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RESEARCH ARTICLE

Impact of Sequential Practice of *Kaphalabhati* and *Nadi Shodhana Pranayama* on Heart Rate Variability in Healthy Volunteers

Poornachandran Kumaresan[1*], Poornachandran Prabu[1], Arumugam Naveena[2], Dhandapani Divya[3], Muthappan Sendhilkumar[4] and M. Rajajeyakumar[5]

[1]Department of Yoga, Government Yoga and Naturopathy Medical College, Chennai - 600106, Tamil Nadu, India; dr.k.bnys@gmail.com

[2]Yoga and Naturopathy Department, Southern Railway Headquarters Hospital, Chennai - 600023, Tamil Nadu, India

[3]Yoga and Naturopathy Department, Institute of Obstetrics and Gynecology, Chennai - 600008, Tamil Nadu, India

[4]Independent Researcher, Chennai, Tamil Nadu, India

[5]Department of Physiology, Saveetha Medical College, Thandalam, Chennai - 602105, Tamil Nadu, India

Abstract

Background: *Pranayama* or breath technique is considered as an important component of yoga, which influence wide range of physiological and psychological functions. Practice of *Kaphalabhati* (KB) and *Nadi Shodhana Pranayama* (NSP) are known breathing techniques to influence the autonomic functions. The sequential practice of KB and NSP has not been assessed. In this Context, we assessed the immediate effect of combined practice of KB and NSP on autonomic variables in healthy subjects. **Materials and Methods:** A prospective analytical cross-sectional study was conducted and recruited 28 healthy participants who admitted in SDM Nature cure and Yoga hospital, Dharmasthala for the positive promotion of the health/general well-being. All participants were practiced KB 60 strokes/min for 5 rounds followed by NSP 1:1 ratio, 5 seconds inhalation and 5 seconds exhalation without any retention for 12 rounds. The Heart Rate Variability (HRV) was assessed through MP150 data acquisition system and blood pressure was recorded by using a standard mercury sphygmomanometer. We assessed the BP, Heart Rate (HR), Short term HRV at baseline and immediately after the practice. **Results:** The mean age (SD) of the participants was 33.29 (6.9). The study showed significant decrease in Systolic blood pressure, Diastolic Blood Pressure and RMSSD. There were borderline changes in the time domain measures (Mean R-R, NN50, pNN50) and reduction in the frequency domain of the HRV (LF, HF, LF/HF). However, the difference was not statistically significant. **Conclusion:** Immediate effect of sequential practice of *KB* and *NSP* in healthy volunteers showed positive effect in reduction of SBP, DBP and RMSSD. It can be included in the routine clinical practice for better outcome in the cardiovascular parameters and for the general well-being. Further studies are requisite to give insight in the underlying mechanism.

Keywords: Autonomic Balance, Blood Pressure, Breathing Techniques, Cardiovascular Function, Yoga

**Author for correspondence*

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1. Introduction

Yoga is an ancient practice originated in India around 3000 B.C. according to archeological evidence[1]. Yoga is a science of holistic life discipline to harmonize physical, mental and spiritual well being. Practices involved in the traditional Yoga includes ethical behavior (*Yama*), Self-discipline (*Niyama*), cleansing techniques (*Kriya*), physical postures (*Asana*), breathing techniques (*Pranayama*), sensory withdrawal (*Pratayagara*), concentration (*Dharana*) and contemplation practices (*Dhyana*)[2]. According to National Centre for health statistics 2018, yoga has been most commonly used adjuvant therapy; the popularity of yoga has grown considerably in recent years, from 9.5 percent (22.4 million) in 2012 to 14.3 percent (35.2 million) in 2017 among U.S. adults[3]. There has been increasing scientific evidence on combined or individual effects of the yogic practice and its therapeutic aspects[4,5]. In last two decades, scientific researchers given special attention to pranayama practices. Voluntarily regulated breathing techniques can be used either alone or in combination with other yogic practices to reduce psychological distress and conditions such as hypertension[6,7].

Heart Rate Variability (HRV) is an index of beat-to-beat changes in the heart rate and is a non-invasive assessment of autonomic control of cardiac functions[8]. Reduction in the HRV has been related with negative consequences to health[9]. Previous studies reported that breathing techniques have been practiced to decrease arousal through neurohormonal mechanism, which can be achieved by reducing the sympathetic activity and stimulating vagal efferent activity[5,10].

