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Effect of 12 Weeks Practice of Slow Breathing Pranayama on Cardiac Autonomic Balance in Healthy Young Volunteers

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ABSTRACT

Background: A number of clinical disorders, particularly those associated with chronic stress, may cause disruptions in cardiac autonomic balance. As a result, parasympathetic tone decreases and sympathetic activity rises. One relaxation method that may help restore this equilibrium is slow breathing pranayama.

Aim and Objective: The purpose of this study is to assess how Slow Breathing Pranayama affects cardiac autonomic balance.

Materials and Methods: 60 young, healthy, sedentary volunteers participated in a prospective interventional study in which they performed Slow Breathing Pranayama for 12 weeks. Prior to and during the intervention, measurements were made of heart rate (HR), blood pressure (BP), and heart rate variability (HRV). Both time-domain and frequency-domain characteristics were used to measure HRV. The software Kubios HRV (version 1.1, Finland) was used to analyze HRV.

Results: HRV measurements showed a change toward parasympathetic predominance, whereas HR and blood pressure showed significant decreases.

Conclusion: Practicing slow breathing techniques on a regular basis can help the heart's autonomic balance move toward parasympathetic dominance and can help prevent illnesses linked to autonomic imbalance.

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KEYWORDS

• Slow Breathing Pranayama • Heart rate • Blood pressure • Heart rate variability (HRV)

INTRODUCTION

Worldwide, cardiovascular diseases (CVDs) are a significant public health concern, especially in developing nations where risk factors linked to a poor diet, sedentary lifestyles, and ongoing stress are common. Cardiovascular diseases (CVDs), which include heart failure, myocardial infarction, and hypertension, have become one of the world's main causes of morbidity and mortality in recent decades due to their constantly rising incidence.[1] The disturbance of cardiac autonomic balance, namely an imbalance between the sympathetic nervous system (SNS) and parasympathetic nervous system (PNS), is one of the main causes of CVDs.[2]

An essential part in controlling physiological processes like heart rate, blood pressure, and respiratory rate is the autonomic nerve system (ANS). The SNS, also known as the "fight-or-flight" system, is in charge of priming the body for stressful events by raising blood pressure, heart rate, and rerouting blood flow to vital organs. On the other hand, the PNS, also referred to as the "rest-and-digest" system, which is mostly mediated by the vagus nerve, encourages relaxation by reducing blood pressure and heart rate.[3] Maintaining homeostasis and achieving the best possible cardiovascular function requires a balanced relationship between these two branches.[4]

The practice of yoga, particularly breathing exercises like pranayama, is one successful non-pharmacological strategy that has drawn more attention recently. It has been demonstrated that pranayama, which consists of controlled breathing exercises, affects the autonomic nervous system and helps to rebalance sympathetic and parasympathetic activity.[5,6] Slow Breathing Pranayama, also called Nadi Shuddhi Pranayama or Anulom Vilom, is one of the many types of pranayama that has shown promise in fostering relaxation, lowering stress levels, and enhancing cardiovascular health. It has been proposed that this type of pranayama, which entails slow, regulated alternating nostril breathing, improves heart rate variability (HRV), a measure of autonomic balance, by increasing parasympathetic tone and decreasing sympathetic activity.[7]

The difference in time between consecutive heartbeats, or HRV, is impacted by the heart's sympathetic and parasympathetic nervous systems. Higher HRV indicates a more flexible and balanced autonomic system, making it a dependable, non-invasive indicator of autonomic function. On the other hand, low HRV predicts cardiovascular morbidity and death and is linked to higher sympathetic dominance.[8] According to recent research, therapies like meditation and deep breathing techniques can dramatically increase HRV by increasing parasympathetic activity and causing the autonomic balance to shift in favour of vagal dominance.[9]

It is important to determine whether such interventions can have preventive benefits on cardiac health because young adults are frequently in the midst of forming long-term health behaviours. Thus, the purpose of this study is to assess how 12 weeks of practicing slow breathing pranayama affects cardiac autonomic balance in young, healthy volunteers by concentrating on heart rate, blood pressure, and HRV parameters. By looking into these effects, we hope to raise awareness of yoga and pranayama as complementary therapies for cardiovascular disease prevention and management among young people who are at risk of developing non-communicable heart diseases later in life due to stressful lifestyles.

