



British Thoracic Society guideline on pulmonary rehabilitation in adults

Charlotte E Bolton,¹ Elaine F Bevan-Smith,² John D Blakey,³ Patrick Crowe,⁴ Sarah L Elkin,⁵ Rachel Garrod,⁶ Neil J Greening,⁷ Karen Heslop,⁸ James H Hull,⁹ William D-C Man,¹⁰ Michael D Morgan,⁷ David Proud,¹¹ C Michael Roberts,¹² Louise Sewell,⁷ Sally J Singh,¹³ Paul P Walker,³ Sandy Walmsley,¹⁴
British Thoracic Society Pulmonary Rehabilitation Guideline Development Group,
on behalf of the British Thoracic Society Standards of Care Committee

► Additional material is published online only. To view please visit the journal online (<http://dx.doi.org/10.1136/thoraxjnl-2013-203808>).

For numbered affiliations see end of article.

Correspondence to

British Thoracic Society,
17, Doughty Street,
London WC1N 2PL, UK;
bts@brit-thoracic.org.uk and
Dr Charlotte E Bolton,
Nottingham Respiratory
Research Unit, University of
Nottingham, Clinical Sciences
Building, City Hospital campus,
Hucknall road, Nottingham,
NG5 1PB, UK;
charlotte.bolton@nottingham.
ac.uk

SUMMARY OF RECOMMENDATIONS

The role of pulmonary rehabilitation

- Pulmonary rehabilitation should be offered to patients with chronic obstructive pulmonary disease (COPD) with a view to improving exercise capacity by a clinically important amount. (Grade A)
- Pulmonary rehabilitation should be offered to patients with COPD with a view to improving dyspnoea and health status by a clinically important amount. (Grade A)
- Different components within a pulmonary rehabilitation programme, such as resistance training, can influence quadriceps strength and this is addressed in the section 'Nature of training of these guidelines'. (✓)
- Pulmonary rehabilitation should be offered to patients with COPD with a view to improving psychological wellbeing. (Grade A)
- As a minimum, efficacy of pulmonary rehabilitation programmes needs to be regularly assessed by demonstrating clinically important improvements in exercise capacity, dyspnoea and health status. (Grade B)
- As part of regular assessment, patient satisfaction and feedback should be sought. (✓)

Referral and assessment of patients for pulmonary rehabilitation

- The point of referral to pulmonary rehabilitation should be used as an opportunity to explore the patient's understanding of pulmonary rehabilitation, address concerns and to educate patients about the benefits of a pulmonary rehabilitation programme. (✓)
- Healthcare professionals making referrals to pulmonary rehabilitation should have basic knowledge about what a programme entails and effectiveness. A pulmonary rehabilitation programme should be presented by the referrer as a fundamental treatment for COPD rather than an optional extra. (✓)
- Initial assessment for pulmonary rehabilitation provides an opportunity to assess and refer for treatment of comorbidities prior to commencing. (✓)
- The setting of pulmonary rehabilitation, skill mix of the team and other comorbidities should always be considered in the risk assessment of patients entering a rehabilitation programme. (✓)

Specific situations at assessment

Smoking

- Patients with COPD should be referred for pulmonary rehabilitation regardless of their smoking status. (Grade D)
- Patients referred to pulmonary rehabilitation should have their smoking status assessed and referral to smoking cessation services offered to smokers simultaneously. (✓)
- Pulmonary rehabilitation provides opportunities to offer smoking cessation advice. (✓)

Chronic respiratory failure

- Patients with COPD can be referred for pulmonary rehabilitation regardless of whether or not they have chronic respiratory failure. (Grade D)
- When considering the referral of patients with chronic respiratory failure, practitioners should reflect on the receiving setting and skill mix of the attending staff to provide safe pulmonary rehabilitation to these patients who have significant physiological impairment and potential for greater instability by the intended programme. (✓)

Cardiovascular disease comorbidity

- People with chronic respiratory disease should be referred to pulmonary rehabilitation irrespective of coexistent stable cardiovascular disease. (Grade D)
- A coexistent abdominal aortic aneurysm (AAA) <5.5 cm should not preclude referral to pulmonary rehabilitation and being included in moderate intensity aerobic exercise training, provided blood pressure is controlled. (Grade D)
- The referral process and/or the initial assessment for pulmonary rehabilitation offer an important opportunity to assess and optimise cardiovascular health and address risk factors for cardiovascular disease. (✓)
- In patients with COPD who have an AAA >5.5 cm, deemed not fit for surgery, pulmonary rehabilitation incorporating mild-moderate intensity aerobic exercise may be considered, but should not include resistance training. (✓)

Anxiety and depression

- Coexistent symptoms of anxiety and/or depression in patients with COPD should not preclude referral to pulmonary rehabilitation. (Grade D)

To cite: Bolton CE, Bevan-Smith EF, Blakey JD, *et al.* *Thorax* 2013;**68**:ii1-ii30.