Yoga module may include various groups of *asanas, pranayamas,* relaxation techniques and meditation. In general, sequence of yogic breathing like *kapalbhathi, bastrika,* NSP and *bhramari* can be practiced in single session at different frequency and duration. Studies shows that each pranayama has different physiological effects[11]. However, Earlier studies reported that withdrawal of parasympathetic domain, increased heart rate and blood pressure was noted immediately after the practice of *kaphalabhati* (KB) or High Frequency Yogic Breathing (HFYB)[12,13]. In contrast, vagal dominace, decrease blood pressure and heart rate was showed after *Nadi Shodhana Pranayama* (NSP) or Alternate Nostril Yogic Breathing (ANYB) or *Anuloma viloma* practice. Studies have concluded that NSP is effective inexpensive intervention of hypertension[14-17]. There was few studies has been conducted on impact of sequential practice of above mentioned *pranayama* on cardiovascular parameters and its autonomic function. Hence, the present study was conducted to assess the sequential practice of *Kaphalabhati* and *Nadi shodhana pranayama* on short term heart rate variability, Blood pressure and heart rate.

2. Materials and Methods

2.1 Participants

We recruited 28 participants aged between 22 to 50 years those who admitted in SDM Nature cure and Yoga hospital, Dharmasthala for the positive promotion of the health/general well-being without any illness. The mean age (SD) was 33.29 (6.9), 18 were male and 10 were female.

2.2 Eligibility Criteria

Normal Subjects those who are not having any abnormalities were included for the study. We have done the routine clinical examination for all the participants before recruiting to the study. We excluded the nasal abnormalities participants such as such as nasal polyps or nasal septal deviation, smoker, alcoholic, any acute illness, recent surgery, endocrine disorders, cardiovascular disorders, respiratory issues like COPD/Asthma, or intense regular physical activity/exercise for the past 3 months or advanced yoga practitioner more than 12 months participants from the study.

2.3 Study Design

This was prospective type of analytical cross-sectional study. We assessed the participants at baseline and post intervention. Baseline assessment was done before starting of the practice. Post assessment was done immediately after completion of the *pranayama* practice. Study design was explained to each participant and signed informed consent was obtained. Study was done from April 2014 to June 2014. The study was approved by the institution's ethics committee207/SDM/PG-PRO/IEC-2012.

3. Outcome Variables

Heart Rate Variability (HRV) was assessed in MP150 data acquisition system (BIOPAC System Inc, U.S.A). The Electrocardiogram (ECG) was recorded in Ag/AgCl pre-gelled electrodes (Tyco Healthcare, Germany) and standard bipolar limb lead III configuration. As the participants used their right hand to manipulate the nostrils, we have chosen Limb lead III to minimize the risk of movements The ECG data were acquired at the sampling rate of 1024 Hz. Blood Pressure (BP) was recorded by using a manual standard mercury sphygmomanometer.

4. Brief Procedure

Sequential yogic breathing protocol was followed during the practice. Initially breathe awareness for 5 rounds, then KB for 60 stokes per minute for 5 rounds. Between each round of KB, 5 rounds of breathe awareness were practiced. After completion of 5 rounds KB, NSP were practiced 5 seconds inhalation and 5 seconds exhalation (1:1 ratio) for 12 rounds without any retention. After completion of 12 of NSP 5 rounds of breathe awareness were given.

4.1 Base Position

Participants asked in *sukhasana* (cross-legged pose) on the floor with their spine erect and their eyes closed, throughout session.

4.2 Kapalabhathi

KB practice involves rapid breathing through the both nostril with passive inhalation and active exhalation. The duration of 1 round is 60 sec with one stroke per second. Participants were advised to practice 5 rounds, between each round of KB, 5 breathe awareness were done.

4.3 Nadi Shodhana Pranayama

NSP involves alternate nostril breathing without retention *(Khumbhaka)*. The participants were used their right thumb and ring finger to manipulate the nostrils. The breathing practice begins by Inhalation *(Puraka)* through the left nostril with the right nostril occluded using right thumb; then exhalation *(Rechaka)* through the right nostril by occluded left nostril using right ring finger; followed by inhaling through the right nostril; then exhaling through the left nostril. This completes one cycle. Each inhalation and exhalation is 5 seconds (1:1 ratio). The duration of 1 cycle is 20 seconds. Participants were advised to practice 12 cycles.

4.4 Breathe Awareness

Participants were instructed to be attentive in their normal breathe without any manipulation. They remain in the crossed-legged posture (*sukhasana*) with the spine erect and eyes closed.

4.5 Data Extraction

We collected the HRV data from the participants. Frequency domain and time domain analysis of the HRV were carried out at pre-intervention and post-intervention (5 minutes recordings for each). The total duration of recording was 10 minutes for each participant. The data recorded were inspected off-line and only noise-free data were included for the analysis. Fast Fourier Transform analyses (FFT) of R-R interval was done using the software developed by the biomedical signal analysis group, Department of Applied Physics, University of Eastern Finland Kubios HRV version 2.0[18].

