British Thoracic Society Clinical Statement on Pulmonary Rehabilitation

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Introduction

The evidence-based British Thoracic Society (BTS) Guideline for pulmonary rehabilitation (PR) in adults was published in 2013.(1) There is a strong evidence base for the benefits of PR,(2) and it is one of the most cost-effective interventions for adults with chronic obstructive pulmonary disease (COPD).(3) Furthermore, PR improves exercise capacity and health related quality of life (HRQOL) in COPD to a much greater magnitude than observed with bronchodilator therapy.(4)

Much of the guideline remains relevant today and does not need re-visiting. Since the guideline however, there is deeper understanding of referral characteristics, outcome measures, patient selection, programme delivery, potential adjuncts, and the role of maintenance following PR. The BTS Clinical Statement on PR will provide a snapshot of current knowledge and best practice in topical areas by providing a series of clinical practice points that are informed by evidence where this exists, or based on expert opinion and collective clinical experience where evidence is limited. The intended audience are PR clinicians working within health settings in the United Kingdom and beyond. The clinical statement will provide a framework to inform future British Thoracic Society Quality Standards for PR. We have also highlighted areas of research priority, which will be of interest to clinical researchers.

In this statement, we highlight the growing interest in alternative models of delivering PR (e.g. home-based, remote supervision, use of technology), accelerated by the restrictions placed on face-to-face PR delivery during the global COVID-19 pandemic. Alternative PR models, typically delivered remotely, might potentially increase provision of, and accessibility to PR. However research gaps remain and it is crucial these alternative models are optimised and carefully evaluated before widespread adoption.(2).

A recent international workshop report, using a Delphi process, defined essential and desirable components of PR.(5) We have adapted this to define the core components of PR (Table 3), which will help health payers decide if they are commissioning an intervention that is likely to produce good outcomes.

Methodology

The Clinical Statement Group (CSG) was chaired by Professor William Man and Professor Sally Singh. Membership was drawn from an open application process. Members were selected for their experience either in clinical delivery or academic evaluation (or both), and be representative of the multidisciplinary team. The CSG identified key areas that reflect the scope approved by the BTS Standards of Care Committee (SOCC). Following discussions of broad statement content, individual sections were drafted by CSG members with the overall statement drafted by the chairs and reviewed by a patient representative. A final edited draft was reviewed by the BTS SOCC before posting for public consultation and peer review on the BTS website in (date to be confirmed). The revised document was re-approved by the BTS SOCC in TBC before final publication.

Section 1: Pulmonary Rehabilitation: Access, Referrals, and Uptake

1.1 Access and Referrals

There is a large disparity between the number who are eligible and the number receiving PR.(6) Reasons for this are complex, but barriers may exist at several points of the pathway. Referral from primary care appear to be influenced negatively by increasing age, gender (women less likely), deprivation, comorbidities, respiratory disability and smoking status.(7) The PR outcomes from individuals with lower socioeconomic status are not compromised, but they are less likely to be referred or to complete PR.(8) Over 10% of services in England and Wales did not offer services to those with greatest respiratory disability (Medical Research Council Dyspnoea Scale 5). Equity of access is rarely addressed within UK services, but modification of PR to suit the needs of a diverse population has been proposed in other countries.(9) Health and digital literacy require attention, particularly with ever diversifying modes of PR delivery, including the use of technology.(10, 11)

Although there is a dearth of randomised controlled trial (RCT) data to support specific interventions designed to improve referral for PR,(12, 13) identified referrer barriers include a lack of referrer knowledge around eligibility criteria or how to refer for PR.(14) Several observational studies have provided indirect evidence that improving education can increase referral rates (summarised in Table 1).

Table 1: Effect of referrer education on pulmonary rehabilitation referrals

Action	Effect on referrals
Delivering education to primary care referrers (18-20)	3-5% increase
Patient education as part of a 'patient held score card' with advice to discuss referral at their next COPD review (21)	6% increase
Integrated approach to COPD care (22)	25% increase over three years
Delivering education to secondary care referrers (33, 34)	6% increase RR: 2.78 [2.65; 2.90]
Delivering COPD discharge bundles by pulmonary rehabilitation practitioners versus non-pulmonary rehabilitation practitioners (129)	OR: 14.46 [5.28 to 39.57]

OR – adjusted odds ratio; RR – risk ratio; [ ] 95% confidence intervals

The most recent (pre-pandemic) national audit data identified that the median waiting time from receipt of referral to PR enrolment was 84 days, with only 54% receiving PR within 90 days of referral receipt.(15) A similar waiting time from prescription to receipt of an inhaler would be unacceptable, despite bronchodilators being a less cost-effective intervention to PR.(3) Commissioners need to ensure that accessibility to PR has at least the same priority as access to pharmacological therapy. This would require investment in workforce and training, with the BTS report "A workforce for the future" highlighting the substantial shortage of skilled health care professionals and support staff for PR.

1.2 Uptake and Completion

Barriers to uptake and completion of pulmonary rehabilitation are complex,(16, 17) but factors relating to the quality of a PR service, such as lack of patient-centeredness and coordination within PR team, inadequate professional competence of staff, lack of a holistic approach and limited accessibility, are relevant.(16)

There are few interventional studies targeting uptake and completion. Observational studies have explored interventions such as group opt-in sessions (which led to fewer patients attending assessment for PR (18)), patient-held manuals with research evidence summaries which improved attendance in the most socioeconomic disadvantaged patients,(19) and a nurse-general practitioner partnership care plan which increased attendance at PR by 21.5% compared to usual care.(20) In the acute setting, a patient co-designed education video did not improve post-hospitalisation PR uptake.(21) Other interventions currently being tested include the use of lay health workers to support patients.(22).

