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Effect of Aerobic Exercise Training Versus Pranayama Yoga Training on Patients with Bronchial Asthma

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Abstract
Background: Bronchial asthma is a chronic respiratory disease characterized by airway inflammation and hyper-responsiveness. Regular physical exercise and structured breathing practices are both believed to improve respiratory function and quality of life in asthma patients, but direct comparisons are limited.
Purpose: This study aimed to compare the effects of aerobic exercise training versus pranayama (yogic breathing) training as adjunct therapies for adults with mild-to-moderate bronchial asthma and improve quality of life in these patients.
Subjects, materials and methods: In this randomized controlled trial, sixty adult patients (age 22–40) with clinically diagnosed mild-to-moderate asthma were randomly assigned to the three groups (n=20 each). **Group A** received standard asthma medication plus a supervised aerobic exercise program, **Group B** received standard medication plus pranayama yoga training, and **Group C** (control) received standard medication alone. The two intervention programs were conducted over six weeks with three sessions per week.
Results:
Statistical analysis showed that both groups (A and B) showed significant improvements in pulmonary function (FEV_1, FVC, FEV_1/FVC) exercise capacity, asthma control, and quality of life after 6 weeks, whereas the control group showed no significant changes.
Conclusion: Both aerobic exercise training and pranayama yoga breathing exercises are effective adjunct therapies for improving lung function, symptom control, and quality of life in patients with bronchial asthma. The slightly greater improvement in small-airway function observed with pranayama may reflect the specific benefit of breath-control techniques on airway dynamics.
Keywords: Bronchial Asthma; Aerobic Exercise; Pranayama Yoga; Pulmonary Function; Quality of Life; Randomized Controlled Trial.

Introduction

Bronchial asthma is a chronic disease defined as reversible airflow obstruction, inflammation, and hyper-responsiveness to different stimuli and characterized by wheezing, breathlessness, chest tightness, and coughing. These symptoms reduce patients' quality of life and restrict daily-life physical activity (DLPA) [1]. Asthmatic patients may benefit from exercise training, although the effects of a combined aerobic and resistance training program are still poorly investigated in children and adolescents [2]. The main burden in asthma is reduced control manifesting as exacerbations. Importantly, children and young people with asthma perceive improvement in their asthma control and a reduction in asthma related symptoms following physical activity and report enjoyment and improved quality of life (QOL) from taking part in physical activity programs [3]. Patients with asthma also present higher levels of anxiety and depression, which may reduce adherence to medication and clinical control. Such control is essential to avoid a patient's impairment and reduce the risk of exacerbation and is centered on the amount of medication (controllers and relievers) required to avoid symptoms [1]. The treatment of asthma consists of both medical, primarily through inhalation medication, and non-medical therapy. The aim of treatment is to achieve a normal lifestyle with a normal exercise capacity, the avoidance of serious asthma attacks and the achievement of an optimal lung function with as few symptoms as possible [4]. With aerobic exercise, comes increased oxygen and ventilatory demands, which quickly leads to rapid and deep breathing. These factors have been shown in experimental models to cause airway smooth muscle stretch, bronchodilation and the maintenance of airway caliber [5]. Pranayama is an art of controlling the life force of breath. It is an ancient yoga technique, a spiritual and physical practice which integrates the mind and body. Pranayama is a type of yogic practice which produces many systemic psycho-physical effects in the body, besides its specific effects on the respiratory functions [6].

Subjects and Methods

Design

Randomized controlled trial conducted on two study groups and a control group of asthmatic patients.

Setting

This study recruited 60 asthmatic patients at The Hope Physical Therapy Center from December 2024 to March 2025.

Ethics

The Ethical Committee of the Faculty of Physical Therapy at October 6 University has granted permission with the designation (O6U.P.T.REC/024/003001). In order to carry out this comparative analysis, it was necessary for the participation of smokers to be contingent upon their provision of written consent, following the comprehensive understanding of the study's aims and protocols. Helsinki recommendations were followed during the application of this trial on asthmatic patients.

