Research Article

Effect Of Hatha Yoga On Muscular Endurance, Pulmonary Function And Physical Fitness Among College Students: A Randomized Controlled Trail

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Abstract

Background: College students face declining physical activity levels alongside rising academic and psychological demands both of which affect muscular fitness and respiratory efficiency. Hatha yoga, combining postures (asanas), controlled breathing (pranayama) and relaxation has been proposed as a low-cost intervention to improve physical fitness parameters.

Objective: To evaluate the effect of a 3month structured Hatha yoga program on muscular endurance, pulmonary function and physical fitness among college students.

Methods: A randomized controlled trial was conducted with 180 college students allocated equally to an intervention group (m=90, Hatha yoga, 3 session/wk for 12 wk) and a control group (n-90, no structured intervention). Muscular endurance was assessed using standardized timed repetition tests; pulmonary function was measured via spirometry; physical fitness was assessed using BMI, sit-and-reach flexibility and a 12-min run test. Assessments were conducted at baseline and post-intervention.

Results: The intervention group showed statistically significant improvements relative to control across most muscular endurance and pulmonary function measures ($p<0.05$), with medium-to-large effect sizes (Cohen's $d=0.30$-1.13).

Conclusion: A 12-week hatha yoga intervention may meaningfully improve muscular endurance, pulmonary function and selected physical fitness parameters among college students supporting its integration into campus wellness programs.

Keywords: Hatha yoga, muscular endurance, pulmonary function, college students.

1. Introduction

Sedentary academic practices and physical inactivity are becoming more widely acknowledged as risk factors for decreased muscle fitness and compromised respiratory efficiency in yoga adults attending college. There have been requests for efficient, scalable exercise treatments in academic contexts due to the persistent deterioration in college students physical fitness which has been identified as a major and expanding issue globally (Ye et al., 2022). Reduced ability for physical activity, increased weariness and long-term cardiovascular and metabolic risk are linked to declines in lung function and muscle endurance throughout this development stage. Despite their effectiveness traditional exercise-based therapies frequently encounter difficulties with cost, accessibility and long-term adherence among student populations.

As a non-pharmacological intervention for enhancing pulmonary function yoga an ancient Indian mind-body practice that combines physical postures, controlled breathing techniques and meditation as attracted a lot of scientific attention (Field, 2016; Carmer et al., 2016). The most popular type of yoga in the world, Hatha yoga, focuses on static poses that are synchronized with deep breathing patterns. These poses are thought to improve chest wall compliance, increase alveolar surface area for gas exchange, strengthen respiratory muscles and regulate autonomic nervous system activity (Birkel & Edgren, 2000; Harinath et al., 2004). Early controlled studies showed that among college students even those with asthma or a history of smoking, regular hatha yoga practice resulted in statistically significant increases in vital capacity (Birkel & Edgren, 2000).

This respiratory benefit has been confirmed by subsequent randomised trials in clinical and occupational populations: yoga practice has been demonstrated to significantly increase forced vital capacity, forced expiratory volume and peak expiratory flow rate in comparison to control conditions (Rajbjoj et al., 2023). In patients with obstructive pulmonary disease a randomised study comparing hatha yoga to a conventional training program found yoga to be a practical and safe alternative form of similar findings were reached by a comprehensive review and meta-analysis of yoga treatments in chronic obstructive pulmonary disease which found that yoga significantly improves exercise capacity and pulmonary function when compared to no therapy (Carmer et al., 2019).

In college populations in particular, yoga-based and other conventional mind-body training programs have demonstrated promise for broader physical fitness results beyond respiratory outcomes. In comparison to a no-intervention control group a 12-week Baduanjin exercise program a related traditional practice that combines slow, controlled movement with breath regulation, significantly improved college students composite health-related physical fitness including increases in flexibility, cardiopulmonary fitness and body endurance (Ye et al., 2022). In a similar vein, inactive female college students who participated in a three-month tailored yoga training program saw improvements in cardiopulmonary function, musculoskeletal strength and endurance fitness in addition to decreases in blood pressure and resting heart rate (Mitra et al., 2024). All of the research points to the possibility that organised, breath-focused exercises like hatha yoga might enhance pulmonary function and muscle endurance in yoga, healthy adult populations.

However, there is still a dearth of research on college aged populations that combines generally physical fitness indicators, complete spirometry outcomes including all major lung volumes and capacities and muscular endurance across many muscle groups in a single RCTs. Instead of focusing on a comprehensive physiological profile in health college students the majority of current trials have exclusively focused on either separate fitness metrics or respiratory outcomes in clinical groups. Therefore, this study uses a RCTs to assess the effectiveness of a structured 12-week hatha yoga intervention on (1) muscular endurance, (2) pulmonary function across the entire range of lung volumes and capacities (3) general physical fitness parameters among college students.