The frequency of the power spectrum analysis can be classified into low frequency band (0.05-0.15 Hz), very low frequency band (0.0033–0.04 Hz) and high frequency band (0.15-0.50 Hz). The values in frequencies were expressed as normalized units. The LF/HF ratio was also calculated.

The following components of time domain analysis of HRV were obtained: the mean RR interval (mean of the intervals between adjacent QRS complexes); RMSSD (square root of the mean of the sum of the squares of differences between adjacent NN intervals); NN50 (number of interval differences of successive normal to normal intervals greater than 50 ms), and pNN50 (the proportion derived by dividing NN50 by the total number of NN intervals).

4.6 Data Analysis

All statistical analysis was conducted using SPSS statistical package version 24.0. All the variables are checked for normality using Kolmogorov-Smirnov test, and the variables which are violating the normality assumption were log transformed. The data were expressed as means with standard deviation for normally distributed variables. Paired-t test and Wilcoxon Signed Ranks Test were used to compare means and median between two visits respectively. P-value <0.05 were considered as significant.

5. Results

There was significant decrease in systolic blood pressure and diastolic blood pressure (Table 1). Significant difference was noticed in RMSSD. The Heart Rate Variability parameters such as Mean RR, NN50, pNN50,

Table 1. Result of Blood Pressure and Heart Rate

Parameters	Baseline (Mean ± SD) (n = 28)	Post Intervention (Mean ± SD) (n = 28)	95% CI	Sig
SBP	121.8 ± 14.3	113.9 ± 10.4	1.201 to 14.599	0.021*
DBP	81.1 ± 1.14	73.6 ± 1.12	6.8945 to 8.1055	<0.001**
HR	83.8 ± 11.8	77.5 ± 12.2	-0.131 to 12.731	0.054

*p<0.05**; p<0.001; SBP – Systolic blood pressure; DBP – Diastolic blood pressure; HR – Heart Rate; CI – Confidence Interval; SD – Standard Deviation

Table 2. Result of time domain of Heart Rate Variability

Parameters	Baseline (Mean ± SD) (n = 28)	Post Intervention (Mean ± SD) (n = 28)	95% CI	Sig
Mean RR (s)	731.0 ± 115.1	790.3 ± 131.3	-125.456 to 6.856	0.077
RMSSD (ms)	20.5 ± 2.4	23.6 ± 2.1	-4.308 to -1.892	<0.0001***
NN50 (count)	56.9 ± 29.7	57.0 ± 26.4	15.156 to 14.956	0.967
pNN50 (%)	28.5 ± 14.8	28.5 ± 13.2	-7.514 to 7.514	0.100

HRV – Heart Rate Variability; Mean RR - Mean of the intervals between adjacent QRS complexes; RMSSD - Square root of the mean of the sum of the squares of differences between adjacent NN intervals; NN50 - Number of interval differences of successive normal to normal intervals greater than 50 ms; pNN50 - Proportion derived by dividing NN50 by the total number of NN intervals***; p<0.0001; CI – Confidence Interval; SD – Standard Deviation.

Table 3. Result of frequency domain of Heart Rate Variability

Parameters	Baseline (Mean ± SD) (n = 28)	Post Intervention (Mean ± SD) (n = 28)	95% CI	Sig
VLF (nu)	42.3 ± 17.8	42.4 ± 18.0	-9.691 to 9.491	0.983
LF (nu)	59.1 ± 21.6	58.5 ± 22.5	-11.217 to 12.417	0.919
HF (nu)	40.9 ± 21.6	40.9 ± 22.9	-11.927 to 11.927	0.100
LF/HF (ms)	1.7 ± 2.8	2.8 ± 2.6	-2.548 to 0.348	0.133

VLF – Very Low Frequency; LF – Low Frequency; HF – High Frequency; LF/HF – Low Frequency/High Frequency Ratio; CI – Confidence Interval; SD – Standard Deviation

VLF, LF, HF and LF/HF shows mild changes before and after intervention. However, the difference was not statistically significant (Table 2 and 3).

6. Discussion

The present study was to assess the heart rate variability, blood pressure and heart rate before and immediately after the KB and NSP practice. There was significant change in the SBP and DBP but not in HRV. Evidences reported that physiological and psychological stress disrupts autonomic rhythm, prolonged autonomic imbalance may have a wide range of somatic and mental diseases. Such autonomic imbalance can be measured through HRV. HRV serve as a proxy for neural regulation of cardiovascular system through activation or inhibition of the sympathetic and parasympathetic nervous systems[19] and provides understanding stress and health[20]. Physical, emotional, and cognitive activities can also influence the Heart Rate (HR)[21]. HR and HRV are perhaps the most reliable and accessible indicators of autonomic regulation and vagal activity[22].