Participants

Sixty asthmatic patients were recruited from The Hope physical therapy center. The inclusion criteria consisted of patients who suffer from mild to moderate bronchial asthma, for five to eight years, with age range from 22 to 40 years old. The exclusion criteria consisted of patients who have hypertension/ hypotension, restrictive lung disease, suppurative lung disease, other chronic diseases as Diabetes Mellitus, athletic patients who perform regular exercise, any patient suffers from any other chest diseases that will interfere with the results of the study, any other thoracic surgery.

Interventions

The study groups: Group A (Aerobic exercise) and Group B (Pranayama Yoga) received Three sessions weekly for a duration of six weeks.

The control group didn’t receive any intervention.

Aerobic Exercise

Warm up phase: 10 minutes of walking in open air. Training phase: include 10-15 reps per set, 2-4 sets per exercise,30-60 seconds rest period between sets. Cooling down phase includes hold each stretch for 15-30 seconds, 2-4 repetitions per side and rest for 15-30 seconds between repetitions.

Core exercises**:** in order to train the diaphragm and upper abdominal muscles as:

Half crunches exercise: subject was lying supine on a flat surface with the knees flexed and feet flat. Hands are placed behind the head without pulling on the neck. The patient then lifts the head and shoulders off the surface by contracting the upper abdominal muscles, while the lower back remains in contact with the surface [7].

Curl ups: Subject was lying supine position on a firm surface with one knee bent at approximately 90 degrees and feet flat. Hands are crossed over the abdomen. The participant slowly lifts the head, neck, and upper trunk off the surface in a controlled motion, engaging the abdominal muscles, then returns to the starting position without lifting the lower back from the surface [8].

Bird dog: subject started in a quadruped position with hands aligned under the shoulders and knees under the hips. From this neutral spine position, the participant extends one arm forward and the opposite leg backward simultaneously, maintaining balance and avoiding trunk rotation. The position is held briefly before returning to the starting position, then alternating sides [9&10].

Straight leg raising (SLR): The subject was lying on his back with one knee bent and his foot on the ground, while the other leg was erect and his arms were at his sides. The subject ensured stability by lifting his straight leg to 45 degrees and then gently lowering it while engaging his core [11].
Side-lying leg raises: The subject was lying on his side with his legs extended and his head resting on either an arm. Subject maintained his pelvis in a stacked position by engaging his core. He raised the upper leg to a 45-degree angle, with the toes facing either forward or downward. He then lowered the limb, pausing above the ground before switching sides [12].
Stretching pectoralis major muscle: The subject stood in a corner, with his arms at shoulder height, his forearms against the walls, and his ankles shoulder-width apart. To extend his torso for 15 to 30 seconds, he leaned in and took a single step forward. Before leaning, he extended his arms to a point just above shoulder height in order to reach his lower torso. He returned to the starting position so he completed the task [13].
Open book exercise subject was lying on his side, head resting on arm or pillow, knees and hips were bent 90 degrees with a small pillow or a foam block in between them. Slowly turn your head to one side, moving only the neck while keeping your shoulders relaxed and facing forward. Continue the rotation by twisting your upper back (thoracic spine) towards the same side, allowing the shoulders and chest to follow the movement. Hold the maximum comfortable rotation for about 3–5 seconds without pain or strain. Slowly return to the starting position. Perform 8–10 repetitions on each side, moving smoothly and controlled.
comfortable range [14].
Seated thoracic extension: subject was sitting upright on a chair with their feet flat on the floor, hips and knees at about 90 degrees. Keep your back straight and shoulders relaxed. Position of hands, cross the hands on their chest. Engage the core, tighten their abdominal muscles slightly to stabilize the lower back and pelvis. Extend the thoracic spine, slowly arch the upper back by lifting your chest upwards and backward, aiming to extend the thoracic spine. Hold the position, maintain the stretch for 3–5 seconds, breathing normally. Return to neutral, gently bring their torso back to the starting position.
Perform 8–10 repetitions [15].
Standing cervical/thoracic rotation: Stand upright with feet shoulder-width apart, arms relaxed by your sides. Keep your abdominal muscles gently activated (to stabilize the spine. Slowly turn your head to one side, moving only the neck while keeping your shoulders relaxed and facing forward. Continue the rotation by twisting your upper back (thoracic spine) towards the same side, allowing the shoulders and chest to follow the movement. Hold the maximum comfortable rotation for about 3 to 5 seconds without pain or strain. Slowly return to the starting position (neutral position). Perform 8–10 repetitions on each side [16].