Clinical Practice Points

- PR provider leads should have designated sessional time to coordinate management and delivery of the service. This should include: regular education of potential referrers about PR and referral pathways; the expansion, training and skills maintenance of a specialist workforce to deliver PR; the collation of key organisational metrics.
- PR providers should demonstrate the offer of timely, accessible and high quality services by the regular monitoring and publication of key organisational metrics including waiting time from referral receipt to assessment and enrolment, percentage of referred patients who attend an assessment, percentage of patients who are assessed that attend at least one planned supervision, percentage of the number of attended to planned sessions, percentage of patients attending a discharge assessment.
- PR providers should work closely with relevant national professional societies and other stakeholders to develop consensus training programmes, competency documents and plans to develop and support a skilled workforce to deliver increased PR.

Research gaps

- Development of interventions to improve referrals to, uptake and completion of PR.
- The adaptations and evaluation of PR services to ensure programmes meet the needs of a diverse population, including equity of access.

Section 2: Assessment and Outcomes

PR assessments are documented in the previous BTS guideline and include measures of breathlessness, exercise capacity and HRQOL.(1) These remain core outcomes. However, this section will explore additional assessments and outcomes that are complementary and should be considered as part of a high-quality PR service.

2.1 Holistic Assessment

The PR pathway presents an opportunity to optimise holistic care. A thorough assessment for PR incorporates a multi-system approach. This should help identify individuals who might benefit from other cost-effective interventions such as vaccination and smoking cessation,(3) or those identified with treatable traits associated with poor prognosis that might prompt onward referral.

There is a significantly increased risk of several cardiovascular diseases in COPD (23) so unexplained symptoms (such as chest pain or intermittent claudication), or identification of elevated blood pressure or arrythmias should prompt referral for further evaluation. Long term oxygen therapy for severe hypoxaemia remains one of the few interventions that influence prognosis in adults with COPD.(24, 25) Both low body mass index (specifically unintentional weight loss) and extreme obesity are factors for poor prognosis.(26-28). Frailty, a multisystem syndrome characterised by reduced functional reserve and increased vulnerability following minor stressor events, is associated with adverse prognosis in adults with COPD,(29-31) and increases likelihood of PR non-completion.(32) Mental health issues are common in patients referred for PR (15, 33) and are associated with reduced adherence to interventions, increased dyspnoea, and lower levels of patient activation.(34-37)

Education is a key component of PR; yet assessing the effects of this component is challenging, with limited availability of validated questionnaires, particularly for non-COPD conditions.(38) Although validated COPD knowledge questionnaires have been used in PR settings,(39, 40) further research is needed to determine the impact of the educational component beyond knowledge acquisition. A list of suggested educational topics were published in the previous BTS guidelines.(1)

2.2 Home-based or remote assessment of core outcomes

Since the COVID-19 pandemic, there has been increasing interest in home-based or remote assessment options. Many non-exercise outcomes, such as HRQOL, are assessed through questionnaires. The COPD Assessment Test, Saint Georges Respiratory Questionnaire and Hospital Anxiety and Depression Scale have comparable validity and reliability when delivered over the phone compared to face-to-face delivery.(41, 42)

However, evidence is lacking to support remote delivery of functional or field walking tests as a reliable alternative to face-to-face testing. Although sit to stand, step, and timed up and go tests are feasible in the home-setting, they do not accurately reflect oxygen desaturation with walking or allow exercise prescription.(43) Six-minute walk tests (6MWT) supported by mobile phone application algorithms offers a potentially attractive approach but has not been validated in chronic respiratory disease populations.(44) There are some data to suggest that there is no significant difference in six-minute walk distance when performed indoors or outdoors,(45) although further corroboration is required in variable environmental conditions. Current assessment of patient safety for exercise-training and exercise capacity to facilitate exercise prescription should be conducted in-person, irrespective of the PR delivery model (see Section 4).

2.3 Functional assessments

Simple functional assessments are attractive as they do not require as much space as field walking tests (46) and can be performed in most healthcare settings including the home. These include four metre gait speed (47-49), sit to stand tests (five repetition, 30 seconds, one minute) (50-53), step tests (54-57), timed up and go (58), and composite measures combining several functional tests. These have been reviewed in detail elsewhere (43, 59-61). These functional tests are safe and feasible in the home setting, have a moderate relationship with field walking test performance or muscle strength and are responsive to exercise-based interventions or PR.

However, there are several caveats. Most validation studies have taken place in clinical settings where the tests were directly supervised and therefore the safety and validity of remotely supervised functional tests in patients with chronic respiratory disease have not been established. Some functional tests have floor or ceiling effects that might limit their application in PR. For example, 15% of those referred for PR were not able to complete the five repetition sit to stand,(50) whilst the four metre gait speed is less responsive to PR in higher functioning individuals with COPD.(47) Functional tests are also typically submaximal, and therefore not able to support individualised exercise prescription.(47) Others have used functional tests as surrogate markers of muscle strength. However the relationship between five repetition sit-to-stand test and quadriceps strength is only moderate.(50)

2.4 Physical activity

Reduced physical activity (PA) is associated with poor prognosis in COPD.(62) Although PA can be measured subjectively using questionnaires, there are limitations to this method including recall bias.(63) There is growing literature on measuring PA using wearable devices, including pedometers and accelerometers, but considerable variability has been reported in clinical trials.(64) An International Taskforce on Physical Activity has recommended implementation of standard operating procedures for PA data collection and reporting.(62) Although PA has been identified as an important outcome that may be potentially amenable to PR, further research is required before adoption into routine clinical practice.

