



YONSEI
UNIVERSITY

2025 호흡재활 Year in Review

Ah Young Leem

Division of Pulmonary and Critical Care Medicine

Department of Internal Medicine

Yonsei University College of Medicine

Severance

Overview

- Pulmonary rehabilitation in the guidelines
 - GOLD 2026 guideline
 - ERS clinical practice guideline for the bronchiectasis
- Pulmonary rehabilitation of COPD
- Pulmonary rehabilitation of ILD
- Pulmonary rehabilitation in Korea

Overview

- Pulmonary rehabilitation in the guidelines
 - GOLD 2026 guideline
 - ERS clinical practice guideline for the bronchiectasis
- Pulmonary rehabilitation of COPD
- Pulmonary rehabilitation of ILD
- Pulmonary rehabilitation in Korea

GOLD guideline 2026

| Non-Pharmacological Management of COPD* | | | |
|---|---|-------------------|--|
| Patient Group | Essential | Recommended | Depending on Local Guidelines |
| A | Smoking cessation (can include pharmacological treatment) | Physical activity | Influenza vaccination COVID-19 vaccinations Pneumococcal vaccination Pertussis vaccination Shingles vaccination RSV vaccination |
| B and E | Smoking cessation (can include pharmacological treatment) Pulmonary rehabilitation | Physical activity | Influenza vaccination COVID-19 vaccinations Pneumococcal vaccination Pertussis vaccination Shingles vaccination RSV vaccination |

Figure 3.12

*Can include pharmacological treatment

GOLD guideline 2026

- Pulmonary rehabilitation is defined as
 - Comprehensive intervention based on thorough patient assessment followed by patient-tailored therapies that include, but are not limited to, exercise training, education, self-management intervention aiming at behavior change
 - Designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote the long-term adherence to health-enhancing behaviors
- Patients with high symptom burden and risk of exacerbations (Group B and E), should be encouraged to take part in a formal rehabilitation program
- Optimum benefits are achieved from programs lasting 6 to 8 weeks
 - No additional benefits from extending PR to 12 weeks

GOLD guideline 2026

- Supervised exercise training at least twice weekly is recommended
 - Endurance training, interval training, resistance/strength training
 - Upper and lower limbs
 - Walking exercise
 - Flexibility
 - Inspiratory muscle training
 - Neuromuscular electrical stimulation
- Rehabilitation intervention (content, scope, frequency, and intensity) should be individualized to maximize personal functional gains

GOLD guideline 2026

- Assessment and follow-up of pulmonary rehabilitation
 - Detailed history and physical examination including health behaviors
 - Important for establishing entry suitability and baseline status
 - Measurement of post-bronchodilator spirometry
 - Important for establishing entry suitability and baseline status
 - Assessment of (functional) exercise capacity
 - Measurement of health status and impact of breathlessness and fatigue
 - Assessment of inspiratory and expiratory muscle strength and lower limb strength in patients who suffer from muscle wasting
 - Discussion about individual patient goals, problematic activities of daily living, and expectations and knowledge about the disease

Pulmonary Rehabilitation, Self-Management and Integrative Care in COPD

Figure A4.1

| | |
|---|--|
| <p>Pulmonary Rehabilitation</p> | <ul style="list-style-type: none"> • Rehabilitation is indicated in all patients with relevant <u>symptoms</u> and/or a <u>high risk for exacerbation</u> (Evidence A) • Pulmonary rehabilitation improves <u>dyspnea</u>, <u>health status</u> and <u>exercise tolerance</u> in stable patients (Evidence A) • Pulmonary rehabilitation <u>reduces hospitalization</u> among patients who have had a <u>recent exacerbation</u> (≤ 4 weeks from prior hospitalization) (Evidence B) • Pulmonary rehabilitation leads to a <u>reduction in symptoms of anxiety and depression</u> (Evidence A) • Pulmonary rehabilitation leads to an improvement in <u>sleep quality</u> (Evidence C) |
| <p>Education and Self-Management</p> | <ul style="list-style-type: none"> • Education is needed to change patient's knowledge but there is no evidence that used alone it will change patient behavior (Evidence C) • Self-management intervention with communication with a health care professional improves health status and decreases hospitalizations and emergency department visits (Evidence B) |
| <p>Integrated Care Programs</p> | <ul style="list-style-type: none"> • Integrative care and telehealth have no demonstrated benefit at this time (Evidence B) |
| <p>Physical Activity</p> | <ul style="list-style-type: none"> • Physical activity is a strong predictor of mortality (Evidence A). People with COPD should be encouraged to increase their level of physical activity. Programs that use effective behavioral change techniques, including the use of step counters, have been shown to increase physical activity in the short term. |

GOLD guideline 2026

● Tele-rehabilitation

- Has been proposed as an alternative to traditional approaches
- Become even more relevant in the COVID-19 pandemic era where in-person PR has not been feasible
- Across multiple trials performed in groups and individuals with a large variety of tele-rehabilitation delivery platforms, the reported results suggest that tele-rehabilitation is safe and has similar benefits to those of center-based pulmonary rehabilitation across a range of outcomes.
 - Evidence-based models from the Cochrane review were published before the COVID-19 pandemic, and have all included an in-person exercise test at the center prior to commencement
- The evidence base is still evolving and best practices are not yet established

Overview

- Pulmonary rehabilitation in the guidelines
 - GOLD 2026 guideline
 - ERS clinical practice guideline for the bronchiectasis
- Pulmonary rehabilitation of COPD
- Pulmonary rehabilitation of ILD
- Pulmonary rehabilitation in Korea

ERS clinical practice guideline for the bronchiectasis



EUROPEAN RESPIRATORY JOURNAL
ERS OFFICIAL DOCUMENTS
J.D. CHALMERS ET AL.

European Respiratory Society clinical practice guideline for the management of adult bronchiectasis

James D. Chalmers ^{1,33}, Charles S. Haworth², Patrick Flume³, Merete B. Long¹, Pierre-Régis Burgel ⁴, Katerina Dimakou⁵, Francesco Blasi ^{6,7}, Beatriz Herrero-Cortina ^{8,9}, Raja Dhar¹⁰, Sanjay H. Chotirmall ^{11,12}, Felix C. Ringshausen ^{13,14,15}, Josje Altenburg¹⁶, Lucy Morgan ¹⁷, Mattia Nigro ^{18,19}, Megan L. Crichton¹, Chayenne Van Meel²⁰, Oriol Sibila²¹, Alan Timothy²², Eliza Kompatsiari²², Tanja Hedberg²², Thomas Vandendriessche²⁰, Pamela J. McShane²³, Thomy Tonia ²⁴, Kevin Winthrop²⁵, Michael R. Loebinger²⁶, Natalie Lorent ^{27,28}, Pieter Goeminne ²⁹, Michal Shteinberg ^{30,31}, Eva Polverino³² and Stefano Aliberti ^{19,20,33}

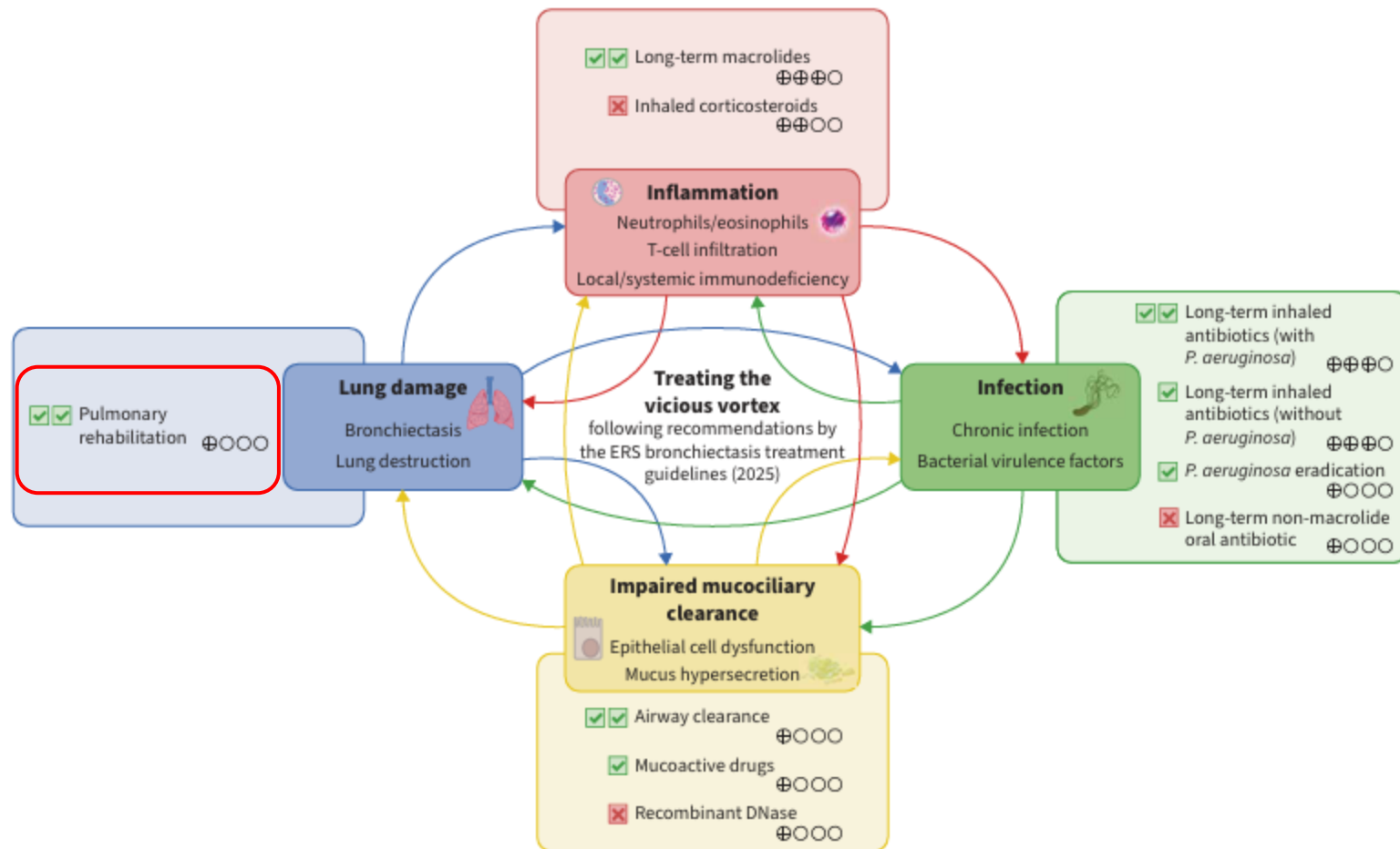


FIGURE 1 The vicious vortex of bronchiectasis with the treatments evaluated in the 2025 European Respiratory Society (ERS) bronchiectasis guidelines. Green indicates treatments that receive a recommendation in favour (two green ticks indicates a strong recommendation for the intervention, one green tick indicates a conditional recommendation for the intervention). Red indicates treatments that receive a recommendation against (a red cross indicates a conditional recommendation against the intervention). The certainty of evidence is indicated by the crossed circles after each topic (1 cross=very low certainty, 2 crosses=low certainty, 3 crosses=moderate certainty, 4 crosses=high certainty). *P. aeruginosa*: *Pseudomonas aeruginosa*.

ERS clinical practice guideline for the bronchiectasis

PICO Question 8: Pulmonary rehabilitation

Should pulmonary rehabilitation be used (compared with no pulmonary rehabilitation) in adults with bronchiectasis?

Recommendation

We recommend that patients with breathlessness and/or impaired exercise capacity should be offered pulmonary rehabilitation. *(Strong recommendation for the intervention, very low certainty of evidence.)*

Remarks

- The educational component of pulmonary rehabilitation should ideally be bronchiectasis specific and include discussion of airway clearance strategies.
- Patients with bronchiectasis should be encouraged to undertake regular physical activity, given its multiple health benefits.

Overview

- Pulmonary rehabilitation in the guidelines
 - GOLD 2026 guideline
 - ERS clinical practice guideline for the bronchiectasis
- Pulmonary rehabilitation of COPD
- Pulmonary rehabilitation of ILD
- Pulmonary rehabilitation in Korea

A Comparison of GOLD and STAR Severity Stages in Individuals With COPD Undergoing Pulmonary Rehabilitation



Pasquale Ambrosino, MD, PhD; Michele Vitacca, MD, FERS; Giuseppina Marcuccio, MD, PhD; Antonio Spanevello, MD, FERS; Nicolino Ambrosino, MD, FERS; and Mauro Maniscalco, MD, PhD, FERS

- Aim
 - To assess the agreement between the GOLD and STAR classifications in a large cohort of patients with COPD undergoing in-hospital PR
 - Evaluated whether these two scoring systems may differ in their predictive ability for key PR outcomes
- Multicenter retrospective study, Italy
- 1,516 patients with COPD (median age: 72 years) undergoing PR
- GOLD
 - Stage 1 to 4 based on FEV₁ % predicted values of ≥ 80%, ≥ 50% to < 80%, ≥ 30% to < 50%, and < 30%
- Staging of Airflow Obstruction by Ratio (STAR)
 - Stage 1 to 4 based on FEV₁/FVC ratios of ≥ 0.6 to < 0.7, ≥ 0.5 to < 0.6, ≥ 0.4 to < 0.5, and < 0.40

PR of COPD: A Comparison of GOLD and STAR Severity Stages in Individuals With COPD Undergoing PR

● Assessments

- Comparison of baseline functional variables (6MWD, mMRC, lung function) and their changes after the PR program

● PR

- Supervised by a multidisciplinary team comprising chest physicians, physical therapists, nurses, dietitians, and psychologists
- Including progressive abdominal as well as upper and lower limb muscle exercises with incremental weight lifting
- Supervised cycle exercise training is incorporated until participants achieve 30 min of continuous cycling at 50% to 70% of the maximal load, calculated based on the baseline 6MWD test
- During exercise sessions, pulse oximetry, arterial BP, and heart rate are closely monitored
- Total daily duration of activities ranges from 2 to 3 hours

PR of COPD: A Comparison of GOLD and STAR Severity Stages in Individuals With COPD Undergoing PR

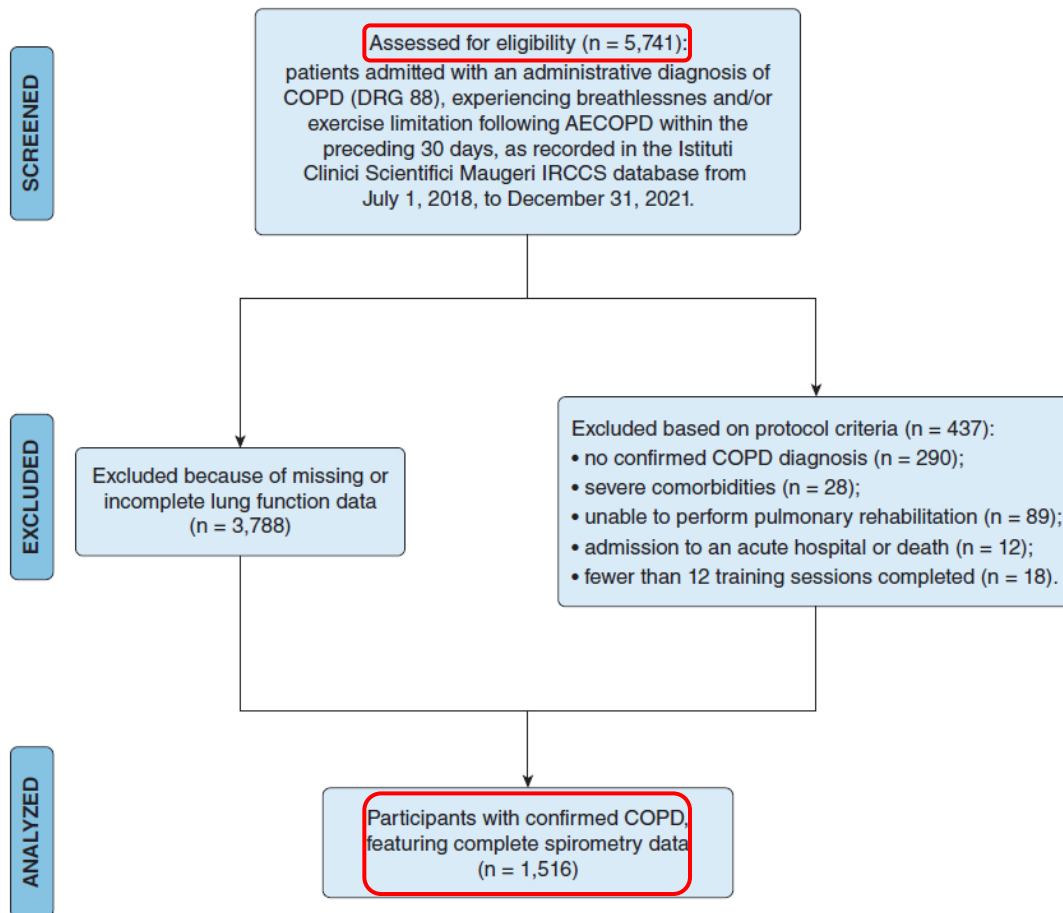


Figure 1 – Strengthening the Reporting of Observational Studies in Epidemiology flow diagram of study participants. AECOPD = acute exacerbation of COPD; DRG = diagnosis-related group.

