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Effect of Pilates Vs. Yoga on Respiratory Muscle Strength in Patients with Chronic Obstructive Pulmonary Disease (Copd): A Case Study

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ABSTRACT

Background: Chronic Obstructive Pulmonary Disease (COPD) leads to progressive respiratory muscle weakness, which is independently associated with dyspnea, reduced exercise capacity, and increased mortality. Mind-body exercises such as Yoga and Pilates have shown promise in improving respiratory muscle strength. However, individual responses vary, and detailed case-level reports are lacking. This single case study examines the effect of an 8-week structured Yoga program on respiratory muscle strength, functional capacity, dyspnea, quality of life, and cardiovascular fitness in one patient with moderate COPD.

Case presentation: A 54-year-old male (Patient ID Y017) with a 29 pack-year smoking history, diagnosed with GOLD Stage 2 COPD (FEV_1 = 55% predicted, FEV_1/FVC = 0.62), and clinically stable for 6 weeks prior to enrolment. Baseline respiratory muscle strength was severely reduced: maximal inspiratory pressure (MIP) = 46 cmH_2O (51% predicted), maximal expiratory pressure (MEP) = 67 cmH_2O (52% predicted). He had marked dyspnea (mMRC grade 3), poor health-related quality of life (COPD Assessment Test score = 24), and reduced functional exercise capacity (6-minute walk distance = 340 m). Resting heart rate was 90 bpm, and estimated VO_2 max was 18.6 mL/kg/min.

Intervention: The patient participated in a supervised Yoga program consisting of 45-minute sessions, three times per week for 8 consecutive weeks (total 24 sessions). The protocol included asanas (modified postures: Tadasana, Trikonasana, Cat-Cow, Bhujangasana, Setu Bandhasana, Viparita Karani) and pranayama (Ujjayi, Kapalabhati, Bhastrika, Kumbhaka), with progressive intensity.

Results: Post-intervention, MIP increased by 52% to 70 cmH_2O, and MEP increased by 21% to 81 cmH_2O. The 6-minute walk distance improved by 32 m (from 340 to 372 m). The CAT score decreased by 4 points (from 24 to 20), surpassing the minimal clinically important difference (2 points). Resting heart rate reduced from 90 bpm to 83 bpm, and estimated VO_2 max increased to 20.5 mL/kg/min. The patient experienced a mild COPD exacerbation during week 7 (managed with outpatient antibiotics and corticosteroids, no hospitalization), but completed the protocol with 79.2% adherence. No serious adverse events occurred.

Conclusion: In this single case of moderate COPD, an 8-week Yoga program produced clinically meaningful improvements in inspiratory muscle strength, functional capacity, dyspnea, and quality of life, despite a mild exacerbation. The findings support the use of

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pranayama-based Yoga as a feasible and effective adjunct to pulmonary rehabilitation, particularly when inspiratory muscle weakness is prominent. Further single-case replications and larger trials are warranted.

Keywords: COPD, Yoga, respiratory muscle strength, maximal inspiratory pressure, case study, pranayama, pulmonary rehabilitation.

1. INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory condition characterized by persistent airflow limitation and chronic inflammation of the airways and lung parenchyma, primarily caused by long-term exposure to noxious particles or gases, most commonly tobacco smoke (Global Initiative for Chronic Obstructive Lung Disease [GOLD], 2023). Beyond airflow obstruction, COPD is associated with significant extrapulmonary manifestations, including skeletal muscle dysfunction, cardiovascular comorbidities, and—critically—respiratory muscle weakness (Gea et al., 2015).

Respiratory muscle weakness, involving both the inspiratory muscles (diaphragm, external intercostals) and expiratory muscles (abdominal wall muscles), is a hallmark of moderate to severe COPD. Mechanically, lung hyperinflation places the diaphragm at a disadvantage on its length-tension curve, reducing its force-generating capacity by up to 50% (Similowski et al., 1991). Biologically, oxidative stress, systemic inflammation, and corticosteroid use induce fiber atrophy and a shift from fatigue-resistant Type I fibers to more fatigable Type IIb fibers (Levine et al., 1997). Reduced maximal inspiratory pressure (MIP) is associated with exertional dyspnea and reduced exercise capacity, while reduced maximal expiratory pressure (MEP) impairs cough effectiveness and increases the risk of respiratory infections (Kim & Sapienza, 2005). Importantly, MIP and MEP are independent predictors of mortality in COPD (Schünemann et al., 2000).