Clinical Practice Points

- As well as establishing safety and suitability for exercise training and facilitation of exercise prescription, a high quality PR assessment should encompass a holistic approach incorporating documentation of vaccination and smoking/vaping status; resting oxygen saturations, heart rate and blood pressure measurements; nutritional assessment; frailty; presence of anxiety and depression; and disease knowledge. This information should be communicated to other relevant healthcare professionals involved in the individual's management so that required action can be coordinated.
- Assessment of patient safety for exercise-training and exercise capacity to facilitate exercise prescription should be conducted in-person using a validated field walking test (incremental shuttle walk, 6MWT) or laboratory cardiopulmonary exercise test.
- There is no evidence to support the safety or validity of field walking tests or simple functional tests that are supervised remotely.

- When routine face-to-face assessments are restricted, hybrid assessments can be considered with questionnaire-based assessments conducted over the telephone and a directly supervised, face-to-face assessment of exercise capacity.
- Functional tests are complementary to, but not a replacement for, validated exercise walking tests. There is no evidence to support aerobic or strength exercise prescription from simple functional tests.

Research gaps

- Development of outcomes that assess the effectiveness of the education component of the PR programme
- Studies to assess the safety and validity of remotely supervised exercise and functional outcomes through video-conferencing or mobile applications.
- Alternative strategies to prescribe exercise and deliver effective PR in the absence of a directly supervised validated exercise test.
- Clarify the value of measuring PA and other physiological data obtainable from wearables as part of routine clinical practice in PR.

Section 3: Extending the Scope of Pulmonary Rehabilitation

3.1 Chronic Respiratory Disease other than COPD

There is a growing evidence-base and real-world experience of delivering PR to people with asthma, bronchiectasis and interstitial lung disease (ILD). Systematic reviews have demonstrated that exercise training, compared with control interventions, significantly improves exercise capacity and HRQOL.(65-68) Furthermore, real-world data suggest that these improvements are of similar magnitude to those observed in matched patients with COPD.(33, 69, 70)

Considerations and potential adaptations needed to deliver PR to people with non-COPD chronic respiratory disease are outlined in Table 2. For asthma, to minimise risk of adverse events, patients should be medically optimised prior to referral for PR.(71) Similarly, as bronchiectasis is characterised by excessive sputum production, a review and optimisation of airway clearance technique should be considered prior to starting PR.(72) There are no data to support increased risk of cross-infection of multi-resistant organisms,(73) but local infection control policies should be followed. Compared with COPD, profound exercise-induced oxygen desaturation is more common in IPF and some subtypes of ILD; this needs to be considered as part of the safe assessment and delivery of PR in these patients. Although most standard PR education is relevant to people with non-COPD respiratory disease, some adaptations are needed (eg. medications) or particular components prioritised (eg. airway clearance in bronchiectasis).

Table 2. Disease-specific considerations for pulmonary rehabilitation

Asthma	• To minimise risk of adverse events, patients should be medically optimised prior to PR referral.(71)
Bronchiectasis	• Bronchiectasis is characterised by excessive sputum production, therefore a review and optimisation of airway clearance technique is recommended prior to starting PR.(72) • There are no data on risk of cross-infection of multi-resistant organisms during PR, but local infection control policies should be followed.
Interstitial lung disease	• Compared with COPD, profound exercise-induced desaturation is more common in idiopathic pulmonary fibrosis and some sub-types of interstitial lung disease; this needs to be considered as part of the safe assessment and delivery of PR in these patients.
Post-COVID-19	• Check for contraindications and beware unexplained chets pain. Unidentified (and therefore untreated) pulmonary thromboembolic disease (84) and myocarditis (172) have been reported in the post-COVID-19 syndrome, which are relative contraindications to PR. • Assessment: A proportion of patients will have post-intensive care syndrome with multi-systemic symptoms. The following symptoms should be assessed to enable the exercise and education components to be individualised: fatigue, muscle weakness, breathing pattern disorder, post-traumatic stress, swallow/speech difficulties, and peripheral neuropathy. • Monitoring: Post-exertional symptom exacerbation (PESE) is a widely reported symptom in post-Covid 19 syndrome.(173) Given the potential for deterioration in function following overexertion, fatigue and PESE should be closely monitored during PR.
Lung cancer	• Due to time sensitivity for curative surgery, conventional PR programmes would require adaptation to be suitable for prehabilitation.

Chronic heart failure	• Programme adaptations/considerations might include:(99)
	  ○ Exercise assessment with an exercise ECG.
	  ○ Provision of disease-specific education and non-exercise interventions to address breathless and psychological needs of patients and carers.
	  ○ Workforce training to understand signs of an episode of decompensated heart failure.
	• Inclusion of a heart failure nurse in the multi-disciplinary team.

Pulmonary hypertension	• To be eligible for PR, people with pulmonary hypertension should:(101, 103)
	  ○ Have stable disease (>3 months).
	  ○ Be prescribed drug therapy with no change in previous two months.
	  ○ Have no recent syncope.
	• International guidelines recommend that exercise is supervised by specialist exercise professionals.(103)

Abbreviations: ECG: Electrocardiogram; PR: Pulmonary Rehabilitation.

3.2 Post-COVID-19

Previous guidance from the BTS regarding the role of adapted PR to meet the recovery needs in post-COVID-19 syndrome has been previously published.(74) Several observational studies have demonstrated that PR following hospitalised COVID-19 is associated with significant improvements in exercise capacity, breathlessness, and HRQOL.(75-80) Without a control group, natural recovery cannot be dismissed as the main driver of improvements.(56) However, symptom burden, reduced exercise tolerance and sequelae of hospitalisation for COVID-19 remain substantial at five months post-discharge,(81) with negligible improvement one year after discharge.(82) Initial trial data suggest a role for PR in the recovery of individuals with post-COVID-19 syndrome,(83) and the results of further trials are awaited

Several factors need to be considered when providing PR to individuals with post-COVID-19 syndrome (Table 2). A proportion will have post-intensive care syndrome with multi-organ impairment, and there should be a wider assessment for symptoms such as fatigue, muscle weakness, breathing pattern disorder, post-traumatic stress, swallow/speech difficulties, and peripheral neuropathy. These should also be considered with regards to individualising the exercise and education components of the programme. Unidentified (and therefore untreated) pulmonary thromboembolic disease (84) and myocarditis (85) have been reported in the post-COVID-19 syndrome, which are relative contraindications to PR. Furthermore, post-exertional symptom exacerbation (PESE) is a widely reported symptom in post-Covid 19 syndrome.(86) Given the potential for deterioration in function following over-exertion, fatigue and PESE should be closely monitored during PR.

