayama at a rate of 6 bpm reduces HR and BP in hypertensive patients within 5 minutes of practice by normalizing autonomic cardiovascular rhythms as a result of increased vagal modulation and/or decreased sympathetic activity and improved baroreflex sensitivity [7].

Respiratory sinus arrhythmia (RSA) is a noninvasive sensitive index of parasympathetic cardiac control. It is based on variation of HR with respiration wherein inspiration increases HR while expiration decreases it. Factors modulating RSA are known to be the respiratory rate, tidal volume as also the expiratory/inspiratory time ratio [8]. The inspiration/expiration ratio may significantly influence heart rate asymmetry thus playing a role in cardiovascular regulation and health [9].

Different pranayamas of the yoga tradition utilize different ratios of inspiration and expiration and claim differential benefits of such techniques [10]. We postulated that pranayamas with differing ratios of inspiration and expiration may produce differing effects on HR and RSA in healthy volunteers.

## AIM

Hence, this study was undertaken to evaluate such changes utilizing a simple and cost-effective analysis of electrocardiographic (ECG) tracings obtained during performance of four pranayama techniques.

## MATERIALS AND METHODS

The present cross-sectional study was conducted at the Centre for Yoga therapy Education and Research (CYTER), Mahatma Gandhi Medical College and Research Institute, Puducherry, India. It was done in April and May 2015 as part of a larger study on the effects of yoga training in nursing students for which ethical clearance had been obtained from Institutional Human Ethics Committee. Fifty two volunteers (35 female, 17 male), aged 25.85 ± 11.17 (SD) years, with body mass index of 22.36 ± 12.93 (SD) attending regular yoga training at CYTER were recruited for the study by convenience sampling.

Four yogic breathing techniques (pranayama) utilizing different ratios for inspiration and expiration were selected and as the subjects were already receiving biweekly yoga training, they were well conversant with them. The following breathing techniques detailed by Swami

Gitananda Giri [10] were used in the present study:

i. Breathing in for a count of four followed by breathing out for a count of four (1:1 ratio) as done in sukha pranayama,

ii. Breathing in for a count of four followed by breathing out for a count of eight (1:2 ratio) in traditional pranayama pattern,

iii. Breathing in for a count of four followed by breathing out for a count of twelve (1:3 ratio) while making the audible sound of aaa-uuu-mmm as done in pranava pranayama, and

iv. Savitri pranayama was performed by breathing in for a count of four holding in for count of two, breathing out for a count of four and holding out for count of two (with a ratio of 2:1:2:1).

All recordings were carried out in CYTER lab between 10 am and 12 noon, 2 hour after a light breakfast and after emptying bladder. The environment was quiet, with a comfortable temperature and subdued lighting. The subjects were briefed about the study protocol and written informed consent was obtained from them.

The subjects were randomized into four groups of 13 each. Each group performed the four breathing techniques in a different sequence in order to neutralize any 'carry over' effect from the performance of the earlier techniques.

- Group 1:Sukha → Traditional → Pranav → Savitri
- Group 2: Savitri → Pranava → Traditional → Sukha
- Group 3: Pranava → Traditional → Sukha → Savitri
- Group 4:Traditional → Sukha → Savitri → Pranava

Prior instruction and adequate demonstration of the techniques and procedure were given before starting recordings. Subjects were seated comfortably in a semi reclining chair and instructed to breath slowly and deeply to their maximum capacity. One of the investigators provided an audible count at the rate of one count/second to provide guidance to the subject on inspiration and expiration throughout the period of study.

VESTA 101 Single Channel ECG (Recorders & Medicare Systems, Panchkula) was used for the study and after connecting limb leads, the subjects were asked to perform four rounds of each technique in the order assigned for their group. The first two rounds were dummy rounds and then ECG was recorded during 3rd and 4th rounds. A rest period of five minutes was given between each of the techniques so as to avoid the influence of the preceding one on the succeeding one.