PR of COPD Severity Sta

TABLE 1] Baseline Clinical and Functional Parameters of 1,516 Patients With COPD

| Variable | Value |
|--|---------------------|
| Demographic | |
| Age, y | 72.0 (66.0-78.0) |
| Female | 511 (33.7) |
| Anthropometric | |
| Weight, kg (n = 1,478) | 72.0 (60.0-86.0) |
| Height, cm (n = 1,493) | 165.0 (159.0-170.0) |
| BMI, kg/m ² (n = 1,509) | 26.7 (22.7-31.0) |
| Heart rate, beats/min (n = 1,474) | 77.0 (68.0-88.0) |
| GOLD classification | |
| Stage 1 | 44 (2.9) |
| Stage 2 | 441 (29.1) |
| Stage 3 | 554 (36.5) |
| Stage 4 | 477 (31.5) |
| STAR classification | |
| Stage 1 | 198 (13.1) |
| Stage 2 | 454 (29.9) |
| Stage 3 | 545 (35.9) |
| Stage 4 | 319 (21.0) |
| Lung function | |
| Respiratory failure | 434 (28.6) |
| FEV ₁ , % predicted | 44.0 (34.0-84.0) |
| FVC, % predicted | 70.0 (58.0-84.0) |
| FEV ₁ /FVC | 0.47 (0.42-0.56) |
| D _{lco} , % predicted (n = 280) | 45.0 (31.0-62.7) |
| RV, % predicted (n = 630) | 163.0 (134.0-190.0) |
| Arterial blood gas test | |
| Pao ₂ , mm Hg (n = 314) | 67.7 ± 11.5 |
| Paco ₂ , mm Hg (n = 314) | 40.0 (36.5-44.9) |
| pH (n = 314) | 7.43 (7.41-7.45) |
| Spo ₂ , % (n = 1,478) | 94.0 (92.0-96.0) |
| Blood laboratory parameters | |
| Hemoglobin, g/dL (n = 1,180) | 13 (11.6-14.2) |
| Eosinophils, cells/μL | 170.0 (100.0-237.5) |
| Glucose, mg/dL (n = 1,159) | 85.0 (77.0-98.0) |
| Creatinine, mg/dL (n = 1,186) | 0.83 (0.73-1.03) |
| Total cholesterol, mg/dL (n = 1,130) | 171.0 (143.7-200.0) |
| LDL, mg/dL (n = 724) | 104.0 (80.0-133.0) |
| HDL, mg/dL (n = 1,089) | 46.0 (38.0-56.0) |
| Uric acid, mg/dL (n = 685) | 5.7 (4.6-7.0) |

TABLE 1] (Continued)

| Variable | Value |
|--|---------------------|
| eGFR, mL/min/1.73 m ² (n = 495) | 86.2 (71.6-94.4) |
| BP | |
| SBP, mm Hg (n = 372) | 130.0 (120.0-140.0) |
| DBP, mm Hg (n = 372) | 80.0 (70.0-80.0) |
| Functional scores | |
| mMRC (n = 885) | 3.0 (3.0-4.0) |
| CAT (n = 703) | 19.0 (13.0-25.0) |
| Barthel Index (n = 650) | 95.0 (85.0-100.0) |
| Barthel Index-dyspnea (n = 826) | 27.0 (16.0-41.0) |
| Braden scale (n = 324) | 21.0 (20.0-22.0) |
| Morse scale (n = 590) | 15.0 (15.0-30.0) |
| CIRS (n = 675) | 4.0 (2.0-5.0) |
| SPPB (n = 893) | 9.0 (6.0-10.0) |
| Exercise capacity | |
| 6MWD, m (n = 1,116) | 300.0 (197.2-399.0) |
| Use of pulmonary medications | |
| ICS | 963 (63.5) |
| LAMA | 1,403 (92.5) |
| LABA | 973 (64.2) |
| Triple therapy | 323 (39.1) |

joining PR

Continuous data are presented as mean ± SD or median (interquartile range) in case of skewed distribution. Categorical variables are summarized as relative frequencies. 6MWD = 6-min walking distance; CAT = COPD Assessment Test; CIRS = Cumulative Illness Rating Scale; DBP = diastolic BP; D_{lco} = diffusing lung capacity for carbon monoxide; eGFR = estimated glomerular filtration rate; GOLD = Global Initiative for Chronic Obstructive Lung Disease; HDL = high-density lipoprotein; ICS = inhaled corticosteroid; LDL = low-density lipoprotein; mMRC = modified Medical Research Council questionnaire; LABA = long-acting β₂-agonists; LAMA = long-acting muscarinic antagonists; RV = residual volume; SBP = systolic BP; Spo₂ = oxygen saturation; SPPB = Short Physical Performance Battery; STAR = Staging of Airflow Obstruction by Ratio.

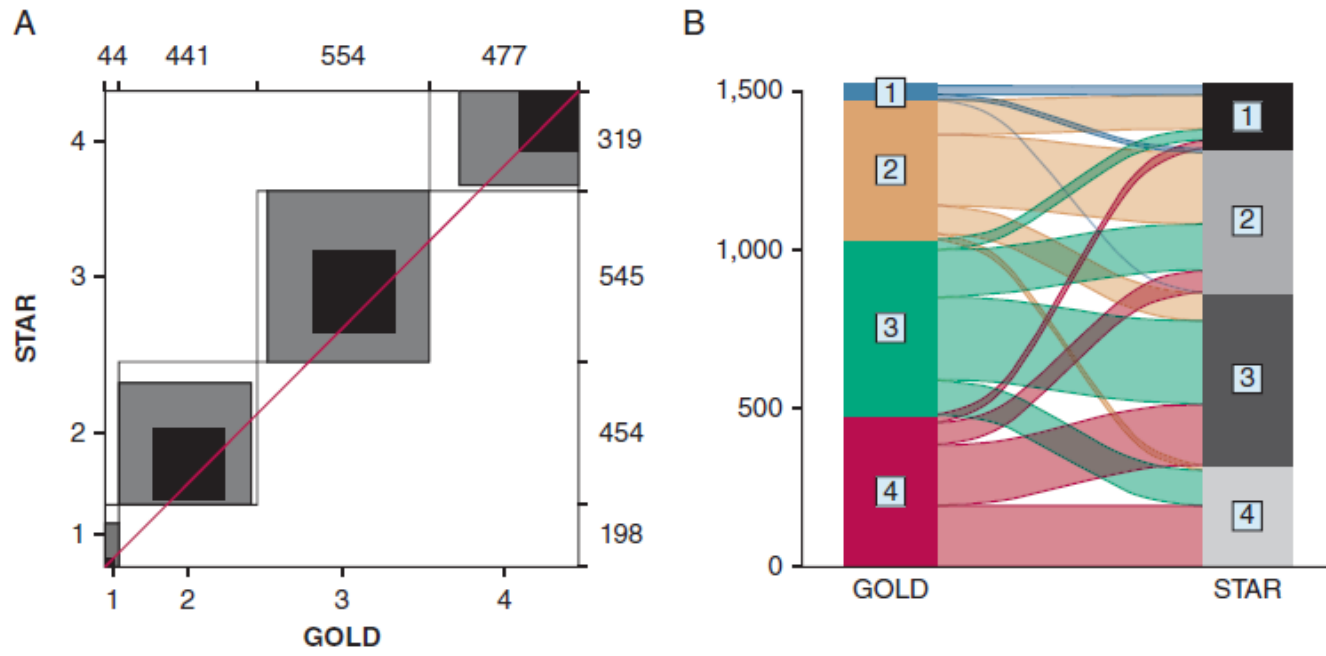


Figure 2 – A, B, Classification by GOLD and STAR severity schemes of 1,516 patients with COPD. A, Bangdiwala agreement chart. B, Alluvial plot representing the redistribution of patients from GOLD to STAR stages. In panel A, the agreement plot is depicted as a contingency table, with the numbers on the top and right axes representing the participants assigned to each stage by GOLD and STAR scoring systems, respectively. Large rectangles illustrate the marginal totals of rows and columns, thus indicating the highest achievable agreement. Dark squares signify complete agreement, whereas shaded rectangles indicate partial agreement and are proportional to the number of participants whose classifications differ. Perfect agreement would be depicted when all the rectangles form perfect squares, aligned precisely along the diagonal identity line. GOLD = Global Initiative for Chronic Obstructive Lung Disease; STAR = Staging of Airflow Obstruction by Ratio.

TABLE 2] Redistribution of GOLD Severity Stages According to STAR Classification in 1,516 Patients With COPD

| GOLD Stage | STAR | | | |
|------------|------------|------------|------------|------------|
| | Stage 1 | Stage 2 | Stage 3 | Stage 4 |
| Stage 1 | 28 (63.6) | 13 (29.5) | 3 (6.8) | 0 |
| Stage 2 | 109 (24.7) | 225 (51.0) | 88 (20.0) | 19 (4.3) |
| Stage 3 | 34 (6.1) | 147 (26.5) | 263 (47.5) | 110 (19.9) |
| Stage 4 | 27 (5.7) | 69 (14.5) | 191 (40.0) | 190 (39.8) |

Categorical variables are summarized as relative frequencies. Patients are categorized as GOLD stage 1 to 4 based on FEV₁ % predicted values of ≥ 80%, ≥ 50% to < 80%, ≥ 30% to < 50%, and < 30%, respectively, and into STAR stage 1 to 4 based on FEV₁/FVC ratios of ≥ 0.6 to < 0.7, ≥ 0.5 to < 0.6, ≥ 0.4 to < 0.5, and < 0.40. GOLD = Global Initiative for Chronic Obstructive Lung Diseases; STAR = Staging of Airflow Obstruction by Ratio.

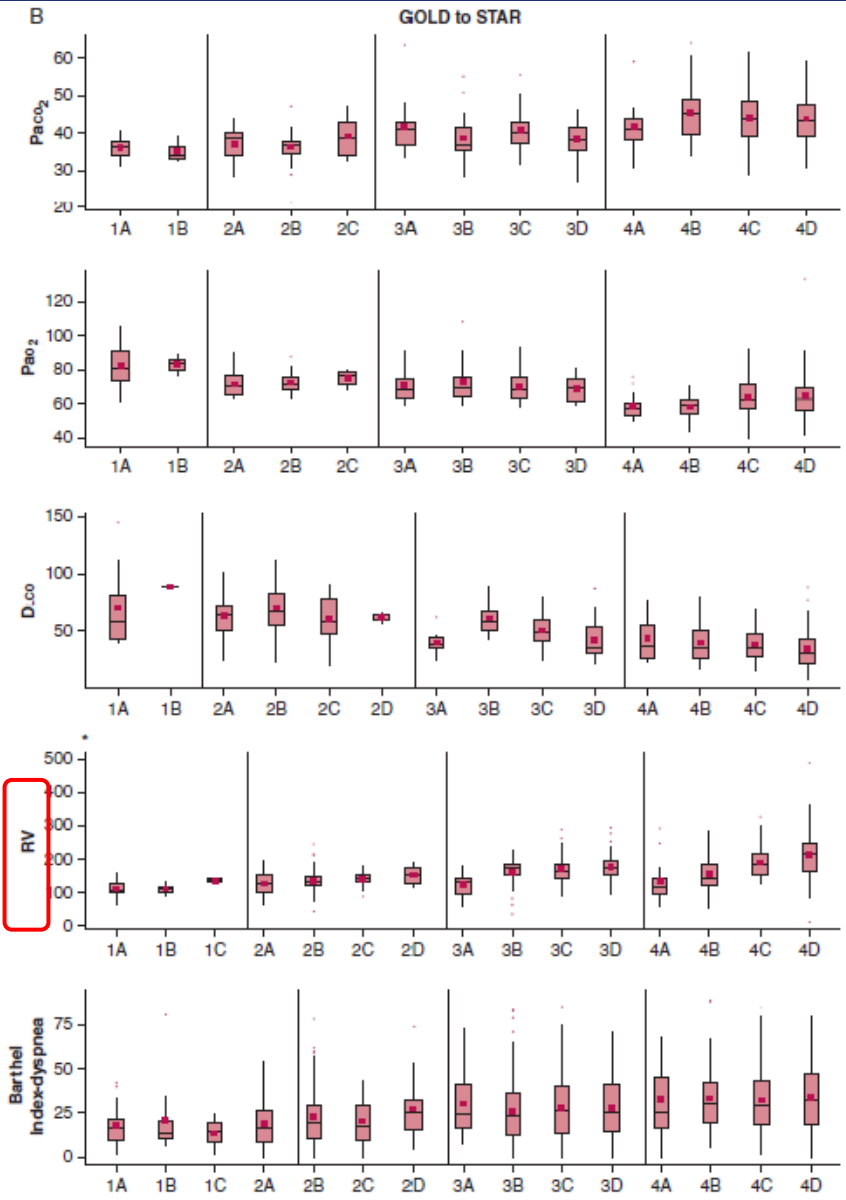
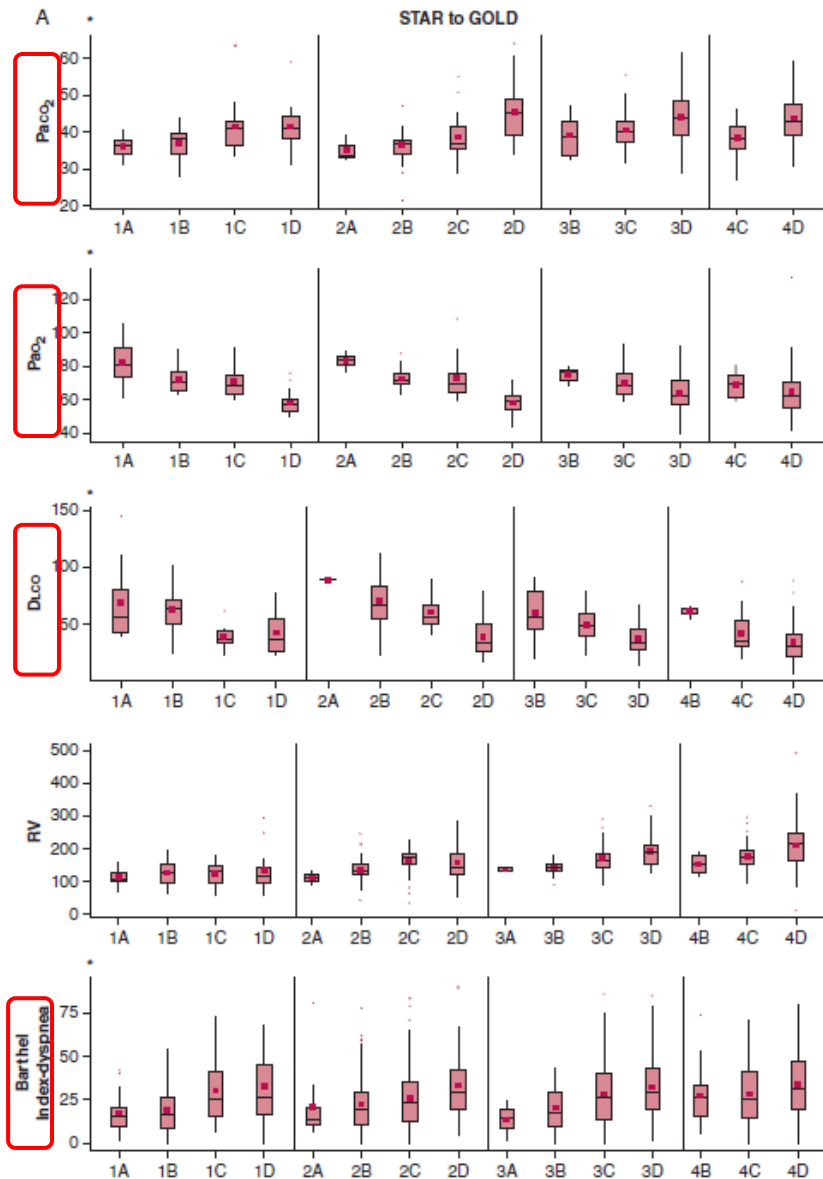


