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Original Research Article

EFFECT OF STRUCTURED PRANAYAMA ON PULMONARY FUNCTION AND AUTONOMIC PARAMETERS IN HEALTHY YOUNG ADULTS: A QUASI-EXPERIMENTAL STUDY

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ABSTRACT

Background: Controlled breathing practices such as pranayama are known to influence respiratory mechanics and autonomic regulation. However, data in healthy young adults remain limited. **Aim:** To assess the impact of a structured pranayama program on pulmonary function and selected autonomic parameters.

Materials and Methods: A quasi-experimental pre–post study was conducted among 59 healthy adults aged 20–40 years. Baseline and post-intervention assessments included resting heart rate (HR), respiratory rate (RR), breath-holding time (BHT) and spirometric indices (FVC, FEV1/FVC ratio, PEFR, MVV). Participants practiced supervised pranayama for three months. Pre–post comparisons were performed using paired t-test. Results: Following the intervention, HR and RR showed significant reductions, while BHT increased significantly. Among pulmonary variables, FVC, PEFR and MVV demonstrated statistically significant improvement, whereas FEV1/FVC ratio remained unchanged.

Conclusion: Regular pranayama practice enhances ventilatory function and promotes favorable autonomic adaptations in healthy individuals.

Keywords: Pranayama; Pulmonary Function Tests; Spirometry; Autonomic Nervous System; Breath-Holding Time; Healthy Adults.

INTRODUCTION

Cardiorespiratory fitness reflects the integrated ability of the respiratory, cardiovascular and musculoskeletal systems to transport and utilize oxygen during physical activity and is considered an important indicator of overall physiological health.[1] Reduced cardiorespiratory fitness has been associated with increased cardiovascular risk and adverse health outcomes.[2]

Sedentary lifestyles and physical inactivity contribute substantially to the global burden of chronic diseases and are recognized as important modifiable risk factors affecting overall health.[3]

Yoga is a traditional mind–body practice that combines physical postures, meditation and breathing exercises to promote physical and psychological health.[4]

Among its various components, pranayama refers to the conscious regulation of breathing through controlled inspiration, expiration and breath retention.[5] Because respiration is one of the few autonomic functions that can be voluntarily modified, pranayama has the potential to influence autonomic nervous system activity and cardiorespiratory function.[5,6]

Previous studies have demonstrated beneficial effects of pranayama on autonomic regulation, pulmonary function, and cardiovascular health.[5-7] Slow and rhythmic breathing practices have been shown to enhance parasympathetic activity, improve ventilatory efficiency, and improve respiratory performance.[6-9]

Improvements in pulmonary function parameters following regular pranayama practice have also been reported, with enhanced respiratory muscle strength, improved alveolar ventilation and better breathing efficiency proposed as possible underlying mechanisms.[8-11]

Despite growing evidence supporting the physiological benefits of pranayama, relatively few studies have simultaneously evaluated both pulmonary function and autonomic parameters in healthy young adults. A comprehensive assessment of these outcomes may provide a better understanding of the integrated effects of pranayama on respiratory and autonomic regulation. Therefore, the present study was undertaken to assess the effect of a structured pranayama program on pulmonary function and autonomic parameters in healthy young adults.

MATERIALS AND METHODS

Study Design and Setting

This quasi-experimental pre–post interventional study was conducted in the Department of Physiology, Kodagu Institute of Medical Sciences, Madikeri, Karnataka, India, after obtaining approval from the Institutional Ethics Committee. (Approval No: KoIMS/IEC47/23-24, dated 21/02/2024). Written informed consent was obtained from all participants prior to enrolment in the study.

Sample size was estimated using the standard formula for comparison of paired continuous variables based on data from a previously published study evaluating the physiological effects of pranayama. The minimum required sample size was calculated to be 42 participants at a 95% confidence level and 80% study power. To compensate for anticipated attrition during the intervention period, a larger sample was recruited.

Study Participants

Apparently healthy young adults aged between 20 and 40 years were recruited by convenience sampling from the local community and institution. A total of 80 participants were enrolled in the study. Following completion of the three-month pranayama intervention, data from 59 participants were available for final analysis.

