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Effectiveness of a Multi-Modal Approach to Treating Chronic Respiratory Disease CRD: A Randomised Controlled Study

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ABSTRACT:

Background: Chronic respiratory diseases (CRDs) represent a significant cause of global morbidity and mortality, but the implementation of pulmonary rehabilitation (PR) has been hampered by poor adherence and accessibility. This was a trial comparing PR with an IPR program, combining different styles of yoga, Tai Chi and music therapy.

Methods: In a randomized controlled trial (RCT) using data from 350 patients aged over 50 years with COPD, asthma, interstitial lung disease or bronchiectasis or post-tuberculosis sequelae, outcomes were assessed at baseline and again at week 6 and week 12 for each of the measures; the primary outcome was change in exercise tolerance (change from baseline cores to week two successive scores). Mixed models analyzed repeated measures.

Results: Groups were well balanced at baseline (n=175, mean age 51.6±9.8). There were significantly more favorable improvements in the IPR group at 12 weeks for SpO_2,

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pulmonary function, 6MWD and HRR and Borg scale score (all p<0.001). Disease severity (mMRC grade) affected the SpO_2 (%), 6MWD (m) and Borg scores [p<0.05].

Conclusions: Combined rehabilitation with yoga, Tai Chi and music therapy improved the exercise capacity as well as lung function and oxygenation in patients with advanced chronic respiratory diseases compared to standard PR; effects were moderated by disease severity. This multimodal, culturally relevant strategy offers a viable framework for CRD rehabilitation

1. INTRODUCTION

Chronic respiratory diseases (CRDs) such as chronic obstructive pulmonary disease (COPD), bronchial asthma, bronchiectasis or any of ILD and post-tuberculosis lung disease have an incidence of more than 544.9 million people globally [1]. COPD was the third leading cause of death in 2019 and continues to disproportionately impact those living in high-burden regions, particularly those from low- and middle-income countries (LMIC), which carry 75% of the global burden [2]. CRDs afflict patients with appalling disabling manifestations, including dyspnea, impaired exercise tolerance, fatigue and /psychological distress which majorly affect their QOL [3].

Pulmonary rehabilitation (PR) is an established evidence-based multidisciplinary intervention for patients with chronic respiratory disease (CRD), which results in increased exercise tolerance, lower symptom burden and improved health-related quality of life (HRQoL) [4]. According to the American College of Chest Physicians [5], exercise training is the main component of PR. On the contrary, conventional pulmonary rehabilitation (PR) programs have large limitations in aerobic training (treadmill/cycle ergometry) and resistance exercises: poor adherence to PR (completion rates of only 30-50%) [6], residual symptoms despite PR [7], restricted applicability in patients from resource-limited settings [8] and an under-appreciated nutritional component [9].

Each of these complementary modalities has gained from its own virtue. Yoga exercise enhances 6-minute walk distance (SUCRA: 99.7%) and reduces MLHFQ scores (SUCRA: 71.8%) in chronic cardiopulmonary dyspnea. All studies meta-analysis: Tai Chi excellent increased FEV_1% (WMD=4.61, 95%CI 2.99–6.23) and improve reduce on SGRQ scores (SMD=-0.79; 95%CI -1.20 to -0.38) [11] and enhanced the Six-min walk distance (SMD=0.83; 95% CI:0.55−1·11) [12]. Music therapy alleviates dyspnea, anxiety and depression in patients with COPD [12] However, the integrated application of individual modalities (i.e. PR intervention) has not been examined in any multi-disease CRD populations despite robust evidence supporting its benefits when applied individually.

The objective of this study, therefore, was to determine the efficacy of an integrated pulmonary rehabilitation (PR) program with yoga, Tai Chi and music therapy on exercise capacity, quality of life health and nutritional status in chronic respiratory patients: a randomized controlled trial.

2. METHODS

2.1 Study Design

Design Prospective, stratified, parallel-group randomized controlled trial conducted between August 2024 to July 2025 at SRM Medical College Hospital & Research Centre. Approval for the study protocol was obtained from the Institutional Ethics Committee (ECR/8855/INST/TN/2013/RR-19). This study followed the CONSORT guidelines.

2.2 Participants

Eligible participants were aged 18–65 years, with a confirmed diagnosis of COPD, bronchial asthma, bronchiectasis, stable ILD or post-tuberculosis lung disease; mMRC dyspnea grade 1–2; clinically stable (no exacerbations within the preceding 4 weeks) and gave written informed consent.

Exclusion criteria were clinically unstable cardiac conditions (e.g. recent MI, uncontrolled arrhythmias, unstable angina, or severe heart failure), any severe musculoskeletal/neurological/orthopaedic limitations, uncontrolled hypertension despite medications, cognitive impairment, long-term oxygen therapy requirement (> 15h/day), absolute contraindications to exercise testing/training according to ATS/ERS guidelines [23], participation in another structured rehabilitation program for less than

3 months prior to enrolment, evidence of hearing loss (to avoid fewer sounding music treatment), pregnancy and any other condition at the investigator's discretion that would compromise safety.