Figure 3 – A, B, Comparison of clinical and functional parameters across corresponding and discrepant GOLD and STAR categories. A, Within each STAR stage, concordant/discordant classes according to GOLD are relabeled as A, B, C, or D, corresponding to GOLD classes 1, 2, 3, or 4, respectively. B, Within each GOLD stage, concordant/discordant classes according to STAR are relabeled as A, B, C, or D, corresponding to STAR classes 1, 2, 3, or 4, respectively. Black squares indicate mean values, horizontal lines within the boxes show median values, box heights represent interquartile ranges, vertical lines depict whiskers, and black dots signify outliers. The presence of the asterisk signifies better discrimination of one of the two scoring systems, demonstrating a monotonic reduction or increase when moving within each of the four classes. DLCO = diffusing lung capacity for carbon monoxide; GOLD = Global Initiative for Chronic Obstructive Lung Disease; RV = residual volume; STAR = Staging of Airflow Obstruction by Ratio.

PR of COPD: A Comparison of GOLD and STAR Severity Stages in Individuals With COPD Undergoing Pulmonary Rehabilitation

TABLE 3] Main Functional Parameters at Baseline and Following PR and Achievement of an MCID in Patients With COPD

| Variable | Baseline (N = 1,516) | Following PR (N = 1,516) | P Value |
|---|----------------------|--------------------------|------------------|
| Functional scores | | | |
| mMRC (n = 885) | 3.0 (3.0-4.0) | 2.0 (2.0-2.0) | < .001 |
| CAT (n = 703) | 19.0 (13.0-25.0) | 11.0 (5.0-17.0) | < .001 |
| Barthel Index (n = 650) | 95.0 (85.0-100.0) | 100.0 (90.0-100.0) | < .001 |
| Barthel Index-dyspnea (n = 826) | 27.0 (16.0-41.0) | 16.0 (8.0-28.0) | < .001 |
| Braden scale (n = 324) | 21.0 (20.0-22.0) | 22.0 (21.0-22.0) | < .001 |
| Morse scale (n = 590) | 15.0 (15.0-30.0) | 15.0 (15.0-30.0) | .148 |
| CIRS (n = 675) | 4.0 (2.0-5.0) | NA | NA |
| SPPB (n = 893) | 9.0 (6.0-10.0) | 11.0 (8.0-12.0) | < .001 |
| 6MWD, m (n = 1,116) | 300.0 (197.2-399.0) | 351.0 (256.5-439.2) | < .001 |
| MCID | | | |
| MCID _{mMRC} (n = 885) | NA | 773 (87.3) | NA |
| MCID _{CAT} (n = 703) | NA | 626 (89.0) | NA |
| MCID _{Barthel Dyspnea} (n = 826) | NA | 323 (39.1) | NA |
| MCID _{SPPB} (n = 893) | NA | 616 (69.0) | NA |
| MCID _{6MWD} (n = 893) | NA | 684 (61.3) | NA |

Continuous data are presented as mean ± SD or median (interquartile range) in case of skewed distribution. Categorical variables are summarized as relative frequencies. A P value < .05 was considered statistically significant (bold font). 6MWD = 6-min walking distance; CAT = COPD Assessment Test; CIRS = Cumulative Illness Rating Scale; MCID = minimally clinical important difference; mMRC = modified Medical Research Council questionnaire; NA = not applicable; PR = pulmonary rehabilitation; SPPB = Short Physical Performance Battery.

TABLE 4] Random Forest Algorithm: Performance of GOLD and STAR Severity Schemes in Predicting Achievement of an MCID in Functional Scores and Exercise Capacity Following PR by Using AUC_{ROC}

| Variable | Classification | AUC_{ROC} | SE | LCL | UCL |
|---------------------------------|----------------|-------------|-------|-------|-------|
| MCID _{mMRC} | GOLD | 0.562 | 0.039 | 0.537 | 0.586 |
| | STAR | 0.518 | 0.021 | 0.505 | 0.531 |
| MCID _{CAT} | GOLD | 0.643 | 0.042 | 0.617 | 0.668 |
| | STAR | 0.628 | 0.029 | 0.610 | 0.645 |
| MCID _{Barthel Dyspnea} | GOLD | 0.539 | 0.018 | 0.528 | 0.550 |
| | STAR | 0.530 | 0.012 | 0.523 | 0.538 |
| MCID _{SPPB} | GOLD | 0.474 | 0.024 | 0.459 | 0.489 |
| | STAR | 0.500 | 0.021 | 0.487 | 0.514 |
| MCID _{6MWD} | GOLD | 0.540 | 0.021 | 0.526 | 0.553 |
| | STAR | 0.509 | 0.017 | 0.498 | 0.519 |

6MWD = 6-min walking distance; AUC_{ROC} = area under the receiver-operating characteristic curve; CAT = COPD Assessment Test; GOLD = Global Initiative for Chronic Obstructive Lung Diseases; LCL = 95% lower confidence limit; MCID = minimal clinically important difference; mMRC = modified Medical Research Council questionnaire; PR = pulmonary rehabilitation; SPPB = Short Physical Performance Battery; STAR = Staging of Airflow Obstruction by Ratio; UCL = 95% upper confidence limit.

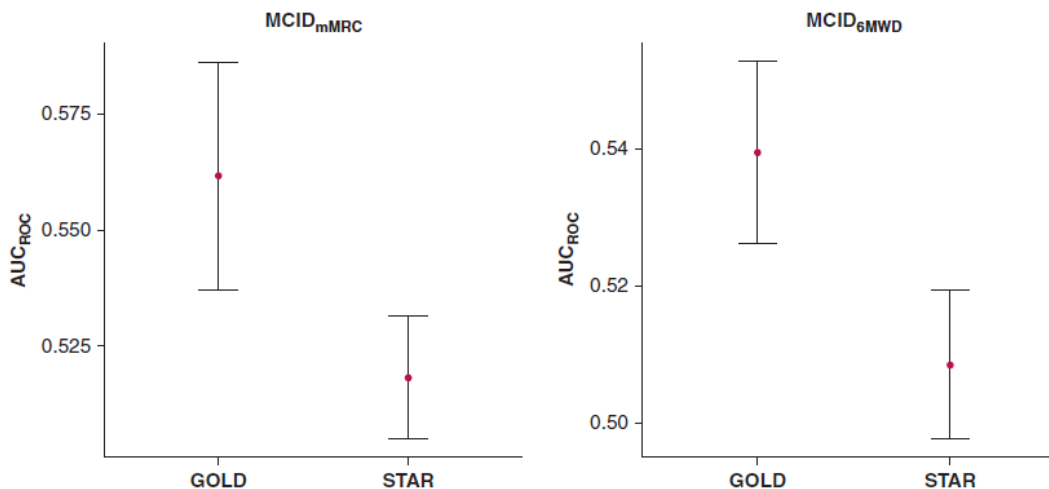





Figure 4 – Random forest algorithm: performance of GOLD and STAR severity schemes in predicting the achievement of an MCID in mMRC score and 6MWD after pulmonary rehabilitation using the AUC_{ROC} . In the absence of overlap of the CIs, there is a strong rationale to believe that the use of a specific scoring system offers a predictive advantage in terms of outcome predictability. 6MWD = 6-min walking distance; AUC_{ROC} = area under the receiver operating characteristic curve; GOLD = Global Initiative for Chronic Obstructive Lung Disease; MCID = minimal clinically important difference; mMRC = modified Medical Research Council; STAR = Staging of Airflow Obstruction by Ratio.

PR of COPD: A Comparison of GOLD and STAR Severity Stages in Individuals With COPD Undergoing Pulmonary Rehabilitation

● Conclusion

- STAR exhibited a more uniform gradation of disease severity and enhanced performance in detecting hyperinflation
- Findings do not endorse its utilization in the rehabilitation setting

Effect of pulmonary rehabilitation duration on exercise capacity and health-related quality of life in people with chronic obstructive pulmonary disease (PuRe Duration Trial): A randomized controlled equivalence trial

Joshua A. Bishop^{1,2}  | Lissa M. Spencer^{1,3}  | Tiffany J. Dwyer¹ |
Zoe J. McKeough¹ | Amanda McAnulty³ | Regina Leung⁴ | Jennifer A. Alison^{1,5} 

● Aim

- Determine whether an 8-week PR programme was equivalent to a 12-week PR programme in improving endurance exercise capacity in people with COPD

● Prospective, multisite, randomized controlled equivalence trial

● Three sites in Sydney, Australia, between January 2017 and January 2020

● Participants with COPD

- Postbronchodilator FEV₁/FVC ratio <0.7 and below the lower limit of normal
- FEV₁ <80%predicted

=> Randomized to either an 8-week (8-wk Group) or 12-week (12-wk Group)

PR of COPD: Effect of PR duration on exercise capacity and health-related quality of life in people with COPD (PuRe Duration Trial)

- Twice weekly supervised PR programme consisting of endurance and strength training and individualized self-management education
- Between group comparisons were made at completion of each programme (i.e., week 8 or week 12), for both programmes at week 12, and at 6-12-month follow-up
- Primary outcome
 - Endurance exercise capacity measured by the endurance shuttle walk test (ESWT) with the minimally important difference of 186 s set as the equivalence limit
- Secondary outcomes
 - Functional exercise capacity was measured using the 6MWT
 - HRQoL was measured using the St George's Respiratory Questionnaire (SGRQ)
 - Health status was measured using the COPD Assessment Test (CAT)

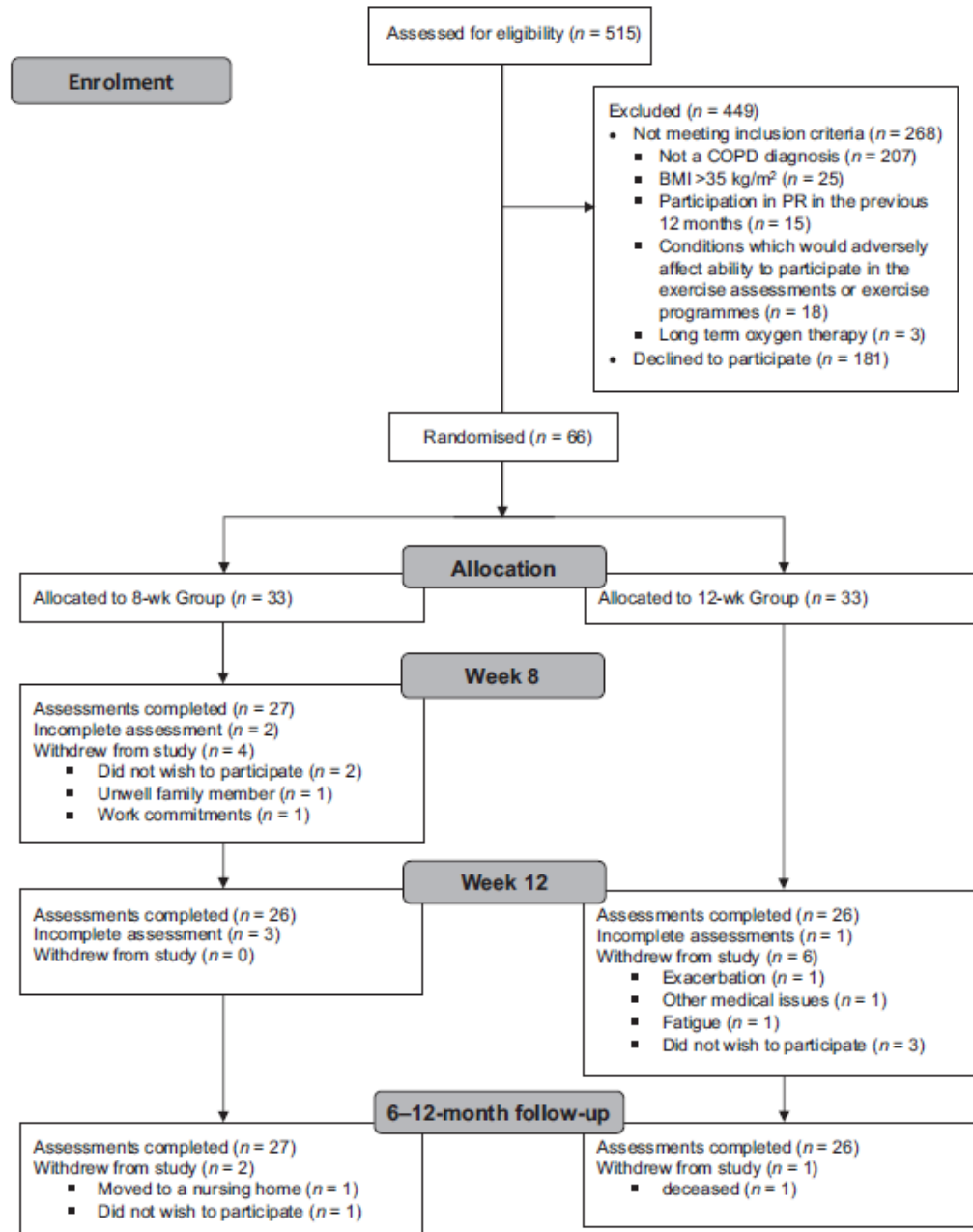


FIGURE 1 Consort flow diagram. Incomplete assessment, numbers of participants who did not complete assessment at that time point but remained in the study at following assessment time points.

TABLE 1 Baseline characteristics.

| Variable | 8-wk Group | 12-wk Group |
|--|---------------|---------------|
| | <i>n</i> = 33 | <i>n</i> = 33 |
| Age, years | 68 (8) | 69 (6) |
| Sex, Male:Female | 20:13 | 18:15 |
| BMI, kg/m ² | 26 (5) | 25 (6) |
| FEV ₁ , %predicted | 47 (17) | 48 (17) |
| FVC, %predicted | 81 (18) | 82 (20) |
| FEV ₁ /FVC ratio | 0.45 (0.13) | 0.46 (0.14) |
| GOLD grade | | |
| II—Moderate | 16 | 15 |
| III—Severe | 11 | 10 |
| IV—Very severe | 6 | 8 |
| Smoking status | | |
| Previous | 25 | 27 |
| Current | 7 | 6 |
| Never | 1 | 0 |
| Smoking pack years, years | 44 (26) | 39 (17) |
| Exercise-induced oxygen desaturation, <i>n</i> (%) | 14 (42) | 14 (42) |
| Commenced PR within 4 weeks of hospitalization, <i>n</i> (%) | 7 (21) | 6 (18) |
| 6MWD <350 m, <i>n</i> (%) | 8 (24) | 8 (24) |

Note: Data are mean and standard deviation (SD) unless otherwise indicated.