Eligibility Criteria

Inclusion Criteria: Apparently healthy individuals aged 20–40 years.

Exclusion Criteria: Individuals with a history of chronic systemic illness, respiratory or cardiovascular disorders, smoking or alcohol consumption, regular practice of yoga or participation in structured exercise programs were excluded from the study.

Pranayama Intervention

Participants underwent supervised pranayama training for a duration of three months under the guidance of a trained yoga instructor. Sessions were conducted five days per week between 5:00 PM and 5:30 PM under standardized conditions in a quiet and well-ventilated environment.

Each session lasted for 30 minutes and included the following sequence of pranayama practices

Sequence	Pranayama Technique	Duration
1	Preparation and relaxation	2 minutes
2	Kapalabhati	8 minutes
3	Bhastrika	8 minutes
4	Pranav Pranayama	6 minutes
5	Savitri Pranayama	6 minutes

Participants were instructed to maintain a comfortable sitting posture throughout the session. Attendance and compliance with the intervention protocol were monitored regularly during the study period.

Assessment of Autonomic Parameters

Resting heart rate and respiratory rate were recorded under resting conditions before initiation of the intervention and after completion of the three-month pranayama program. Breath-holding time was assessed using standard procedures under similar environmental conditions during both assessments.

Pulmonary Function Testing

Pulmonary function tests were performed using a computerized spirometer (RMS Helios 702, Recorders and Medicare Systems Pvt. Ltd., India). The parameters assessed included forced vital capacity (FVC), FEV_1/FVC ratio, peak expiratory flow rate (PEFR) and maximum voluntary ventilation (MVV). Pulmonary function testing was carried out in accordance with standard spirometry guidelines under similar environmental conditions before and after the intervention period.[12]

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD). Pre- and post-intervention comparisons were performed using paired t-test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 80 participants were initially enrolled in the study. Among them, 59 participants completed the entire pranayama intervention protocol and were included in the final analysis.

Baseline Characteristics of Study Participants

The study included apparently healthy young adults aged between 20 and 40 years who underwent structured pranayama training for a duration of three months.

Table 1: Baseline Characteristics of Study Participants

Variable	Value
Total participants enrolled	80
Total participants completed	59
Age group (years)	20-40
Mean age (years)	27.1 ± 4.96
Male participants, n (%)	29 (49.2%)
Female participants, n (%)	30 (50.8%)
Mean BMI (kg/m²)	23.44 ± 3.82
Underweight participants, n (%)	4 (6.7%)
Normal BMI participants, n (%)	26 (44.1%)
Overweight participants, n (%)	29 (49.2%)

Effect of Pranayama on Autonomic Parameters

Following the pranayama intervention, significant changes were observed in autonomic parameters. Resting heart rate and respiratory rate showed statistically significant reductions after the intervention, while breath-holding time demonstrated a significant increase.

The mean resting heart rate decreased from 79.47 ± 5.75 beats/min before the intervention to 78.68 ± 6.53 beats/min after pranayama training (p = 0.009). Similarly, respiratory rate decreased from 14.88 ± 1.90 breaths/min to 14.22 ± 2.79 breaths/min (p = 0.01). Breath-holding time increased significantly from 35.75 ± 5.52 seconds to 36.86 ± 6.42 seconds following the intervention (p = 0.008).

Table 2: Effect of Pranayama on Autonomic Parameters Before and After Intervention

Parameter	Baseline Mean ± SD	Post Mean ± SD	Mean Difference (Pre − Post)	p value
Resting heart rate (beats/min)	79.47 ± 5.75	78.68 ± 6.53	0.79 ± 2.26	0.009
Respiratory rate (breaths/min)	14.88 ± 1.90	14.22 ± 2.79	0.66 ± 2.07	0.01
Breath holding time (seconds)	35.75 ± 5.52	36.86 ± 6.42	−1.11 ± 3.11	0.008