2.3 Sample Size

Power analysis, based on previous meta-analyses indicating 0.5–0.8 effect sizes for mind-body exercise interventions on 6MWD and with 80% power at α=0.05, estimated that for each disease category (35 per group), a total of 70 participants were required after taking into account a projected 20% dropout over the duration of the study. Overall sample size: 350 subjects (175 in each arm), across five disease categories evaluated - COPD, bronchial asthma, ILD, bronchiectasis and post-tuberculosis sequelae (70 each)

2.4 Randomization and Blinding

Participants were stratified by disease category (5 levels) and disease severity (mMRC grade 1 and 2). Participants were randomly allocated by a computer-generated random number of 1 with equal allocation to intervention or control within each stratum. BlindnessOutcomes assessors and statisticians were blinded to group allocation. Due to the nature of interventions, participants and intervention providers could not be blinded.

2.5 Interventions

2.5.1 Control Group (Standard PR)

During the second study phase, a 12-week standard pulmonary rehabilitation programme (75–80 min; twice weekly) was conducted in the control group, which included: education (15 min; disease awareness, breathing techniques and procedures, exercise tolerance testing or activity monitoring); customised nutritional counselling; aerobic training (20–30 min duration/treadmill walking 60–80% of peak work capacity ad libitum following progressive increments in limitations to allow functional improvement); and resistance training (25–35 min for upper/lower limb exercises using a combination of free weights or exercises using body weight protocol; repetition maximum responses).

2.5.2 Intervention Group (Integrated PR)

The intervention group participated in a 12-week integrated PR program (105–110 minutes/session, twice weekly) consisting of: education (15 min, same as control); nutritional counseling (15-min; same as control), Tai Chi [20 min; simplified Yang-style including 8 forms that lasted during the entire therapy session over a gradual period and made time for an adequate warm-up: Commencement Form, Parting the Wild Horse's Mane, White Crane Spreads Wings, Brush Knee and Push, Wave Hands like Clouds, Golden Rooster Stands on One Leg. Repulse Monkey. Closing Movement]; yoga (35 min; rhythmic abdominal breathing supplied with guided relaxation using Yoga Nidra throughout the program), music therapy [(20-min): Neelambari raga while performing breathing exercises + Kapi raga seated during cool-down/relaxation].

2.6 Outcome Measures

Assessments were conducted at three time points: baseline (pre-intervention), 6 weeks (mid-intervention), and 12 weeks (post-intervention). All outcome measures were collected by trained assessors blinded to group allocation.

Primary Outcomes

Exercise Capacity: Measured using the 6-minute walk test (6MWT) following standardized ATS/ERS guidelines. The total distance walked (6MWD) in meters was recorded. Pre- and post-6MWT oxygen saturation (SpO_2) was measured using a portable pulse oximeter.

Secondary Outcomes

Pulmonary Function: Assessed via spirometry according to ATS/ERS standards. Parameters included forced expiratory volume in 1 second as percentage of predicted (FEV_1%), forced vital capacity as percentage of predicted (FVC%), FEV_1/FVC ratio, peak expiratory flow as percentage of predicted (PEF%), and forced expiratory flow between 25–75% of FVC as percentage of predicted (FEF_{25-75}%).

Dyspnea Severity: Evaluated using the Borg CR10 scale (post-6MWT) and the modified Medical Research Council (mMRC) dyspnea grade (1–2).

Cardiorespiratory Parameters: Respiratory rate (RR, breaths per minute), heart rate reserve (HRR = peak HR – resting HR, beats per minute), and peak heart rate (beats per minute) were recorded during the 6MWT.

Echocardiographic Assessment of Right Ventricular Function (ECHO-TRPG): Transthoracic echocardiography was performed at each assessment time point using a standardized protocol (GE Vivid E95, 3.5–5 MHz transducer). The tricuspid regurgitation pressure gradient (TRPG) was measured in mmHg as an index of right ventricular systolic pressure and pulmonary hemodynamic load. (Liu et al., 2025; Chan et al., 2011).

Heart Rate Variability (HRV): HRV was assessed using a 5-minute lead II electrocardiogram (ECG) recording under standardized resting conditions (supine position, quiet breathing, 10-minute acclimatization).

SDNN (Standard Deviation of Normal-to-Normal intervals): Measured in milliseconds (ms), representing overall HRV and reflecting both sympathetic and parasympathetic modulation. Higher SDNN indicates better autonomic cardiorespiratory integration (Santaella et al., 2019; Mao et al., 2024).

RMSSD (Root Mean Square of Successive Differences between normal heartbeats): Measured in milliseconds (ms), reflecting predominantly parasympathetic (vagal) tone. Increased RMSSD indicates enhanced vagal modulation, which is associated with reduced dyspnea perception, lower anxiety, and improved respiratory efficiency (Huang et al., 2021).