Abbreviations: 6MWD, 6-minute walk distance; FEV₁, forced expiratory volume in one second; FVC, forced vital capacity; GOLD, Global Initiative for Obstructive Lung Disease grades (moderate: FEV₁50%–79%predicted; kg, kilogram; m, metres; *n*, number; PR, pulmonary rehabilitation; severe FEV₁30%–49%predicted; very severe: FEV₁ <30%predicted).

**PR of COPD: Eff
related quality of**

**y and health-
ion Trial)**

PR of COPD: Effect of PR duration on exercise capacity and health-related quality of life in people with COPD (PuRe Duration Trial)

TABLE 2 Clinical outcomes at each assessment time point.

| Clinical outcomes | 8-wk Group | | | | 12-wk Group | | |
|------------------------------------|------------------------------|----------------------------|--------------------------|--|------------------------------|-----------------------------|---|
| | Baseline (<i>n</i> = 33) | Week 8 (<i>n</i> = 29) | Week 12 (<i>n</i> = 29) | 6–12-month follow-up (<i>n</i> = 27) | Baseline (<i>n</i> = 33) | Week 12 (<i>n</i> = 27) | 6–12-month follow-up (<i>n</i> = 26) |
| ESWT, s | 391 (188) | 661 (368) | 649 (380) | 455 (407) | 407 (244) | 741 (429) | 585 (423) |
| 6MWD, m | 430 (114) | 443 (115) | 438 (120) | 409 (126) | 439 (99) | 494 (94) | 474 (112) |
| SGRQ symptoms | 58 (25) | 51 (23) | 54 (19) | 54 (25) | 54 (21) | 42 (22) | 43 (19) |
| SGRQ activity | 62 (15) | 62 (18) | 61 (20) | 69 (16) | 59 (21) | 51 (21) | 52 (22) |
| SGRQ impact | 31 (14) | 31 (18) | 36 (18) | 39 (22) | 31 (13) | 22 (13) | 26 (15) |
| SGRQ total | 45 (13) | 44 (15) | 47 (17) | 51 (19) | 43 (13) | 34 (14) | 37 (15) |
| CAT | 20 (6) | 17 (7) | 19 (9) | 20 (7) | 17 (6) | 15 (6) | 15 (8) |
| HADS anxiety | 8 (4) | 8 (4) | 7 (4) | 7 (5) | 5 (3) | 5 (3) | 5 (4) |
| HADS depression | 6 (3) | 6 (3) | 6 (4) | 6 (3) | 5 (3) | 3 (2) | 4 (3) |
| Steps, number per day ^a | 6073 (4006) | 5687 (3498) | NA | NA | 6450 (3910) | 6205 (3689) | NA |

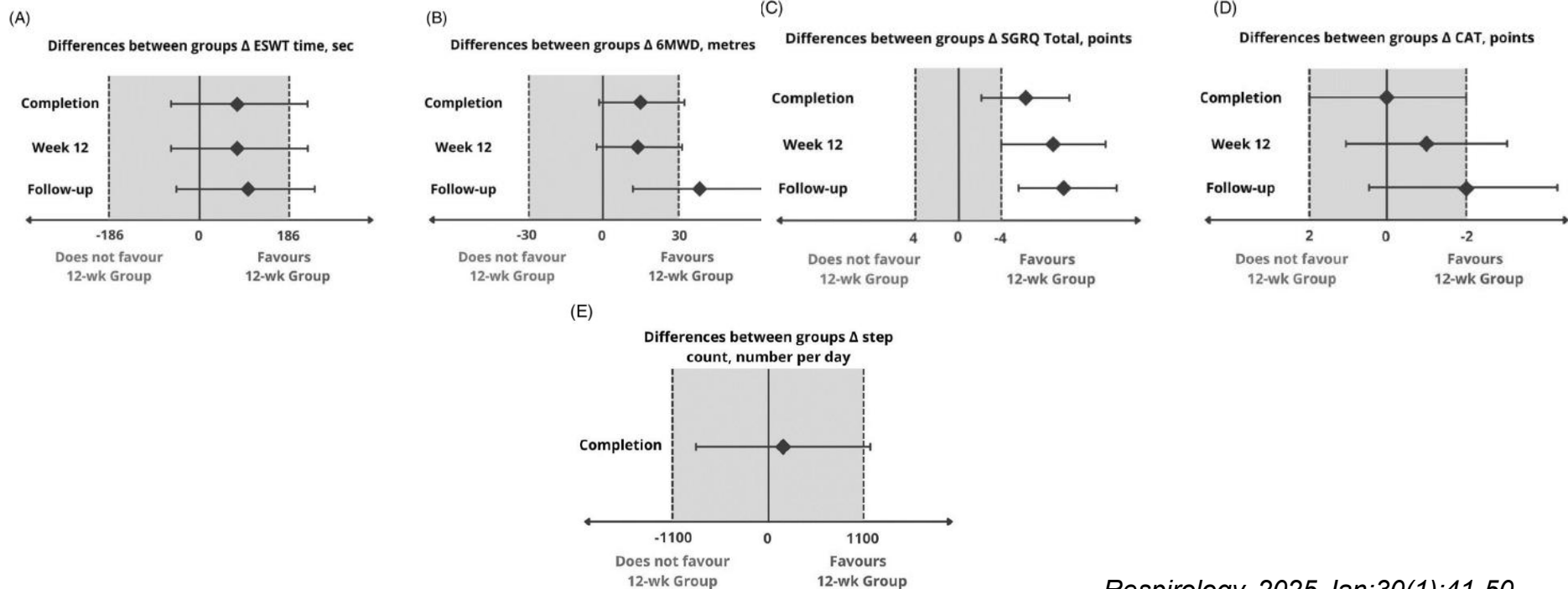
Note: Data are presented as mean and standard deviation (SD); The 6–12-month follow-up analyses included the 6-month data from 33% (*n* = 15) of participants for the exercise tests, and 24% (*n* = 12) of participants for the questionnaires.

Abbreviations: 6MWD, 6-minute walk distance; CAT, COPD Assessment Test; ESWT, endurance shuttle walk test; HADS, Hospital Anxiety and Depression Scale; *n*, number; SGRQ, St George's Respiratory Questionnaire.

^aStep data, *n* = 39 (*n* = 18 in 8-wk Group at baseline and week 8, *n* = 21 in 12-wk Group at baseline and week 12).

TABLE 3 Between-group differences in outcomes evaluated for equivalence at each measurement time point.

| Outcome measures | Equivalence limits | 12-wk Group minus 8-wk Group | | |
|-----------------------|--------------------|---------------------------------|------------------------------|----------------------------------|
| | | Baseline to PR completion | Baseline to week 12 | Baseline to 6–12-month follow-up |
| ESWT, seconds | ±186 | 71 (−61 to 203) ^b | 70 (−68 to 208) ^b | 93 (−52 to 239) ^b |
| 6MWD, m | ±30 | 15 (−2 to 33) ^b | 14 (−3 to 31) ^b | 37 (12 to 62) ^c |
| SGRQ symptoms | ±4 | −3 (−10 to 4) ^b | −6 (−13 to 1) ^c | −6 (−14 to 2) ^c |
| SGRQ activity | ±4 | −6 (−11 to −1) ^c | −5 (−10 to 0) ^c | −12 (−17 to −7) ^d |
| SGRQ impact | ±4 | −6 (−11 to −2) ^c | −11 (−16 to −6) ^d | −10 (−16 to −5) ^d |
| SGRQ total | ±4 | −6 (−10 to −2) ^c | −9 (−13 to −4) ^d | −10 (−15 to −6) ^d |
| CAT | ±2 | 0 (−2 to 2) ^a | −1 (−3 to 1) ^b | −2 (−4 to 1) ^b |
| HADS anxiety | ±1.5 | −1 (−3 to 0) ^b | 0 (−1 to 1) ^a | −1 (−2 to 1) ^b |
| HADS depression | ±1.5 | −1 (−2 to 0) ^b | −1 (−2 to 0) ^b | −1 (−2 to 0) ^b |
| Steps, number per day | ±1100 | 207 (−809 to 1223) ^b | NA | NA |



PR of COPD: Effect of PR duration on exercise capacity and health-related quality of life in people with COPD (PuRe Duration Trial)

TABLE 4 Healthcare utilization during the 12 months after programme completion for 8-wk and 12-wk groups.

| Outcome measure | 8-wk Group | 12-Wk Group |
|---|-----------------|---------------------|
| Respiratory cause ED presentations | 12 | 13 |
| Person-years, <i>n</i> | 33 | 33 |
| Incidence rate (per person-years) (95% CI) | 0.36 (0.13–0.6) | 0.39 (0.05–0.74) |
| Incidence rate ratio (95% CI) | 1 [reference] | 1.083 (0.494–2.374) |
| <i>p</i> -value | — | 0.842 |
| Respiratory cause hospitalisations | 11 | 14 |
| Person years, <i>n</i> | 33 | 33 |
| Incidence rate (per person-years) (95% CI) | 0.33 (0.1–0.56) | 0.42 (0.07–0.78) |
| Incidence rate ratio (95% CI) | 1 [reference] | 1.273 (0.578–2.803) |
| <i>p</i> -value | — | 0.549 |

Note: *p*-value test of equality verses 8-wk Group.

Abbreviations: ED, emergency department; *n*, number; PR, pulmonary rehabilitation.

PR of COPD: Effect of PR duration on exercise capacity and health-related quality of life in people with COPD (PuRe Duration Trial)


● Conclusion

- Equivalence was shown between 8-and 12-week PR programmes for endurance exercise capacity, but superiority could not be ruled out for the 12-wk Group
- Decisions about programme duration may depend on local waitlist times, healthcare budgets and patient preference

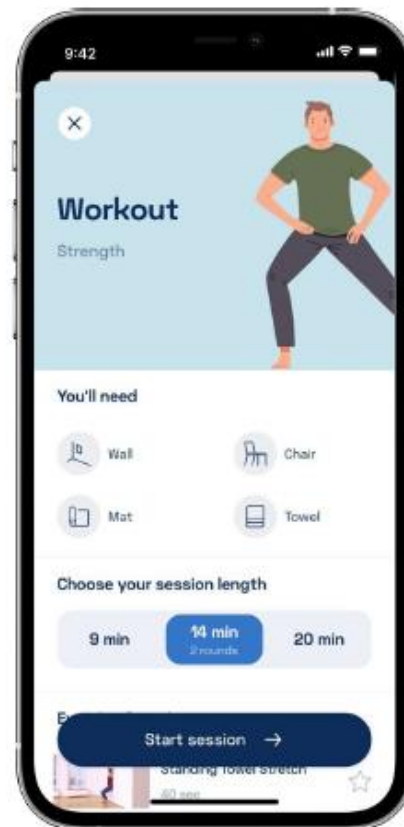
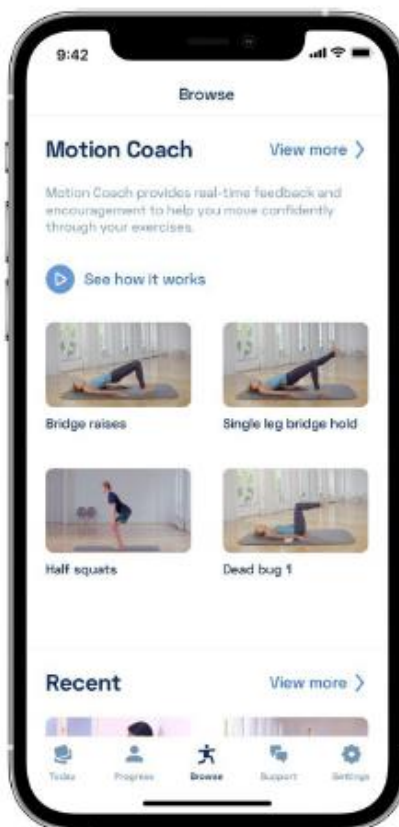
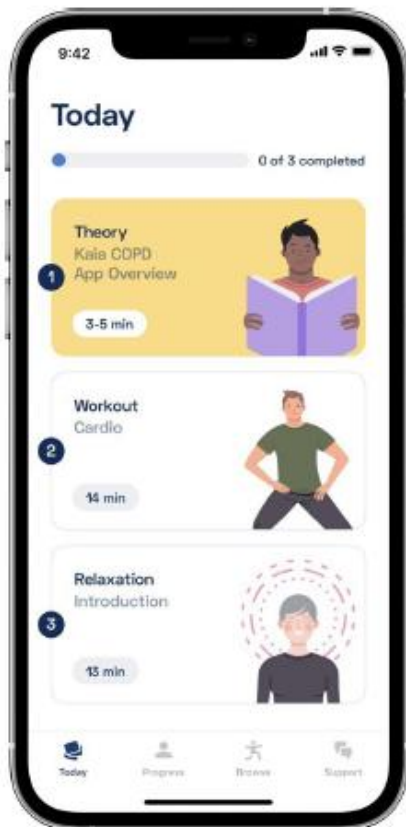


Original research

Smartphone application-based pulmonary rehabilitation in COPD: a multicentre randomised controlled trial

Rainer Gloeckl ,^{1,2} Marc Spielmanns,^{3,4} Asta Stankeviciene,⁵ Anne Plidschun,⁵ Daniela Kroll,^{1,2} Inga Jarosch,^{1,2} Tessa Schneeberger,^{1,2} Bernhard Ulm,⁶ Claus F Vogelmeier,⁷ Andreas Rembert Koczulla^{1,2,8}

- Multicenter, randomised controlled trial, May 2021- May 2023
- Patients with COPD from 18 sites in Germany and Switzerland
 - Aged ≥ 40 years
 - Diagnosed with COPD, with post-bronchodilator forced expiratory volume in 1 s $\geq 30\%$ predicted
 - COPD Assessment Test (CAT) total score ≥ 20
 - Receiving stable maintenance COPD treatment (ie, with no treatment changes in the 4 weeks prior to entry)
- To evaluate the impact of 12 weeks of a mobile app (intervention group) on quality of life, measured by COPD Assessment Test (CAT), and exercise capacity, assessed by 1-minute-sit-to-stand-test (1MSTST), compared with a control group receiving 'enhanced standard-of-care'
- 278 patients in COPD (Intervention Group n=135, Control group n=142)
- Intervention duration : 12 weeks



- Multimodal personalised therapy app 'Kaia COPD' (Kaia Health Software, Munich, Germany)
 - Individualised exercise training
 - 15–20 min, completed in an unsupervised manner
 - Muscle strengthening, balance and mobility, with visual and verbal instructions provided by video tutorials and a countdown timer
 - Educational content
 - Breathing/relaxation sessions
- Inactive participants (<3 days of app usage per week) were contacted by study staff and were motivated

PR of COPD

: Smartphone application-based PR in COPD

- Primary endpoint

Table 2 The COPD Assessment Test total score and 1-minute sit-to-stand test at baseline, and change from baseline at 12 (co-primary outcomes) and 24 weeks (follow-up)

| | Intention-to-treat population (including all patients) | | Intervention group vs control group differences | Per-protocol population (including only adherent application users in the IVG) | | |
|--|---|----------------------------|--|---|------------------------------|--|
| | Control group (n=142) | Intervention group (n=136) | | Control group (n=122) | Intervention group (n=46) | Intervention group vs control group differences |
| COPD Assessment Test total score | | | | | | |
| Baseline | 23 (21 to 26) | 23 (21 to 26) | | 23 (21 to 25) | 22 (20 to 25) | |
| Week 12, change from baseline | -3 (-8 to 0) | -4 (-8 to -1) | 0 (-1 to 2) p=0.697 | -3 (-8 to 0) | -4 (-8 to -2) | 1 (-1 to 3) p=0.409 |
| Week 24, change from baseline | -3.5 (-8 to 1) | -4 (-9 to -1) | 2 (-0 to 3) p=0.074 | -3 (-8 to 1) | -4 (-9 to -2) | 2 (-0 to 4) p=0.075 |
| 1-minute sit-to-stand test, repetitions | | | | | | |
| Baseline | 18 (14 to 22) | 17 (13 to 22) | | 18 (24 to 23) | 18 (13 to 22) | |
| Week 12, change from baseline | 2 (0 to 6) | 1 (-1 to 4) | 1 (0 to 2) p=0.120 | 2 (0 to 6) | 3 (0 to 4) | 0 (-2 to 2) p=0.901 |
| Week 24, change from baseline | 4 (0 to 7) | 3 (0 to 6) | 0 (-1 to 2) p=0.485 | 4 (0 to 7) | 3 (1 to 6.5) | 0 (-2 to 1) p=0.709 |

COPD, chronic obstructive pulmonary disease; IVG, intervention group.