Pulmonary rehabilitation, the non-pharmacological cornerstone of COPD management, improves exercise capacity, dyspnea, and quality of life but has only modest direct effects on respiratory muscle strength (McCarthy et al., 2015). Specific inspiratory muscle training using threshold or resistive devices is effective but suffers from poor long-term adherence due to device dependence, cost, and perceived tedium (Hill et al., 2010). Consequently, there is growing interest in mind-body exercise modalities that integrate controlled breathing with physical activity—particularly Yoga and Pilates—as engaging, low-tech, and scalable alternatives or adjuncts.

Yoga, through its pranayama (breath-control) techniques, applies resistive, threshold, and isometric loads to the respiratory muscles. Ujjayi breathing provides inspiratory resistance via partial glottis constriction; Kapalabhati and Bhastrika involve rapid, forceful expiratory and inspiratory excursions; Kumbhaka (breath-holding) imposes isometric loading. Meta-analyses have confirmed that Yoga interventions significantly improve MIP and MEP in COPD (Cebrià i Iranzo et al., 2021; Cramer et al., 2014). Pilates, with its emphasis on lateral costal breathing

and forceful exhalation coordinated with core stabilization, has also been shown to increase MEP more than MIP (Turmero & Cuesta-Vargas, 2019; Silva et al., 2021).

The parent randomized controlled trial (Verma et al., 2023), from which this case is drawn, directly compared an 8-week Yoga program versus a matched Pilates program in 60 patients with mild to moderate COPD. That trial found that Yoga was superior for improving MIP (adjusted mean difference 5.8 cmH_2O, $p = 0.023$, Cohen's $d = 0.61$) while Pilates was superior for MEP (adjusted mean difference 7.7 cmH_2O, $p = 0.010$, $d = 0.69$). Both interventions equally improved functional exercise capacity, dyspnea, and quality of life.

However, group averages may mask individual variability. Single-case study designs are valuable for understanding personalized responses, identifying barriers and facilitators, and generating hypotheses for future research. This case report provides a detailed, longitudinal account of one patient with moderate COPD who underwent the Yoga intervention, with the aim of illustrating the real-world feasibility, safety, and effectiveness of Yoga for respiratory muscle strengthening in a clinical context.

2. CASE PRESENTATION

2.1 Patient History and Demographics

The patient was a 54-year-old male (Patient ID Y017 from the parent trial database) who presented to the outpatient pulmonary rehabilitation clinic of a tertiary care teaching hospital in northern India. He had a 29 pack-year smoking history (20 cigarettes per day for 29 years) and had quit smoking 5 years prior to enrolment. He was a retired factory worker with no history of occupational exposure to biomass fuels or industrial chemicals.

He was diagnosed with COPD 6 years earlier based on typical symptoms (chronic cough, sputum production, progressive exertional dyspnea) and spirometry confirming a post-bronchodilator FEV_1/FVC ratio < 0.70. His most recent spirometry, performed 2 months before enrolment, showed: FEV_1 = 55% predicted, FVC = 68% predicted, $FEV_1/FVC = 0.62$, consistent with GOLD Stage 2 (moderate) COPD.

His medical history was otherwise unremarkable. He had no known coronary artery disease, hypertension, diabetes mellitus, musculoskeletal disorders, cognitive impairment, or psychiatric illness. He denied any history of tuberculosis, asthma, or bronchiectasis.

His regular medications were stable for the preceding 6 months: tiotropium bromide 18 µg once daily (via HandiHaler) and as-needed salbutamol inhaler (used approximately 2–3 times per week for breakthrough dyspnea). He was not on any oral corticosteroids or long-term oxygen therapy.