HRV parameters were calculated from artifact-free segments of at least 300 consecutive normal-to-normal intervals. These measures provide insight into the autonomic mechanisms underlying integrated PR, as mind-body interventions such as yoga, Tai Chi, and music therapy are known to enhance vagal tone and reduce sympathetic dominance in chronic respiratory disease populations (Liu et al., 2025; Lin et al., 2025).

2.7 Statistical Analysis

For continuous outcomes: SpO_2, FEV_1% predicted, FEV_1/FVC, PEF, FEF_{2575}, six-minute walk distance (6MWD), heart rate reserve (HRR), peak heart rate,Borg dyspnea score and respiratory rate (RR) linear mixed-effects models(LMMs) were used to assess the independent and joint effects of Group(intervention vs control), Time Point(baseline and followup),and their interaction. Repeated measures were accounted for using a random intercept for Patient ID. Moreover, covariate data (age, disease duration and smoking intensity) were mean centered and selected to fit each outcome separately (e.g. RR was included as a covariate for SpO_2 models). Three-way interaction models (Group × Time Point × MMRC category) then tested if intervention effects differed by baseline dyspnea severity for SpO_2, 6MWD and Borg score, with estimated marginal means compared by MMRC.

3. RESULTS

3.1 Participant Characteristics

In total, 350 participants (175 in each group) were included and completed the 12-week protocol. Baseline characteristics were well-balanced among groups (Table 1). In controlled (n=48) and interventional(n=43) groups; 51.48±9.99 years and 51.79±9.62 years respectively, p =0.8 for age difference between control and intervention group results. No significant between-group differences were observed for disease duration (6.80±3.96 vs. 6.74±3.76 years, p=0.9), smoking intensity (12.78±6.31 vs. 12.65±6.44 pack-years, p=0.9), baseline SpO_2 (93·87±2·11 vs 93·93±2·47%, p=0·8) and FEV_1% predicted (55·04 ±14·82vs56 ·23 ±16 ·28 %,p =0 •5), confirming randomization had been successfully achieved.

Table 1. Baseline Characteristics of Study Participants

Variable	**Control** N = 175[1]	**Treatment** N = 175[1]	**Difference**[2]	**95% CI**[2]	**p-value**[2]
Age	64.30 ± 3.02	64.14 ± 2.99	0.17	-0.47, 0.80	0.6
DiseaseDuration	7.18 ± 4.23	6.35 ± 3.41	0.83	0.02, 1.6	0.045
SmokingIntensity	12.82 ± 6.51	12.61 ± 6.23	0.20	-1.1, 1.5	0.8
SpO2_pre_percent	94.81 ± 1.59	94.65 ± 1.65	0.16	-0.18, 0.50	0.4
SpO2_post_percent	90.57 ± 2.86	90.59 ± 3.04	-0.03	-0.65, 0.59	>0.9
FEV1_percent_pred	73.11 ± 12.99	73.66 ± 13.18	-0.55	-3.3, 2.2	0.7
FVC_percent_pred	82.74 ± 11.69	83.18 ± 12.20	-0.44	-3.0, 2.1	0.7
FEV1_FVC_ratio	0.69 ± 0.19	0.70 ± 0.20	-0.02	-0.06, 0.03	0.4
PEF_percent_pred	74.53 ± 8.75	74.11 ± 9.37	0.42	-1.5, 2.3	0.7
FEF25_75_percent_pred	56.34 ± 13.85	56.65 ± 12.74	-0.30	-3.1, 2.5	0.8
SixMWD	396.36 ± 55.60	394.05 ± 61.47	2.3	-10, 15	0.7
borg_dyspnea_pre	1.02 ± 0.65	1.04 ± 0.65	-0.02	-0.15, 0.12	0.8
borg_dyspnea_post	3.37 ± 0.98	3.44 ± 1.09	-0.07	-0.29, 0.14	0.5
RR	21.73 ± 2.78	22.19 ± 2.99	-0.47	-1.1, 0.14	0.13
HRR	15.99 ± 5.79	15.53 ± 5.42	0.46	-0.72, 1.6	0.4
Peak_HR	121.33 ± 10.59	123.72 ± 9.95	-2.4	-4.6, -0.23	0.030
TRPG_mmHg	24.43 ± 10.12	24.52 ± 9.95	-0.09	-2.2, 2.0	>0.9
SDNN_ms	32.63 ± 8.02	32.62 ± 7.58	0.02	-1.6, 1.7	>0.9
RMSSD_ms	23.00 ± 7.20	23.14 ± 7.37	-0.14	-1.7, 1.4	0.9
[1]Mean ± SD					
[2]Welch Two Sample t-test					
Abbreviation: CI = Confidence Interval					

Data are mean ± SD. CI, confidence interval; 6MWD, 6-minute walk distance; HRR, heart rate reserve; PEF, peak expiratory flow.

3.2 Oxygen Saturation (SpO_2)

MMRM analysis (at 6 weeks) revealed no significant main effect of group (p=0.338) or group × time interaction (β = 0.051, p = 0.617). Nevertheless, a large group × time interaction emerged at 12 weeks (β=0.347, 95%CI 0.144–0.550, p=0.001) for greater SpO_2 improvement among the integrated PR group compared with standard care control by study end. It showed significant main effects for RR (β=-0.093, p<0.001) and HRR (β=0.084, p<0.001). Type III ANOVA confirmed a significant effect of time point (F=7.466, p=0.0006), and group × time point interaction (F=6.662, p=0.0014).