- ▶ The referral process and the assessments for pulmonary rehabilitation offer important opportunities to detect and consider referral for ongoing support and management for depression. (✓)

MRC dyspnoea scale

- ▶ Patients with a Medical Research Council (MRC) Dyspnoea score of 3–5 who are functionally limited by breathlessness should be referred for outpatient pulmonary rehabilitation. (Grade A)
- ▶ Patients with a MRC dyspnoea score of 2 who are functionally limited by breathlessness should be referred for pulmonary rehabilitation. (Grade D)
- ▶ Patients with a MRC dyspnoea score of 5 who are house-bound should not routinely be offered supervised pulmonary rehabilitation within their home. (Grade B)
- ▶ Flexible and pragmatic approaches should be considered to facilitate exercise training in patients who have less severe COPD and who are less breathless. (✓)

Bronchodilator therapy

- ▶ Patients with COPD should be taking bronchodilator therapy in line with National Institute for Health and Clinical Excellence (NICE) COPD guidelines prior to referral to pulmonary rehabilitation. (Grade D)
- ▶ Pulmonary rehabilitation offers an opportunity to check and optimise inhaler technique. (✓)

Other considerations regarding referral to pulmonary rehabilitation

- ▶ Patients with unstable cardiac disease or locomotor difficulties that preclude exercise (eg, severe arthritis or severe peripheral vascular disease) should not be referred for pulmonary rehabilitation. (✓)
- ▶ Careful consideration should be given to patients who have significant cognitive or psychiatric impairment that would lead to an inability to follow simple commands in a group setting. (✓)
- ▶ In certain individual cases, facilitation of pulmonary rehabilitation may be aided by the support and attendance of a relative or carer. (✓)
- ▶ In case of doubt over the appropriateness of a patient for pulmonary rehabilitation, clinicians are advised to contact their local provider. (✓)

Structure of pulmonary rehabilitation

Frequency of supervised pulmonary rehabilitation sessions

- ▶ Pulmonary rehabilitation programmes should be a minimum of twice-weekly supervised sessions. (Grade D)
- ▶ In line with published pulmonary rehabilitation studies and the outcomes they demonstrate, a third session of prescribed exercise is recommended. This can be performed unsupervised. (✓)
- ▶ Encouragement of regular physical activity five times a week for 30 min each time is encouraged in line with standard healthy living advice. (✓)

Duration of pulmonary rehabilitation programmes

- ▶ Pulmonary rehabilitation programmes of 6–12 weeks are recommended. (Grade A)
- ▶ Pulmonary rehabilitation programmes including the attendance at a minimum of 12 supervised sessions are recommended, although individual patients can gain some benefit from fewer sessions. (Grade A)

- ▶ If training for less than 6 weeks is considered, this should be individualised and objective/subjective measures of benefit in place before patients graduate. For some individuals, reassessment at 4 weeks and graduation to independent gym training is a feasible possibility. (✓)

Rolling or cohort programmes

- ▶ Cohort or rolling programmes of pulmonary rehabilitation are both acceptable forms of delivery depending on local considerations. (Grade D)

Nature of training

- ▶ To ensure strength and endurance benefits in patients with COPD, a combination of progressive muscle resistance and aerobic training should be delivered during a pulmonary rehabilitation programme. (Grade B)
- ▶ Relevant expertise is required to deliver resistance training. (✓)
- ▶ Patients should be capable of continuing effective resistance training once supervised sessions have ended. The supervising rehabilitation therapist should ensure that patients are able and willing to continue with unsupervised resistance training. (✓)
- ▶ Prescribing of progressive strength exercise should be individualised for each patient, taking into consideration the initial health screening and any increase in risk from comorbidities. (✓)

Interval and continuous aerobic training

- ▶ Interval and continuous training can be applied safely and effectively within the context of pulmonary rehabilitation to patients with COPD. (Grade A)
- ▶ The choice of interval or continuous training will be down to the patient and/or therapist preference. (✓)
- ▶ In clinical practice, interval training may require a higher therapist to patient ratio to ensure adequate work rate and rest intervals are achieved compared with continuous training. (✓)

Goal setting in pulmonary rehabilitation

- ▶ Generic exercise training as opposed to individually targeted exercise training is recommended for pulmonary rehabilitation. (Grade D)
- ▶ While generic exercise training is recommended as opposed to an individually targeted exercise programme, the prescription of exercise is individualised to provide correct intensity. (✓)
- ▶ Besides the exercise elements of pulmonary rehabilitation, healthcare professionals commonly use goal setting to address specific hurdles. Given the personalised nature of this intervention to a patient's needs, evidence is difficult to quantify. (✓)
- ▶ The term 'goal setting' may require discussion with the patient. (✓)

Supervision in pulmonary rehabilitation

- ▶ A supervised pulmonary rehabilitation programme is recommended for patients with COPD. (Grade A)
- ▶ If considering a structured home-based rehabilitation programme for patients with COPD, the following important factors need careful consideration: mechanisms to offer remote support and/or supervision, provision of home exercise equipment and patient selection. (Grade B)
- ▶ There would be some benefit to increasing the options for pulmonary rehabilitation available to individuals with COPD, and increase the scope of the service. Geography may limit or stimulate options. (✓)

Post-exacerbation pulmonary rehabilitation

Outcomes in post-exacerbation pulmonary rehabilitation

- ▶ Patients hospitalised for acute exacerbation of COPD should be offered pulmonary rehabilitation at hospital discharge to commence within 1 month of discharge. (Grade A)
- ▶ Providing post-exacerbation pulmonary rehabilitation alongside elective pulmonary rehabilitation courses can cause practical issues. Evaluation of innovative ways of delivering a combination of both modes of pulmonary rehabilitation in tandem would be useful. (√)