3.3 Lung Cancer

Prehabilitation is the focus on modifiable risk factors in individuals preparing for lung cancer treatment, typically commencing at the point of diagnosis and is multimodal in approach.(87) A systematic review suggested that exercise pre-surgery improves physical and pulmonary function, although the interventions were very heterogeneous in nature and duration.(88) Whilst PR addresses some modifiable factors, the time-sensitivity of lung cancer resection means that the traditional outpatient PR model would need significant adaptations to be suitable for prehabilitation (Table 2).

A Cochrane review identified eight RCTs of exercise-training following surgical resection of non-small cell lung cancer (89). Compared with usual care, improvement in exercise capacity was greater in the intervention group, but trial populations were small and there was lower certainty for other outcomes. Due to the significant heterogeneity of the interventions, the optimal timing, setting, nature or duration of exercise-training for post-lung cancer surgery patients remains unclear. Few patients are currently referred for PR after lung cancer surgery.(90) Little data exists on rehabilitation interventions that combine pre- and post-lung cancer surgery exercise-training.

3.4 Lung Volume Reduction Surgery

Lung volume reduction surgery (LVRS) is recommended by the National Institute for Health and Care Excellence (NICE) for the treatment of selected individuals with emphysema and hyperinflation.(91) As part of the work-up for LVRS, all individuals should receive PR, a prerequisite to randomisation in landmark trials of LVRS.(92) Furthermore, it plays an important role in selecting individuals for LVRS with up to 20% improving their exercise tolerance to such an extent that they change LVRS risk stratification groups.(93)

In the UK, only a small minority of eligible patients undergo LVRS due to the absence of standardised referral pathways.(94) However, PR practitioners may have a role in identifying potential candidates as the post-PR assessment represents the point at which the patient's functional capacity and management of breathlessness should be optimised. Recent analysis of data from the National Asthma and COPD Audit suggested that up to 18.1% of PR completers met the NICE criteria for a LVRS-focused respiratory review (Non-smoker, MRC≥3, 6MWT > 140m or ISWT >80m).(95)

3.5 Lung Transplantation

Before referral for lung transplantation, individuals with advanced lung disease should have been optimised, including completion of PR. Unlike for lung cancer, waiting time for lung transplantation is unpredictable, and there is little guidance on the ideal content or duration of a prehabilitation programme for lung transplantation, and consequently few published data.

Exercise-training following lung transplantation has been studied in more detail. A Cochrane review to determine the benefits and safety of exercise training in adult lung transplant recipients included eight RCTs involving 438 participants.(96) However, results could not be aggregated due to the small number of underpowered trials and the heterogeneity of the interventions. The authors concluded that the effects of exercise-based rehabilitation following lung transplantation were uncertain due to imprecise estimates of effects and high risk of bias.(96)

3.6 Cardiac Disease and Pulmonary Hypertension

Cardiac comorbidity is highly prevalent in patients attending PR.(15) There is no convincing data to suggest that stable cardiac comorbidity is associated with worse outcomes to PR.(97) Exercise-based cardiac rehabilitation is safe in individuals with chronic heart failure (CHF) and improves exercise capacity and HRQOL.(98) Integrating individuals with CHF and those with chronic respiratory disease into breathlessness rehabilitation programmes is feasible with minor adaptations (Table 2).(99) These improve exercise capacity in CHF, with a magnitude similar to that observed in COPD.(100) Only 18% of PR services in the UK currently accept patients with CHF.(15)

In a systematic review of seven trials in patients with primarily pulmonary arterial hypertension (PAH) (including some with chronic thromboembolic pulmonary hypertension: CTEPH), exercise-based rehabilitation improved 6MWT distance and peak oxygen consumption compared with usual care.(101) However, the quality of evidence was low and the rehabilitation interventions were inpatient-based and atypical of PR practice in the NHS. Collective experience is that exercise-training is safe and effective in PAH,(102) and in those with pulmonary hypertension secondary to chronic lung disease. However, expert consensus is that patient selection is key (stable disease with no recent change in drug therapy or recent history of syncope).(101, 103). In PAH and CTEPH, exercise-based rehabilitation should be directly supervised in person by specialist exercise health care professionals.(103)

3.7 Pulmonary Rehabilitation around the time of a hospitalised exacerbation of COPD

Extrapulmonary manifestations of hospitalised exacerbations include reduced walking performance (104, 105), HRQOL (106, 107), low physical activity levels (108) and muscle dysfunction (109) – all of which are associated with poor prognosis,(30, 104, 110) but also potentially responsive to PR.

The BTS Guideline on PR recommended that individuals hospitalised for acute exacerbation of COPD should be offered PR at hospital discharge to commence within one month of discharge.(1) The Cochrane systematic review included 20 trials and 1477 participants and demonstrated moderate to large effects of rehabilitation on HRQOL and exercise capacity in patients with COPD after an exacerbation.(111) Additionally there is evidence that PR after hospitalised exacerbation may reduce the risk of readmission (112, 113) and improve survival with a dose-response effect.(114) However, the content, setting and duration of rehabilitation interventions were heterogeneous.