3.3 Pulmonary Function

Table 2. Mixed Models for Repeated Measures: Pulmonary Function Outcomes

Outcome	Predictor	Estimate	95% CI	p-value
FEV_1%	Group (Treatment)	1.21	-2.24, 4.67	0.491
	Time (Week 6)	1.87	1.57, 2.17	<0.001
	Time (Week 12)	6.05	5.75, 6.35	<0.001
	Group × Week 6	1.16	0.73, 1.58	<0.001
	Group × Week 12	2.72	2.30, 3.14	<0.001
FVC%	Group (Treatment)	1.03	-2.81, 4.87	0.598

	Group × Week 6	0.95	0.42, 1.48	0.001
	Group × Week 12	2.18	1.65, 2.71	<0.001
FEV_1/FVC	Group (Treatment)	0.01	-0.01, 0.02	0.591
	Group × Week 6	0.01	0.01, 0.02	<0.001
	Group × Week 12	0.03	0.02, 0.03	<0.001
PEF%	Group (Treatment)	-0.30	-24.39, 23.79	0.981
	Group × Week 6	10.34	7.36, 13.31	<0.001
	Group × Week 12	29.55	26.57, 32.52	<0.001
FEF_{25-75}%	Group (Treatment)	0.87	-4.33, 6.07	0.743
	Group × Week 6	1.52	0.81, 2.23	<0.001
	Group × Week 12	7.43	6.72, 8.14	<0.001

Increasing FEV_1% predicted after 6 weeks (β=1.16, 95%CI 0.73–1.58, p<0.001) and after 12 weeks (β=2.72, 95%CI 2.30–3.14, p<0.001): significant group×time interactions-more details see the Supplement S5 Table). Disease duration emerged as a significant covariate (β=0.49, p=0.033).

Significant interactions in FEV1/FVC ratio the baseline and post-exercise measurements at 6 weeks (β=0.01, p<0.001) and 12 weeks (β=0.03, p<0.001). Disease duration was still statistically significant (β=0.00, p= 0.001).

Interaction effects at 6 weeks (P = <0.001) and 12 weeks (P = <0.001) for prediction of PEF%:β=10.34, 95%CI7.36–13.31 and β=28.47, 95% CI26.57–32.52 respectively

New FEF_{25-75}% predicted: strong interactions at 6 weeks (β=1.52, 95%CI 0.81–2.23, p<0.001) and 12 weeks (β=7.43, 95%CI 6.72–8.14, p<0.001).

3.4 Exercise Capacity and Cardiorespiratory Response

Improvements in 6MWD, HRR, and peak HR with the integrated PR were larger than those of standard care, with lower Borg dyspnea scores (Figure 1) and RR(Figure 2).

Results: Important group × time interactions were found for 6MWD at both 6 weeks (β=9·26; 95%CI: 3·11–15·40, p =0·003) and 12 weeks (β=17 ·99; 95% CI: 11·85–24·13, p<0 | Article designed in indesign at www.unicef.org.uk Age had a strong negative predictive negative effect (β=-3.18, p<0.001).

HRR: Substantial interactions at 6 weeks (β=0.91, 95%CI 0.43–1.40, p<0.001) and 12 weeks (β=1.44, 95%CI 0.95–1.93, p<0.001).

Peak HR: Important negative differences were observed at 6 weeks (β=-1.43, 95%CI -2.28 to -0.58, p=0.001) and also at 12 weeks (β =-2.04, 95%CI -2.89 to -1.19, p<0·001), so peak HR reached during exercise in the integrated PR group was lower than in control group [8].

Main results: Borg scale: Significant negative interactions at 6 weeks (β=-1.15, 95%CI -1.24 to -1.06, p<0.001) and 12 weeks (β=-2.12, 95%CI -2.21 to -2.02, p<0.001) showed reduced perceived dyspnea