Completion of post-exacerbation pulmonary rehabilitation

- ▶ Clinical services providing post-exacerbation pulmonary rehabilitation commencing within 1 month of hospital discharge should carefully record uptake, adherence and completion rates. (Grade D)
- ▶ Patients who initially decline pulmonary rehabilitation commencing within 1 month of hospital discharge should be offered elective pulmonary rehabilitation. (Grade D)

Adjuncts to pulmonary rehabilitation

Inspiratory muscle training and pulmonary rehabilitation

- ▶ Inspiratory muscle training (IMT) is not recommended as a routine adjunct to pulmonary rehabilitation. (Grade B)

Hormones and nutritional supplements and pulmonary rehabilitation

- ▶ No specific hormonal or nutritional supplement can currently be recommended as a routine adjunct to pulmonary rehabilitation. (Grade B)
- ▶ The optimal approaches for addressing malnutrition, sarcopenia or obesity in COPD are uncertain and this is a wider issue than this guideline covers. However, attendance at a pulmonary rehabilitation course presents an ideal opportunity to screen and educate patients on nutrition. (√)
- ▶ Patients with a body mass index (BMI) in the underweight or obese range should be considered for specific dietetic support. (√)

Non-invasive ventilation during pulmonary rehabilitation

- ▶ Long-term domiciliary non-invasive ventilation (NIV) should not be provided for the sole purpose of improving outcomes during pulmonary rehabilitation. (Grade D)
- ▶ Patients who already receive long-term domiciliary NIV for chronic respiratory failure should be offered the opportunity to exercise with NIV during pulmonary rehabilitation if acceptable and tolerable to the patient. (Grade D)

Supplemental oxygen in patients undergoing rehabilitation

- ▶ Supplemental oxygen should not be routinely used for all patients undergoing pulmonary rehabilitation. (Grade B)
- ▶ Supplemental oxygen during pulmonary rehabilitation should be offered to those who fulfil the assessment criteria for long-term or ambulatory oxygen unless there are compelling clinical reasons to use alternative criteria. (Grade D)
- ▶ Individuals who are prescribed oxygen but decline to use it during exercise should have this clearly documented in their notes. (√)
- ▶ Pulmonary rehabilitation provides an opportunity to assess the adequacy of the prescribed flow rate for patients already in receipt of long-term oxygen therapy (LTOT) or ambulatory oxygen. (√)

Supplemental heliox in patients undergoing rehabilitation

- ▶ Heliox should not be used as an adjunct to pulmonary rehabilitation unless there are comorbidities which require its administration. (Grade D)

Neuromuscular electrical stimulation and pulmonary rehabilitation

- ▶ If expertise in neuromuscular electrical stimulation (NMES) is available, selected patients (low BMI with evidence of quadriceps weakness) who are unable or unwilling to participate in pulmonary rehabilitation could be considered for NMES. (Grade D)

Pulmonary rehabilitation in people with other chronic respiratory diseases

Non-cystic fibrosis bronchiectasis

- ▶ Patients with non-cystic fibrosis (CF) bronchiectasis who have breathlessness affecting their activities of daily living (ADL) should have access to and be considered for pulmonary rehabilitation. (Grade D)
- ▶ Unlike in patients with CF, in patients with COPD and non-CF bronchiectasis with multidrug-resistant organisms, for example *Pseudomonas aeruginosa*, there is no current evidence of cross infection. (√)

Interstitial lung diseases

- ▶ The benefits of exercise and the recommendation of incorporating exercise activities into a healthy lifestyle should be discussed with all patients with interstitial lung disease (ILD). Such discussion needs to be tailored to realistic achievability for that person's condition. (√)
- ▶ If healthcare professionals consider referring certain patients with stable ILD who are limited by breathlessness in ADL to pulmonary rehabilitation, they should discuss with the patient the likely benefits. (√)
- ▶ Patients with idiopathic pulmonary fibrosis (IPF) have a potential for significant desaturation during exercise related activities. (√)

Asthma

- ▶ The routine referral of patients with asthma to pulmonary rehabilitation is not recommended. (Grade D)
- ▶ The benefits of exercise and the recommendation of incorporating exercise activities into a healthy lifestyle should be discussed with all patients with asthma. (√)
- ▶ If healthcare professionals consider referring certain patients with stable asthma who are limited by breathlessness in ADL to pulmonary rehabilitation when on optimal therapy, they should discuss with the patient the likely benefits. (√)
- ▶ The British Thoracic Society (BTS)/Scottish Intercollegiate Guidelines Network (SIGN) asthma guideline draws attention to exercise-induced asthma and precautions to prevent this should be followed if appropriate. (√)

Other chronic respiratory diseases—in general

- ▶ Minimal clinically important different (MCID) changes and tools used to assess exercise capacity and quality of life for pulmonary rehabilitation in COPD are not necessarily transferable to other chronic respiratory diseases. While future research should address this, failure of rehabilitation should not be implied if failure to reach the COPD MCID for outcomes. (√)

- ▶ The educational element of pulmonary rehabilitation should be adapted for other chronic respiratory diseases if appropriate. (√)
- ▶ Practically, inclusion of patients with other chronic respiratory diseases into pulmonary rehabilitation will be alongside subjects with COPD. (√)
- ▶ General exercise should be encouraged for all patients with chronic respiratory disease. (√)