Aim:

This study aims to evaluate how 12 weeks of practicing slow breathing pranayama affects cardiac autonomic balance, specifically as it relates to heart rate, blood pressure, and HRV metrics.

Objectives:

1. To assess how Slow Breathing Pranayama affects blood pressure (BP) and heart rate (HR).
2. To evaluate HRV changes after 12 weeks of practice, including time-domain and frequency-domain parameters.

3. To investigate how Slow Breathing Pranayama can help tip the autonomic scales in favour of parasympathetic dominance.

MATERIALS AND METHODS

With approval from the Institutional Ethics Committee, the current investigation was carried out as a single-group pre-post prospective interventional study at the Department of Physiology, Seth G.S. Medical College, Mumbai. Participants included sixty first-year medical students, ages 18 to 22. All participants were healthy, inactive men and women without a history of serious conditions like diabetes, heart disease, or high blood pressure. Exclusion criteria included people with significant health problems, a history of major surgery, or regular physical activity or other forms of exercise, while inclusion criteria included healthy people within the designated age range who led a sedentary lifestyle and had never practiced yoga. Prior to their registration in the trial, all individuals provided written informed consent. This study was done in continuation with our previous study.[10]

For 12 weeks, participants engaged in daily, 15-minute morning sessions of Nadi Shuddhi Pranayama under the guidance of a certified yoga trainer. During the pranayama exercise, the nostrils alternated rhythmically as the left nostril was inhaled for four seconds and the right nostril was exhaled for eight seconds.[10] Prior to and following the intervention, a number of physiological indicators were noted. After five minutes of rest, the radial pulse was used to measure the heart rate (HR), and an automated sphygmomanometer was used in the supine position to measure the blood pressure (BP). After 15 minutes of supine rest with controlled breathing, a 5-minute ECG was used to collect heart rate variability (HRV), and Kubios HRV software was used to analyze the HRV.[11]

Both time domain and frequency domain measurements were used in the HRV study. Time domain metrics were computed, including the number of consecutive RR intervals that differed by more than 50 ms (NN50), the root mean square of successive RR interval differences (RMSSD), the standard deviation of NN intervals (SDNN), and the ratio of NN50 to total NN intervals (pNN50). Low-frequency (LF) and high-frequency (HF) power spectrum measurements as well as the LF/HF ratio were included of the frequency-domain study.[12]

Statistical Analysis:

SPSS software (Version 17.0) was used to analyze the data. Measurements taken before and after the intervention were compared using a paired t-test. P-values less than 0.05 were regarded as statistically significant.

RESULTS

After practicing Nadi Shuddhi Pranayama for 12 weeks, there was a significant drop-in heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP), according to analysis using the paired t-test. Table 1 Significant increases in time-domain HRV measures (SDNN, RMSSD, NN50, and pNN50) suggested greater parasympathetic activity. Table 2 The shift toward parasympathetic dominance and better autonomic regulation were further supported by frequency-domain analysis, which revealed an increase in HF power and decrease in LH/HF ratio. Table 3

Table 1: Changes in Heart Rate and Blood Pressure

Parameter	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	p-value
Heart Rate (bpm)	79.45 ± 8.20	73.80 ± 6.10	< 0.001
Systolic BP (mmHg)	118.30 ± 6.45	111.05 ± 5.72	< 0.001
Diastolic BP (mmHg)	78.90 ± 7.25	73.10 ± 5.85	< 0.001