2.2 Baseline Clinical Status

At the pre-intervention assessment (Visit 1), the patient reported:

- **Dyspnea:** He stopped for breath after walking approximately 100 meters on level ground (modified Medical Research Council [mMRC] grade 3). He reported breathlessness during activities of daily living such as bathing and dressing.

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- **Cough and sputum:** Daily morning cough with small amounts of white sputum, no hemoptysis.
- **Fatigue:** He felt tired after minimal exertion.
- **Quality of life:** He completed the COPD Assessment Test (CAT), scoring 24 out of 40, indicating a high disease impact. He specifically endorsed significant limitations in walking uphill, doing housework, and sleeping.
- **Exercise capacity:** His 6-minute walk distance (6MWD) was 340 meters, which is approximately 55% of the predicted value for his age and sex (predicted ~620 m). During the test, his oxygen saturation dropped from 97% at rest to 88% at the end, and he reported Borg dyspnea score of 4 (moderate to severe).
- **Cardiovascular fitness:** Resting heart rate after 10 minutes of seated rest was 90 bpm. Estimated maximal oxygen consumption (VO_2 max) using the Astrand-Rhyming submaximal cycle ergometer test was 18.6 mL/kg/min, indicating poor cardiorespiratory fitness.
- **Respiratory muscle strength (primary outcomes):** MIP was 46 cmH_2O (51% of predicted normal for age/sex, predicted ~90 cmH_2O). MEP was 67 cmH_2O (52% of predicted, predicted ~130 cmH_2O). Both values indicated moderate to severe respiratory muscle weakness.
- **Anthropometrics:** Height 166 cm, weight 72 kg, body mass index 26.1 kg/m^2 (overweight category). Blood pressure was 128/82 mmHg.

2.3 Eligibility for the Intervention

The patient satisfied all inclusion criteria: age 40–55 years (actual 54), spirometrically confirmed mild to moderate COPD (GOLD Stage 2, FEV_1 = 55% predicted), clinically stable for at least 6 weeks (no exacerbations, no medication changes), and willing to attend supervised sessions three times per week for 8 weeks. He had no exclusion criteria: no severe COPD (FEV_1 < 50% predicted), no exacerbation in the preceding 4 weeks, no unstable comorbidities, no oxygen requirement, no musculoskeletal contraindications to floor-based Yoga, and not participating in another structured exercise program.

He provided written informed consent (a bilingual consent form in English and Hindi, as per institutional ethics committee requirements).

3. METHODS

3.1 Study Design Context

This case study is derived from a prospective, randomized, parallel-group comparative trial (Registered under Clinical Trials Registry – India). The parent trial was approved by the Institutional Ethics Committee (IEC No. 2022/RT/COPD-07) and followed the Declaration of Helsinki (2013 revision). The patient described here was randomly allocated to the Yoga group.

3.2 Setting and Supervision

All sessions were conducted in the physiotherapy outpatient department of the same tertiary care hospital. The intervention was delivered by a certified yoga therapist with 8 years of

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experience and additional training in prescribing exercise for chronic respiratory diseases. The therapist to participant ratio was 1:6. Sessions occurred on non-consecutive days (Monday, Wednesday, Friday) to allow adequate recovery.

3.3 Yoga Intervention Protocol

The Yoga protocol was a standardized, 8-week, Hatha-based program designed specifically for mild to moderate COPD. Each session lasted 45 minutes, divided into:

Phase	Duration	Content
Warm-up	5 min	Joint mobilisation (Sukshma Vyayama), gentle neck, shoulder, and spine rotations, breathing awareness
Asanas (postures)	15 min	Modified therapeutic postures: Tadasana (mountain), Urdhva Hastasana (upward salute), Trikonasana (triangle) with block, Marjaryasana-Bitilasana (cat-cow), Bhujangasana (cobra) modified, Setu Bandhasana (bridge), Supta Matsyendrasana (supine spinal twist), Viparita Karani (legs up the wall). Each posture held for 3–5 breath cycles.
Pranayama (breath control)	20 min	**Ujjayi:** Slow deep breathing with partial glottis constriction, inhalation:exhalation ratio 1:2, 5 min. **Kapalabhati:** Forceful rapid expiratory abdominal contractions, 20 breaths/round × 3 rounds with 1 min rest, 5 min. **Bhastrika:** Forceful rapid inhalations and exhalations, 10 breaths/round × 3 rounds, 5 min. **Kumbhaka:** Intermittent breath-holding after inhalation (comfortable duration), integrated with Ujjayi, 5 min.
Cool-down	5 min	Shavasana (corpse pose) with guided relaxation and natural breath observation.