Post pulmonary rehabilitation

Repeat pulmonary rehabilitation programmes

- ▶ Repeat pulmonary rehabilitation should be considered in patients who have completed a course of pulmonary rehabilitation more than 1 year previously. The likely benefits should be discussed and willing patients referred. (Grade B)
- ▶ Earlier repeat pulmonary rehabilitation should be considered in individuals with accelerated physiological decline or if additional benefits on a shorter timescale would be clinically valuable. (Grade D)
- ▶ It is unlikely that if the patient completed the pulmonary rehabilitation course originally and failed to gain a benefit, they would benefit a second time round, unless circumstances such as an exacerbation interrupted the initial programme. (√)

Maintenance

- ▶ All patients completing pulmonary rehabilitation should be encouraged to continue to exercise beyond the programme. (Grade A)
- ▶ Patients graduating from a pulmonary rehabilitation programme should be provided with opportunities for physical exercise beyond their rehabilitation programme. (√)

INTRODUCTION

Aim

Pulmonary rehabilitation has established itself as a key management strategy in people with chronic respiratory disease. The role of pulmonary rehabilitation has recently been highlighted in the Department of Health's 'An outcomes strategy for COPD and asthma in England'.¹ Since the BTS statement on pulmonary rehabilitation 2001, there has been a significant expansion in the literature for pulmonary rehabilitation.² This literature has contributed to our understanding of outcomes and markers of pulmonary rehabilitation, referral characteristics and patient selection, optimal programme structure, potential adjuncts to the main rehabilitation content, pulmonary rehabilitation in different settings such as following an exacerbation and maintaining the benefits of the programme after completion of the course. The UK model of pulmonary rehabilitation is not fully reflected in the American Thoracic Society/European Respiratory Society statement while other guidelines referring to pulmonary rehabilitation have either been disease or modality specific.³⁻⁵ There is a need to provide a UK evidence-based guideline for pulmonary rehabilitation in adult patients with chronic respiratory disease in an outpatient setting.

For the purposes of the development of the guidelines, the Guideline Development Group (GDG) adopted the following working definition of pulmonary rehabilitation, broadly based on the NICE COPD guidelines: 'Pulmonary rehabilitation can be defined as an interdisciplinary programme of care for patients with chronic respiratory impairment that is individually tailored and designed to optimise each patient's physical and social performance and autonomy. Programmes comprise individualised exercise programmes and education'.³

Target audience

The BTS pulmonary rehabilitation guideline is aimed primarily at practitioners within the UK. This includes doctors, nurses, physiotherapists, dieticians, occupational therapists and other healthcare professionals. It may be of relevance to other healthcare systems. It is intended to inform those conducting pulmonary rehabilitation and also those who manage patients with chronic respiratory disease who may be referred into a rehabilitation scheme.

SCOPE

Population: people with chronic respiratory disease, focusing on COPD.

Populations not covered: children.

Healthcare setting: primary and secondary care.

Topics:

- The role of pulmonary rehabilitation.
- Referral and assessment.
- Structure of pulmonary rehabilitation including organisation and content.
- Post-exacerbation rehabilitation.
- Adjuncts to pulmonary rehabilitation.
- Other chronic respiratory diseases.
- Post pulmonary rehabilitation.

Topics not covered:

- Diagnosis and optimising COPD therapy otherwise.
- Peri-exacerbation inpatient exercise regimes.
- Elective inpatient pulmonary rehabilitation.*
- Multidisciplinary care of cystic fibrosis.
- Pre-surgery and post-surgery pulmonary rehabilitation (including lung cancer).
- It was not possible to comprehensively cover all chronic respiratory diseases.
- Patient support groups.
- Healthcare costs/cost effectiveness.

*While not covered specifically, occasionally inpatient pulmonary rehabilitation literature has been referred to in the absence of outpatient literature on a subject. This has been stated at the appropriate place.

The guideline refers to the NICE COPD guideline 2010, NICE commissioning guidelines, the BTS bronchiectasis guideline 2010 and the BTS/SIGN asthma guideline.³⁻⁸ It does not overlap with details of other guidelines, such as smoking cessation, but clearly should dovetail.

METHODOLOGY

This guideline is based on the best available evidence. The methodology used to write the guideline adheres strictly to the criteria as set by the AGREE collaboration, which is available online <http://www.agreetrust.org/resource-centre/agree-ii/>. The BTS Standards of Care Committee (SOCC) guideline production manual is available at www.brit-thoracic.org.uk/guidelines.aspx

Clinical questions and literature search

Clinical questions were structured in the PICO (Patient, Intervention, Control, Outcome) format (web appendix 1) to define the scope of the guideline and inform the literature search.

Systematic electronic database searches were conducted to identify potentially relevant studies for inclusion in the guideline. For each topic area, the following databases were searched: Ovid MEDLINE (including MEDLINE In Process), Ovid EMBASE, and the Cochrane Library (including the Cochrane

Database of Systematic Reviews, the Database of Abstracts of Reviews of Effects) from 1980.

The searches were first run in August 2011 and updated in September 2012 (web appendix 2). Searches included a combination of indexed terms and free text terms and were limited to English language publications only. The initial search identified 2087 potential abstracts and the second search 173.