Pranayama Yoga

Duration of these exercises is 20 to 30 minutes with alternating rest periods to avoid hyperventilation.
Bhastrika: subject was sitting comfortably in a cross-legged position with the spine erect and shoulders relaxed. Take a deep, slow breath to settle your mind and body. Forceful inhalation: Inhale deeply and quickly through both nostrils using your diaphragm and abdominal muscles, filling your lungs fully. Forceful exhalation: Exhale quickly and forcefully through both nostrils, pushing the air out with your abdominal muscles. Continue this rapid inhalation and exhalation cycle at a steady pace, approximately 1 to 2 breaths per second. Start with 10-20 breaths (one round), then pause and breathe normally [17].
Anulom-Vilom: subject was sitting in a cross-legged position with the spine straight and shoulders relaxed. Rest your left hand on your lap. Hand position: Use your right hand's thumb to close the right nostril and your ring finger (or little finger) to close the left nostril. Gently close your right nostril with your thumb and inhale slowly and deeply through your left nostril. Close your left nostril with your ring finger, release the thumb from the right nostril, and exhale slowly through the right nostril. Keeping the left nostril closed, inhale slowly through the right nostril. Switch nostrils: Close the right nostril again with your thumb, release the left nostril, and exhale slowly through the left nostril. This completes one round. Continue for 5–10 minutes, maintaining slow, smooth, and even breaths. End with an exhale on the left nostril and breathe normally [18].