Progression: In weeks 1–2, pranayama ratios were shorter (1:1 for Ujjayi, 10 breaths/round for Kapalabhati). By weeks 6–8, Ujjayi ratio increased to 1:2, and breath-hold durations increased from 3 seconds to up to 8 seconds as tolerated.

3.4 Outcome Measures

The following assessments were performed at baseline (week 0) and within 5 working days after the final session (week 8), using the same equipment, at the same time of day, and by an assessor blinded to group allocation:

- **Primary:** MIP and MEP using a calibrated handheld digital respiratory pressure meter (MicroRPM, CareFusion) with a flanged mouthpiece and nose clip, following ATS/ERS guidelines (highest of 3 reproducible maneuvers).
- **Secondary:** Spirometry (FVC, FEV_1), 6-minute walk distance (6MWD), mMRC dyspnea grade, Visual Analogue Scale (VAS) for dyspnea (0–10 cm), COPD Assessment Test (CAT) score, resting heart rate (after 10 min seated rest), and estimated VO_2 max (submaximal cycle ergometer, Astrand-Rhyming).
- **Adherence and adverse events:** Session attendance recorded; adverse events documented and reported.

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3.5 Data Analysis for Case Study

For this single case, pre-post comparisons are presented descriptively. Percentage change and achievement of minimal clinically important differences (MCID) are reported where available (MCID for MIP = 11 cmH_2O, for MEP = 10 cmH_2O, for 6MWD = 25–30 m, for CAT = 2 points).

4. RESULTS

4.1 Adherence and Safety

The patient attended 19 out of 24 scheduled sessions (adherence rate = 79.2%). Missed sessions were due to a mild COPD exacerbation in week 7 (see below) and one session missed due to personal travel. He was considered adherent per protocol (≥70% attendance).

Adverse events: During week 7, the patient developed increased cough, purulent sputum, and worsened dyspnea (mMRC grade 4 on the day of onset). He did not have fever or altered mental status. He was assessed by the study pulmonologist and diagnosed with a mild acute exacerbation of COPD. He was treated with oral antibiotics (azithromycin 500 mg daily for 3 days) and a short course of oral prednisolone (30 mg daily for 5 days). He did not require hospitalization or emergency department visit. The exacerbation resolved completely within 7 days, and he resumed Yoga sessions after an 8-day break. No serious adverse events (death, life-threatening event, hospitalization, persistent disability) occurred. He reported transient mild knee discomfort during Bhujangasana in week 3, which resolved after modifying the posture with a folded blanket.

4.2 Primary Outcomes: Respiratory Muscle Strength

Measure	Baseline	Post-intervention	Absolute Change	% Change	MCID achieved?
MIP (cmH_2O)	46	70	+24	+52%	Yes (>11)
MEP (cmH_2O)	67	81	+14	+21%	Yes (>10)

Both MIP and MEP exceeded the minimal clinically important difference. The improvement in MIP was particularly striking, more than doubling the MCID.

4.3 Secondary Outcomes

Outcome	Baseline	Post-intervention	Change	MCID achieved?
FVC (L)	2.55	2.67	+0.12	—
FEV_1 (L)	1.55	1.60	+0.05	—
FEV_1/FVC	0.61	0.60	-0.01	—
6MWD (m)	340	372	+32	Yes (>30)
mMRC grade (0–4)	3	2	-1	Yes (≥1)

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VAS dyspnea (0–10 cm)	6.1	3.9	-2.2	Yes (≥1)
CAT score (0–40)	24	20	-4	Yes (≥2)
Resting heart rate (bpm)	90	83	-7	—
Estimated VO_2 max (mL/kg/min)	18.6	20.5	+1.9	—

Spirometry: Small improvements in FVC and FEV_1 were noted, but the FEV_1/FVC ratio remained essentially unchanged, as expected in COPD.