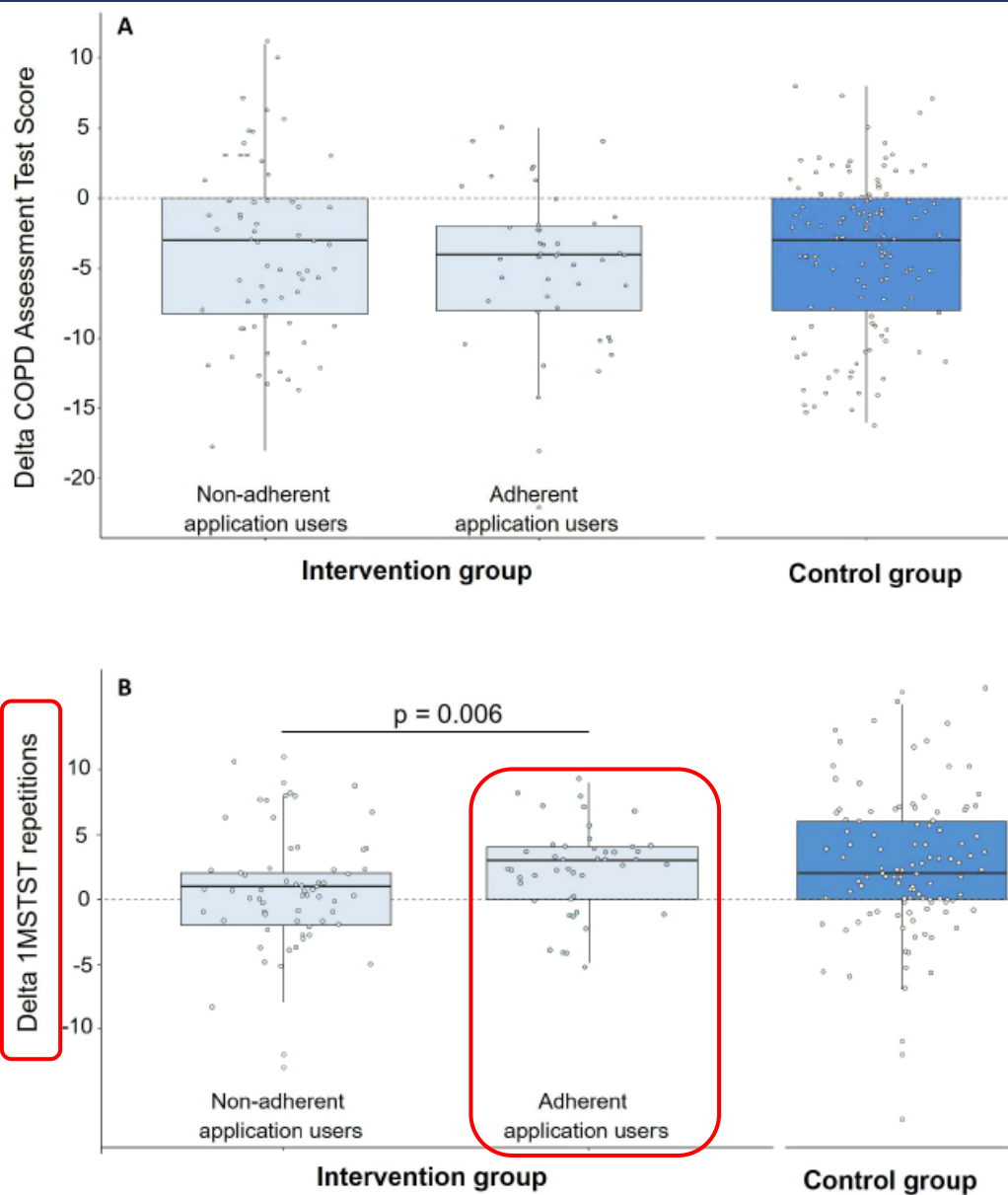
PF
● f


Figure 3 Changes in COPD Assessment Test score (A) and changes in 1-minute sit-to-stand test (1MSTST) repetitions (B) from baseline to week 12 between adherent application users ($\geq 75\%$ adherent training weeks, $n=46$) and non-adherent application users ($< 75\%$ adherent training weeks, $n=68$) in the intervention group and the control group ($n=122$). COPD, chronic obstructive pulmonary disease.

Table 3 Between-group results in the per-protocol population (ie, including only **adherent application users** in the intervention group) for changes from baseline in **secondary endpoints** at weeks 12 and 24

| | Control group (n=122) | Intervention group (n=46) | Intervention group vs control group differences |
|--|--------------------------|------------------------------|--|
| Veterans RAND 12-Item health survey: physical component score | | | |
| Baseline | 32.3 (27.2 to 37.5) | 33.4 (29.3 to 40.7) | |
| Week 12, change from baseline | 0.3 (-2.7 to 6.1) | 1.3 (-2.8 to 6.3) | 0 (-3 to 2); p=0.764 |
| Week 24, change from baseline | 1.9 (-2.7 to 5.8) | 1.7 (-2.2 to 4.8) | 0 (-3 to 2); p=0.778 |
| Veterans RAND 12-Item health survey: mental component score | | | |
| Baseline | 47.1 (38.3 to 54.3) | 52.2 (38.9 to 59.4) | |
| Week 12, change from baseline | -2.5 (-7.2 to 3.5) | -0.1 (-4.0 to 2.7) | -2 (-5 to 1); p=0.209 |
| Week 24, change from baseline | -0.9 (-7.2 to 4.8) | 0.1 (-6.1 to 3.7) | -1 (-4 to 3); p=0.719 |
| Patient Activation Measure 13 | | | |
| Baseline | 42 (39 to 45) | 44 (40 to 47) | |
| Week 12, change from baseline | 0 (-3 to 2) | 1 (-1 to 3) | -1 (-2 to 0); p=0.169 |
| Week 24, change from baseline | 0 (-2 to 3) | 2 (-1 to 4) | -1 (-3 to 0); p=0.152 |
| Hospital Anxiety and Depression Scale: total score | | | |
| Baseline | 11 (8 to 16) | 9 (6 to 16) | |
| Week 12, change from baseline | 1 (-2 to 4) | -1 (-5 to 1) | 2 (0 to 4); p=0.043 |
| Week 24, change from baseline | 0 (-3 to 4) | 0 (-3.5 to 3) | 1 (-1 to 3); p=0.546 |
| Hospital Anxiety and Depression Scale: anxiety | | | |
| Baseline | 5 (3 to 8) | 5 (3 to 7) | |
| Week 12, change from baseline | 0 (-1 to 2) | 0 (-3 to 1) | 1 (-0 to 2); p=0.111 |
| Week 24, change from baseline | 0 (-2 to 2) | 0 (-2 to 2) | 0 (-1 to 2); p=0.424 |
| Hospital Anxiety and Depression Scale: depression | | | |
| Baseline | 6 (4 to 8) | 4 (2 to 7) | |
| Week 12, change from baseline | 0 (-2 to 2) | -1 (-2 to 1) | 1 (-0 to 2); p=0.056 |
| Week 24, change from baseline | 0 (-2 to 2) | 0 (-1 to 1.5) | 0 (-1 to 1); p=0.634 |

All continuous variables are shown with median (IQR) and were compared via Mann-Whitney U test.

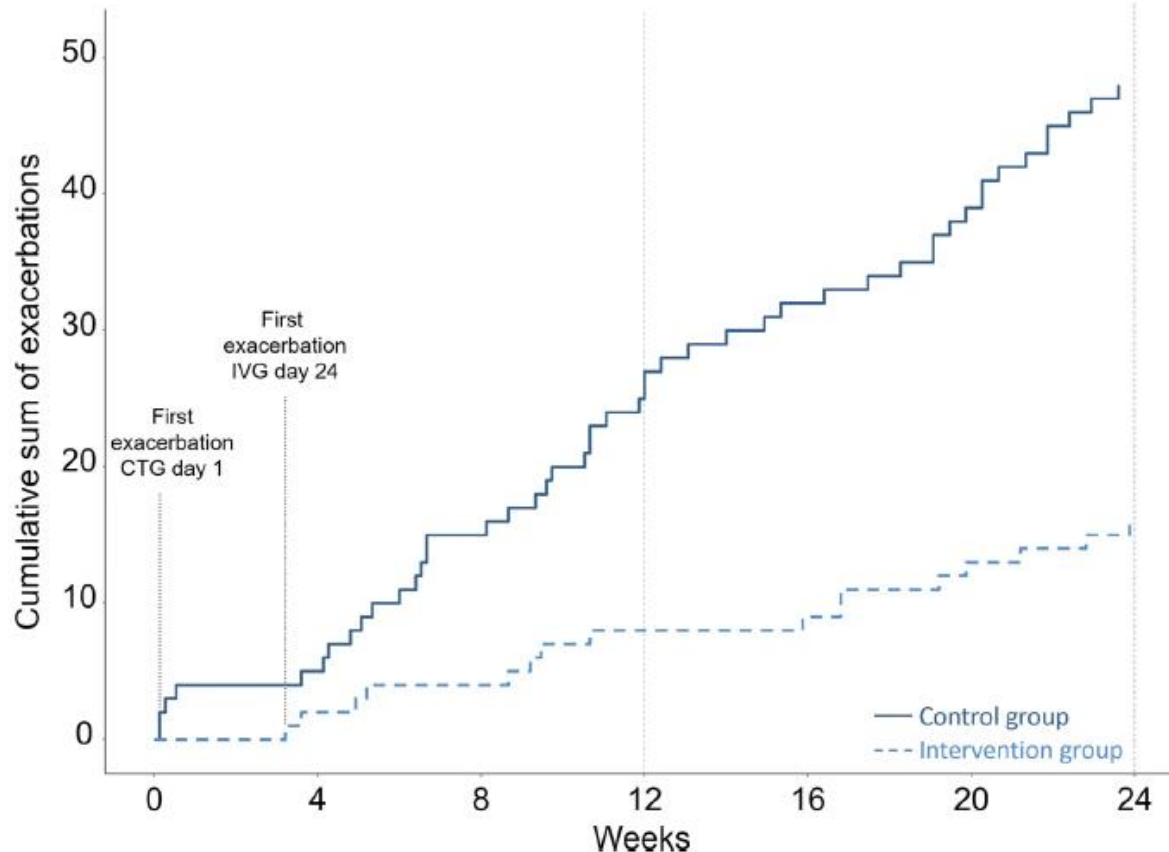


Figure 4 This Kaplan-Meier plot shows the cumulative sum of exacerbations in the per-protocol population over 24 weeks (control group: 48 acute exacerbations and 16 acute exacerbations in the intervention group). The difference was not statistically significant. The first exacerbation occurred on day 1 in the control group (CTG) and on day 24 in the intervention group (IVG); HR (95% CI) IVG 0.83 (0.41, 1.69) (post-hoc analysis).

● Conclusions

- Did not show statistically significant differences in the primary outcome between the app-using group and the enhanced standard of care group.
- Some benefits were observed in adherent app users, including an improvement in exercise capacity compared with non-adherent users

Original research

Short-term effects of home-based pulmonary rehabilitation during outpatient-managed exacerbations of COPD: a randomised controlled trial

Ana Machado,^{1,2,3,4,5} Cíntia Dias,^{1,2} Cátia Paixão ,^{1,2,4} António Pedro Gonçalves,⁶ Chris Burtin,^{3,5} Alda Marques ^{1,2}

- To explore the the short-term effects and self-reported impact of a home-based PR programme for people with outpatient-managed ECOPD
- RCT in people with outpatient-managed ECOPD, Portugal
 - Previous diagnosis of COPD according to the GOLD criteria
 - Current diagnosis of ECOPD, defined as an acute worsening of respiratory symptoms that resulted in additional therapy (ie, any escalation of the COPD treatment)
 - Included within 48 hours of the ECOPD diagnosis
- Randomly assigned to the control (n=26) or experimental (n=24, usual care and 3-week home-based PR) group within 48 hours of the diagnosis
- Assessments were performed at baseline and after 3 weeks (post)

PR of COPD: Short-term effects of home-based PR during outpatient-managed exacerbations of COPD

- Primary outcome
 - CAT
- Secondary outcomes
 - Measures of symptoms and functional capacity
- PR
 - Two sessions/week (approximately 60 min/session)
 - Exercise training, breathing control and retraining, airway clearance techniques, education and psychosocial support

Table 3 Effects of a 3-week home-based pulmonary rehabilitation programme during exacerbations of chronic obstructive pulmonary disease (n=50)

| | Experimental group (n=24) | Control group (n=26) | Group×Time interaction |
|--|------------------------------|-------------------------|---------------------------|
| | Mean Δ (95% CI) | Mean Δ (95% CI) | |
| BPAAT, total score | 3.5 (2.7; 4.3)* | -0.4 (-1.2; 0.3) | <0.001 |
| mMRC, grade | -0.5 (-0.8; -0.3)* | 0 (-0.3; 0.3) | 0.006 |
| CAT, total score | -12.5 (-15.4; -9.5)* | -5.8 (-8.7; -3)* | 0.002 |
| LCADL, total score | -5.4 (-8.1; -2.7)* | 0.1 (-2.5; 2.7) | 0.006 |
| LCADL, % score | -9.1 (-13.1; -5.2)* | 0 (-3.8; 3.9) | 0.001 |
| FACIT-F, total score | 11.2 (8.3; 14.1)* | 3.4 (0.6; 6.2) | 0.001 |
| CASA-Q, score | | | |
| Cough symptoms | 46.7 (33.4; 60)* | 23.1 (10.3; 35.9)* | 0.006 |
| Cough impact | 43.8 (32.2; 55.4)* | 23.7 (12.5; 34.8)* | 0.047 |
| Sputum symptoms | 46.5 (32.3; 60.8)* | 31.1 (17.4; 44.8)* | 0.081 |
| Sputum impact | 36.6 (23.6; 49.5)* | 28.7 (16.2; 41.1)* | 0.948 |
| CIS-8, total score | -11.8 (-15.8; -7.8)* | -4.3 (-8.2; -0.5) | 0.003 |
| Handgrip strength, kg | 2.1 (0.9; 3.3)* | -0.5 (-1.8; 0.7) | 0.003 |
| Handgrip strength, %pred | 6.9 (3; 10.7)* | -1.4 (-5.4; 2.6) | 0.004 |
| Biceps muscle strength, kgf | 2.3 (1.1; 3.5)* | -0.1 (-1.2; 1.1) | 0.004 |
| Biceps muscle strength, %pred | 10.4 (5; 15.8)* | -0.5 (-6.1; 5) | 0.006 |
| Quadriceps muscle strength, kgf | 3.9 (2; 5.9)* | -0.4 (-1.7; 0.9) | <0.001 |
| Quadriceps muscle strength, %pred | 12.4 (6.5; 18.2)* | -1.3 (-5.3; 2.8) | <0.001 |
| 5-repetitions sit-to-stand test, s | -2.6 (-5.1; -0.2)* | -0.4 (-2.7; 1.8) | 0.002 |
| SPPB, total score | 1.4 (0.8; 2)* | 0.6 (-0.1; 1.2) | 0.049 |
| 1 min sit-to-stand test, repetitions | 4.4 (2.5; 6.3)* | 2 (0.3; 3.8) | 0.061 |
| 1 min sit-to-stand test, %pred | 13.7 (7.8; 19.7)* | 7.1 (0.8; 13.4) | 0.086 |
| Chester step test, n° of steps | 23.4 (6.2; 40.5)* | 11.6 (1; 22.3)* | 0.047 |
| N° ECOPD-related unscheduled healthcare visits (at Post) | 0 (0; 0) | 0 (0; 2) | 0.025† |

Data are presented as mean (95% CI), unless stated otherwise. Bold denotes a significant group×time interaction. Mean Δ, mean change post-baseline.

