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THE SCIENCE OF KAPALBHATI: TRANSFORMING HEART RATE VARIABILITY THROUGH BREATHING EXERCISE

Physiology

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ABSTRACT

Introduction: Heart Rate Variability (HRV) is a non-invasive marker widely used to assess autonomic nervous system function and overall cardiovascular health. It reflects the dynamic balance between sympathetic and parasympathetic activity. Yoga, particularly pranayama, has been shown to improve autonomic modulation and cardiopulmonary function. This study evaluated and compared the effect of Kapalbhati on Heart Rate Variability **Aims and Objectives:** To assess and compare the effect of Kaplbhati on HRV variable over a 3-month period. Methods: This cross-sectional observational study was conducted in the Department of Physiology, Atal Bihari Vajpayee Government Medical College, Vidisha, from June 2024 to June 2025. Ninety healthy adults aged 18-25 years, who were not previously practicing any breathing exercise were purposively sampled and allocated into a group of 30. All practiced kapalbhati for 15 minutes each morning for 5 consecutive days per week over 3 months. Baseline and measurements at the end of 3rd month were taken for HRV variables(time and frequency domain parameters). Ethical clearance was obtained prior to study initiation. **Results:** Baseline characteristics such as age, sex, height, and initial HRV parameters were comparable across groups. Kapalbhati showed significant improvement. There was a marked reduction in weight, BMI, and waist circumference in the Kapalbhati group ($p < 0.05$). Systolic and diastolic blood pressure significantly decreased. Heart rate showed a notable decline in the Kapalbhati ($p = 0.001$). HRV analysis demonstrated significant improvements in both time and frequency domain measures, with increased RMSSD, SDNN, HF, and reduced LF and LF/HF ratio, indicating enhanced parasympathetic activity. **Conclusion:** Regular practice of kapalbhati for 3 months significantly improves autonomic balance, cardiovascular parameters and anthropometric indices in healthy young adults. These findings highlight the potential of Kapalbhati as an effective non-pharmacological tool for promoting cardiovascular health and autonomic regulation.

KEYWORDS

INTRODUCTION

The heart is a vital organ in human body, playing pivotal role of maintaining circulation throughout the body. This cardiac function is depends on connection with the brain, called as Neurocardiology 1. The autonomic nervous system (ANS) which consists of sympathetic and parasympathetic nervous system plays an essential role in maintaining heart activity. With every beat, blood is pumped out of cardiac chamber and establishing circulation to all the organs. Heart beat can be varied based on cardiac rhythm, regulated by the neuroendocrine system. Heart rate variability measures the beat-to-beat variability. Hence helps in assessing the influence of autonomic function. It is an easier and convenient method of assessing the Neurocardiac Physiology2.

Recently, heart rate variability, non- invasive measurement has turned out to be the one of the best indicators of general well-being of an individual. It aids in evaluating psychological status like stress, anxiety due to its relation with changes in heart rate 3. HRV assesses different metrics such as time- domain measure, frequency-domain measure and an advanced metrics- nonlinear measures.

Time-domain measures analyse the interval between two successive heartbeats (NN intervals). It evaluates SDNN, reflecting total heart rate variability, RMSSD (Root Mean Square of Successive Difference) – denoting short term HRV, regulated by parasympathetic reflex, pNN50 – indicating percentage of NN interval varying by more than 50ms and SDANN (Standard deviation of the average NN interval in 5 mins segment) – notifying long term HRV4.

The frequency domain measure evaluates the frequency components of heart rate variability. Low frequency (LF) indicates both sympathetic and parasympathetic activity. High frequency (HF) signifies parasympathetic activation via respiratory sinus arrhythmia. The LF/HF ratio signifies the equilibrium between sympathetic and vagal activity. Very low frequency (VLF) is associated with hormonal control5.

Yoga, an olden practice, originated from India about 5,000 years ago is crucial in balancing the body, mind and emotions. Yoga has been recognized worldwide for its unique characteristics. Regular yoga practising in the form of physical body movement (asanas) or breathing exercise (pranayama) have found to alleviate many diseases. This approach of using yoga in managing disease is yoga therapy 6. Therapeutic yoga uses yoga practices to prevent or cure any imbalance in the body. Studies have found that yoga therapy have alleviated many diseases such as anxiety, depression, chronic pain, reduction in addiction and sleep disorders. Apart from these neurological conditions, yoga practices had beneficial effect in chronic urological disorders, chronic low back pain, multiple sclerosis, respiratory disorders and endocrine dysfunctions7.

The Kapalbhati pranayama is originated from two words, kapal -skull and bhati- shining. This technique of pranayama involves short and strong voluntary exhalation and followed by automatic inhalation 8.It should be done at the rate of 120 breath cycles per min. it must be practiced for 1 min. This kapalbhati pranayama has shown to detoxify lungs and boosts oxygen supply, in addition, due to deep forceful breathing, abdominal muscle tone is improved and thereby reduces abdominal fat9.