Table 2: Changes in Time-Domain HRV Parameters

Parameter	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	p-value
SDNN (ms)	42.10 ± 4.95	52.80 ± 5.70	0.04
RMSSD (ms)	30.85 ± 3.40	41.70 ± 4.95	0.04
NN50	29.70 ± 5.20	46.80 ± 3.75	0.03
pNN50	4.90 ± 1.40	8.20 ± 3.50	0.04

Table 3: Changes in Frequency-Domain HRV Parameters

Parameter	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	p-value
LF (ms^2)	60.30 ± 8.40	49.20 ± 5.60	0.02
HF (ms^2)	40.50 ± 4.30	50.90 ± 7.00	0.04
LF/HF Ratio	2.18 ± 0.48	1.95 ± 0.85	0.04

DISCUSSION

The purpose of this study was to examine how Slow Breathing Pranayama (Nadi Shuddhi Pranayama) affected the cardiac autonomic balance of young, healthy volunteers as indicated by heart rate (HR), blood pressure (BP), and heart rate variability (HRV) measures. Following 12 weeks of pranayama practice, the results show significant changes in autonomic regulation, including a decrease in blood pressure and heart rate and an increase in heart rate variability (HRV), which suggests a shift towards parasympathetic dominance.

Effects of Pranayama Slow Breathing on Blood Pressure and Heart Rate.

The findings of this study are consistent with earlier studies that demonstrate a reduction in blood pressure and heart rate after practicing yoga and pranayama. In particular, participants' heart rates (from 76.88 ± 7.75 to 72.67 ± 5.62 bpm) and blood pressure (from 114.2 ± 5.98 to 109.93 ± 5.41 mmHg and from 75.60 ± 6.80 to 71.43 ± 5.73 mmHg) significantly decreased after 12 weeks of Nadi Shuddhi Pranayama. The results of earlier research on the impact of yoga and pranayama on cardiovascular health are in line with this drop-in heart rate and blood pressure.[13,14]

The regulation of autonomic nervous system activity explains the mechanisms underlying this decrease in blood pressure and heart rate. Breathing slowly and deliberately raises parasympathetic (vagal) tone, which lowers sympathetic activation. Both heart rate and blood pressure drop as a result of this transition to parasympathetic dominance.[7] Additionally, the detrimental consequences of chronic stress, a recognized cause of higher HR and BP, may be offset by the decreased sympathetic activity.[15]

A balanced autonomic system that can adapt well to physiological and environmental stimuli is indicated by a greater HRV, which is a potent indicator of autonomic regulation. Following a 12-week pranayama practice, the current study showed a significant rise in a number of time and frequency domain HRV parameters, indicating an improvement in autonomic balance.

- Time Domain HRV Measures: Specifically, the number of consecutive RR intervals that differed by more than 50 ms (NN50), the proportion of NN50 to total RR intervals (pNN50), the standard deviation of NN intervals (SDNN), and the root mean square of successive RR interval differences (RMSSD) all showed notable increases. Higher values of these parameters, which are frequently employed to measure parasympathetic activity, indicate stronger parasympathetic modulation and increased vagal tone.[16] The idea that slow breathing techniques can increase parasympathetic activity and improve autonomic regulation is supported by the improvement in these metrics after pranayama practice.[17]
- HRV measurements in the frequency domain: Pranayama practice resulted in a notable increase in high-frequency (HF) power and a decrease in low-frequency (LF) power in the frequency domain, along with a matching fall in the LF/HF ratio. While the LF component is believed to represent a combination of both sympathetic and parasympathetic activity, the HF component shows parasympathetic activity, namely vagal tone.[18] Following pranayama practice, a decrease in LF power and an increase in HF power indicate a shift toward parasympathetic dominance, which is advantageous for cardiovascular health. Since larger LF/HF ratios are generally observed in situations of sympathetic dominance or imbalance, the lowered LF/HF ratio lends additional credence to this change.[19]