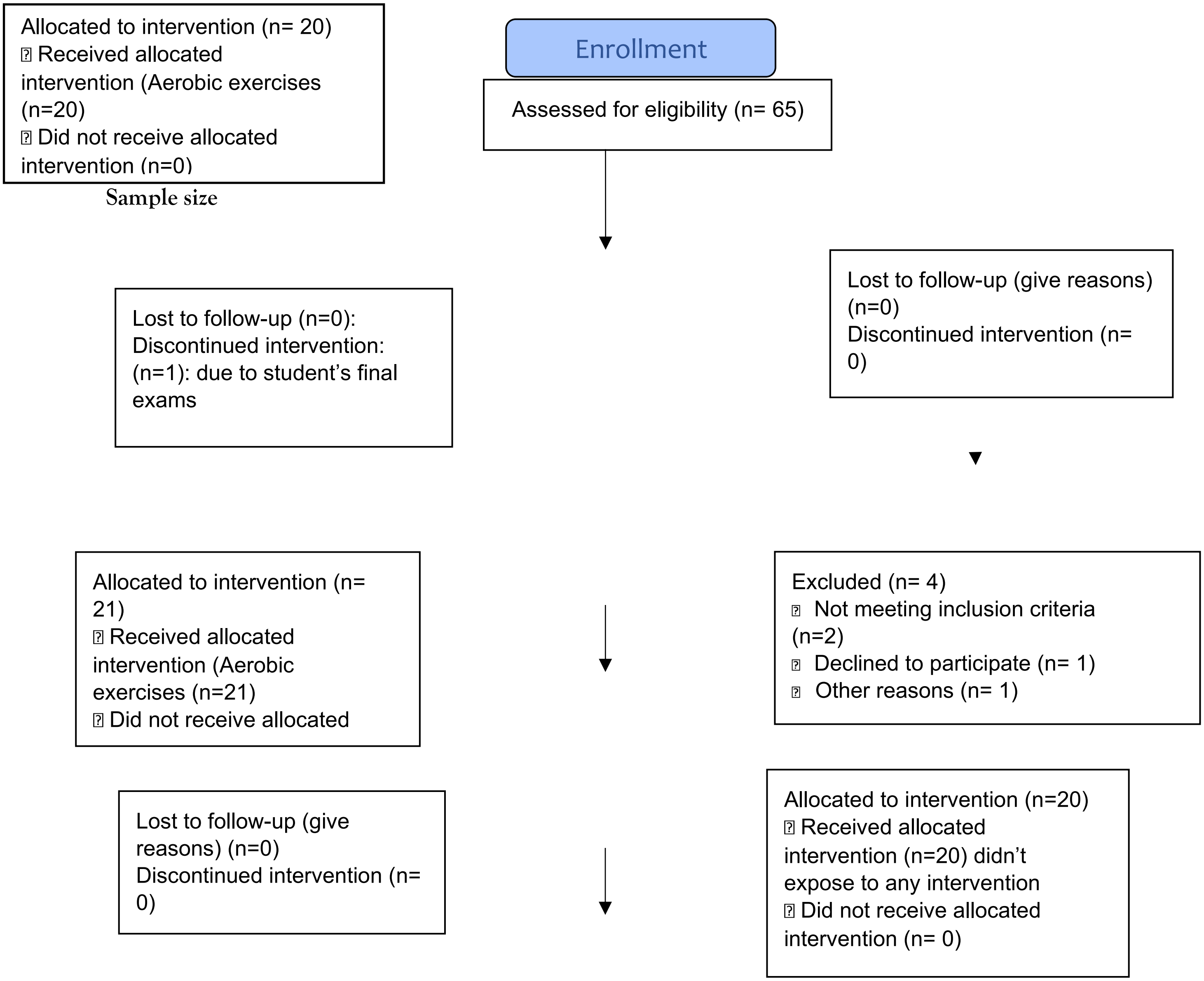
Kapalbhati: subject was sitting in a comfortable cross-legged position with the spine straight and shoulders relaxed. Take a deep breath in through both nostrils. Forceful exhalation: Exhale sharply and forcefully through your nose by contracting your abdominal muscles, pushing the air out quickly. Passive inhalation: Allow your lungs to refill naturally with a passive, relaxed inhalation. Continue this cycle of active exhalations and passive inhalations at a steady pace (about 1 exhalation per second). Begin with 20-30 breaths (one round), then rest and breathe normally [19].
Bahya pranayama: subject was sitting in a comfortable meditative posture with the spine erect and shoulders relaxed. Take a slow, deep breath in through both nostrils, filling your lungs completely. Exhale fully and forcefully, emptying your lungs entirely. External breath retention: Hold your breath with lungs empty, pulling your abdominal muscles inward and upward (like a mild stomach contraction). Retain this breath comfortably for a few seconds (start with 5-10 seconds). Release and inhale: Relax the abdomen and inhale slowly to resume normal breathing. Perform 5-8 cycles, gradually increasing retention time as comfortable [20].
Bhramri: subject was sitting in a comfortable cross-legged posture with the spine erect and shoulders relaxed. Gently close your eyes and take a few deep breaths to relax. Take a slow, deep breath in through both nostrils. While exhaling, produce a steady humming sound (like a bee) by gently pressing the tongue against the roof of the mouth or simply making the humming sound in the throat. Focus: Concentrate on the vibration and sound to calm the mind. Perform 5-10 rounds, resting briefly between each [21].
Udgit Om uchcharan: subject was sitting in a meditative posture with the spine straight and shoulders relaxed. Close your eyes and take a few deep, calming breaths. Take a slow, deep breath in through your nose. Chant “Om”: Begin chanting “Om” slowly and loudly. Pronounce the “A” sound from the lower abdomen, the “U” sound from the chest, and the “M” sound with your lips closed, letting it resonate in your head. Prolong the sound: Extend the “M” sound for as long as comfortable, feeling the vibration throughout your body. Pause and breathe: After completing the chant, hold your breath for a moment if comfortable, then exhale gently. Continue for 5–10 rounds, maintaining steady, calm breathing between chants [22].

Outcome measures

Practical Application of the Peak Flow Meter: The therapist explains the procedure and ensure patient cooperation. Have the patient either sitting or standing upright to maximize lung capacity. Attach a clean mouthpiece to the device.
Turn on the device, ensuring it’s reset and ready to measure. Instruct the Patient to Inhale Deeply. The patient takes a maximal inhalation to fill the lungs completely. The patient places their lips tightly (forming a tight seal) around the mouthpiece to avoid air leaks.
Ask the patient to blow out as hard and fast as possible in a single breath. The device measures Peak Expiratory Flow (PEF) in L/min and, FEV_1, FVC in liters. The digital screen displays the result. Record the best of three consistent efforts (differences within 40 L/min), allowing rest between attempts. Remove and discard the mouthpiece or clean it by alcohol [23].