BPAAT, Brief Physical Activity Assessment Tool; CASA-Q, Cough and Sputum Assessment Questionnaire; CAT, COPD Assessment Test; CIS-8, Checklist Individual Strength 8-Items Questionnaire; COPD, chronic obstructive pulmonary disease; FACIT-F, Functional Assessment of Chronic Illness Therapy—Fatigue Scale; LCADL, London Chest Activity of Daily Living Scale; mMRC, modified Medical Research Council dyspnoea questionnaire; SPPB, short physical performance battery.

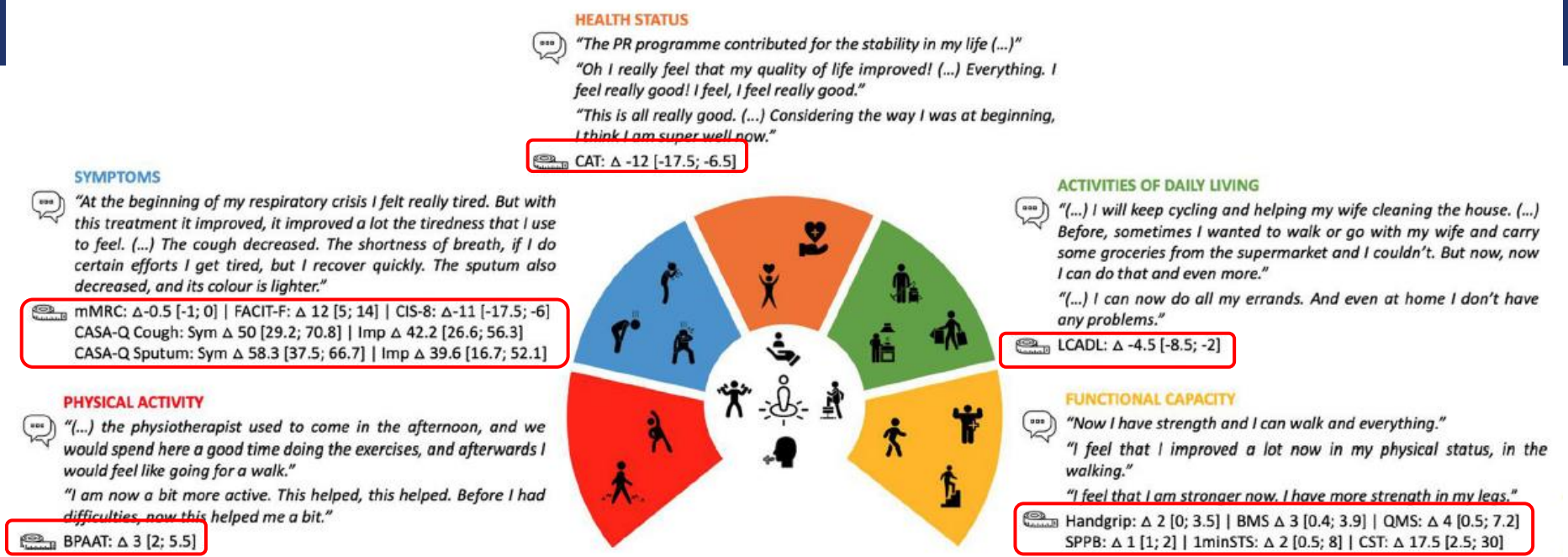


Figure 2 Joint display presenting the integration of quantitative and qualitative data. Data are presented as median change [first quartile; third quartile] and represent the results obtained in the experimental group. 1-minSTS, 1 min sit-to-stand test; BMS, biceps muscle strength; BPAAT, Brief Physical Activity Assessment Tool; CASA-Q, Cough and Sputum Assessment Questionnaire; CAT, COPD Assessment Test; CIS-8, Checklist Individual Strength 8-Items Questionnaire; CST, Chester Step Test; FACIT-F, Functional Assessment of Chronic Illness Therapy—Fatigue Scale; Imp, impact subscore; LCADL, London Chest Activity of Daily Living Scale; mMRC, modified Medical Research Council dyspnoea questionnaire; PR, pulmonary rehabilitation; QMS, quadriceps muscle strength; SPPB, short physical performance battery; Sym, symptoms subscore.

● **Conclusions**

- A 3-week home-based PR programme is safe, meaningful and more effective than just standard medication in improving symptoms, functional capacity and health status, outcomes often associated with poor prognosis
- => highlights the role of PR in improving the recovery process during outpatient-managed ECOPD and might contribute to a better prognosis in these individuals

The Responsiveness of Exercise Tests in COPD



A Randomized Controlled Trial

*Theresa C. Harvey-Dunstan, PhD; Molly M. Baldwin, PhD; Ruth Tal-Singer, PhD; Matthew Allinder, MS; Michael I. Polkey, PhD; Alan Hamilton, PhD; Matthew Richardson, PhD; Sarah A. Edwards, BSc; Michael C. Steiner, MD; Mike D. Morgan, MD; and Sally J. Singh, PhD; on behalf of the COPD/MAP Consortium**

- Aimed to evaluate what exercise test possesses the greatest sensitivity to change from before to after intervention in patients with COPD
- Glenfield Hospital, Leicester, England, from March 2013 until October 2017
- Prospective, parallel-group, single-masked, randomized controlled clinical trial
- Moderate or severe COPD ($FEV_1 < 80\%$ predicted and $FEV_1/FVC < 0.70$), MRC dyspnea grade of ≤ 2 , 40 to 85 years of age, and no contraindication to PR

PR of COPD

: The Responsiveness of Exercise Tests in COPD

- 154 Patients with symptomatic COPD were recruited and randomized (2:1:1) to 6 weeks of LAMA(tiotropium [18 mg once daily] delivered by HandiHaler device), pulmonary rehabilitation (PR), or usual care
 - Randomized between March 2013 and October 2017
 - UC (n = 21), LAMA (n = 58), or PR (n = 24)
- PR
 - Six week supervised course, twice a week
 - Each session consisted of one hour supervised exercise training, and one hour of education
 - Exercise prescription comprised of a combination of aerobic and resistance training
 - The target duration was 30 min
 - A home exercise programme mirroring the training programme was encouraged and monitored with a home training diary

PR of COPD

: The Responsiveness of Exercise Tests in COPD

- Before and after intervention, performed an incremental cycle exercise test (ICET) and constant work rate cycle test (CWRCT), incremental shuttle walk test (ISWT) and endurance shuttle walk test (ESWT), 6-min walk test (6MWT), and 4-m gait speed test (4MGS)

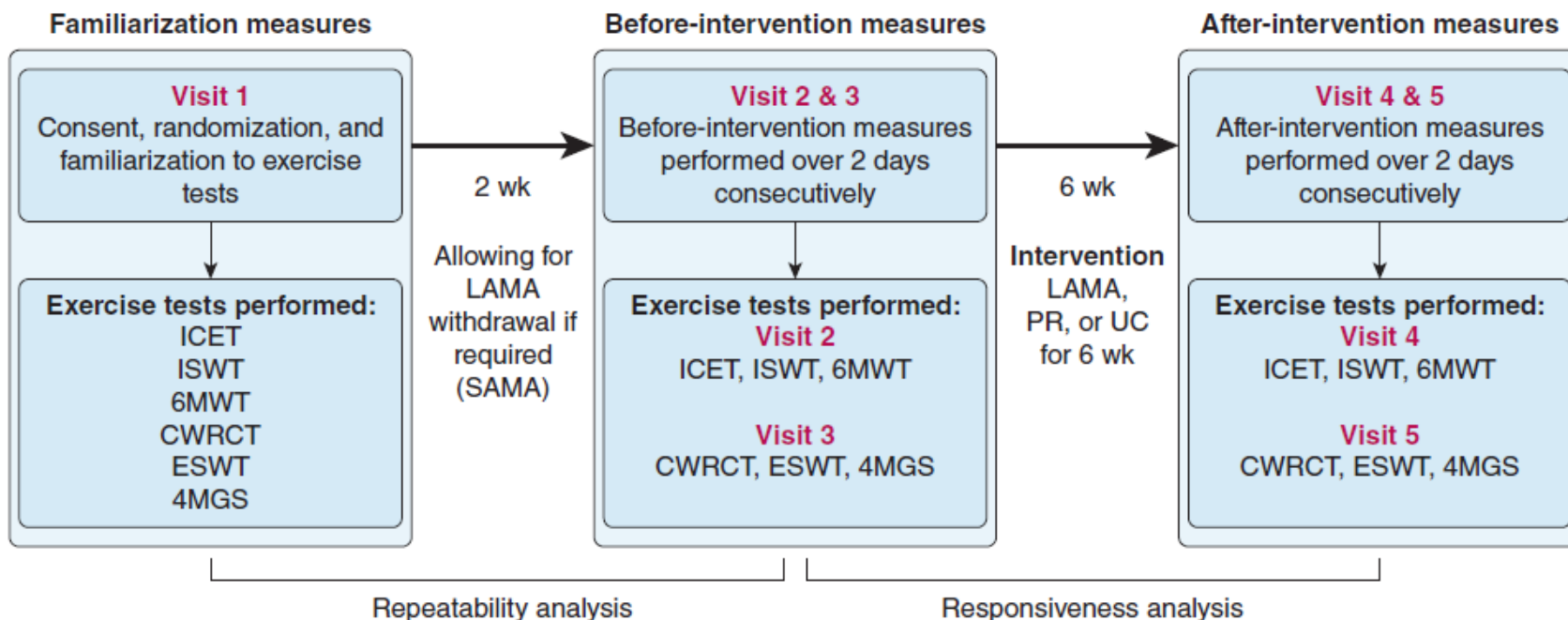


Figure 1 - Diagram showing visit and testing schedule. 4MGS = 4-m gait speed; 6MWT = 6-min walk test; CWRCT = constant work rate cycle test; ESWT = endurance shuttle walk test; ICET = incremental cycle exercise test; ISWT = incremental shuttle walk test; LAMA = long-acting muscarinic antagonist; PR = pulmonary rehabilitation; SAMA = short-acting muscarinic antagonist; UC = usual care.

TABLE 5] Comparison of Responsiveness of Incremental, Constant Work Rate, and Self-paced Protocol Exercise Tests (n = 103)

| Variable | UC | | | LAMA | | | | | PR | | | | | |
|---------------------------------|-----|------------------------------|-----|------|------------------------------|-----|------|-----------|-----|---------------------------------|-----|--------|------------------|------------------|
| | No. | MD ± SD (95% CI) | % C | No. | MD ± SD (95% CI) | % C | ES | BGd to UC | No. | MD±SD (95% CI) | % C | ES | BGd to UC | BGd to LAMA |
| CWRCT T _{lim} , s | 16 | -26 ± 135 (-96 to 43) | -8 | 47 | 4 ± 138 (-96 to 43) | 1 | 0.22 | 30 | 21 | 129 ± 228 (31-228) ^a | 42 | 0.83 | 155 ^a | 125 ^a |
| ESWT T _{lim} , s | 21 | -7 ± 239 (-116 to 102) | 2 | 58 | 24 ± 284 (-50 to 98) | 7 | 0.12 | 31 | 24 | 152 ± 251 (46-258) ^b | 41 | 0.65 | 159 | 128 |
| ICET peak power output, W | 19 | 1 ± 16 (-7 to 9) | 2 | 45 | -3 ± 16 (-7 to 2) | -5 | 0.24 | -4 | 23 | 10 ± 19 (2-18) ^a | 18 | 0.50 | 9 | 13 |
| ICET $\dot{V}O_{2peak}$, L/min | 19 | -0.02 ± 0.16 (-0.09 to 0.51) | -2 | 45 | 0.03 ± 0.26 (-0.04 to 0.11) | 2 | 0.23 | 0.05 | 23 | 0.03 ± 0.22 (-0.07 to 0.12) | 3 | 0.28 | 0.05 | 0 |
| ISWT, m | 21 | 5 ± 34 (-10 to 21) | 2 | 57 | 7 ± 55 (-7 to 22) | 2 | 0.04 | 2 | 24 | 34 ± 59 (9-59) ^a | 10 | 0.60 | 29 | 27 |
| 6MWT, m | 21 | -1 ± 37 (-16 to 15) | 0 | 57 | 1 ± 41 (-10 to 12) | 0 | 0.04 | 2 | 24 | 41 ± 56 (16-66) ^b | 10 | 0.86 | 42 | 40 |
| 4MGS, m/s | 19 | -0.01 ± 0.10 (-0.66-0.04) | 0 | 53 | -0.04 ± 0.19 (-0.09 to 0.02) | 4 | 0.04 | -0.03 | 21 | 0.00 ± 0.16 (-0.07 to 0.08) | 0 | > 0.00 | 0.01 | 0.04 |

BGd = between-group difference; CWRCT = constant work rate cycle test; ES = effect size (calculated using Cohen d); ESWT = endurance shuttle walk test; 4MGS = 4-m gait speed; ICET = incremental cycle exercise test; ISWT = incremental shuttle walk test; LAMA = long-acting muscarinic antagonist; MD = mean difference; % C = percent change from baseline; PR = pulmonary rehabilitation; 6MWT = 6-min walk test; T_{lim} = time to limitation; UC = usual care; $\dot{V}O_{2peak}$ = peak oxygen uptake.

^aWithin-group difference P < .05.

^bWithin-group difference P < .01.