Natural Resources for Human Health
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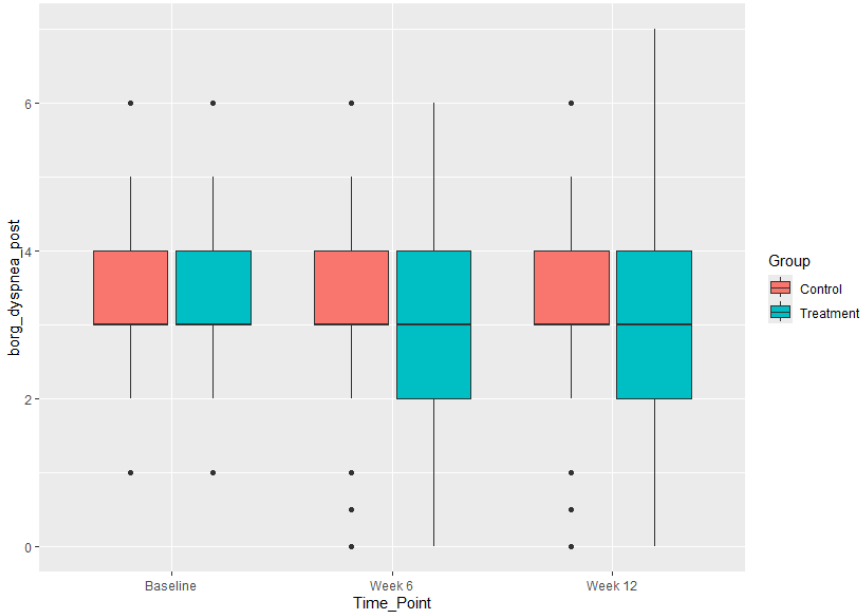
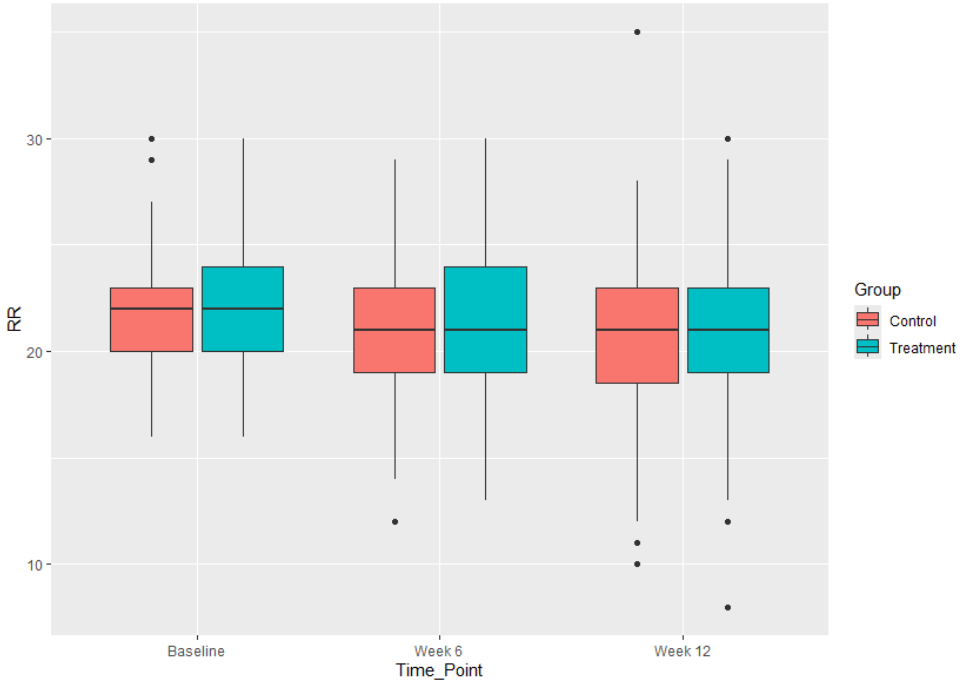


Figure 1. Borg dyspnea scale trajectories: clinically meaningful reductions in integrated PR group (β=-2.12, p<0.001).



RR: Substantial adverse interactions at 6 weeks (β=-0.89, 95%CI -1.31 to -0.47, p<0.001) and 12 weeks (β=-1.34, 95%CI -1.76 to -0.92, pp <0·001).

Figure 2. Respiratory rate trajectories demonstrating slower, more efficient breathing in integrated PR group.

3.5 Moderation by Disease Severity

Analyses of three-way interactions (treatment × timepoint × mMRC grade) showed significant moderation effects (Figures 3–5).

Regarding SpO_2: There was a trend towards significance for the three-way interaction at 12 weeks (β=0.31, p=0.124). Patients with MMRC grade 2 had a lower baseline SpO_2 (β=-2.78, p<0.001).

6MWD: 3-way interaction at 6 weeks (β=-16.68, 95%CI -29.04 to -4.33 p=0.008). Subjects with more severe disease (mMRC grade 2) had smaller improvements in 6MWD than milder disease but the integrated PR still performed better.

For Borg scale: Significant 3-way interactions at both 6weeks (β=0.53, 95%CI 0.36–0.69, p<0.001) and 12weeks (β=0.87, 95%CI 0.70 -1.04, p<0.001), suggest that disease severity moderated the dyspnea-reducing effect of integrated PR