In the UK setting, inpatient rehabilitation may not be feasible given the short duration of hospital stays. Two trials conducted in the NHS setting evaluated PR initiated during the inpatient stay and progressing to a more "light touch" approach to post-discharge outpatient treatment with the aim of addressing both the initial insult of the hospitalisation as well promoting recovery.(115, 116); however benefits were less impressive than observed in post-exacerbation outpatient PR trials.(112, 115-117) Rehabilitation started one month after hospitalisation yielded better overall results than rehabilitation started during the hospital admission.(118) A systematic review, including 30 studies, identified that longer programmes, starting after hospital discharge and including an educational component (as well as exercise), were most effective at reducing hospital readmissions.(119)

Implementation of PR following an exacerbation remains a challenge. Real-world data suggests that uptake is between 1.5% and 9%.(114, 120) Strategies to improve referral, uptake and completion have been limited.(21) "Delayed" PR following a hospital admission is still associated with benefits (121) and therefore it is important to re-offer PR to people who initially decline in the immediate post-hospitalisation period.

Clinical Practice Points

- PR should be offered to symptomatic individuals with asthma, bronchiectasis and ILD.
- PR may be helpful in the recovery of subgroups of patients with post-Covid-19 syndrome.
- The assessment, exercise and education components of PR should be adapted for relevant cardiorespiratory diseases, taking into account disease-specific issues.
- The workforce should receive training and be competent to deliver high-quality PR for relevant cardiorespiratory diseases.
- PR practitioners should have the skill set to support prehabilitation interventions for patients awaiting lung cancer and lung transplant surgery, but the current delivery model of PR needs to be adapted in order to be appropriately time sensitive.
- PR practitioners have a role in identifying potential candidates for LVRS.
- Patients with stable CHF, PAH or CTEPH can be incorporated safely within directly supervised outpatient PR programmes.
- Outpatient supervised PR, incorporating both exercise-training and education should be offered to all appropriate patients discharged from hospital after exacerbation of COPD.
- Members of the integrated care team should re-offer "delayed" PR in individuals who decline an initial offer of post-hospitalisation PR.

Research gaps

- Trials to understand the role of PR in the recovery of post-Covid-19 syndrome.
- Trials to determine the optimal timing, setting, nature or duration of exercise-training for post-lung cancer and post-lung transplant surgery.
- Trials to evaluate the effects of PR in hospitalised exacerbations of chronic respiratory disease other than COPD.
- Interventional trials designed to increase referral to and uptake of post-exacerbation PR.
- The role of alternative remote PR models in the post-exacerbation setting.

Section 4: Alternatives Models of Pulmonary Rehabilitation

Barriers to traditional hospital-based PR have been well documented.(17, 122) This has highlighted the need for alternative modes of delivering PR, as these may potentially increase uptake and accessibility.

National audit data show that non-medical, community-based settings are increasingly used to deliver supervised PR in the UK.(6) PR delivered in a community setting has similar efficacy to that produced in a hospital-based setting.(123) Supervised PR using minimal resources have similar efficacy to programmes using specialist exercise equipment.(124)

Home-based rehabilitation spans a range of delivery options ranging from standardised manuals, web-based applications, tele-rehabilitation and face-to-face supervision. Across all these modes, the level and frequency of supervision and contact with a health care professional may vary dramatically. Commissioners need to consider carefully whether alternative models delivered by providers include core components detailed in Table 3. Although some PR models might involve remote supervision, published trials have all incorporated a directly supervised face-to-face, validated exercise test prior to the intervention to evaluate safety and facilitate exercise prescription. A further consideration is digital literacy (10, 11) and avoiding the exclusion of individuals uncomfortable with technology.

Table 3: Core Components of a Pulmonary rehabilitation programme

- An initial face-to-face assessment by a suitably trained health care professional;
- Initial assessment must include a validated exercise test from which an individualised exercise prescription can be obtained;
- Endurance and resistance training, which is individually prescribed and progressed with regular supervision from suitably trained health care professionals;
- A structured education programme;
- Delivered by a dedicated team of health care professionals trained in exercise assessment, prescription and progression and delivery of education on chronic respiratory disease management;
- The programme model, including assessment and delivery components, must have been previously tested in a clinical trial and shown to be safe and effective;
- Measurement of core outcomes before and after PR, including a validated exercise test;
- Participation in regular audit of organisational and clinical outcomes; for example engagement with a recognised national audit programme where available.
- Regular external peer review, for example engagement with a recognised accreditation programme where available.

4.1 Home-based, non-digital

In this model, individual patients are provided with a manual, exercise diary or written material which provides structured exercise and educational components (Table 4). These are usually supported by remote supervision from skilled PR health care professionals. Previous data suggest that this model does improve HRQOL and exercise capacity compared with usual care, although differences are modest.(125) Trials that have compared home-based models supported by manual and telephone support with outpatient, centre-based PR have produced short-term clinical outcomes that are similar to centre-based PR.(126-128) However, an interesting observation is that "gold-standard" centre-based rehabilitation did not produce the expected improvements in exercise capacity. In a real-world study, a home-based, manual-structured programme with weekly telephone supervision produced similar improvements in HRQOL, but smaller changes in exercise capacity, compared to a propensity-matched cohort undergoing twice-weekly centre-based supervised programme.(129)

Although home-based programmes typically involve less frequent staff contact than centre-based approaches, that contact is conducted one-to-one, and therefore data are required to evaluate the cost effectiveness of such an approach. Other home-based therapies include the use of neuromuscular electrical stimulation which improves muscle weakness in those with advanced disease.(130, 131) However, the effect on exercise capacity is unclear.(130, 132).