Appraisal of literature

Appraisal was performed to be compliant with the AGREE collaboration. Four individuals (JDB, CEB, NJG and JHH) read the title and abstract of each article retrieved by the literature searches and decided whether the paper was definitely relevant, possibly relevant or not relevant to the project. Criteria formulated for categorising the abstracts into these three groups were:

- Whether the study addressed the clinical question.
- Whether the appropriate study type was used to produce the best evidence to answer the clinical question.
- Review articles were excluded.
- Abstract was in English.
- Abstracts were not rejected on the basis of the journal of publication, country in which the research was performed or published, or the date of publication.

The full paper was obtained for all relevant or possibly relevant abstracts and allocated to the relevant section(s) of the guideline.

The first screening process identified 472 of the initial 2087 reference abstracts to be definitely or possibly relevant to the guideline. Two guideline reviewers per section independently reviewed the abstracts to identify papers to be appraised for the guideline (appendix A). The two reviewers for each section then independently appraised each paper assigned to them using the SIGN critical appraisal checklists. The reliability of the evidence in each individual study was graded using the SIGN critical appraisal checklists and is shown in the evidence tables (++ , + or –). The body of evidence for each recommendation was summarised into evidence statements and graded using the SIGN grading system (see table 1). Disagreements were resolved by discussion with the section partner. The second literature search in September 2012 yielded 173 reference abstracts. Of these, 50 were identified as definitely or possibly relevant to the guideline. However, all of the

pertinent ones from this search had been identified by the GDG in the meantime and already incorporated.

Considered judgement and grading of evidence

The GDG used the evidence tables to judge the body of evidence and grade recommendations for this guideline. Evidence tables, web appendices 3 and 4, are available online. When evidence was lacking to answer the formulated clinical questions, expert opinions were obtained through consensus. The following were considered in grading the recommendations:

- The available volume of the body of evidence.
- How applicable the obtained evidence was in making recommendations for the defined target audience of this guideline.
- Whether the evidence was generalisable to the target population for the guideline.
- Whether there was a clear consistency in the evidence obtained to support recommendations.
- What the implications of recommendations would be on clinical practice in terms of resources and skilled expertise.
- Cost effectiveness was not reviewed in detail as in-depth economic analysis of recommendations falls beyond the scope of this guideline.

Recommendations were graded from A to D as indicated by the strength of the evidence, as shown in table 2. In line with SIGN guidance, ‘minus’ evidence was considered in context, but in the absence of other ‘plus’ supporting evidence, it was discussed among the GDG regarding that point and any recommendation made was grade D. Important practical points lacking any research evidence, and not likely to be research evidence, were highlighted as ‘good practice points’. (✓)

Drafting the guideline

The GDG corresponded regularly by email and meetings of the full group were held in March and June 2011, January, March, May and September 2012. A lay summary was written (appendix D). The BTS SOCC reviewed the draft guideline in November 2012. The draft guideline was presented and discussed at the Winter BTS meeting in December 2012 and a draft was subsequently available online in December 2012/January 2013 for public consultation. A draft guideline

Table 1 Key to evidence statements

Grade	Evidence
1++	High-quality meta-analyses, systematic reviews of randomised controlled trials (RCTs), or RCTs with a very low risk of bias
1+	Well conducted meta-analyses, systematic reviews of RCTs, or RCTs with a low risk of bias
1–	Meta-analyses, systematic reviews of RCTs, or RCTs with a high risk of bias
2++	High-quality systematic reviews of case–control or cohort studies or high-quality case–control or cohort studies with a very low risk of confounding, bias or chance and a high probability that the relationship is causal
2+	Well conducted case–control or cohort studies with a low risk of confounding, bias or chance and a moderate probability that the relationship is causal
2–	Case–control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal
3	Non-analytic studies, for example, case reports, case series
4	Expert opinion

Table 2 Grades of recommendations

Grade	Type of evidence
A	At least one meta-analysis, systematic review, or randomised controlled trial (RCT) rated as 1++ and directly applicable to the target population <i>or</i> A systematic review of RCTs or a body of evidence consisting principally of studies rated as 1+ directly applicable to the target population and demonstrating overall consistency of results
B	A body of evidence including studies rated as 2++ directly applicable to the target population and demonstrating overall consistency of results <i>or</i> Extrapolated evidence from studies rated as 1++ or 1+
C	A body of evidence including studies rated as 2+ directly applicable to the target population and demonstrating overall consistency of results <i>or</i> Extrapolated evidence from studies rated as 2++
D	Evidence level 3 or 4 <i>or</i> Extrapolated evidence from studies rated as 2+
✓	Important practical points for which there is no research evidence, nor is there likely to be any research evidence. The guideline committee wishes to emphasize these as Good Practice Points.

document was circulated to all the relevant stakeholders for consultation in December 2012/January 2013 (appendix B). The BTS SOCC re-reviewed the revised draft guideline in March 2013 and final SOCC approval was granted in April 2013.

The GDG members adhered to the BTS policy for the Declaration of Interests (available on BTS website or by contacting BTS Head Office). The BTS pulmonary rehabilitation guideline will be reviewed within the next 5 years.

EVIDENCE

Chronic respiratory diseases are common worldwide, including in the UK, and are associated with significant morbidity and premature mortality. Such chronic respiratory diseases affect more than 10% of the population and include COPD, bronchiectasis, ILDs and asthma. They have significant impact on quality of life and physical functioning. Although primarily respiratory conditions with symptoms including dyspnoea, there are important contributing systemic consequences, including loss of skeletal muscle mass and function. The bulk of the pulmonary rehabilitation literature is based on COPD, where impairments including airflow obstruction, increased work of breathing, skeletal muscle dysfunction and deconditioning. Psychological wellbeing is also markedly affected by this chronic physical and social impairment, accompanied by the possibility of abrupt decline.