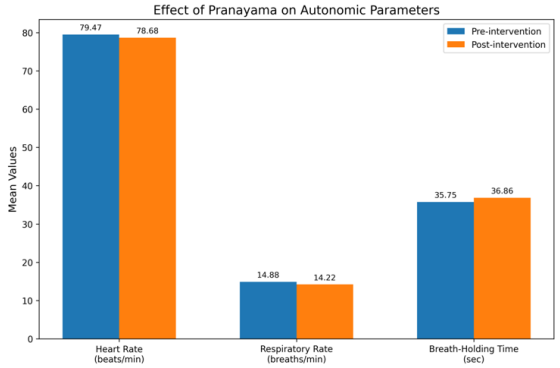

Figure 1: Comparison of Autonomic Parameters Before and After Pranayama Intervention

Effect of Pranayama on Pulmonary Function Parameters

Pulmonary function parameters demonstrated measurable improvement following pranayama training. Significant increases were observed in forced vital capacity (FVC), peak expiratory flow rate (PEFR) and maximum voluntary ventilation (MVV). However, the FEV_1/FVC ratio did not show a statistically significant change.

The mean FVC increased from 3.04 ± 0.22 L before the intervention to 3.07 ± 0.23 L after the intervention (p = 0.013). PEFR increased significantly from 4.54 ± 0.57 L/s to 4.66 ± 0.74 L/s (p = 0.02). Similarly, MVV increased from 95.63 ± 8.57 L/min to 97.37 ± 10.14 L/min following pranayama training (p = 0.021). The FEV_1/FVC ratio increased slightly from 80.37 ± 3.01% to 80.58 ± 5.38%, but the change was not statistically significant (p = 0.73).

Table 3: Effect of Pranayama on Pulmonary Function Parameters Before and After Intervention

Parameter	Baseline Mean ± SD	Post Mean ± SD	Mean difference (Pre − Post)	p value
Forced Vital Capacity (FVC) (L)	3.04 ± 0.22	3.07 ± 0.23	-0.03 ± 0.10	0.013
FEV_1 /FVC ratio (%)	80.37 ± 3.01	80.58 ± 5.38	−0.20 ± 4.50	0.73
Peak Expiratory Flow Rate (PEFR) (L/s)	4.54 ± 0.57	4.66 ± 0.74	−0.12 ± 0.41	0.02
Maximum Voluntary Ventilation (MVV) (L/min)	95.63 ± 8.57	97.37 ± 10.14	−1.74 ± 5.65	0.021

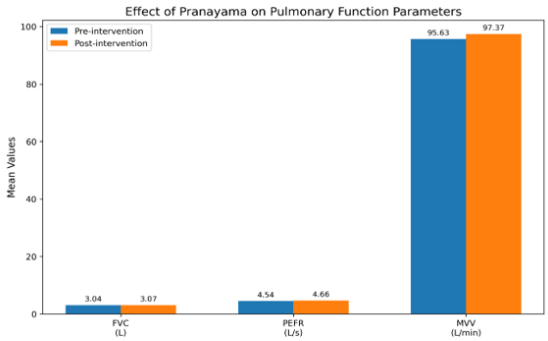

Figure 2: Comparison of Pulmonary Function Parameters Before and After Pranayama Intervention

Overall, the findings of the present study suggest that regular pranayama practice improves autonomic balance and enhances pulmonary function in healthy young adults.

DISCUSSION

The present study evaluated the effects of structured pranayama practice on pulmonary function and autonomic parameters in healthy young adults. Significant improvements were observed in resting heart rate, respiratory rate, breath-holding time, forced vital capacity (FVC), peak expiratory flow rate (PEFR), and maximum voluntary ventilation (MVV) following the three-month intervention.

The reduction in resting heart rate and respiratory rate observed after pranayama practice suggests improved autonomic balance with enhanced parasympathetic activity. Similar reductions in heart rate and improvements in autonomic function have been reported following yogic breathing interventions.[11,13] Slow and controlled breathing has been shown to influence autonomic regulation through modulation of respiratory centres and vagal pathways, resulting in reduced sympathetic activity and improved cardiovascular stability.[5-7] These findings support the role of pranayama in promoting favourable autonomic adaptations and improving cardiorespiratory regulation.

The significant increase in breath-holding time observed after the intervention suggests improved respiratory endurance and enhanced voluntary control of respiration. Similar improvements in breath-holding capacity following yogic breathing practices have been reported previously. [13] Repeated exposure to controlled breathing and breath-retention techniques during pranayama may contribute to adaptive changes in respiratory control mechanisms, enhanced diaphragmatic control, and greater tolerance to carbon dioxide accumulation.[6,14,15] Such adaptations may improve respiratory efficiency and contribute to better overall ventilatory performance.