Materials & Methods

MATERIALS AND METHODS

The study was an interventional study. This study was conducted at Department of Physiology, Atal Bihari Vajpayee Government Medical College from June 2024 to June 2025. Approval from the Institutional Ethics Committee was obtained prior to the commencement of the study. The study was conducted according to the guidelines laid down by ICMR on the conduct of biomedical research.

Study design: Interventional Study

Study participants: Healthy young adults in the age group of 18 to 25 years

Study duration: 12 months

SAMPLE SIZE: 30 young adults were taken after taking written consent.

SELECTION CRITERIA:

Inclusion criteria:

1. Subjects in the age group of 18-25 years (both male and female are equal in numbers).

2. Subjects who are not practicing any breathing exercises before.

3. Subjects who have given written consent

Exclusion criteria:
1. Subjects with the history of any acute disease and any systemic disease

2. Subjects with history of any kind of addiction.

3. Subjects with hernia, gastric ulcer, epilepsy, vertigo, migraine headaches, significant nose bleeds, retinal detachment, glaucoma, history of stroke, and for anyone who has undergone any surgery

4. Subjects with any skeletal deformity

5. Subjects who are practicing any kind of exercise

A detailed history including personal history, past history, family history was procured from all enrolled subjects. Then the subjects had undergone general physical examination, measurement of anthropometric parameters like age, sex, weight, BMI and waist circumference. The vital parameters such as blood pressure, pulse rate and respiratory rate were also recorded.

Before starting of the experiment, a baseline values of HRV variables, Blood Pressure and Anthropometric Measurements were taken followed by which the subjects were advised to practice kapalbhati for the period of 3 months 15 mins/day, 5 days a week.

I PHYSIOLOGICAL PARAMETERS:
1.Anthropometric measurements:
At the time of examination, the participant's weight and height were measured.

Weight was measured using digital balance scales to within 100 kg measurements. Weight has been taken with subjects wearing light clothing and no shoes.

Height was measured in centimetres in standing position, with shoulders and buttocks against the wall, the subject looking straight ahead, with joined feet, and arms hanging on both sides by using a wall mounted inch tape.

BMI was computed as weight/height2 (kg/m2).

CARDIOPULMONARY PARAMETERS:
1. Heart rate variability: Using PowerLab26T instrument by AD instruments. The participants were asked to be in a lying position and 3 limb leads were connected to the arms and legs of the participants. Initially the participants were asked to relax, and a resting baseline HRV and recorded for duration of 10 minutes. The recordings were analysed by the lab chart software to determine the heart rate variability. Under time domain method average RR interval in milliseconds, Standard deviation of R-R intervals (SDRR), Root mean square of successive differences (RMSSD) and Percentage of successive R-R interval that differ by more than 50 milliseconds(pRR50) in % were calculated and analysed. Under frequency domain very low -frequency power (VLF) in low-frequency power (LF) high -frequency power (HF) and LF/HF ratio were analysed

Precaution:
The room light must be dim.

Electronic items like mobile, watches and metallic wearables must be kept away.

No noise disturbance.
Subject must be still with eyes closed

2. Blood pressure: The participants were asked to be in a sitting position and relax for few minutes and then blood pressure was recorded manually by using a sphygmomanometer in the right arm of the participant.

3. Resting Heart rate: The participants were asked to remain relaxed in the sitting position and the resting heart rate was recorded in beats per minute.

RESULTS
Table 1: Comparison of BMI (kg/m²) at Baseline and end of 3rd Month of practicing Kapalbhati.

Group	Baseline Mean ± SD	3rd Month Mean ± SD	Mean Difference	t test	P value
Kapalbhati	24.34 ± 2.35	22.39 ± 2.64	1.94	5.218	<0.001

Table 2: Comparison of Waist Circumference (cm) at Baseline and end of 3rd Month of practicing Kapalbhati.

Group	Baseline Mean ± SD	3rd Month Mean ± SD	Mean Difference	t test	P value
Kapalbhati	86.89 ± 4.87	82.05 ± 5.37	4.84	3.543	0.001

Table 3: Comparison of Systolic Blood Pressure (mmHg) at Baseline and end of 3rd Month of practicing Kapalbhati.

Group	Baseline Mean ± SD	3rd Month Mean ± SD	Mean Difference	t test	P value
Kapalbhati	121.80 ± 7.97	113.77 ± 7.46	8.03	3.878	0.001

The Kapalbhati exhibited a significant decrease from 121.80 ± 7.97 mmHg at baseline to 113.77 ± 7.46 mmHg at 3 months (mean difference: 8.03 mmHg, p = 0.001).