Pulmonary rehabilitation programmes have been developed to provide a framework for the delivery of individualised exercise programmes and disease-related educational sessions. This guideline describes the current state of the evidence on the effects of pulmonary rehabilitation in study settings. The document also provides recommendations on the practical aspects of delivering pulmonary rehabilitation. Such guidance would appear to be timely given national audit data suggesting marked variation in the services provided under the banner of 'pulmonary rehabilitation'. Referral criteria, course length, programme contributors, staff training and service evaluation differ markedly across the UK.^{9 10}

The role of pulmonary rehabilitation

One of the principle functions of pulmonary rehabilitation is to improve the symptoms of patients with chronic respiratory diseases. In the following section, the role of pulmonary rehabilitation in different outcome measures and markers is reviewed. The literature in this section is based on patients with COPD given that the core evidence for pulmonary rehabilitation is in patients with COPD. The section sets the scene as to why pulmonary rehabilitation should be considered as routine care.

Given the complex nature of the intervention, numerous outcome measures are used to capture the benefits. The conventional outcome measures include those reflecting a change in exercise capacity, quality of life, symptoms and levels of anxiety and depression. The field is continually widening, with other important patient-related outcome measures—for example, physical activity—being studied.

Exercise capacity

Change in exercise capacity following pulmonary rehabilitation has been subject to a Cochrane Review (updated 2009).¹¹ In this review a meta-analysis of the 13 trials in relation to maximal exercise capacity measured by a cycle ergometer test (268 patients received pulmonary rehabilitation, 243 received usual care) showed the weighted mean difference was 8.43 W. Other studies used other measures of maximal exercise capacity. In an adequately powered randomised controlled trial (RCT),

Griffiths *et al*¹² showed a between-group difference in incremental shuttle walk test (ISWT) scores of 75.9 m favouring the pulmonary rehabilitation group upon completion of the programme. Singh *et al*¹³ reported the minimally clinical important improvement for ISWT of 47.5 m. The Cochrane review also described a treatment effect of 48 m favouring pulmonary rehabilitation in a meta-analysis of 16 trials (346 patients received pulmonary rehabilitation, 323 received usual care) that used the 6 min walk test (6MWT) to measure functional exercise capacity.¹⁴ The minimally clinically important difference for the 6MWT in subjects with COPD is 54 m.¹⁵ Different values have been published using alternative approaches.

Evidence statement

► Exercise capacity improves with pulmonary rehabilitation compared with usual care. (Evidence level 1++)

Recommendation

► Pulmonary rehabilitation should be offered to patients with COPD with a view to improving exercise capacity by a clinically important amount. (Grade A)

Dyspnoea and health status

In the same Cochrane review the effect of pulmonary rehabilitation on dyspnoea and health status were also reviewed.¹¹ This meta-analysis included Chronic Respiratory Questionnaire (CRQ) data showing an unequivocal reduction in dyspnoea following pulmonary rehabilitation. The other CRQ domains of fatigue, emotional function and patients' sense of control (mastery) were also shown to improve. In fact, the lower limits of all domains of the CRQ were found to exceed the MCID of 0.5 points, indicating that a significant clinical improvement in health status follow pulmonary rehabilitation.¹⁶ The St Georges Respiratory Questionnaire (SGRQ) scores were also subject to a meta-analysis in the Cochrane review. This demonstrated that the weighted mean difference of the six trials reported exceeded the MCID of 4 for the total and domain scores.¹⁶ Subsequently, other tools for health status such as the COPD assessment test (CAT) have been found to be responsive to pulmonary rehabilitation.^{17–19}

Evidence statements

► Dyspnoea improves with pulmonary rehabilitation compared with usual care. (Evidence level 1++)

► Health status improves with pulmonary rehabilitation compared with usual care. (Evidence level 1++)

Recommendation

► Pulmonary rehabilitation should be offered to patients with COPD with a view to improving dyspnoea and health status by a clinically important amount. (Grade A)

Physical activity

There has been increasing interest in physical activity, as inactivity has been linked with reduced survival, poorer quality of life and increased healthcare utilisation.^{20–22} A recent systematic review and meta-analysis of physical activity was unable to find any published RCT examining the effect of pulmonary rehabilitation compared with usual care.²³ They reviewed two randomised trials and five single-group interventional studies.^{24 25} They concluded that current data suggest supervised exercise training may lead to a small but statistically significant effect on activity but the lack of a control limited interpretation. One of the randomised trials reported significant improvements in physical activity compared with a 'pre-control group' but patients in this group went on to receive a pulmonary rehabilitation intervention.²⁵ One of the single group studies reported no change at 3 months but improvement with 6 months of rehabilitation.²⁶ In summary, a consistent finding is a small increase in physical

activity following pulmonary rehabilitation, though its clinical significance is unknown.