HR was calculated by taking average of two shortest and two longest RR intervals obtained from Lead I of the ECG during inspiration and expiration phases respectively. These values were entered in excel sheet and maximum HR during inspiration ($I_{max}$), minimum HR during expiration ($E_{min}$), differences between $I_{max}$ and $E_{min}$ (Δ), percentage differences between $I_{max}$ and $E_{min}$ (Δ%) and expiration: inspiration ratio (E:I) calculated by respective formulae.

## STATISTICAL ANALYSIS

After obtaining the study data, it was statistically analyzed using Graph Pad In Stat version 3.06 for Windows 95, (Graph Pad Software, San Diego California USA, www.graphpad.com). All data passed normality testing by Kolmogorov-Smirnov Test and hence further analysis was done using repeated measures of ANOVA followed by Tukey-Kramer multiple comparisons test between groups.

## RESULTS

The results are given in [Table/Fig-1]. Statistical analysis by repeated measures of ANOVA revealed significant differences between the groups in all five aspects namely: p= 0.0093 for mean $I_{max}$, p = 0.0009 for mean $E_{min}$, and p < 0.0001 for Δ HR (I-E), Δ% HR (I-E) and E:I ratio.

| | Sukha pranayama | Traditional pattern | Pranava pranayama | Savitri pranayama | p-value |
|---|---|---|---|---|---|
| Mean $I_{max}$ | 83.93 ± 11.00 | 85.06 ± 11.05 | 87.27 ± 11.78** | 85.23 ± 12.51 | 0.0093 |
| Mean $E_{min}$ | 69.64 ± 8.72 | 68.41 ± 10.61 | 66.19 ± 11.24 *** ^ | 68.94 ± 10.83 | 0.0009 |
| Δ | 14.29 ± 7.26 | 16.65 ± 7.12 | 21.08 ± 7.49 ***^^^ψψψ | 16.29 ± 6.42 | < 0.0001 |
| Δ% | 16.61 ± 7.54 | 19.47 ± 8.03 # | 24.12 ± 7.79 ***^^^ψψψ | 18.91 ± 6.65 | < 0.0001 |
| E:I | 1.21 ± 0.11 | 1.25 ± 0.12 # | 1.33 ± 0.14 ***^^^ψψψ | 1.24 ± 0.11 | < 0.0001 |

**[Table/Fig-1]:** Mean of maximum heart rate during inspiration($I_{max}$), mean of minimum heart rate during expiration ($E_{min}$), differences between mean $I_{max}$ and mean $E_{min}$(Δ),% differences between mean $I_{max}$ and mean $E_{min}$(Δ%) and expiration: inspiration ratio (E:I) in 52 subjects while performing sukha (1:1 ratio), traditional pattern (1:2 ratio), pranava (1:3 ratio) and savitri (2:1:2:1 ratio) pranayamas.
Values are given as mean±SD. p-values are given for intergroup compassions done by repeated measures of analysis of variance with Tukey-Kramer Multiple Comparisons Test (TKMCT).
**p<0.01 and ***p<0.001 for pranava versus sukha.
^p<0.05 and ^^^p<0.001 for pranava versus savitri
ψψψp<0.001 for pranava versus traditional pattern.
#p<0.05 for sukha vs traditional pattern.

Pranava pranayama produced the greatest changes in all five comparisons and the differences between pranava and sukha in mean $I_{max}$ was significant (p< 0.01) while it was highly significant (p< 0.0001) for mean $E_{min}$, Δ HR, Δ% HR and E:I ratio.

The differences between pranava and savitri in mean $E_{min}$ was significant (p< 0.05) while it was highly significant (p< 0.0001) for Δ HR, Δ % HR and E:I ratio. Δ HR, Δ % HR and E:I ratio comparisons between traditional pattern and pranava were highly significant (p< 0.0001) while Δ % HR and E:I ratio differences between traditional pattern and sukha were also significant (p< 0.05).

## DISCUSSION

Our results give evidence of the differential effects of pranayamas performed with different ratios for inspiration and expiration. Though the duration of inspiration was constant in all four techniques, modifications induced by changing the duration of expiration produced changes that are in agreement with previous reports on pranayama and paced breathing [5,8,11-14].