Functional exercise capacity: The 32-meter improvement in 6MWD surpasses the widely accepted MCID of 25–30 meters for COPD, indicating a clinically meaningful gain in walking ability.

Dyspnea and quality of life: The patient's mMRC grade improved from 3 ("stops after walking 100 m") to 2 ("walks slower than peers or stops after 15 minutes"). CAT score reduction of 4 points indicates a moderate improvement in health status. The patient specifically reported less chest tightness and better sleep.

Cardiovascular fitness: Resting heart rate decreased by 7 bpm, and estimated VO_2 max increased by approximately 10%, suggesting improved cardiorespiratory efficiency.

4.4 Individual Clinical Course

The patient kept a simple daily diary. By week 3, he reported that he could climb one flight of stairs (12 steps) without stopping, whereas previously he needed to stop halfway. By week 6, he noted that his morning cough was less productive and he felt more energetic. The exacerbation in week 7 temporarily set him back, but after recovery he completed the final sessions and his post-assessment showed values above baseline.

5. DISCUSSION

5.1 Summary of Key Findings

This single case study of a 54-year-old man with moderate COPD demonstrates that an 8-week, supervised Yoga program produced clinically meaningful improvements in inspiratory muscle strength (MIP +24 cmH_2O, +52%), expiratory muscle strength (MEP +14 cmH_2O, +21%), functional exercise capacity (6MWD +32 m), dyspnea (mMRC reduction by 1 grade), and health-related quality of life (CAT -4 points). These improvements were achieved despite a mild exacerbation in week 7, which resolved without hospitalization. The patient found the program acceptable and safe, with only transient minor musculoskeletal discomfort.

5.2 Comparison with Parent Trial and Literature

The improvements observed in this patient are broadly consistent with, and in some aspects exceed, the average improvements reported in the parent RCT for the Yoga group. In the parent trial (n = 30 Yoga participants), the mean adjusted change in MIP was +20.9 cmH_2O (95% CI 19.0 to 22.8). Our patient's MIP increase of 24 cmH_2O is within that range and actually slightly higher. For MEP, the parent trial's Yoga group mean change was +12.6 cmH_2O (95% CI 10.8 to 14.4); our patient's +14 cmH_2O is at the upper end. For 6MWD, the parent trial's Yoga group

mean change was +36.5 m; our patient's +32 m is slightly below but still clinically significant. CAT score change in the parent trial was -4.4 points; our patient's -4 points is nearly identical. These comparisons suggest that this patient was a typical responder to the Yoga intervention, not an outlier. The fact that he achieved these gains despite a mild exacerbation supports the robustness of the intervention.

Compared to other published Yoga studies in COPD: Leelarungrayub et al. (2016) reported MIP increases of 17.4 cmH_2O after 6 weeks of Ujjayi and Kapalabhati; our patient's larger gain may be due to the inclusion of Bhastrika and Kumbhaka, which add high-velocity and isometric loading. Ranjita et al. (2016) found MIP improvements of 24% in coal miners with COPD; our patient's 52% improvement is substantially larger, possibly due to differences in baseline severity (our patient had lower baseline MIP, leaving more room for improvement) or the supervised, hospital-based format.

5.3 Mechanisms of Action

The inspiratory muscle strength gain (MIP) is plausibly attributed to the resistive and isometric loading inherent in the pranayama components:

- **Ujjayi** requires sustained contraction of inspiratory muscles against a partially closed glottis, analogous to inspiratory resistive training.
- **Kumbhaka** (breath-holding after inhalation) imposes an isometric load on the diaphragm at high lung volume, which may stimulate hypertrophy and oxidative enzyme adaptation.
- **Bhastrika** involves rapid, forceful inspiratory excursions, which may improve inspiratory muscle power and coordination.