HRV is measured using the R-R interval on an electrocardiogram with beat-to-beat variation reflecting the properties of the heart[19]. The time domain measures of the HRV include RMSSD, NN50, pNN50, and mean R-R interval. Increased time domain shows stronger predictors of parasympathetic activity[23].

High Frequency-HRV is considered to be an index of parasympathetic activity, Left Frequency-HRV is related to sympathetic activity[24].

Few studies on KB reported that increased LF and decreased HF They were concluded that withdrawal of vagal dominance after KB. Studies conducted with similar methods suggest that after KB practice decreases in NN50, pNN50 and mean R-R. They were concluded that during and after the practice KB, there was cardiac sympathetic arousal[25,26].

Few studies on NSP/ANYB rep36orted that there were increase of time domain measures and suggested vagal dominance during and after ANYB. Whereas, the result of the present study showed that there was significant rise in RMSSD and minimal changes in Mean R-R, NN50 and pNN50. Increased time domain measures of HRV indicate the vagal dominance.

Another study by Rajajeyakumar *et al.*, in 2014 concluded that right nostril breathing activates sympathetic activity and left nostril breathing stimulate parasympathetic activity[27]. Whereas, in the present study after KB 60 Stokes/min for 5 rounds followed by NSP 1:1 ratio for 12 rounds and there were significant decreases in the SBP, DBP and reduced in the LF band but not statistically significant. Inclusion of NSP in the intervention could be the reason responsible for reduction in the BP[28]. Effect may be due to practice of NSP which can activate mechanical receptors in the nasal mucosa with air flow into the nostril and this signal transmitted to the hypothalamus[29].

Another study by Raghuraj *et al*., assessed HRV on KB (high frequency breathing, with a breath rate of 1.0 to 2.0 Hz) and NSP (low frequency, i.e., 0.04 Hz) on two separate days with 12 male healthy individuals. The study results suggested that LF and LF/HF were significantly increased and HF were significantly decreased after KB and there were no significant changes in the NSP[30]. To support the present study, there are no significant changes in LF, HF and LF/HF ratio. In another study, ghiya *et al*.,[31] in 2012 reported that LF, HF were increased after 30 min of NSP, it shows increase in cardiac autonomic modulation in twenty healthy individuals with no prior experience with ANB.

Similar like the present study, another study was conducted by Selvaraj *et al.,* to analyze the instantaneous changes in HRV during *sambhavimaha mudra*, it includes *sukhapranayam, 'AUM'* chanting, rapid breathing, and relaxed sitting. The result of the study showed that increased sympathetic modulation and withdrawal of vagal tone during *sukhapranayam*, an increased sympathetic tone during *'AUM'* chanting, and withdrawal of vagal tone during rapid breathing and were no significant changes during relaxed sitting. In the present study the sequence of breathing techniques (KB and NSP) was used as an intervention. Another study reported that after the acute exposure of NSP for 15 min on 40 healthy volunteers (males 20; female 20), age range from 17 to 22 years, there was significant decline in the HR, SBP and DBP[32]. This is in support to the result of the present study where it shows decreases in the SBP and DBP.

Long term exposure of yogic breathing shows a parasympathetic dominance than short term practitioners[33]. However; immediate effect of KB and NSP shows significant reduction in the RMSSD, SBP and DBP, which is responsible for vagal tone.

The VLF power was increased minimally. VLF required more than 90 percent of the total power in the 24 hours heart rate power spectrum[34]. The VLF power partially reflects thermoregulatory mechanisms, oscillation in activity of the renin-angiotensin system, and the peripheral chemoreceptor's[35]. It also reflects on the respiratory changes and physical activities[36]. Hence, the physiological mechanisms for VLF are not fully understood. For this reason, no attempt has been made to discuss the physiological significance of VLF power in the present study.

6.1 Limitation of the Study

Following limitations were noted in the present study, Practice and data was collected at any time of the day. Since HF band power has diurnal variation, it may rise at night and decrease during the day. During assessment, after recovery/rest was not recorded, instead we have recorded pre and post, which was immediately after intervention. Subject's age group was from 23 to 45, wider range of age can alter the outcome. Smaller sample size without control group and randomization.

7. Conclusion

Immediate effect of *Kapalbhathi* and *Nadi shodhana pranayama* on HRV shows no significant change in the both time and frequency domain except in the RMSSD. But significant reduction in the SBP and DBP shows positive effect on the cardiac function. Long term practice of these yogic breathing may help in cardiac autonomic regulation. These yogic breathing techniques can incorporate in the routine clinical practice for the better outcome in the cardiovascular parameter and for the general wellbeing. Hence, further studies are warranted with larger sample size and randomized controlled trial; advanced assessments such as continuous BP monitoring, galvanic skin resistance, baroreceptor sensitivity, and photo plethysmography can be used to assess the underling physiological mechanisms of the combined practice of KB and NSP.

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