Figure 1. Consort flow chart of this study

Sample size


Allocated to intervention (n= 20)
▯ Received allocated intervention (Aerobic exercises (n=20)
▯ Did not receive allocated intervention (n=0)
Enrollment
Assessed for eligibility (n= 65)
Lost to follow-up (n=0):
Discontinued intervention: (n=1): due to student's final exams
Lost to follow-up (give reasons) (n=0)
Discontinued intervention (n= 0)
Allocated to intervention (n= 21)
▯ Received allocated intervention (Aerobic exercises (n=21)
▯ Did not receive allocated
Excluded (n= 4)
▯ Not meeting inclusion criteria (n=2)
▯ Declined to participate (n= 1)
▯ Other reasons (n= 1)
Lost to follow-up (give reasons) (n=0)
Discontinued intervention (n= 0)
Allocated to intervention (n=20)
▯ Received allocated intervention (n=20) didn't expose to any intervention
▯ Did not receive allocated intervention (n= 0)

Sample size calculation

This report presents a detailed statistical analysis of respiratory function data from 60 patients divided equally among three treatment groups (**A**, **B**, and **C**). The study collected pre- and post-treatment measurements of pulmonary function tests (PFTs), exercise capacity, and quality of life metrics. Statistical analysis reveals significant differences in treatment efficacy across groups, with **Groups A** and **B** showing superior outcomes compared to **Group C**.

Statistical analysis:

- Descriptive statistics: Mean, median, standard deviation, range
- Inferential statistics:
    - Paired t-tests for within-group pre-post comparisons
    - One-way ANOVA with post-hoc Tukey's test for between-group comparisons
    - Pearson correlation coefficients for relationship analysis
    - Cohen's d for effect size estimation
- Significance level: $\alpha = 0.05$
- Software: Statistical analysis performed using standard statistical methods

Results

Demographic Characteristics

This table presents the age distribution of participants across three groups with no statistically significant differences (p>0.05), confirming successful randomization. Involving a total of 60 participants, divided equally into **Group A**, **Group B**, and **Group C** (20 participants in each group).

The mean age of all participants was 30.80 years with a standard deviation (SD) of 3.58 years. The median age was 31 years, with a range from 22 to 38 years.

The mean values of the asthmatic patient's age (year) in study groups and control group were 30.65 ± 3.44, 31.00 ± 3.93 and 30.75 ± 3.49 year, respectively

The median [Range] values of the asthmatic patient's age (year) in study groups and control group were 31 [25–35], 31.5 [26–37]and 31 [22–38] year, respectively

Statistical Analysis:

The p-value is 0.871, indicating that there is no statistically significant difference in age among the three groups. A p-value above 0.05 suggests that any observed differences in age are likely due to chance rather than a systematic variation among groups.

Table (1): Pre-treatment Demographic Characteristics by Treatment Group

Characteristic	Overall (n=60)	Group A (n=20)	Group B (n=20)	Group C (n=20)	p-value
Age, years					0.871
Mean ± SD	30.80 ± 3.58	30.65 ± 3.44	31.00 ± 3.93	30.75 ± 3.49	
Median [Range]	31 [22-38]	31 [25-35]	31.5 [26-37]	31 [22-38]	

p-values from one-way ANOVA

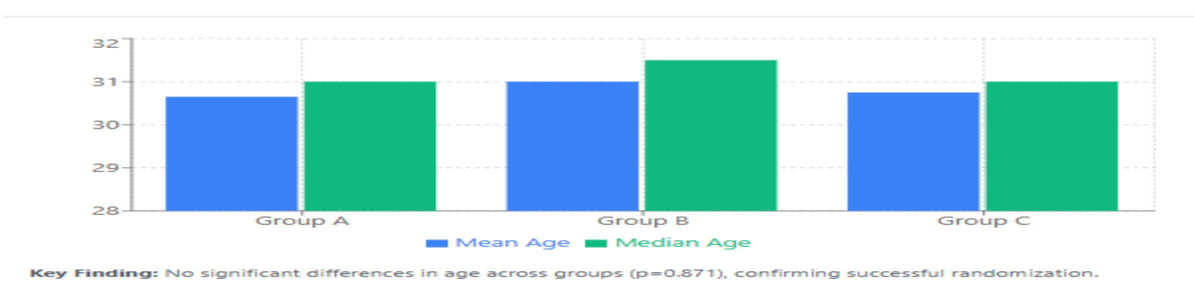


Figure (1): Demographic Characteristics, age distribution across treatment groups showing successful randomization

1. Pulmonary Function Tests: Pre- and Post-Treatment Comparison

This table displays pulmonary function measurements before and after treatment across groups, showing absolute changes and percentage improvements with statistical significance indicators.