Table 4: Comparison of Home-based, non-technology versus centre based PR or usual care: summary of selective studies

Study	Population	Intervention / Control	Outcomes
Maltais 2018 (128)	252 with COPD	Home based (including one home visit and weekly telephone calls) versus Outpatient centre based rehabilitation supervised PR for eight weeks. Both groups received four weeks of in-person centre-based education	Similar changes in dyspnoea, health status and exercise capacity at 3 months and 12 months
Holland 2017 (126)	166 with COPD	Home based (including one home visit and weekly telephone calls) programme versus Outpatient centre based supervised PR for eight weeks	Short term clinical outcomes equivalent to centre based PR but neither effective maintenance at 12 months
Horton 2018 (127)	287 with COPD	Structured unsupervised home based programme including a manual and telephone support for seven weeks versus Centre based supervised PR for seven weeks	Evidence of significant gains in CRQ-D at 7 weeks in both groups. Inconclusive that homebased PR was non-inferior to PR in dyspnoea favouring the centre group at 7 weeks
Nolan 2019 (129)	154 with COPD	Home based structured exercise programme with weekly telephone calls versus Centre-based supervised PR for eight weeks	Significant improvements in both groups in exercise capacity but home-based group demonstrated smaller improvements; clinically and statistically significant improvements in QoL within each group. Completion rates were low in both groups

Mitchell 2014 (125)	184 with COPD	Structured unsupervised home based programme including a manual and telephone support for 6-weeks versus usual care	Significant differences between groups in QoL, exercise performance, anxiety, and disease knowledge at 6 weeks; Intervention did not improve dyspnoea over and above usual care at 6 months

PR – Pulmonary rehabilitation; CRQ-D – Chronic respiratory questionnaire – dyspnoea domain; QoL – Quality of life

4.2 Home-based Web Platform

These are similar to home-based models described in 4.1, except that the programme is supported by a web-based platform or app (Table 5). A home-based, online platform, "MyPR", was compared with face-to-face PR delivered in an outpatient setting, and demonstrated that "MyPR" was safe and well tolerated, and non-inferior to the control arm in terms of effects on exercise capacity and symptom scores.(133) However, the trial population was selective (exclusion criteria included exercise-induced oxygen desaturation, functional limitation, comorbidities, poor digital literacy), and the control arm was not a conventional supervised PR programme, but comprised exercise stations matched to those provided by the online platform.(133) Completers of both a home-based interactive web platform "SPACE for COPD" and a standard care outpatient PR programme showed similar improvements in endurance shuttle walk and dyspnoea.(134) However engagement with digital technology was challenging; only 103 of 2646 invited patients were randomised, whilst 57% of the web platform arm dropped out.(134) Both platforms provided an introductory face to face session, with either contact details provided for further queries (133) or weekly contact via email or telephone using a standardised proforma.(134)

Table 5: Comparison of Home-based, web platform versus centre based PR: summary of selective studies

Study	Population	Intervention / Control	Outcomes
Chaplin 2017 (134)	103 with COPD	Web-based programme (SPACE for COPD) of exercise and education versus centre based supervised PR, twice weekly, 2 hourly sessions for 7 weeks (4 weeks supervised; 3 weeks unsupervised)	Interactive web-based PR programme is feasible and acceptable when compared with centre based PR; statistically significant improvements within groups for exercise capacity and dyspnoea but not between groups. Dropout rates were higher in the web-based programme
Bourne 2017 (133)	90 with COPD	6-week Online PR via log in and access to 'myPR' versus a supervised PR programme group sessions in a local rehabilitation facility	Online supported PR was non-inferior to a conventional model delivered in face-to-face sessions in terms of effects on 6MWT distance and symptom scores. Online PR was safe and well tolerated.

SPACE for COPD – Self management programme of activity, coping and education for Chronic obstructive pulmonary disease; PR – Pulmonary Rehabilitation; 6MWT – six minute walk test

4.3 Video Tele-rehabilitation

Video tele-rehabilitation encompasses synchronous real-time PR supported by video-conferencing. A small trial showed that video tele-rehabilitation improved endurance exercise capacity and self-efficacy in patients with COPD when compared with usual care.(135) Two studies have compared video tele-rehabilitation with face-to-face centre-based PR, and shown similar effects on exercise capacity and HRQOL.(136, 137) However the improvements in exercise capacity were modest in both intervention and standard care arms (Table 6). Furthermore, participants were provided with video technology and specialist exercise equipment to use in the home for free, which may not be generalisable to the NHS setting.

Outside of the home-setting, video-conferencing has also been utilised to support satellite tele-rehabilitation centres (“hub and spoke” model).(138, 139) Trials are needed to test the effects of such models on patient throughput, staffing ratios and travelling for patients.(139)

Table 6: Comparison of video tele-rehabilitation versus usual care without exercise or standard care: summary of selective studies

Study	Population	Intervention / Control	Outcomes
Tsai 2017 (135)	37 with COPD	Supervised home-based real-time video tele-rehabilitation (exercise three times/week for eight weeks) versus usual care without exercise training	Statistical, and clinically significant, improvement in endurance shuttle walk time in video tele-rehabilitation group, but underpowered to demonstrate improvements in incremental shuttle walk or six-minute walk
Hansen 2020 (137)	134 with COPD	10-week video tele-rehabilitation programme versus supervised face-to-face rehabilitation	Similar changes in exercise capacity, breathlessness and HRQOL, but changes in both groups very modest and probably not clinically significant
Cox 2021 (136)	142 with chronic respiratory disease (100 with COPD)	Video tele-rehabilitation programme versus supervised centre-based PR, both interventions 8 weeks with 16 sessions	Video-telerehabilitation appeared safe and provided clinically meaningful improvements in dyspnoea and HRQOL, but equivalence to traditional PR not shown

HRQOL – health-related quality of life; PR – pulmonary rehabilitation

4.4 Virtual reality

Virtual reality is an emerging technology that might provide an interactive and visually stimulating approach to providing PR in the home setting.(140) To date, there are few published data, of which most have limitations in the reporting quality.(141) Acceptability is also unknown in a patient population that traditionally have digital hesitancy.(10)