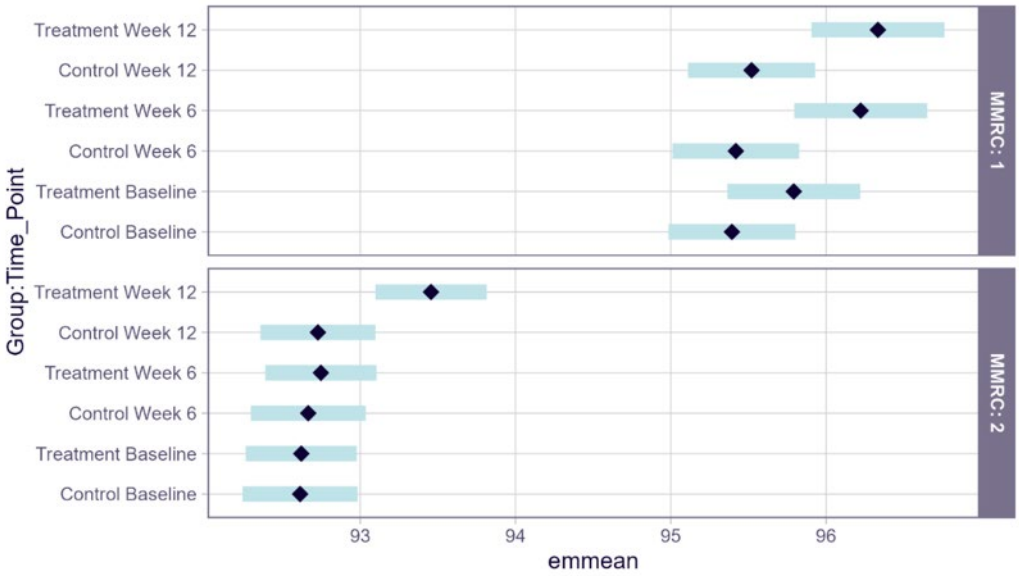


Figure 3. SpO_2 trajectories stratified by mMRC severity, showing treatment moderation effects.

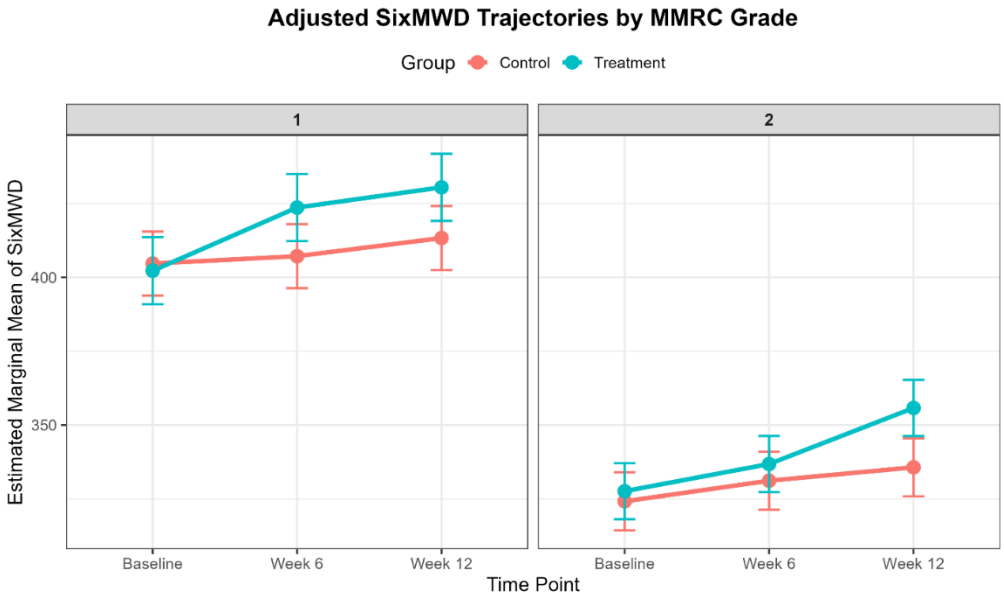


Figure 4. 6MWD trajectories stratified by mMRC severity, with significant three-way interaction at 6 weeks (p=0.008).

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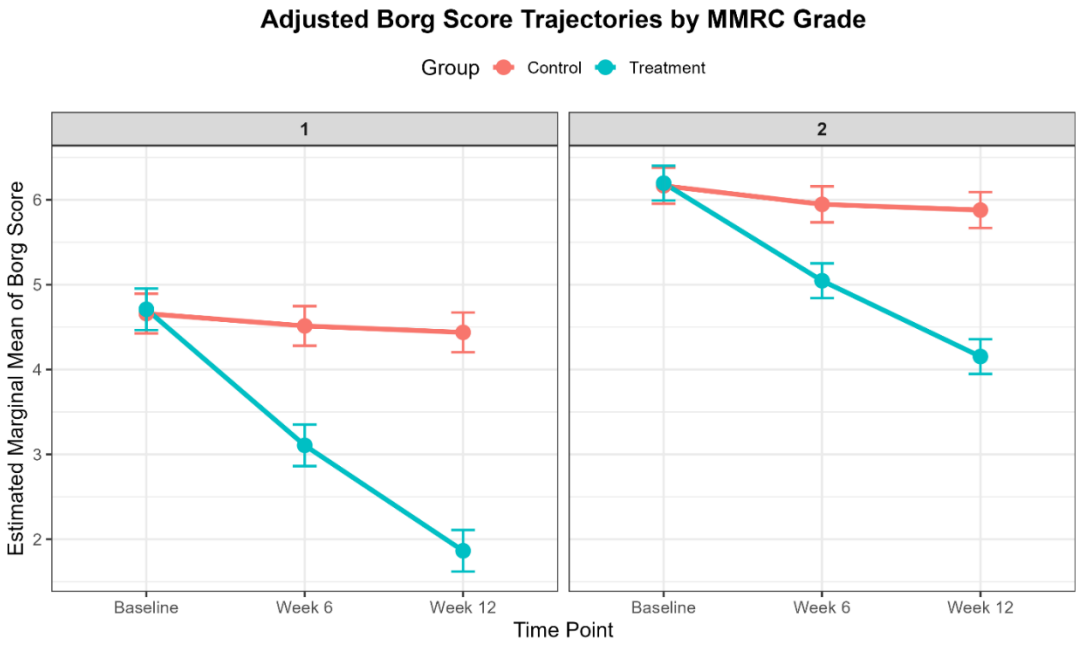