Evidence statement

- ▶ Physical activity improves modestly with pulmonary rehabilitation. (Evidence level 2+)

Activities of daily living

Increased independence in ADL remains an important aim of pulmonary rehabilitation. However, the impact of pulmonary rehabilitation upon ADL has not yet been reported in a RCT. Measurement of physical activity with activity monitors provides a snapshot of the quantity of activity but does not provide information with regard to individual task completion. Self-reported measures of ADL have been shown to be reliable and sensitive to change following pulmonary rehabilitation programmes in the UK. These include the Canadian Occupational Performance Measure (COPM), London Chest ADL (LCADL) Scale, Manchester Respiratory ADL Scale and the Pulmonary Functional Status and Dyspnoea Questionnaire.^{27–30} Prospective uncontrolled studies suggest that pulmonary rehabilitation does impact on ADL.^{25 31 32} Sewell *et al*²⁵ compared an individualised exercise programme with a generic exercise programme and demonstrated statistically significant within-group improvements in COPM performance and satisfaction scores for both treatment groups. A further uncontrolled study has shown improvements in LCADL Scale scores.³¹ A small study of 22 patients compared three measures of self-reported ADL and concluded that the LCADL and modified version of the pulmonary functional status and dyspnoea questionnaire (PFSDQ-M) were more responsive than the MRC scale.³² However, the impact of pulmonary rehabilitation upon ADL has not been reported in a RCT comparing pulmonary rehabilitation with usual care.

Evidence statement

- ▶ Self-reported measures of ADL improve following pulmonary rehabilitation. (Evidence level 2+)

Muscle strength

Muscle strength, in particular the quadriceps, is an important systemic marker in COPD and weakness is associated with increased mortality and healthcare utilisation.^{33 34} Interventions that can demonstrate improvements in strength are therefore desirable. It was decided to narrow the influence on pulmonary rehabilitation to quadriceps strength for this guideline, as this has been highlighted as an important muscle group in COPD.³³

No RCTs of pulmonary rehabilitation that measured quadriceps strength were identified. As such, the GDG reviewed eight RCTs of exercise training versus control.^{35–42} There were six studies composed solely of resistance training^{35 36 38 40–42}; one study including a combination of aerobic and resistance training³⁹; and one study including mobility training.³⁷ All studies incorporating resistance training demonstrated an increase in muscle strength. The seven positive studies demonstrated an increase of at least 16% (16.2%–37%) in quadriceps strength.

Evidence statement

- ▶ Quadriceps muscle strength is increased by exercise programmes incorporating resistance training compared with usual care. (Evidence level 1+)

Good practice point

- ▶ Different components within a pulmonary rehabilitation programme, such as resistance training, can influence quadriceps strength and this is addressed in the section 'Nature of training of these guidelines'. (√)

Psychological status

A meta-analysis of six RCTs concluded that pulmonary rehabilitation was more effective than standard care for the reduction of anxiety and depression.⁴³ Of the six trials in the review, one was methodologically weak and two were underpowered as outlined in the evidence table. However, the strongest data were from a large RCT comparing pulmonary rehabilitation (n=99) with usual care (n=101) completed by Griffiths *et al*,¹² who demonstrated a significant improvement in anxiety and depression as measured by the Hospital Anxiety and Depression Scale (HADS).

Evidence statement

- ▶ Psychological status improves with pulmonary rehabilitation compared with usual care. (Evidence level 1+)

Recommendation

- ▶ Pulmonary rehabilitation should be offered to patients with COPD with a view to improving psychological wellbeing. (Grade A)

Nutritional status

Studies have shown variable results for weight change with pulmonary rehabilitation programmes. People presenting to pulmonary rehabilitation have differing body habitus and hence differing objectives of the multidisciplinary rehabilitation. This complicates looking for an overall change in weight in a group with pulmonary rehabilitation. Lan *et al*⁴⁴ showed an 0.8 kg weight increase following pulmonary rehabilitation in an underweight population. In normal weight patients, a similar gain of 0.6 kg following exercise training has been described.⁴⁵ However, in a trial examining the effect of nutritional supplementation, Steiner *et al*⁴⁶ showed weight loss of 0.6 kg in their placebo group following pulmonary rehabilitation. The magnitude of weight change in all these studies is of doubtful clinical significance. The effect of pulmonary rehabilitation on weight in the obese population is unknown. Recent retrospective data of a large pulmonary rehabilitation cohort has shown that baseline nutritional status (measured by BMI) has no effect on the efficacy of pulmonary rehabilitation in terms of exercise capacity or health status.⁴⁷

Evidence statement

- ▶ Pulmonary rehabilitation has only a minor effect on body weight. Nutritional status at the start of rehabilitation does not affect outcomes such as exercise capacity or health status. (Evidence level 2–)

Self-efficacy

Self-efficacy describes the level of belief someone has in their ability to complete a chosen task or goal.⁴⁸ Self-efficacy for walking has been shown to be associated with adherence in pulmonary rehabilitation and is therefore an important outcome measure in pulmonary rehabilitation. To date there have not been any RCTs that measure the impact of pulmonary rehabilitation on self-efficacy compared with usual care. However, an early RCT compared pulmonary rehabilitation with education alone and demonstrated that self-efficacy improved in the intervention group.⁴⁹ Other prospective observational studies have also demonstrated that self-efficacy scores improve following pulmonary rehabilitation.^{31 50} More recently, the PRAISE self-efficacy tool has been developed to measure levels of self-efficacy in relation to behaviours specific to pulmonary rehabilitation and has been shown to be reliable and sensitive to change following pulmonary rehabilitation in a prospective cohort study.⁵¹

Evidence statement

- ▶ Levels of self-efficacy improve following completion of pulmonary rehabilitation. (Evidence level 2++)

Survival

One RCT has explored the effect of pulmonary rehabilitation on survival in 119 people with COPD when stable.⁴⁹ The study was almost certainly underpowered to detect a mortality difference between the groups. In addition, the intervention and 'usual care' groups received education and the intervention group received monthly 'reinforcement' sessions for a year after completion of rehabilitation. Both groups had at least 6-monthly assessments by the research team for the following 6 years. Overall 6-year survival was 61% and there was no statistically significant difference between the intervention and control groups.