- All groups experienced improvements in pulmonary function.
- **Group B** generally showed the highest improvements, particularly in FEV1 and FVC.
- **Group C** had the least improvements, suggesting its treatment was less effective.
- The p-values (<0.001) show statistically significant differences, reinforcing the reliability of these findings.

1.1. FVC (Forced Vital Capacity in Liters)

Results of FVC comparison between pre- and post-intervention within each group

In Group A, the mean ±SD values of FVC before- and after-intervention were 4.13 ± 0.18 and 4.42 ± 0.11, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant ($p < 0.001$) increase in FVC. The mean difference and change percentage of FVC due to time effect in the study group were 2.52% (**Table 2**).

In Group B, the mean ±SD values of FVC before- and after-intervention were 3.91 ± 0.20 and 4.27 ± 0.11, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant ($p < 0.001$) increase in FVC. The mean difference and change percentage of FVC due to time effect in the study group were 3.24% (**Table 2**).

In the control group (Group C), the mean ±SD values of FVC before- and after-intervention were 4.28 ± 0.19 and 4.35 ± 0.09, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant ($p < 0.001$) increase in FVC (**Table 2**).

1.2. FEV_1 (Forced Expiratory Volume in 1 second, Liters):

Results of FEV_1 comparison between pre- and post-intervention within each group

In Group A, the mean ±SD values of FEV_1 before- and after-intervention were 3.13 ± 0.12 and 3.41 ± 0.12, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant ($p < 0.001$) increase in FEV_1. The mean difference and change percentage of FEV_1 due to time effect in the study group were 2.35% (**Table 2**).

In Group B, the mean ±SD values of FEV_1 before- and after-intervention were 2.91 ± 0.17 and 3.24 ± 0.11, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant ($p < 0.001$) increase in FEV_1. The mean difference and change percentage of FEV_1 due to time effect in the study group were 3.68% (**Table 2**).

In the control group (Group C), the mean ±SD values of FEV_1 before- and after-intervention were 3.19 ± 0.15 and 3.26 ± 0.10, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant ($p < 0.001$) increase in FEV_1. The mean difference and change percentage of FEV_1 due to time effect in the study group were 2.84% (**Table 2**).

1.3. PEFR (Peak Expiratory Flow Rate, Liters/min)

Results of PEFR comparison between pre- and post-intervention within each group

In Group A, the mean ±SD values of PEFR before- and after-intervention were 402.50 ± 9.67 and 442.00 ± 12.50, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant ($p < 0.001$) increase in PEFR.

In Group B, the mean ±SD values of PEFR before- and after-intervention were 387.50 ± 12.51 and 422.50 ± 12.09, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant ($p < 0.001$) increase in PEFR. (**Table 2**).

In the control group (Group C), the mean ±SD values of PEFR before- and after-intervention were 411.75 ± 12.08 and 420.75 ± 10.41, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant ($p < 0.001$) increase in PEFR.

1.4. FEF25–75 (Forced Expiratory Flow at 25% to 75% of FVC, Liters/min)

Results of FEF25–75 comparison between pre- and post-intervention within each group

In Group A, the mean ±SD values of FEF25–75 before- and after-intervention were 302.50 ± 9.67 and 332.00 ± 12.50, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant (p = 0.006) increase in FEF25–75.

In Group B, the mean ±SD values of FEF25–75 before- and after-intervention were 287.50 ± 12.51 and 322.50 ± 12.09, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant (p = 0.006) increase in FEF25–75. (**Table 2**).

Between-groups p-values mostly < 0.001, except post-treatment FEF25–75 (p = 0.006), all indicating significant results.

In the control group (Group C), the mean ±SD values of FEF25–75 before- and after-intervention were 311.75 ± 12.08 and 320.75 ± 10.41, respectively (**Table 2 and Figure 2**). The statistical multiple pairwise comparisons test revealed that there was a significant (p = 0.006) increase in FEF25–75.