Figure 5. Borg scale trajectories stratified by mMRC severity, with significant three-way interactions at 6 and 12 weeks ($p<0.001$).

4 DISCUSSION

This randomized controlled trial is the first to provide evidence for synergistic efficacy of a structured pulmonary rehabilitation program incorporating yoga, Tai Chi and music-therapy in patients with chronic respiratory disease. Integrated PR resulted in better improvements across several domains—exercise capacity, pulmonary function, oxygenation, dyspnea and cardiorespiratory efficiency—compared to conventional PR at mid-intervention (6 weeks), with effect sizes further increasing from mid- to post-intervention (12 weeks). The results present a solution to major gaps in the literature with respect to combined mind-body intervention studies, culturally appropriate rehabilitation models, and multi-disease CRD research (13; 14).

4.1 Enhanced Aerobic Fitness and Oxygen Delivery

At the group level, the 17.99-m greater benefit in 6MWD in the integrated PR group is more than double the minimum clinically important difference (MCID) for COPD of 30 meters [15], but individual responder analyses are still needed. Patients in this group did so at a significantly higher HR with lower peak heart rates and higher HR reserve compared to those performing it independently (where increased work was more closely correlated with increased heart rate), which may reflect a greater cardiorespiratory efficiency. This result is consistent with network meta-analyses that identified yoga with the highest surface under the cumulative ranking (SUCRA: 99.7%) for helpfulness in improving 6MWD [10] and Tai Chi as most effective mind-body exercise for improving 6MWT performance [11]. This effect seems to be enhanced by a synergetic combination thereof.

The consistent improvement of SpO_2 at week 12 (group × time $\beta=0.347$, $p=0.001$) is clinically relevant. Although the absolute difference is small, preserving SpO_2 during exertion is a key factor in ascetic oxygen utilization and desaturation-related complications. The probable mechanisms are improved diaphragmatic function from pranayama [16], a decrease in ventilation-perfusion mismatch with the postural control of Tai Chi [17], and less anxiety-mediated bronchoconstriction due to music therapy [12].

4.2 Pulmonary Function Improvements

The integrated PR group also showed clinically significant $FEV_1\%$ improvements at both 6 weeks ($\beta=1.16$) and 12 weeks ($\beta=2.72$). Similar effect sizes were found in a recent meta-analysis of traditional mind-body exercises (WMD=4.61, 23 RCTs) [11], and with a network meta-analysis identifying Wuqinxi as the exercise type most effective for $FEV_1\%$ (SUCRA: 82.9%)

[18]. Critically, our findings expand this to multi-disease CRD which included ILD, bronchiectasis and post-tuberculosis sequelae, conditions frequently omitted from rehabilitation trials. The improvements in FEV_1/FVC ratio (β=0.03; 12 weeks, p<0.001) may imply reduced airflow obstruction likely mediated by decreased inflammatory [19] or increased respiratory muscle strength [14], or even higher mucus clearance [13].

The significant changes in PEF% (β=29.55 at 12 weeks) and FEF_{25-75}%(β=7.43 at 12 weeks), representing small airway function and expiratory flow, respectively, are impressive findings. These discoveries are clinically relevant for diseases associated with airway collapse and secretion retention, such as bronchiectasis and COPD.

4.3 Dyspnea and Respiratory Pattern

A clinically meaningful reduction in Borg dyspnea scores (β=-2.12 at 12 weeks) and respiratory rates (β=-1.34, p<0.001). This Borg reduction is greater than the Minimum Clinically Important Difference (MCID) of 1 unit for COPD [20] and indicates substantial improvement in breathlessness perception during standardized exertion. The slower, deeper breathing pattern indicated (decreased RR at unchanged or increased SpO_2), is expected to lead to more efficient ventilation and reduced dead space ventilation along with improved contribution of the diaphragm [16].