Increased $I_{max}$, decreased $E_{min}$ and greater changes in Δ and Δ% are indicative of greater RSA in the traditional ratio, Pranava and Savitri pranayamas as compared to sukha ratio of 1:1 that may be considered a control for inter group comparisons. The traditional ratio of 1:2 produced greater changes than 1:1 breathing of the sukha variety thus showing that there may be greater vagal activity when the expiration is doubled. Such changes are usually attributed to influence respiratory centre and/or pulmonary stretch receptors on vagal control of the heart.

Jerath et al., postulated that pranayama induces hyperpolarizing currents that propagate through both neural and non-neural tissue and synchronize neural elements in heart, lungs, limbic system and cortex [5]. As all the pranayamas in our study were done with same duration of inspiration it is plausible that these effects were meditated more by changes in the respiratory centre rather than the pulmonary stretch receptors. When performing pranayama, there is a conscious change from normal breathing (with passive expiratory effort) to a more consciously controlled expiration. This may be enabling higher centers to override vagal inhibitory actions of respiratory centre while stimulating the post inspiratory ones that allow vagal activity to manifest. Though duration of respiration in both traditional pattern and savitri pranayama is same (12 s), savitri doesn't seem to produce this effect and this may be because both expiration and inspiration are of equal duration in savitri. This is further corroborated by the earlier report by Telles and Desiraju that short kumbhak type of pranayamas may not cause a change in the mean HR [12].

The greatest changes were seen in the performance of pranava where all comparisons were significantly greater than the other three pranayama ratios. The greater changes in RSA and E:I ratio produced in pranava signify greater role of the parasympathetic vagal activity that could be attributed to many factors.

Earlier studies on immediate effects of pranava pranayama in patients of hypertension (HT) and in patients with concomitant diabetes mellitus reported healthy reductions in cardiovascular parameters and derived indices within five minutes [15,16]. This was attributed to a normalization of autonomic cardiovascular rhythms brought about by increased vagal modulation and/or decreased sympathetic activity along with augmented endogenous nitric oxide production. It was also hypothesized that prolonged exhalation may be inducing mild valsalva like effect with decreased pre-load. It was suggested that prolonged, audible chanting of pranava can improve the baroreflex sensitivity as well as normalize autonomic cardiovascular rhythms [15,16]. The present study gives further evidence of enhanced parasympathetic (vagal) activity induced by pranava pranayama as evidenced by changes in $\Delta$, $\Delta\%$ and E:I that were highly significant ($p<0.0001$) as compared to other techniques. These changes may also be attributed to short-term plasticity of cardiorespiratory coupling since a previous study on the effects of slow deep breathing concluded that pranayama may strengthen such coupling and evoke short-term plasticity in a subset of individuals [6].

A few studies have suggested the role of pranayama in prevention and management of cardiovascular rhythm conditions. Pranayama has been shown to significantly reduce indices of ventricular repolarization dispersion in patients with arrhythmia [17], frequency of benign ventricular ectopics [18], and frequency of premature ventricular complexes [19].

## LIMITATION

Our study is limited by the fact that we couldn't do real time HRV analysis or beat to beat BP monitoring that would have given some more extensive data on the effects of the pranayama practices on cardiac autonomic tone. We also had to adopt the convenient sampling method rather than randomized controlled method due to local logistical reasons.

## CONCLUSION

Our study gives evidence that pranayamas performed with differing ratios of inspiration and expiration produce differential effects on HR and RSA that may be attributed to enhanced vagal activity due to conscious changes in higher centers that override the lower respiratory centre in the brain stem. Pranava pranayama produced greatest changes in HR, RSA and E:I. We suggest that further short and long term studies be undertaken with pranava pranayama in patients to further qualitatively and quantitatively evaluate inherent mechanisms of this simple technique. We also suggest that, the addition of such cost-effective techniques to the medical armory will help patients of rhythm disorders and other cardiovascular conditions to manage their condition more effectively.

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