Table 4: Comparison of Diastolic Blood Pressure (mmHg) at Baseline and end of 3rd Month of practicing Kapalbhati.

Group	Baseline Mean ± SD	3rd Month Mean ± SD	Mean Difference	t test	P value
Kapalbhati	74.90 ± 9.65	67.50 ± 8.11	7.40	3.615	0.001

A significant reduction was observed, with values decreasing from 74.90 ± 9.65 mmHg to 67.50 ± 8.11 mmHg (mean difference: 7.40 mmHg, p = 0.001).

Table 5: Comparison of Heart Rate (bpm) at Baseline and end of 3rd Month of practicing Kapalbhati.

Group	Baseline Mean ± SD	3rd Month Mean ± SD	Mean Difference	t test	P value
Kapalbhati	90.17 ± 10.93	78.77 ± 8.57	11.40	4.328	<0.001

Table 6: Comparison of LF (nu) at Baseline and end of 3rd Month of practicing Kapalbhati.

Group	Baseline Mean ± SD	3rd Month Mean ± SD	Mean Difference	t test	P value
Kapalbhati	43.67 ± 12.14	31.30 ± 7.63	12.37	4.585	<0.001

Table 7: Comparison of HF (nu) at Baseline and end of 3rd Month of practicing Kapalbhati.

Group	Baseline Mean ± SD	3rd Month Mean ± SD	Mean Difference	t test	P value
Kapalbhati	41.06 ± 14.44	54.88 ± 11.16	-13.82	-4.724	<0.001

Table 8: Comparison of LF/HF Ratio at Baseline and end of 3rd Month of practicing Kapalbhati.

Group	Baseline Mean ± SD	3rd Month Mean ± SD	Mean Difference	t test	P value
Kapalbhati	1.25 ± 0.64	0.59 ± 0.18	0.66	5.744	<0.001

Table 9: Comparison of RMSSD (ms) at Baseline and end of 3rd Month of practicing Kapalbhati.

Group	Baseline Mean ± SD	3rd Month Mean ± SD	Mean Difference	t test	P value
Kapalbhati	55.47 ± 12.46	70.71 ± 12.09	-15.24	-5.206	<0.001

Table 10: Comparison of SDSD (ms) at Baseline and end of 3rd Month of practicing Kapalbhati.

Group	Baseline Mean ± SD	3rd Month Mean ± SD	Mean Difference	t test	P value
Kapalbhati	57.15 ± 8.91	85.09 ± 10.89	-27.94	-11.547	<0.001

Table 11: Comparison of pRR50 (%) at Baseline and end of 3rd Month of practicing Kapalbhati.

Group	Baseline Mean ± SD	3rd Month Mean ± SD	Mean Difference	t test	P value
Kapalbhati	20.30 ± 9.88	27.31 ± 15.94	-7.01	-2.756	0.010

DISCUSSION

The three-month research of breathing technique Kapalbhati, examines its effects on heart rate variability, blood pressure, and anthropometric parameters in individuals aged 18 to 25 years.

Nevertheless, the weight showed considerable loss only in Kapalbhati group ($p < 0.001$), where 66.53 ± 4.18 kg decreased to 61.11 ± 3.88 kg, whereas the other two groups (Anulom Vilom and Bhramari) did not show much, but not significant losses. Consistent with weight reduction, BMI also showed significant decrease only in the Kapalbhati group ($p < 0.001$), from 24.34 ± 2.35 kg/m² to 22.39 ± 2.64 kg/m².

These results are corroborated by **Ruhal et al., 10, 2010,** who did a comparative research on the impact of Kapalbhati on body composition variables and found that body weight, body fat percentage and lean body mass significantly decreased in Kapalbhati practitioners compared to controls. The process associated with the Kapalbhati-induced weight loss can be explained by the fact that the combined effect of the forceful inhalation through expirations and passive inhalation through inspirations of specific volumes of air is a unique ventilatory pattern that effectively elevates the energy expenditure and the metabolic rate during and after the practice T**elles et al., 11, 2016**. Moreover, the contractions in the abdomen during Kapalbhati can provoke the work of digestive organs and increase the rate of metabolic activity **Muktibodhananda et al., 7, 2011.**

In their analytical study, **Kekan et al. 12, 2013**, found highly significant reductions in waist and hip circumference ($p < 0.01$) at 8 weeks of Kapalbhati practice, and none in the control group, which is in direct agreement with our results. The tonic decrease in the waist circumference in Kapalbhati could be justified by the repetitive, intense contractions of abdominal muscles during the exhalation that could stimulate the core musculature and possibly mobilize abdominal fat deposits by means of local metabolic activity **Telles et al., 13, 2018. Akhani et al., 14, 2019** demonstrated improved cardiorespiratory efficiency with reduced BMI and waist circumference following a comprehensive yoga program including pranayama, though individual pranayama effects could not be isolated.