Significant improvements were also observed in pulmonary function parameters, particularly PEFR and MVV. Similar improvements in ventilatory parameters following pranayama practice have been reported by Dinesh et al., Joshi et al., and Makwana et al.[8-10]

PEFR is influenced by airway calibre, lung elasticity, and expiratory muscle strength, whereas MVV reflects overall ventilatory capacity and respiratory muscle endurance.[14,15] The observed improvements may therefore indicate enhanced respiratory muscle efficiency and improved ventilatory performance resulting from regular pranayama practice.

Forced vital capacity demonstrated a modest but statistically significant increase following the intervention. Although the magnitude of improvement was relatively small, similar observations have been reported in previous studies evaluating the effects of pranayama on pulmonary function.[8-10] The relatively small increase in FVC may be attributed to the fact that the study participants had normal baseline pulmonary function, limiting the scope for substantial improvement. Regular pranayama practice may nevertheless enhance lung expansion and improve ventilatory efficiency through repeated deep breathing manoeuvres.

In contrast, the FEV_1 /FVC ratio did not show a statistically significant change following the intervention. This finding is expected in healthy individuals because the FEV_1 /FVC ratio primarily reflects airway obstruction and generally remains stable in the absence of underlying pulmonary disease. The absence of a significant change suggests that pranayama predominantly improves functional ventilatory performance rather than altering airway resistance.

The physiological benefits of pranayama may be attributed to improved diaphragmatic excursion, enhanced alveolar ventilation, better ventilation–perfusion matching, and strengthening of respiratory musculature.[14,15] In addition, autonomic modulation induced by slow breathing may enhance cardiorespiratory coupling and improve overall cardiorespiratory efficiency.[5,6] These mechanisms may collectively contribute to the improvements in pulmonary and autonomic parameters observed in the present study.

Overall, the findings of the present study are consistent with previous reports demonstrating beneficial effects of pranayama on pulmonary function and autonomic regulation.[8-11,13] The observed improvements highlight the potential of pranayama as a simple, safe, and cost-effective non-pharmacological intervention for promoting respiratory health and autonomic balance in healthy individuals.

Strengths and Limitations

Strengths of the present study include the use of a standardized supervised pranayama protocol, assessment of both autonomic and pulmonary outcomes, and evaluation over a three-month intervention period. However, the study was limited by the absence of a control group, convenience sampling, and the inclusion of only healthy young

adults. Furthermore, the long-term sustainability of the observed physiological changes was not assessed. Future controlled studies involving larger and more diverse populations are warranted to further elucidate the long-term physiological effects of pranayama.

CONCLUSION

The present study demonstrated that a structured three-month pranayama program produced significant improvements in both pulmonary function and autonomic parameters among healthy young adults. Regular pranayama practice was associated with reductions in resting heart rate and respiratory rate, increased breath-holding time, and improvements in forced vital capacity, peak expiratory flow rate, and maximum voluntary ventilation. These findings indicate enhanced respiratory efficiency, improved ventilatory performance, and favourable autonomic adaptations, likely mediated through increased parasympathetic activity, improved respiratory muscle function, and more efficient respiratory control mechanisms.

The results support the growing body of evidence suggesting that pranayama exerts beneficial effects on both respiratory and autonomic regulation. As a simple, safe, inexpensive, and non-pharmacological intervention, pranayama may represent an effective strategy for promoting cardiopulmonary health and overall physiological well-being in healthy individuals. Incorporation of structured breathing exercises into daily lifestyle practices may therefore have potential preventive and health-promoting benefits. Further controlled studies with larger sample sizes, longer follow-up periods, and diverse populations are required to confirm these findings and evaluate their long-term sustainability.

Declarations

Ethical Approval

The study was conducted after obtaining approval from the Institutional Ethics Committee of Kodagu Institute of Medical Sciences, Madikeri, Karnataka.

Informed Consent

Written informed consent was obtained from all participants prior to enrolment in the study.

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Conflict of Interest

The authors declare no conflict of interest.

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