Table 2: Pulmonary Function Parameters - Pre and Post-Treatment Results by Group

Parameter	Group A (n=20)	Group B (n=20)	Group C (n=20)	Between Groups p-value
FVC (L)				
Pre-treatment	4.13 ± 0.18	3.91 ± 0.20	4.28 ± 0.19	<0.001*
Post-treatment	4.42 ± 0.11	4.27 ± 0.11	4.35 ± 0.09	<0.001*
Absolute Change (**Δ**)	0.29 ± 0.10***	0.36 ± 0.12***	0.07 ± 0.12*	<0.001*
Percentage Change (%)	7.09 ± 2.52	9.33 ± 3.24	1.59 ± 2.74	<0.001*
FEV_1 (L)				
Pre-treatment	3.13 ± 0.12	2.91 ± 0.17	3.19 ± 0.15	<0.001*
Post-treatment	3.41 ± 0.12	3.24 ± 0.11	3.26 ± 0.10	<0.001*
Absolute Change (**Δ**)	0.27 ± 0.07***	0.33 ± 0.10***	0.07 ± 0.09**	<0.001*
Percentage Change (%)	8.83 ± 2.35	11.50 ± 3.68	2.35 ± 2.84	<0.001*
PEFR (L/min)				
Pre-treatment	402.50 ± 9.67	387.50 ± 12.51	411.75 ± 12.08	<0.001*
Post-treatment	442.00 ± 12.50	422.50 ± 12.09	420.75 ± 10.41	<0.001*
Absolute Change (**Δ**)	39.50 ± 8.87***	35.00 ± 6.07***	9.00 ± 2.22***	<0.001*
Percentage Change (%)	9.82 ± 2.25	9.06 ± 1.65	2.10 ± 0.57	<0.001*
FEF25-75 (L/min)				
Pre-treatment	302.50 ± 9.67	287.50 ± 12.51	311.75 ± 12.08	<0.001*
Post-treatment	332.00 ± 12.50	322.50 ± 12.09	320.75 ± 10.41	0.006*
Absolute Change (**Δ**)	29.50 ± 8.87***	35.00 ± 6.07***	9.00 ± 2.22***	<0.001*
Percentage Change (%)	9.77 ± 3.05	12.26 ± 2.34	2.70 ± 0.73	<0.001*

*Significance levels: *p<0.05, **p<0.01, ***p<0.001 for within-group changes; Between-groups p-values from one-way ANOVA*

Figure (2): Pre- and Post-Treatment Pulmonary Function measures

Treatment Effect Analysis

This table quantifies treatment effects using Cohen's d, demonstrating large effect sizes for **Groups A** and **B** across all parameters, with **Group C** showing predominantly small to medium effects.

This table measures how strong the treatment effects were in each group by using Cohen's d.

Groups A and **B** showed large effect sizes (d > 0.8) for all outcomes, indicating highly effective interventions.

Group C had small to medium effect sizes, meaning its treatment was far less impactful (**Table 3**).

The η^2 values (far right column) indicate the proportion of variance explained by group differences, ranging from moderate (0.54 for FVC) to high (0.83 for SpO2) (**Table 3**).

Table 3: Effect Size Analysis Using Cohen's d

Parameter	Group A vs. Pre-treatment	Group B vs. Pre-treatment	Group C vs. Pre-treatment	Between Groups (η^2)
FVC	1.91 (Large)	2.06 (Large)	0.45 (Small)	0.54
FEV1	2.59 (Large)	2.22 (Large)	0.56 (Medium)	0.58
PEFR	3.62 (Large)	2.88 (Large)	0.87 (Large)	0.79
FEF25-75	2.77 (Large)	2.96 (Large)	0.77 (Medium)	0.74

Effect size interpretation: <0.2 negligible, 0.2-0.5 small, 0.5-0.8 medium, >0.8 large; η^2 represents proportion of variance explained by group differences

Discussion

When comparing the two active interventions, improvements were largely comparable. The only statistically significant between-exercise difference was seen in FEF_{25-75}%: Group B (pranayama) gained slightly more than Group A (p=0.029). All other between-group contrasts (Group A vs B) were non-significant (p>0.05), indicating generally equivalent efficacy. In summary, both exercise modalities produced robust gains (all p<0.001 vs control) with pranayama yielding a marginally greater improvement in small-airway flow.