The expiratory muscle strength gain (MEP), although smaller, likely results from **Kapalabhati** (forceful rapid exhalations) and the active exhalation phase during Ujjayi (prolonged exhalation). This dual training effect—both inspiratory and expiratory—is a distinct advantage of pranayama over isolated inspiratory muscle training.

The improvement in 6MWD (32 m) is multifactorial: reduced dynamic hyperinflation (as suggested by small FVC improvement), reduced dyspnea perception, improved leg muscle blood flow (from repeated standing postures), and perhaps a placebo or motivation effect. The 4-point CAT improvement indicates tangible real-world benefit.

5.4 The Mild Exacerbation: Implications

The patient experienced a mild exacerbation in week 7. Importantly, he was able to resume training after a short break and still showed substantial improvements. This suggests that Yoga does not need to be discontinued permanently after an exacerbation; rather, a brief pause followed by gradual reintroduction is feasible. The parent trial excluded patients with exacerbation in the preceding 4 weeks, but our case shows that even if an exacerbation occurs *during* training, the patient can still benefit. This has practical implications for pulmonary rehabilitation programs that often exclude patients during or immediately after exacerbations.

5.5 Comparison with Pilates (From Parent Trial Perspective)

Although this case received only Yoga, the parent trial's comparative finding was that Yoga is superior for MIP whereas Pilates is superior for MEP. For this patient, whose inspiratory weakness was more severe (MIP 46 vs. MEP 67 at baseline, both low but MIP relatively worse), the Yoga intervention was an appropriate choice. If a patient presented with predominant expiratory weakness (e.g., very low MEP, poor cough, recurrent infections), Pilates might be preferred. This case illustrates the concept of **modality-specific prescription** based on individual respiratory muscle deficiency profiles.

5.6 Limitations of This Single Case

As a single case, findings are not generalizable. The absence of a control period (A-B design without reversal or multiple baselines) means we cannot definitively attribute improvements solely to Yoga; natural history, regression to the mean, or placebo effects could contribute. However, COPD is a progressive disease, and spontaneous sustained improvement over 8 weeks is unlikely without intervention. The patient was not blinded to the intervention, and the therapist was not blinded, introducing potential performance and detection bias. The mild exacerbation could have temporarily confounded results, but post-exacerbation values were still much better than baseline. Finally, long-term follow-up is lacking; we do not know if gains were maintained after the program ended.

5.7 Clinical and Research Implications

For clinicians: This case provides detailed, granular evidence that a structured Yoga program can be safely implemented in a patient with moderate COPD, even when mild exacerbations occur. The 45-minute, 3×/week format is feasible in outpatient settings. Patients with prominent inspiratory muscle weakness and dyspnea may benefit preferentially from Yoga over Pilates.

For researchers: Single-case experimental designs (e.g., ABAB or multiple baseline across behaviors) could be used in future to establish causal inference. Larger trials should stratify patients by baseline MIP/MEP ratio to test for differential treatment effects. Mechanistic studies using diaphragmatic ultrasound or electromyography could explore the physiological basis of the large MIP gain observed here.

5.8 Patient Perspective

In an informal exit interview, the patient stated: *"Earlier, I could not even walk to the bathroom without gasping. Now I can walk to the nearby market. The breathing exercises were hard at first, but after 3 weeks I felt a difference. Even after I got sick in week 7, I recovered faster than before."* He expressed willingness to continue Yoga at home using a recorded video.

6. CONCLUSION

This single case study of a 54-year-old man with moderate COPD provides detailed evidence that an 8-week supervised Yoga program, combining asanas and pranayama (Ujjayi, Kapalabhati, Bhastrika, Kumbhaka), can produce clinically meaningful improvements in inspiratory and expiratory muscle strength, functional exercise capacity, dyspnea, and health-related quality of life. The patient achieved a 52% increase in MIP and a 21% increase in MEP, with a 32-meter improvement in 6-minute walk distance and a 4-point reduction in

CAT score. A mild exacerbation during week 7 did not negate the benefits. These findings support the use of Yoga as a safe, effective, and engaging mind-body intervention for respiratory muscle strengthening in COPD, particularly when inspiratory muscle weakness is prominent. Single-case replications and larger comparative effectiveness trials are warranted.

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