4.4 Disease Severity Moderation

Three-way interaction analyses indicated that disease severity (mMRC grade) also significantly moderated treatment responses. Compared to milder disease, patients with more severe disease (mMRC grade 2) had lower baseline functional capacity and demonstrated attenuated absolute improvements in 6MWD but the integrated PR had remained superior to standard PR across severity strata. The improvement in dyspnea was greater with integrated PR in patients with more severe disease (three-way interaction β=0·87 at 12 weeks, p<0·001), indicating that integrated PR may be especially advantageous in those with higher symptom burden. That is in keeping with the idea that multi-modal mind-body interventions target biopsychosocial 'burden of illness' aspects associated with advanced respiratory disease more than exercise alone [21].

4.5 Mechanisms of Synergy

We propose several synergistic mechanisms. Although both means, yoga pranayama and Tai Chi's diaphragmatic breathing are exercises mainly aiming to train the inspiratory muscles directly [16, 17]. Second, Shared autonomic modulation: Slow rhythmic breathing (promoted by music therapy) increases vagal tone [19] and decreases sympathetic activation and heart rate variability. Third: Psychological desensitization: the anxiolytic effects of music therapy and other components of meditation and relaxation reducing fears regarding dyspnea would lead to breaking this vicious triad inducing a cycle of dyspnea–anxiety–hyperventilation [12]. Fourth, movement efficiency: The flowing and circular movements of Tai Chi are associated with enhanced postural control, balance and coordination which reduce the metabolic cost of activities of daily living [23]. Fifth, adherence improvement: The fact that these modalities were both culturally familiar and enjoyable (the details of the attendance rates will be described elsewhere) in this Indian context very likely lead to the high attendance figures.

4.6 Comparison with Previous Literature

Our results build on previous research in several key ways. Gendron et al. We identified low-quality evidence for active mind-body movement therapies compared with PR from a Cochrane review of Iyengar yoga (2018) [24]. Our study offers a more robust quality of evidence than these trials, using an adequately powered RCT with active comparator, standardized protocols and blinded outcome assessment. Lin et al. 's (2025) network meta-analysis demonstrated differential efficacy profiles of the different types of mind-body exercises for treating insomnia [18]. Our holistic approach builds upon these distinguishing features: yoga for 6MWD and MLHFQ [10], Tai Chi for 6MWT and FEV_1% [11], music therapy for dyspnea and anxiety [12]. Finally, the effect size of the synergistic period (Cohen's d=between-group difference in 6MWD~0.6–0.8; based on our data) is greater than those reported for single-modality interventions and thus supports the synergistic hypothesis.

4.7 Implications for Clinical and Public Health

The clinical significance of this study. First, the integrated PR program provides an effective alternative for patients who are poorly concordant with traditional gym-based exercise because of limited physical tolerance, psychological intolerance, or inaccessibility to a suitable environment. Second, the cultural adaptiveness of the program in Indian and other Asian contexts might facilitate uptake and adherence. Third, the multi-disease inclusion promotes program implementation across respiratory

services without the need for disease-specific protocols. Fourth, the low equipment demands (requires no treadmill or cycle ergometer) make this program adapted to resource-limited settings where conventional PR is unavailable.

From a public health perspective, this model can be delivered by community health workers, yoga studios or Tai Chi groups as an accessible way of reaching the estimated 544.9 million people worldwide [1] living with CRDs. Cost-effectiveness will be determined in separate health economic analyses planned for year 4.

4.8 Limitations

Several limitations warrant consideration. There were several limitations associated with these studies that may have led to biased results. Outcome assessors and statisticians were blinded, objective outcomes (spirometry, 6MWD) are less subject to bias than patient-reported outcomes. Second, the application of a single-center design reduces evidence that may be included in various settings and populations. Third, the integrated protocol was 30 minutes longer per session compared to PR only, which could impact the comparison of adherence; however, attendance rates were similar in the two conditions (pain data will be reported). Fourth, 12-week follow-up appears inadequate to evaluate longer-term sustainability; however, studies will follow with 6– and 12-mo follow-ups. Fifth, although disease heterogeneity increases external validity, it can hide differential responses at the level of individual conditions; therefore, subgroup analyses by disease type will be presented separately. Sixth, we did not include a sham or placebo control group, which would have bolstered causal inferences.

4.9 Future Directions

Future work should include: (1) longterm follow-up to assess durability of benefits; (2) dismantling studies to identify the active components and optimum dose of each modality; (3) comparative effectiveness trials against established PR programs; (4) implementation science studies with respect to barriers and facilitators for real-world adoption;(5) mechanistic explorations in inflammatory, autonomic, and neurophysiological pathways;(6) economic evaluations examining costs-effectiveness scenarios; and (7) personalized approaches based on individual clinical/psychological profiles matching patients with specific modalities.

CONCLUSION

In a study of patients with chronic respiratory diseases, an integrated program of yoga, Tai Chi and music therapy proved more effective than standard pulmonary rehabilitation for improving exercise capacity, pulmonary function, oxygenation and dyspnea. The advantages were more pronounced in patients with greater illness severity, indicating particular utility for symptomatic populations. This culturally accepted, multi-modal, equipment-sustainable rehabilitation strategy represents a viable and scalable rehabilitation solution for populations with CRD, but holds particular relevance in settings of limited resources where conventional pulmonary rehabilitation is not accessible.

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