Importantly, these improvements were **clinically meaningful**. The magnitude of change in Groups A and B exceeded established minimal clinically important differences (MCIDs) for pulmonary function, 6MWT and AQLQ. All patients in the two exercise groups achieved clinically significant gains in walking distance, whereas none of the controls did. Likewise, the proportion of "high responders" (patients with large improvements) was much higher in the training arms (60% in Group A and 70% in Group B) than in controls (0%). Thus, aerobic and pranayama training produced not only statistically significant changes but also substantial real-world benefits in lung function, functional capacity, and quality of life.

The results of this trial reinforce the value of both aerobic exercise and pranayama yoga as effective adjuncts in asthma management. Consistent with previous work, we found that a **structured exercise program significantly improves pulmonary outcomes and quality of life** in asthma. Exercise training likely mitigates systemic inflammation and deconditioning, leading to better airflow (FEV_1, PEFR) and symptom control. Likewise, yoga breathing exercises specifically target respiratory muscle control and ventilation; in our study, the pranayama group showed especially large proportional gains in airflow measures (notably FEF_{25-75}%). These findings echo **Shankarappa et al. (2012)**, who reported marked PFT improvements after only six weeks of pranayama [6].

The comparative effectiveness of the two interventions was surprisingly similar. Both aerobic and yoga training produced significant and sizeable improvements over control, with only one outcome (FEF_{25-75}%) favoring pranayama. This parallels recent trials (e.g. **Evaristo et al. 2020**) showing that neither aerobic nor breathing-focused programs is clearly superior overall. In practical terms, this suggests that **either modality can be beneficial**. Aerobic exercise may build general fitness and endurance, while yoga breathing may more directly enhance small-airway function; in combination or alone, both boost patient well-being. The absence of major differences also implies that patient preference and access can guide choice of intervention [1].

In the study, **Group A** experienced a notable rise in FEF_{25-75}, whereas the **Group B**'s change was smaller. This outcome follows the trend that full-body exercise tends to enhance small-airway flows. **Wu et al. (2020)** found aerobic training increased FEF_{25-75} by about 9.6% predicted. In contrast, the Cochrane analysis found no significant FEF_{25-75} effect of yoga (95% CI, *p*=.23). This study's results mirror this divergence: the aerobic intervention yielded significant mid-flow gains, as reported by **Wu et al., (2020)** whereas pranayama alone produced only marginal improvements (consistent with the Cochrane's null finding) [24].

Sodhi et al. (2009) did report yoga-related increases in FEF_{25-75} in a mild-asthma sample, but their very controlled inpatient setting (daily pranayama on top of meds) may not generalize to our outpatient context. Statistically, Group A's FEF_{25-75} rise was significant, echoing meta-analyses, whereas Group B was not. Clinically, mid-expiratory flow is a sensitive marker of small-airway function; improvements here (on the order of 5–10% of predicted) suggest better small-airway patency, which could reduce exercise-induced obstruction [25].

In this study, the findings have practical implications: since both aerobic exercise and pranayama are low-cost, low-risk modalities with broad adoption potential, the comparable efficacy suggests either can be recommended as part of asthma rehabilitation. The choice may be tailored to patient preference and baseline fitness, knowing that both routes can achieve statistically reliable and clinically significant improvements.

In the present study there were reported improvements in Groups A and B were statistically significant compared to baseline, and were significantly greater than changes in the control group. These findings are consistent with emerging evidence that structured physical training is a powerful adjunct in asthma management.

Both the aerobic and pranayama groups showed **marked, statistically significant improvements** on all measured outcomes relative to controls.

Conclusion

Both interventions (Aerobic exercise and Pranayama Yoga) yield comparable benefits, with no statistically significant differences in most outcomes. However, pranayama demonstrated a unique advantage in enhancing mid-expiratory flow rates (FEF25–75%), a marker of small-airway function, suggesting its specific role in optimizing airway dynamics through controlled breathing techniques. These results align with the growing recognition of non-pharmacological interventions as essential components of holistic asthma management, particularly for patients seeking alternatives or complements to medication and are equally viable, low-cost, and safe adjuncts to pharmacotherapy.

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