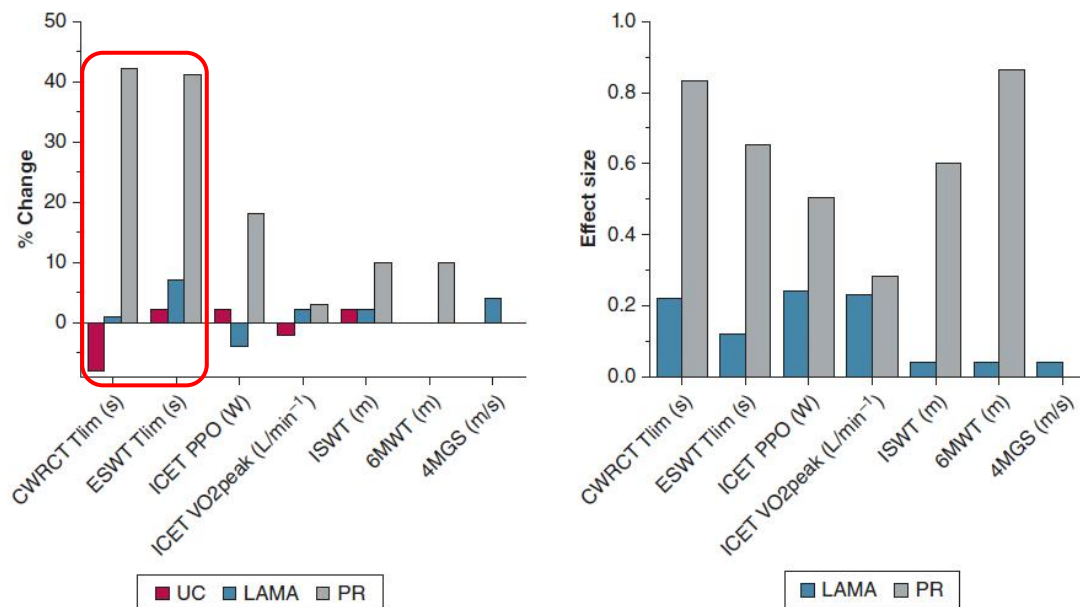


Figure 4 - A, B, Bar graphs showing the percentage improvement (A) and Cohen d effect size (B) for exercise tests after bronchodilation (LAMA), PR, and UC. 4MGS = 4-m gait speed; 6MWT = 6-min walk test; CWRCT = constant work rate cycle test; ESWT = endurance shuttle walk test; ICET = incremental cycle exercise test; ISWT = incremental shuttle walk test; LAMA = long-acting muscarinic antagonist; PPO = peak power output; PR = pulmonary rehabilitation; T_{lim} = time to limitation; UC = usual care; $\dot{V}O_{2peak}$ = peak oxygen uptake.

PR of COPD

: The Responsiveness of Exercise Tests in COPD

● Conclusions

- The ESWT and CWRCT seemed to be the most responsive exercise test protocol to LAMA and PR therapy
- The magnitude of change was much greater after a program of rehabilitation compared with bronchodilator therapy

Overview

- Pulmonary rehabilitation in the guidelines
 - GOLD 2026 guideline
 - ERS clinical practice guideline for the bronchiectasis
- Pulmonary rehabilitation of COPD
- Pulmonary rehabilitation of ILD
- Pulmonary rehabilitation in Korea

Impact of Pulmonary Rehabilitation on Survival in People With Interstitial Lung Disease



Leona M. Dowman, PhD; Baruch Vainshelboim, PhD; and Anne E. Holland, PhD



● Aim

- Compared the survival outcomes in people with ILD who were allocated to PR vs those who were allocated to control in 2 published randomized controlled trials
- The combined data from the 2 previous RCTs of PR in ILD were included
 - The first RCT of PR in ILD by Holland et al : two site, Australia
 - The largest RCT of PR in ILD and the first to establish the impact of etiology and disease severity on response to exercise training by Dowman et al: three tertiary hospitals, Australia

PR of ILD: Impact of Pulmonary Rehabilitation on Survival in People With Interstitial Lung Disease

- PR
 - Twice weekly supervised outpatient exercise training
 - Consisting of 30 minutes of aerobic exercise, cycling, and walking, at moderate intensity, plus upper and lower limb resistance training
 - Weekly education sessions delivered by a multidisciplinary team
- Primary end points
 - Death or lung transplantation
- Time from start of PR until date of death, lung transplantation, or censoring was calculated
- Kaplan-Meir and Cox proportional hazard regression analysis were used to assess the impact of PR on survival

PR of ILD: Impact of Pulmonary Rehabilitation on Survival in People With Interstitial Lung Disease

TABLE 1] Baseline Characteristics of Participants

| Characteristic | Pulmonary Rehabilitation (n = 93) | Control Group (n = 89) |
|--|--------------------------------------|---------------------------|
| Age, y | 69 [10] | 69 [11] |
| Sex, male | 53 (63) | 56 (60) |
| Diagnosis | | |
| IPF | 44 (47) | 43 (48) |
| CTD ILD | 13 (14) | 14 (16) |
| Dust ILD | 10 (11) | 14 (16) |
| HP | 8 (9) | 4 (5) |
| Sarcoidosis | 4 (4) | 3 (3) |
| CPFE | 3 (3) | 3 (3) |
| Other ILD | 11 (12) | 8 (9) |
| FVC % predicted ^a | 75 [20] | 76 [21] |
| TLCO % predicted ^b | 49 [18] | 48 [15] |
| RVSP, mm Hg ^c | 33 [14] | 36 [12] |
| 6MWD, m | 446 [122] | 426 [145] |
| Nadir Sp _o ₂ on 6MWD | 86 [7] | 86 [8] |

Values are presented as mean [SD] or No. (%). 6MWD = 6-min walk distance; CTD = connective tissue disease; CPFE = combined pulmonary fibrosis emphysema; HP = hypersensitivity pneumonitis; ILD = interstitial lung disease; IPF = idiopathic pulmonary fibrosis; RVSP = right ventricular systolic pressure; Sp_o₂ = oxyhemoglobin desaturation; TLCO = carbon monoxide transfer factor.

^an = 146 (PR group: n = 73; control group: n = 73) for RVSP.

^bn = 180 (PR group: n = 92; control group: n = 88) for FVC % predicted.

^cn = 176 (PR group: n = 91; control group: n = 85) for TLCO % predicted.

PR of ILD: Impact of Pulmonary Rehabilitation on Survival in People With Interstitial Lung Disease

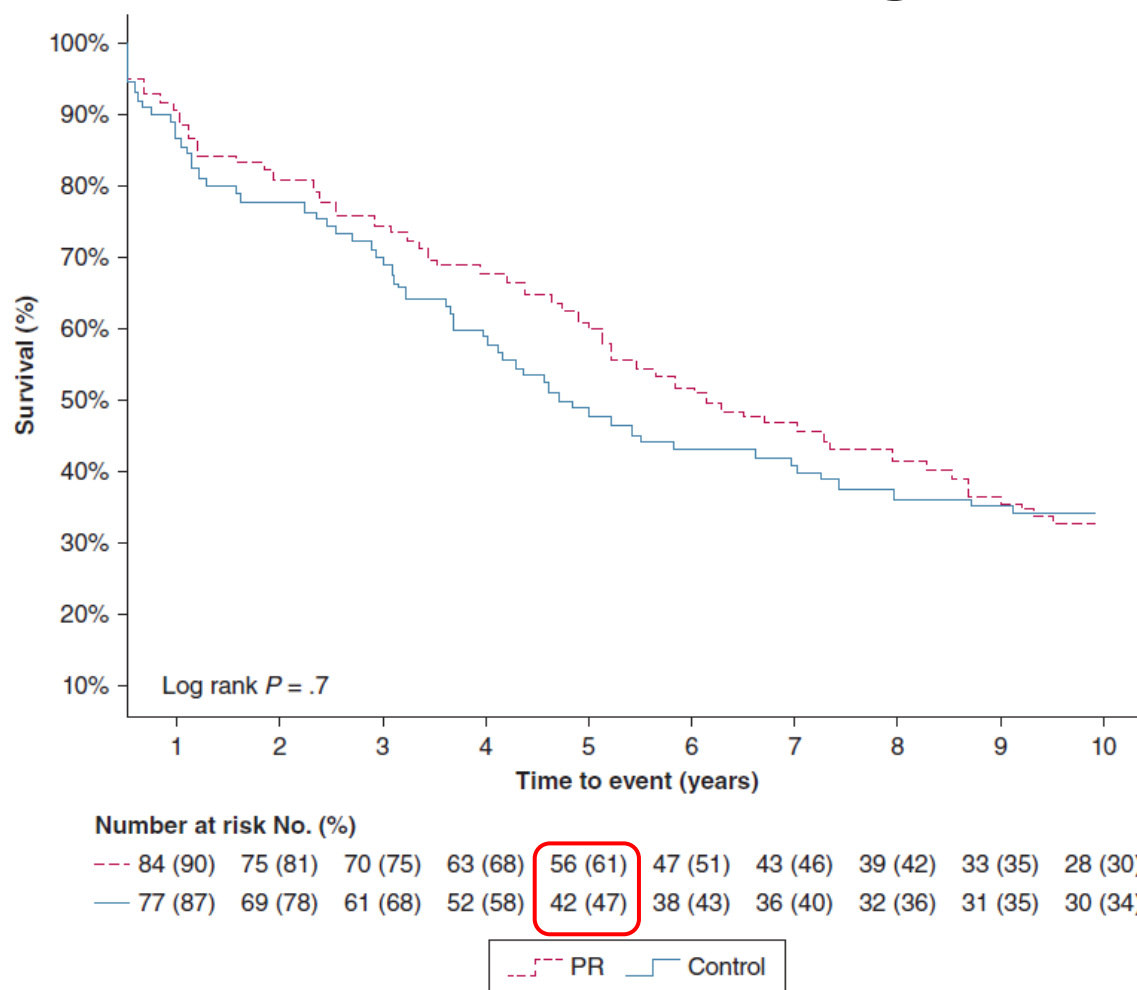


Figure 1 – Kaplan-Meier survival curve for PR vs control group. PR = pulmonary rehabilitation.

PR of ILD: Impact of Pulmonary Rehabilitation on Survival in People With Interstitial Lung Disease

TABLE 2] Cox Proportional Hazards Regression Analysis for 5- and 10-Year Survival

| Variables | 5 y | | 10 y | |
|------------------------------|-------------------|---------|-------------------|---------|
| | HR (95% CI) | P Value | HR (95% CI) | P Value |
| Group allocation | | | | |
| Control | NA | | NA | |
| PR | 0.56 (0.23-0.88) | .01 | 0.8 (0.56-1.18) | .30 |
| Diagnosis | | | | |
| IPF | NA | | NA | |
| Non-IPF ILD | 0.68 (0.43-1.08) | .10 | 0.56 (0.41-0.88) | .01 |
| Age ^a | 1.03 (0.99-1.06) | .07 | 1.04 (1.02-1.07) | .001 |
| Sex | | | | |
| Male | NA | | NA | |
| Female | 0.38 (0.23-0.63) | .01 | 0.42 (0.28-0.63) | < .001 |
| Nadir SpO₂ | | | | |
| ≤ 85% | NA | | NA | |
| > 85% | 0.22 (0.14-0.37) | < .001 | 0.24 (0.16-0.36) | < .001 |
| FVC | | | | |
| % predicted < 50% | NA | | NA | |
| % predicted 50%-79% | 0.55 (0.28-1.08) | .08 | 0.48 (0.26-0.90) | .02 |
| % predicted > 80% | 0.23 (0.12-0.61) | .002 | 0.38 (0.19-0.79) | .009 |
| 6MWD, m | | | | |
| < 250 | NA | | NA | |
| 250-350 | 0.29 (0.13-0.55) | .003 | 0.37 (0.218-0.75) | .006 |
| 350-450 | 0.28 (0.14-0.54) | < .001 | 0.31 (0.18-0.56) | < .001 |
| > 450 | 0.21 (0.093-0.47) | < .001 | 0.32 (0.12-0.50) | < .001 |

Reference categories were control group, men, and the category representing worse disease, which were diagnosis of IPF, SpO₂ ≤ 85%, FVC < 50%, and baseline 6MWD < 250 m. 6MWD = 6-min walk distance; HR = hazard ratio; ILD = interstitial lung disease; IPF = idiopathic pulmonary fibrosis; NA = not applicable; PR = pulmonary rehabilitation; SpO₂ = oxyhemoglobin desaturation.

^aAge was entered as a continuous variable and therefore has no reference category.

PR of ILD: Impact of Pulmonary Rehabilitation on Survival in People With Interstitial Lung Disease

- Conclusion

- Participation in PR among people with ILD may impact survival at 5 years
- Along with clinical improvements after PR, the potential for a survival benefit further strengthens the importance of PR in the standard care of people with ILD

Overview

- Pulmonary rehabilitation in the guidelines
 - GOLD 2026 guideline
 - ERS clinical practice guideline for the bronchiectasis
- Pulmonary rehabilitation of COPD
- Pulmonary rehabilitation of ILD
- Pulmonary rehabilitation in Korea

Original Paper

Smartphone App–Guided Pulmonary Rehabilitation in Chronic Respiratory Diseases: Randomized Controlled Trial

Chiwook Chung^{1,2*}, MD, PhD; Deog Kyeom Kim^{3*}, MD, PhD; Jung-Kyu Lee³, MD, PhD; Eun Young Heo³, MD, PhD; Hee Kwon⁴, BS; Dongbum Kim⁴, MS; Woo Jin Kim⁵, PhD, MD; Sei Won Lee², MD, PhD

- Aimed
 - Evaluate the efficacy of smartphone app–guided pulmonary rehabilitation in improving exercise capacity in individuals with chronic respiratory diseases
- Multicenter prospective, single-blind, RCT conducted in 2022
- 100 participants with chronic respiratory disease, including COPD, asthma, and lung cancer, were recruited
 - Asan Medical Center, Kangwon National University Hospital and Seoul Metropolitan Government Seoul National University Boramae Medical Center
- > equal distribution (50:50) between the intervention group and the control group
 - Intervention group: followed a 12-week app-guided rehabilitation program
 - Control group: received standard outpatient treatment.
- Primary outcome: 6MWD after the 12-week rehabilitation period
- Secondary outcomes: included quality of life questionnaires and health care usage

Figure 1. Screenshots of the Redpill Breath app. Shown are the following: (A) opening screen; (B) account creation; (C) the 6-minute walk test, which displays step counts and test time; (D) walking distance and timer for walking exercises; (E) completion of walking exercise, which displays walking distance, heart rate, oxygen saturation, and rating of perceived exertion scale evaluated after exercise; (F) exercise level change; (G) instruction videos for muscle training exercise program; (H) completion of muscle training exercise; and (I) exercise report, which displays exercise completion rate per week and day.