4.5 Active Mind-Body Movement Therapies

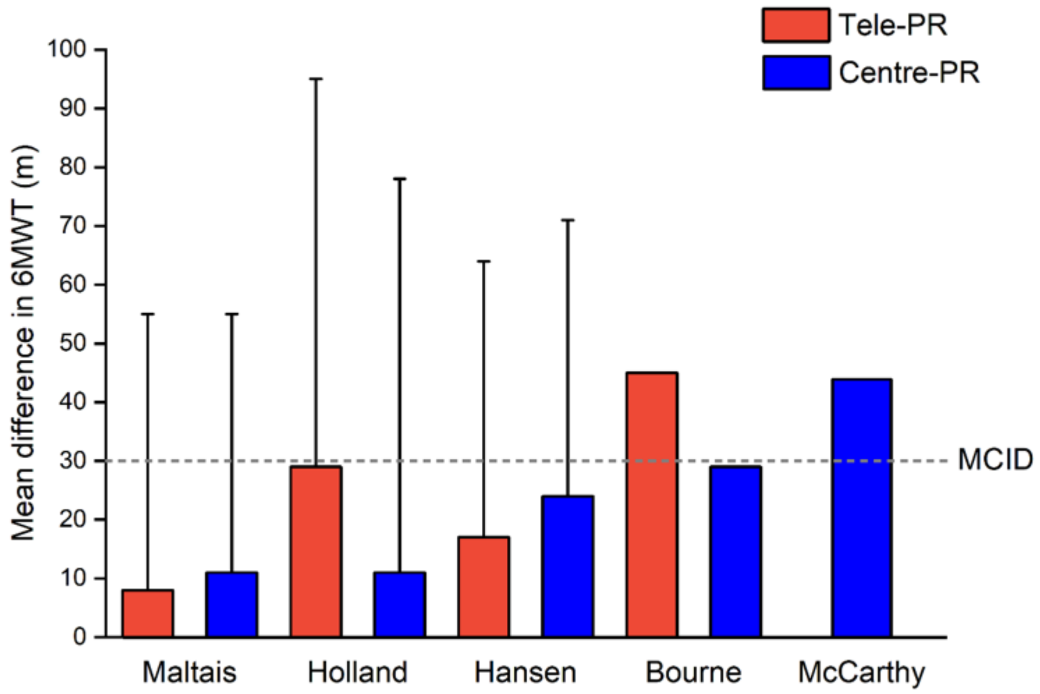
Three systematic reviews have examined the deployment of active mind-body movement therapies as an alternative to pulmonary rehabilitation.(142-144) Two reviews compared Tia' Chi or yoga against non-exercise control groups and identified statistically significant improvements in both exercise capacity and HRQOL, concluding that tai chi or yoga may be a useful adjunct to rehabilitation (142, 143). A later review compared active mind-body movement therapies (largely tai chi and/or qigong) as an adjunct to or in comparison with pulmonary rehabilitation.(144) Overall, the data was of poor quality, the impact on both exercise capacity and HRQOL remained inconclusive, and none conducted in NHS settings.(53) A recent trial directly compared PR (three sessions a week) to Tai Chi (five sessions a week) for 12 weeks.(145) While there were important changes in HRQOL in both groups, neither group reached the minimal clinically important difference for the 6MWT distance.(145) The population was atypical of those usually referred for PR with a pre-PR 6MWT distance of over 500 metres. Standardised reporting is crucial to our understanding and development of these modes of delivery, which is important to attract a more diverse population.(146)

Overall, the outcomes of alternative models of PR have been heterogeneous and studies need to be interpreted with caution. Although systematic reviews have suggested that alternative models of PR achieve outcomes similar to those seen in traditional centre-based PR,(147) the certainty of evidence is limited by the small number of studies with relatively few participants, varying models of care, and whether models are generalisable to the NHS setting. Almost all published data are restricted to COPD.

Notably, a near universal observation is the lower-than-expected benefits associated with the "gold-standard" centre-based arm in equivalence or non-inferiority trials. This may reflect selective trial populations lacking equipoise. Furthermore, systematic reviews of telerehabilitation studies have shown that the mean change in six minute walk distance with telerehabilitation are lower than the established minimum clinically important difference,(147) and lower than that observed with centre-based PR (Figure 1).(2) Real-world observational data have shown that home-based, remotely supervised PR are associated with a smaller magnitude of change in exercise-capacity, about half of that seen in directly supervised, centre-based PR.(129) There is no published data on hybrid models (which combine limited centre-based with home-based PR).

Figure 1

Data taken from two Cochrane reviews a) Cox N et al (147) and McCarthy B et al (2) comparing the 6MWT response data to home-based telerehabilitation and directly supervised PR based interventions. Data for the 4 trials on the left is data from 4 RCT's comparing tele-rehabilitation and centre based rehabilitation, and the data point on the right is combined data from 38 trials included in the Cochrane review of supervised pulmonary rehabilitation which used six minute walk as an outcome.



Clinical Practice Points

- Every individual referred for PR should have the opportunity to access directly supervised, centre-based PR in a timely way as this model is supported by a convincing evidence base.
- In patients who decline or drop out from supervised centre-based PR, providers should offer an alternative model of delivery. Any alternative model should have a supporting evidence base (published trials, ideally in the NHS setting), and incorporate a directly supervised, validated exercise test from which individualised exercise can be prescribed.
- Both staff and patients require training to support alternative PR models, particularly those involving digital technology.
- Commissioners and providers should ensure that the delivery of alternative PR models do not promote digital exclusion.

Research gaps

- Further trials are required to evaluate the efficacy and clinical effectiveness of alternative models of PR, including hybrid models, particularly in the NHS setting.

- An agreed framework for the reporting of technology-based interventions, including core datasets and outcomes.
- Alternative models of PR delivery should be evaluated in chronic respiratory diseases other than COPD.

Section 5: Adjuncts to and Maintenance of Pulmonary Rehabilitation

Since the BTS guideline,(1) several trials have informed on the potential utility of adjunctive strategies to improve PR outcomes.