2. Methods

2.1 Study Design and Ethics

Between December 2024 and March 2025, this parallel group, RCTs was carried out. The MAHER (Meenakshi Academy of Higher Education and Research) Institutional Ethics Committee gave its approval to the study protocol (Approval no; MAHER/IEC/PhD/48/Nov24). Before enrolment, each subject provided written informed permission. The experiment was carried out in compliance with the 2010 CONSORT standards and the Declaration of Helsinki (2013 version) (Schulz et al., 2010).

2.2 Participants

Stratified random sample from registered undergraduate students, 180 college students (intervention n=90; control=90) were selected Meenakshi College of Yoga Science and Therapy, India. Ages 18 to 25 full time enrolment, no prior regular yoga practice (>6 months) and medical clearance for physical activity are the requirements for inclusion. Pre-existing musculoskeletal injuries, a diagnosis of cardiovascular illness or pregnancy are exclusion factors. Every participant provided written informed permission.

2.3 Randomization and Allocation Concealment

A computer-generated random number sequence was used to randomly assign participants (1:1) to either the hatha yoga group or the traditional physical activity control group (www.randomizer.org). An independent researcher who was not engaged in data collection or intervention delivery constructed opaque, sealed envelops with sequential numbers to guarantee allocation concealment. The outcome assessor and data analyst were blinded to group allocation but participant and teacher blinding was not possible due to the nature of the intervention.

2.4 Interventions

For 12 weeks, participants participated in 60 sessions of supervised Hatha yoga, five days a week, for 60 min day. Anulom Vilom, Kapalabhati, Bhastrika, Bhramari and Dhanuarsana, Matsyasana, Ustrasana, Setu Bandhasana, Trikonaasana and Ardha Matsyendrasana (20 min) were included in each session. A certified yoga instructor with at least five years of teaching experience led each class.

2.5 Conventional Physical Activity Group (Control)

For 12 weeks, participants participated in 60 sessions of supervised conventional physical exercise five days a week for 60min each day. Each session included (a) 10-min jogging and dynamic stretching warm up; (b) 30min of aerobic exercises (brisk walking, light jogging, aerobic dance) at 50-70% o the age-predicted maximum heart rate; (c) 10min of flexibility exercises and (d) a 10min cool down. A certified physical education teacher oversaw the sessions. There were no elements of yoga, pranayama or meditation.

2.6 Outcome Measures

A computerised spirometer (Medspiror, Meditron Enterprises, India) was used for all pulmonary function tests (PFTs) in compliance with the 2019 standardisation standards of the American Thoracic Society. Europena Respiratory Society (ATS/ERS (Graham et al., 2019). Testing was done while sitting and wearing a nasal clip between 8 and 10 AM. Before testing, participants were told to abstain from large meals, coffee and strenuous activity for at least four hours. The best results were noted after three acceptable and repeatable manoeuvres were carried out. A blinded assessor performed all evaluations at baseline and 12 week (post).

2.7 Primary Outcome

1. The largest amount of air that can be forcibly expelled following a maximal inhalation is known as the FVC in lits. 2. The amount of air expelled in the first second of a forced expiration is known as the FEV1. 3. FEV1/FEVC Ration a measure of airway blockage that represents the percentage of vital capacity evacuated in the first second. 4. Peak Expiratory Flow Rate PEFR the fastest rate of expiration indicating strong expiration muscles and a big airway.

2.8 Secondary Outcome

Forced expiratory flow at 25-75% of FVC: the average flow rate during the middle half of the FVC, sensitive to small airway disease: (5) Maximum Voluntary Ventilation (MVV): the maximum amount of air that can be inhaled and exhaled in a min, reflecting respiratory muscle endurance;(6) vital capacity.

2.9 Statistical Analysis

SPSS was used to analyse the data. The Shapiro-wilk test was used to determine normality. Independent-sample t test were used to assess baseline equivalency between groups. Paired sample t tests were used to examine within group pre post changes Analysis of covariance with group as the fixed factor and baseline score as covariate was used to examine between group differences at post test, adjusted for baseline scores. Corens'd was used to report effect size. The threshold for statistical significance was established at $p<0.05$.

3. Results

Randomisation was effective since baseline demographic and outcome characteristics did not substantially differ between the intervention and control groups ($p>0.05$) for all comparisons.

3.1 Muscular Endurance Outcomes

Table 1: Baseline BMI, age and sex distribution of participants.