This acute sympathetic stimulation-acute parasympathetic rebound pattern could be the reason behind the better long-term cardiovascular effects of regularly practicing Kapalbhati **Malhotra et al., 15, 2022**. The same finding was also reported by **Jha et al., 16, 2017** who found a significant reduction in systolic pressure and diastolic pressure following Kapalbhati but the change of heart rate was not evaluated. **Meitei et al., 17, 2025** by Meitei et al. directly compared Kapalbhati to deep breathing exercises and concluded that the blood pressure reductions with Kapalbhati were far greater, which appears to support our comparative results.

Heart Rate Variability Parameters

A non-invasive measure of cardiac autonomic activity, heart rate variability, showed significant improvement in all three pranayama groups after three months of practice with Kapalbhati always showing the greatest improvement. Baseline HRV parameters were similar between groups and this was a confirmation of homogenous autonomic status as at the time of intervention.

Frequency Domain Measures:

The vast between-group differences appeared at the three-month point that concerned LF power ($p = 0.033$) and LF/HF ratio ($p = 0.021$). The lowest LF values (31.29 ± 7.63 nu) and the best LF/HF ratio (0.59 ± 0.19) were observed in Kapalbhati, which means that the sympathetic activity was lower and the sympathovagal balance was better. Though the HF power significantly increased in each of the groups, with the highest value received by Kapalbhati (54.88 ± 11.16 nu), these differences were not considered significant statistically ($p = 0.286$).

Malhotra et al., 15, 2022 evaluated immediate neurological and autonomic changes during Kapalbhati and reported significant alterations in both time and frequency domain HRV parameters, with increased sympathetic activity during practice followed by enhanced parasympathetic modulation post-practice. This biphasic response may explain the superior HRV improvements observed with regular Kapalbhati practice in our study, as repeated sympathetic challenges may enhance adaptive autonomic plasticity **Shaffer et al., 8, 2017**.

Time Domain Measures:

There was also a strong between-group difference on all time domain parameters at three months: RMSSD ($p = 0.002$), SDSD ($p < 0.001$), and pRR50 ($p = 0.013$). Kapalbhati was the one who showed the greatest values (RMSSD: 70.71 ± 12.10 ms, SDSD: 85.09 ± 10.89 ms, pRR50: 27.31 ± 15.94%), then Bhramari and finally Anulom Vilom. These measures of time domain are highly indicative of parasympathetic activity, which suggests that Kapalbhati generates the most significant improvement of the vaginal modulation.

Shankarappa et al., 18, 2013 compared stretching exercises to pranayama and found that the HRV was significantly higher in regular yoga practitioners but there is no separate analysis of individual techniques of pranayama. **Jensen et al., 19, 2022** showed the possibility of modulating the HRV of patients with autoimmune disorders with deep breathing exercises, which indicates the potential of breathing interventions in the treatment of autonomic dysfunction. The HRV improvement in our Kapalbhati group is also of a clinical significance, because low HRV is linked to HRV-related cardiovascular mortality, psychological stress, and inflammatory conditions **Jarczok et al., 1, 2015; Lennartsson et al., 2, 2016; Immanuel et al., 3, 2023.**

Kapalbhati acts in a biphasic 2 acute sympathetic stimulation during practice and an increase in parasympathetic rebound after practice **Malhotra et al., 15, 2022.** This trend is similar to high-intensity interval training of the autonomic nervous system, which is probably more adaptively responsive than steady-state stimulation.

LIMITATIONS

The following were the limitations of the current study,

a. The sample size (n=90) was small and this could restrict the power to statistically detect smaller inter-group differences.

b. Only healthy young adults were selected to increase the limitations on

generalizing the research outcomes to older or clinical groups.

c. The diet, exercise, and lifestyle were not managed and this could have

affected the anthropometry-cardiovascular outcomes.

d. No long-term follow-up was carried out and therefore there was no evaluation

of pranayama benefits sustainability.

CONCLUSION

The current research revealed that consistent engagement in pranayama significantly improves anthropometric, cardiovascular, and heart rate variability metrics in healthy young individuals. Of the three approaches assessed, **Kapalbhati pranayama yielded the most significant advantages**, with more substantial decreases in weight, BMI, waist circumference, systolic and diastolic blood pressure, and heart rate, as well as enhanced HRV markers.

These results indicate that Kapalbhati is a very promising form of breathing to enhance autonomic balance and cardio-metabolic wellbeing.

Overall, the study underscores the positive role of pranayama in promoting physiological well-being and supports its integration into routine health practices.

In this study I wish to add that a simple breathing technique itself has this much influence on the autonomic and cardiovascular. To live a healthy, disease-free life we have to incorporate a regular exercise routine to keep us mentally and physically fit. In the same study we have noted the stress level and the total performance of the individual have improved at the end of three months.

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