The results of this investigation align with a number of other studies that have looked at how slow breathing techniques affect heart rate variability. Slow, regulated breathing techniques significantly improve HRV, indicating increased autonomic flexibility, according to a study by Chandla SS *et al.* (2013).[20] Likewise, Tharion E *et al. (*2012) discovered that slow, deep breathing can stimulate the parasympathetic nervous system, improving heart rate variability (HRV), which is linked to improved cardiovascular health.[21]

Possible Processes Underpinning the Benefits of Pranayama for Slow Breathing

There are a number of ways to explain why Slow Breathing Pranayama improves autonomic regulation. The respiratory sinus

arrhythmia (RSA), a natural variation in heart rate that happens with the breathing cycle, has been demonstrated to synchronize with slow breathing, especially at rates of about 6 breaths per minute.[22] Pranayama may increase the activity of the vagus nerve, which regulates heart rate and encourages relaxation, by slowing the breath and extending the exhale.[23]

Through the brainstem, the parasympathetic activation brought on by slow breathing most likely affects the central nervous system, especially the vagus nerve nucleus, which directly controls blood pressure and heart rate.[22] The medulla oblongata and the hypothalamus, two brain areas involved in autonomic regulation, can be impacted by controlled breathing strategies.[24] Additionally, it has been discovered that consistent pranayama practice lowers the hypothalamic-pituitary-adrenal (HPA) axis activation brought on by stress, which lowers cortisol levels and overall stress.[25]

Pranayama exercises may also improve baroreflex sensitivity, a system that keeps blood pressure steady during variations.[26] Chronic stress is a significant risk factor for hypertension and other cardiovascular disorders; thus, this would be very helpful in reducing its impact on the heart.[27]

Broader Applications and Clinical Implications

According to the study's findings, practicing slow breathing can be a simple and efficient way to enhance autonomic balance and support cardiovascular health. In light of the rising incidence of cardiovascular disorders, especially in young people who are subjected to high levels of stress, integrating pranayama into daily routines may provide a non-pharmacological means of averting more cardiovascular issues.

Even though the participants in this study were young and healthy, more research is necessary to fully understand the potential advantages of pranayama for older persons or those who already have cardiovascular risk factors. For hypertension, arrhythmias, and other cardiovascular disorders, pranayama may be used in addition to conventional therapies, lowering the need for medication and enhancing general health.[28] Pranayama is also an excellent intervention for a variety of populations, including those in environments with limited resources, due to its affordability, low equipment requirements, and simplicity of practice.

LIMITATIONS

It should be noted that this study has a number of limitations. First, because there was no control group to compare the observed improvements to, the study design was a single-group pre-post intervention. This means that pranayama practice alone cannot be solely blamed for the changes that were seen. More solid proof of causality would be provided by randomized controlled trials (RCTs) in future research. The results cannot be applied to other populations, especially older people or people with pre-existing medical issues, because the sample size was limited (n=60) and all participants were young, healthy medical students.

The absence of long-term follow-up data to determine if the gains in cardiovascular and HRV indicators are maintained after stopping pranayama practice is another drawback. To ascertain the long-term effects of pranayama on cardiovascular health and autonomic function, longer-term research is required.

CONCLUSION

The study's findings indicate that practicing Slow Breathing Pranayama for 12 weeks significantly improves autonomic balance, as shown by a decrease in blood pressure and heart rate and an increase in heart rate variability. According to these results, pranayama can be used as a non-pharmacological intervention to prevent autonomic abnormalities that may lead to the development of cardiovascular disorders and to improve cardiovascular health. To verify these results and investigate the long-term advantages of pranayama practice, further research is required, especially randomized controlled studies with bigger, more diverse populations.

Conflict of Interest: None

Funding: None

Ethics Declaration: Prior to their registration in the study, all subjects provided written informed consent. The Institutional Ethics Committee granted permission to carry out the study (ECR/229/Inst/MH/2013).

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