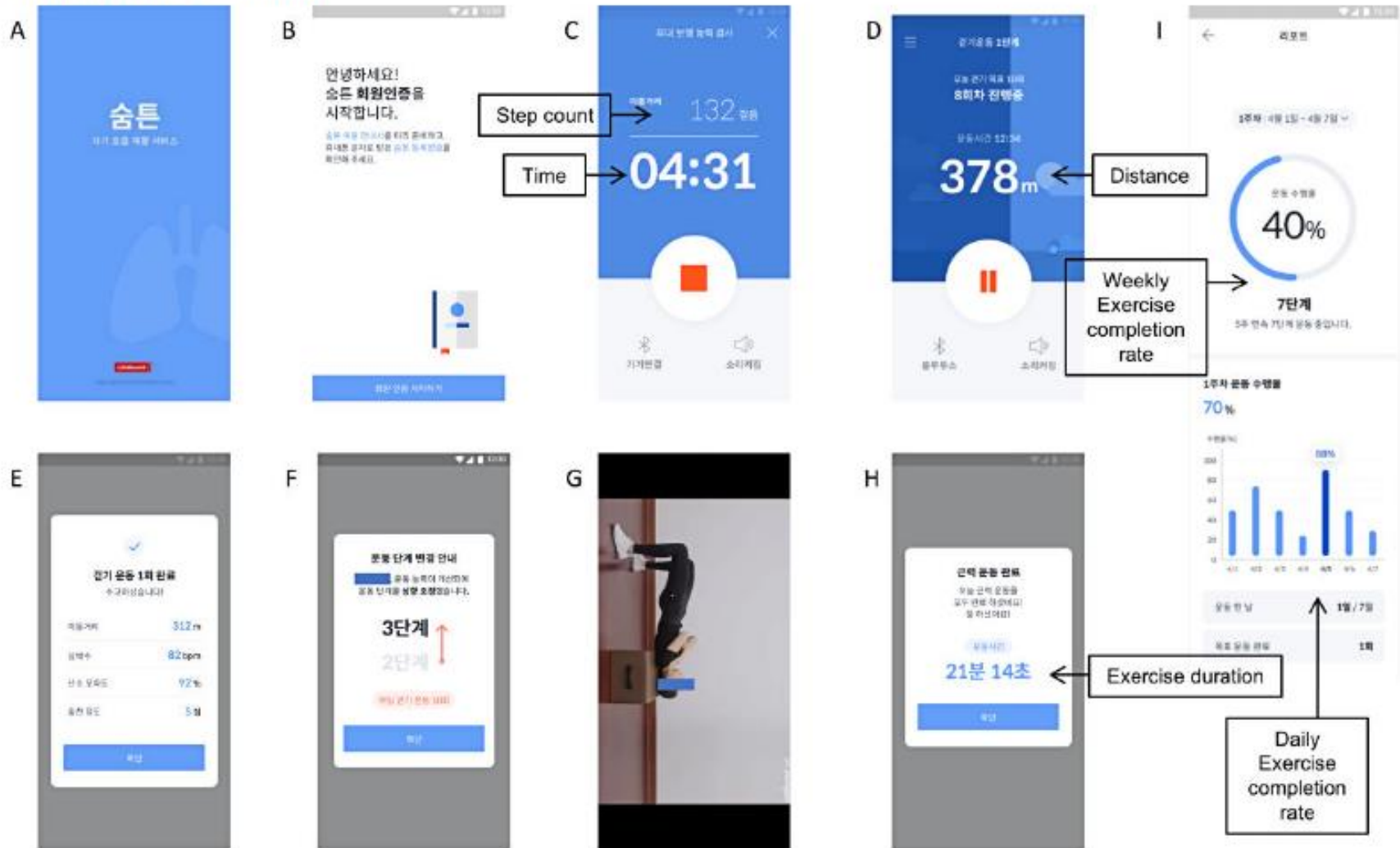
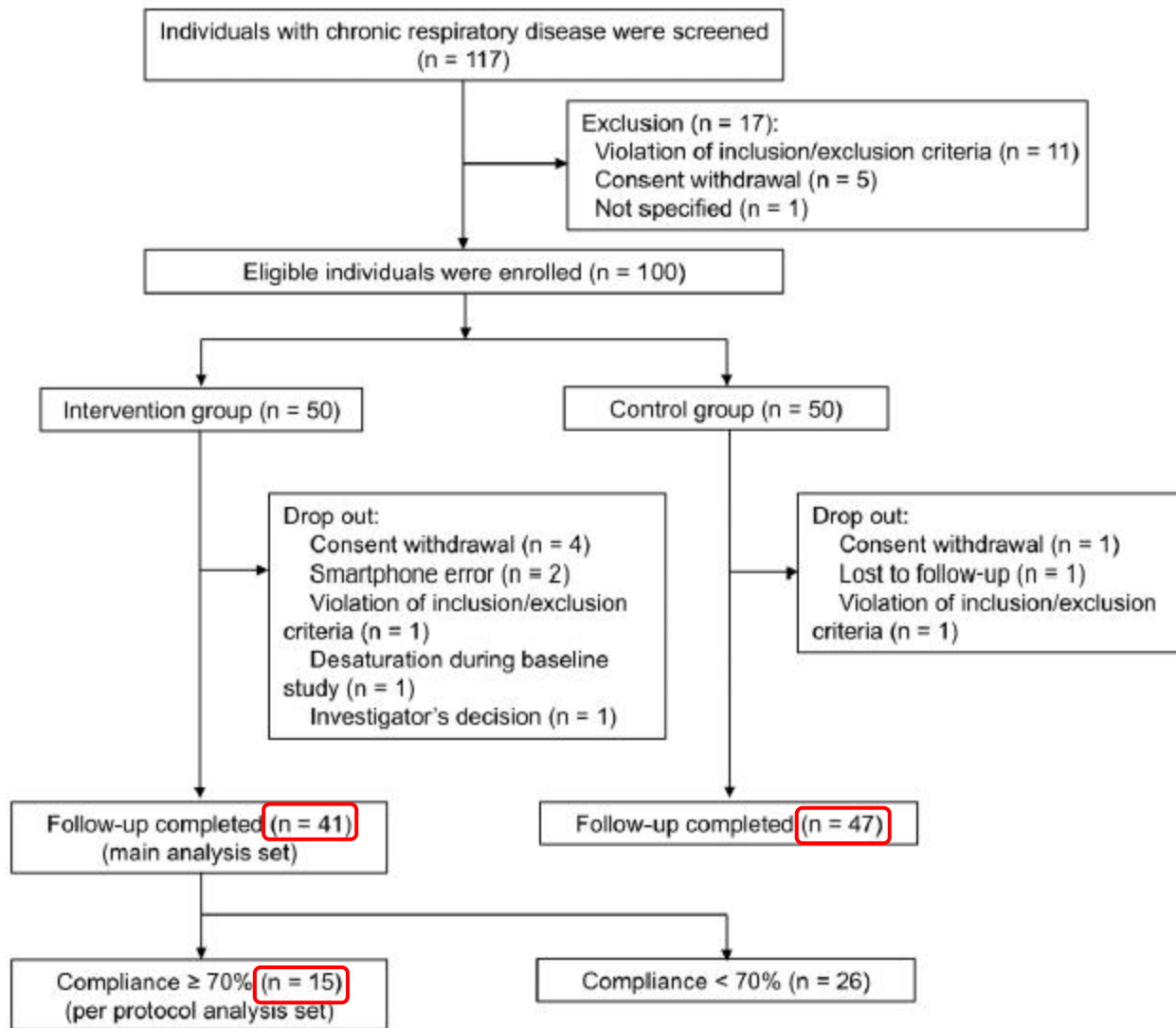


Figure 2. Study flowchart.



PR in Korea: Smartphone App–Guided PR in Chronic Respiratory Diseases: Randomized Controlled Trial

Table 1. Baseline characteristics of study participants.

| Variables | Total (n=88) | Intervention (n=41) | Control (n=47) | P value |
|---|---------------------|---------------------|---------------------|---------|
| Age (years), median (IQR) | 68.0 (62.0-73.0) | 67.0 (59.0-71.0) | 69.0 (63.3-73.0) | .10 |
| Male sex, n (%) | 72 (81.8) | 36 (87.8) | 36 (76.6) | .14 |
| Height (cm), median (IQR) | 165.0 (159.1-169.0) | 166.0 (159.1-170.1) | 164.0 (159.3-168.0) | .28 |
| Body weight (kg), median (IQR) | 65.0 (56.0-73.0) | 67.0 (56.5-77.0) | 64.0 (6.0-71.0) | .25 |
| BMI (kg/m ²), median (IQR) | 24.1 (21.7-26.7) | 24.9 (21.9-27.5) | 24.0 (21.7-26.4) | .56 |
| Respiratory disease, n (%) | | | | .26 |
| COPD ^a | 85 (96.6) | 41 (100.0) | 44 (93.6) | |
| Asthma | 2 (2.3) | 0 (0.0) | 2 (4.3) | |
| Bronchiectasis | 1 (1.1) | 0 (0.0) | 1 (2.1) | |
| Duration of disease (years), median (IQR) | 4.9 (2.1-9.7) | 4.8 (1.9-9.4) | 5.0 (2.2-10.1) | .51 |
| Ever-smokers, n (%) | 70 (79.5) | 34 (82.9) | 36 (76.6) | .47 |
| Amount, pack-years (n=70), median (IQR) | 40.0 (20.0-45.0) | 35.0 (22.5-45.0) | 40.0 (20.0-45.0) | .72 |
| Lung function, median (IQR) | | | | |
| FEV1 ^b (% predicted) | 63.0 (50.5-71.5) | 63.0 (53.0-71.3) | 63.0 (48.3-71.8) | .98 |
| FVC ^c (% predicted) | 83.0 (73.5-88.5) | 84.0 (75.5-89.3) | 81.0 (73.0-87.8) | .57 |
| FEV1/FVC | 0.54 (0.44-0.62) | 0.54 (0.45-0.62) | 0.54 (0.43-0.64) | .88 |

PR in Korea: Smartphone App–Guided PR in Chronic Respiratory Diseases: Randomized Controlled Trial

Table 2. Comparison of clinical outcomes of study participants at baseline and follow-up (main analysis).

| Variables | Total (n=88) | Intervention (n=41) | Control (n=47) | <i>P</i> value |
|---------------------------------|---------------------|---------------------|---------------------|----------------|
| Baseline, median (IQR) | | | | |
| mMRC ^a dyspnea scale | 1.0 (1.0-2.0) | 1.0 (1.0-2.0) | 1.0 (1.0-1.8) | .40 |
| 6MWD ^b (m) | 483.5 (444.0-520.0) | 495.0 (460.0-541.3) | 480.0 (440.0-503.8) | .10 |
| HADS ^c | 9.0 (6.0-14.0) | 10.0 (7.0-14.3) | 8.5 (5.0-14.0) | .16 |
| SGRQ ^d | | | | |
| Total | 30.3 (20.1-39.6) | 26.5 (18.8-36.5) | 32.8 (20.6-41.2) | .18 |
| Symptoms | 44.1 (33.5-54.9) | 41.7 (30.1-53.8) | 48.5 (33.6-57.5) | .13 |
| Activity | 45.2 (32.2-57.9) | 44.4 (30.5-53.9) | 50.7 (32.4-63.5) | .24 |
| Impacts | 15.5 (7.3-28.3) | 13.0 (5.9-25.8) | 18.3 (8.3-30.7) | .26 |
| Follow-up, median (IQR) | | | | |
| mMRC dyspnea scale | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | .35 |
| 6MWD (m) | 485.0 (460.0-544.0) | 490.0 (468.8-556.3) | 485.0 (440.0-527.3) | .35 |
| HADS | 10.0 (5.0-14.0) | 10.0 (5.0-13.3) | 10.0 (4.3-15.0) | .70 |
| SGRQ | | | | |
| Total | 30.9 (18.5-44.6) | 27.9 (17.6-43.7) | 33.5 (22.1-44.8) | .21 |
| Symptoms | 44.8 (32.4-61.2) | 44.9 (25.2-54.1) | 44.6 (33.2-65.4) | .34 |
| Activity | 50.7 (31.5-64.0) | 44.4 (25.7-57.8) | 51.6 (40.1-64.9) | .12 |
| Impacts | 16.9 (5.9-30.1) | 13.8 (5.1-27.2) | 18.0 (7.8-31.2) | .34 |

^amMRC: modified Medical Research Council.

^b6MWD: 6-minute walk test distance.

^cHADS: Hospital Anxiety and Depression Scale.

^dSGRQ: St George's Respiratory Questionnaire.

Table 3. Comparison of clinical outcomes of study participants at baseline and follow-up (compliance $\geq 70\%$, per-protocol analysis).

| Variables | Total (n=62) | Intervention (n=15) | Control (n=47) | P value |
|---------------------------------|---------------------|---------------------|---------------------|---------|
| Baseline, median (IQR) | | | | |
| mMRC ^a dyspnea scale | 1.0 (1.0-2.0) | 1.0 (1.0-1.8) | 1.0 (1.0-1.8) | >.99 |
| 6MWD ^b (m) | 480.0 (440.0-520.0) | 480 (421.3-551.8) | 480.0 (440.0-503.8) | .65 |
| HADS ^c | 9.0 (5.8-14.0) | 9.0 (6.3-16.0) | 8.5 (5.0-14.0) | .54 |
| SGRQ ^d | | | | |
| Total | 31.4 (20.2-39.5) | 26.5 (19.5-36.0) | 32.8 (20.6-41.2) | .26 |
| Symptoms | 46.8 (33.5-54.1) | 38.0 (19.5-53.4) | 48.5 (33.6-57.5) | .16 |
| Activity | 50.7 (33.0-58.6) | 44.4 (44.4-56.2) | 50.7 (32.4-63.5) | .66 |
| Impacts | 16.3 (7.8-30.4) | 12.1 (6.1-17.5) | 18.3 (8.3-30.7) | .23 |
| Follow-up, median (IQR) | | | | |
| mMRC dyspnea scale | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | .29 |
| 6MWD (m) | 485.0 (440.0-538.0) | 485.0 (463.3-558.8) | 485.0 (440.0-527.3) | .54 |
| HADS | 10.5 (5.0-15.0) | 11.0 (5.0-15.0) | 10.0 (4.3-15.0) | .90 |
| SGRQ | | | | |
| <hr/> | | | | |
| Variables | Total (n=62) | Intervention (n=15) | Control (n=47) | P value |
| Total | 31.2 (18.5-44.8) | 27.9 (15.2-42.4) | 33.5 (22.1-44.8) | .22 |
| Symptoms | 41.0 (30.6-62.8) | 36.8 (21.2-53.1) | 44.6 (33.2-65.4) | .12 |
| Activity | 51.4 (33.1-64.1) | 44.4 (22.6-56.2) | 51.6 (40.1-64.9) | .13 |
| Impacts | 17.5 (6.7-31.5) | 12.8 (4.3-33.7) | 18.0 (7.8-31.2) | .44 |

^amMRC: modified Medical Research Council.

^b6MWD: 6-minute walk test distance.

^cHADS: Hospital Anxiety and Depression Scale.

^dSGRQ: St George's Respiratory Questionnaire.

PR in Korea: Smartphone App–Guided PR in Chronic Respiratory Diseases: Randomized Controlled Trial

- None of the participants required hospitalization or emergency room visits related to their underlying respiratory disease or rehabilitation program
 - Conclusions
 - Smartphone app–guided PR failed to improve exercise capacity and quality of life in patients with chronic respiratory diseases
 - Older adults with chronic respiratory conditions can safely use smartphone app–guided PR
- => smartphone app–guided pulmonary rehabilitation may be a feasible option for older adults with chronic respiratory disease

Summary

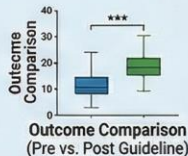
2025 PULMONARY REHABILITATION: YEAR IN REVIEW

KEY ADVANCES, GUIDELINES, AND DIGITAL TRANSFORMATION

I REVISED STANDARDS & GUIDELINES



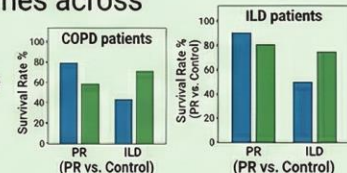
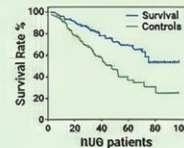
- **ERS 2025 Bronchiectasis Guideline Update**
- Transition from **Conditional** to **STRONG RECOMMENDATION** for PR in Bronchiectasis
- Emphasis on **Individualized Risk-Based Care & Early Intervention**



Digital Data informing PR

II EXPANDED CLINICAL EVIDENCE

- **SURVIVAL BENEFIT IN ILD:** PR impact on 5-year survival rates identified
- **Long-term data** on QoL & Clinical Outcomes across Chronic
- **Standard Care integration** for ILD



2025: A YEAR OF TRANSFORMATION IN PR

III. PRECISION & TAILORED APPROACH



TREATABLE TRAITS: Targeting Sarcopenia, Anxiety, Nutrition (Multi-disciplinary PR)



Flexible Program Duration: Equivalence shown between 8-week & 12-week models



Decisions based on local waitlists, budgets, & patient preference



Personalized Plans

Digital Data informing Precision PR

IV. DIGITAL FRONTIER: mHEALTH & TELE-PR



Smartphone App-guided PR (e.g., Redpill Breath): Large-scale data

SAFETY & FEASIBILITY: Confirmed in Older Adults with Chronic Respiratory Diseases

REALITY CHECK: Failed to surpass in-person PR in exercise capacity improvement, prompting hybrid models



Digital PR Workflow:

- Remote Monitoring
- Audio Guidance
- Video Instruction



YONSEI UNIVERSITY
COLLEGE OF MEDICINE