Variable	Int. Pre (M±SD)	Int. Post (M±SD)	Ctrl Pre (M±SD)	Ctrl Post (M±SD)	Between p	Cohen's d
Upper body (push-ups)	17.5±4.7	22.4±6.3	18.3±4.8	18.9±4.9	0.0001	0.62
Lower body (wall-sit, s)	45.8±12.7	59.9±16.5	43.1±11.7	43.5±12.2	<0.0001	1.13
Abdominal (sit-ups/min)	22.0±5.6	27.6±7.1	23.6±5.8	24.3±6.1	0.0009	0.51

The intervention group showed statistically significant improvements over control in all three muscular endurance domains at post test ($p<0.01$) with the largest effect observed for lower-body endurance ($d=1.13$, large effect).

3.3 Pulmonary Function Outcomes

Variable	Int. Pre (M±SD)	Int. Post (M±SD)	Ctrl Pre (M±SD)	Ctrl Post (M±SD)	Between p	Cohen's d
Tidal Volume (L)	0.52±0.09	0.57±0.10	0.50±0.08	0.50±0.08	<0.0001	0.71
Insp. Reserve Vol. (L)	2.09±0.41	2.43±0.49	1.95±0.42	1.97±0.44	<0.0001	0.97
Exp. Reserve Vol. (L)	1.08±0.28	1.23±0.32	1.12±0.32	1.13±0.33	0.047	0.30
Residual Volume (L)	1.21±0.26	1.14±0.25	1.23±0.24	1.23±0.24	0.015	-0.37
Vital Capacity (L)	3.61±0.66	4.13±0.78	3.65±0.52	3.71±0.58	0.0001	0.61
Func. Residual Cap. (L)	2.29±0.45	2.43±0.50	2.24±0.41	2.25±0.43	0.013	0.37
Total Lung Cap. (L)	4.88±0.73	5.37±0.85	4.82±0.76	4.89±0.84	0.0002	0.56

All lung function indicators showed significant between group improvements in favour of the yoga group. The intervention group's residual volume significantly decreased in comparison to the control group ($d=-0.37$) which is consistent with increased expiratory efficiency.

3.4 Physical Fitness Outcomes

Variable	Int. Pre (M±SD)	Int. Post (M±SD)	Ctrl Pre (M±SD)	Ctrl Post (M±SD)	Between p	Cohen's d
BMI (kg/m²)	23.8±2.9	22.9±2.8	23.2±2.8	23.2±3.1	0.420	-0.12
Flexibility (sit-and-reach, cm)	18.5±6.0	21.9±7.7	18.2±5.7	18.4±5.9	0.0006	0.52
Cardio endurance (12-min run, m)	1865±193	2083±223	1830±230	1852±249	<0.0001	0.98

While BMI change did not differ significantly between groups (p=0.42),flexibility and cardiovascular endurance improved significantly more in the yoga group than in the control group (p<0.001), indicating that the intervention effects were more noticeable for functional fitness than body composition over the course of the 12 week period.

4. Discussion

In comparison to a no-intervention control group, a 12-week hatha yoga intervention resulted I statistically significant, medium to large gains in muscle endurance, pulmonary function and some physical fitness indices among college students according to this randomised controlled experiment. These results are consistent with the hypothesised mechanisms through which yoga practice may improve physical fitness, diaphragmatic and pranayama breathing techniques plausibly increase lung volumes and respiratory muscle strength, while prolonged isometric postural hold during asana practice probably contribute to muscular endurance gains. The improvements in pulmonary function seen here are largely inline with previous research showing that hatha yoga greatly enhances vital capacity in college students (Birkel & Edgren, 2000) and with randomised data showing that yoga practice raises forced vital capacity and expiratory flow rates in comparison to control (Rajbhoj et al., 2023). Despite improvements in cardiovascular endurance and flexibility, there was almost no change in BMI. This suggests that the benefits of hatha yoga in this population may primarily come from neuromuscular and respiratory adaptation rather then significant changes in body composition over a relatively short 12-week period. This is in line with yoga's designation as a low to moderate intensity activity which would need to be practiced more frequently or for longer periods of time in order to result in noticeable changes in body composition. This pattern is consistent with results from a similar 12 week classical mind-body training study in college students which also showed notable improvements in composite physical fitness areas including cardiopulmonary endurance and flexibility (Ye et al., 2022).

5. Conclusion

In comparison to a non-intervention control group, 12 week structured hatha yoga intervention considerably enhanced college students muscular endurance (upper body, lower body and abdominal), pulmonary function across several lung volume and capacity measures and specific physical fitness parameters (flexibility, cardiovascular endurance). These results validate hatha yoga as a approachable, empirically supported strategy for improving physical fitness in college-aged individuals.

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