5.1 Oxygen supplementation

Oxygen supplementation in the experimental setting acutely enhances endurance exercise performance in individuals with COPD.(148-150) However, this has not translated to augmented outcomes in PR. In a multicentre trial, 111 participants with COPD and exercise-induced oxygen desaturation were randomised to receive either supplemental oxygen or room air during an eight-week exercise-training programme.(151) Exercise capacity and HRQOL improved in both groups, with no additional benefit from training with supplemental oxygen.(151) The majority of participants had only modest exercise induced oxygen desaturation, and the acute physiological response to oxygen was not tested prior to the training programme.(152) Limited data exist regarding the role of supplemental oxygen during PR in conditions other than COPD.

5.2 Non-invasive ventilation (NIV)

Systematic reviews and meta-analyses of studies using NIV during supervised exercise training provide conflicting evidence of the benefits. One meta-analysis showed improvements in endurance exercise capacity with the addition of NIV (153), whilst another meta-analysis found similar responses to exercise training between NIV supported and sham arms (154). In hospitalised exacerbations of cystic fibrosis and bronchiectasis, Dyer and colleagues demonstrated that application of NIV could acutely improve endurance cycling time (155), but there were concerns about patient acceptability. Practical considerations include the additional equipment needed and time required to supervise patients on NIV during PR; this is less problematic in those already established on domiciliary NIV.(156)

5.3 Inspiratory muscle training (IMT)

Since the guideline, three large RCTs have investigated the value of IMT as an adjunct to PR. Although IMT improved inspiratory muscle strength, particularly in those with inspiratory muscle weakness,(157) significant additive benefits of IMT to PR in core outcomes such as exercise capacity or HRQOL are less convincing (157-159). Limited and conflicting data exist in respiratory disease other than COPD.(160, 161)

5.4 Physical activity (PA) counselling

Physical inactivity is associated with poor prognosis in COPD.(62) The effects of PR alone on physical activity levels are relatively modest (162). A systematic review demonstrated that PA promotion with pedometers as an adjunct to PR improves step counts/day,(163) although studies were small and results heterogeneous. A trial conducted in the NHS setting randomised 152 participants with COPD to an eight-week PR programme either with or without pedometer-directed step targets reviewed weekly.(164) No significant differences in change in time spent in moderate intensity activity, exercise capacity or HRQOL were seen between groups.(164) Studies exploring behavioural counselling as an adjunct to PR, typically using motivational interviewing, have produced mixed results.(165-167) As discussed in Section 2.4, PA data collection and reporting should conform to international consensus recommendations.(62)

5.5 Maintenance of pulmonary rehabilitation

The beneficial effects of PR decline over one year.(168) The previous BTS guidelines recommended that PR graduates should be encouraged to continue exercise. However the format and delivery of maintenance programmes reported in the literature vary significantly.(169)

The evidence for maintenance programmes after PR are inconsistent (Table 7). A Cochrane review of supervised maintenance programmes showed clinically important improvements in HRQOL with maintenance intervention but no significant differences in exercise capacity.(170) In contrast, the long-term efficacy of PR with home-based or low frequency maintenance programmes showed improved maintenance of exercise capacity but no differences in HRQOL.(171)

Further studies are needed to explore the optimal frequency and duration of supervised and unsupervised maintenance programmes, and the cost-effectiveness of such programmes compared with alternative approaches (e.g. repeated PR offers).

Table 7: Systematic Reviews of Maintenance PR: summary of selective studies

Study	Number of trials	Review question	Results
Malaguti, 2021 (170)	21 RCTs	Supervised maintenance programmes following pulmonary rehabilitation compared to usual care for COPD.	Supervised maintenance programmes not associated with increased adverse events, may improve health-related quality of life, and could improve exercise capacity at 6-12 months. Strength of evidence was limited (high risk of bias and small sample size).
Imamura, 2020 (171)	7 RCTs	Long-term efficacy of pulmonary rehabilitation with home-based or low frequent maintenance programs in COPD patients compared to those who had no maintenance programme.	PR with maintenance significantly improved 6MWD, but not HRQOL was observed.
Jenkins, 2018 (174)	8 RCTs	Efficacy of supervised maintenance exercise programmes following pulmonary rehabilitation compared to usual care on health care use.	Supervised maintenance exercise led to clinically important reduction in the rate of respiratory-cause hospital, overall risk of an exacerbation and mortality).
Busby, 2014 (175)	8 RCTs	Review of existing maintenance interventions following pulmonary rehabilitation	Most studies showed initial positive intervention effects, which declined to non-significance within 3-12 months after completion of maintenance.

Clinical Practice Points

- Oxygen supplementation should not be routinely used as an adjunct to PR except in individuals already established on long-term or ambulatory oxygen therapy.
- NIV should not be routinely used as an adjunct to PR in those naïve to domiciliary NIV, but could be offered to those already established on domiciliary NIV.
- IMT, as an adjunct to PR, is associated with improvements in muscle function, but this has not translated to improvements in core outcomes.
- PA counselling should be a core component of the PR educational component. The use of pedometers or/and additional PA counselling as adjuncts to PR require further evaluation.
- PR programmes should deliver self-management education and advice around the importance of regular exercise after the PR programme has been completed. There is insufficient evidence to support the routine formal delivery of maintenance programmes

Research gaps

- The role of oxygen supplementation during PR in specific subgroups: severe exercise induced oxygen desaturation (e.g. below 80%), those who demonstrate acute physiological response to oxygen.
- Understanding the role of behavioural change on physical activity promotion and maintenance of the benefits of PR.
- Optimising the frequency, duration and content of supervised and unsupervised maintenance programmes with concomitant assessment of cost-effectiveness.
- Trials comparing maintenance interventions with repeated PR.

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