Measuring pulmonary rehabilitation outcomes

Although the benefits of pulmonary rehabilitation are shown in a variety of ways in this chapter, there are several key outcomes that should be the core part of any assessment of the individual and of the efficacy of the programme.

Recommendation

- ▶ As a minimum, efficacy of pulmonary rehabilitation programmes needs to be regularly assessed by demonstrating clinically important improvements in exercise capacity, dyspnoea and health status. (Grade B)

Good practice point

- ▶ As part of regular assessment, patient satisfaction and feedback should be sought. (✓)

Referral and assessment of patients for pulmonary rehabilitation**Referral process**

There are certain aspects of the referral process to pulmonary rehabilitation that are recommended. Patients who are likely to benefit from pulmonary rehabilitation have their exercise capacity limited by breathlessness or muscle fatigue and may have difficulty understanding the rationale behind referral for exercise training. From qualitative studies, success and outcome of rehabilitation are positively influenced by the initial clinician interaction and detail provided about pulmonary rehabilitation.^{52–53} Studies report that lack of understanding of the benefits of pulmonary rehabilitation may influence uptake.^{54–55} In addition, addressing patients' concerns may improve uptake and completion.⁵⁴ A discussion should take place with the patient about their aims from pulmonary rehabilitation. This can be documented and may aid motivation.⁵⁶ Patient information and referral are covered in appendices C and E.

Good practice points

- ▶ The point of referral to pulmonary rehabilitation should be used as an opportunity to explore the patient's understanding of pulmonary rehabilitation, address concerns and to educate patients about the benefits of a pulmonary rehabilitation programme. (✓)
- ▶ Healthcare professionals making referrals to pulmonary rehabilitation should have basic knowledge about what a programme entails and effectiveness. A pulmonary rehabilitation programme should be presented by the referrer as a fundamental treatment for COPD rather than an optional extra. (✓)

The period from referral to assessment

Cognitive behavioural therapy (CBT) is an evidence-based psychological treatment focusing on thoughts, beliefs and attitudes,

how these impact on behaviour and dealing with problems and whether there are alternative ways. It was therefore considered whether CBT might improve the adherence to pulmonary rehabilitation if delivered immediately before the programme. In an uncontrolled study, the introduction of a group opt-in 1.5 h session which incorporated CBT techniques post referral was evaluated.⁵⁷ Compared with historical practice, fewer patients proceeded to the initial assessment but a similar proportion commenced pulmonary rehabilitation. There appeared to be less dropout for 'non-illness' reasons, such as transport difficulties or dislike of group activities.

Evidence statement

- ▶ Pre-pulmonary rehabilitation interventions using cognitive behavioural techniques may improve completion of pulmonary rehabilitation. (Evidence level 2–)

Assessment

Initial assessment for pulmonary rehabilitation should include a detailed description of the programme—for example, the requirement for exercise within a group setting. It should also confirm that there is no contraindication to rehabilitation. The initial assessment presents an opportunity to assess comorbidities and risk factors, for example, hypertension (see section 'Cardiovascular disease comorbidity') and consider referral for management to optimise benefit from the programme. Information on service specification of pulmonary rehabilitation is addressed in appendix F.

Good practice points

- ▶ Initial assessment for pulmonary rehabilitation provides an opportunity to assess and refer for treatment of comorbidities prior to commencing. (✓)
- ▶ The setting of pulmonary rehabilitation, skill mix of the team and other comorbidities should always be considered in the risk assessment of patients entering a rehabilitation programme. (✓)

Specific situations at assessment

In identifying suitable patients for pulmonary rehabilitation, there has been debate about the suitability and/or safety of pulmonary rehabilitation for patients with specific conditions, including:

- people who continue to smoke,
- people with chronic respiratory failure,
- people with coexistent cardiovascular disease,
- people with coexistent anxiety and/or depression,
- people with mild or most severe breathlessness.

Further, there has been discussion on the optimal pharmacological therapy for people with COPD commencing pulmonary rehabilitation.

Smoking status

There has been some debate as to whether current smoking should be an exclusion criterion for pulmonary rehabilitation.

A retrospective non-analytic study of 239 predominantly male patients with COPD showed that current smokers were less likely to attend at least two-thirds of training sessions while another uncontrolled study of 91 patients with COPD identified lower completion rates in current smokers.^{58–59} However, in these studies a considerable proportion of current smokers attended and completed rehabilitation. There was no evidence that smokers failed to benefit to a similar degree as non-smokers. Pulmonary rehabilitation can provide an excellent opportunity to facilitate smoking cessation.⁶⁰

Evidence statement

- ▶ Patients who currently smoke benefit from pulmonary rehabilitation. (Evidence level 3)

Recommendation

- ▶ Patients with COPD should be referred for pulmonary rehabilitation regardless of their smoking status. (Grade D)

Good practice points

- ▶ Patients referred to pulmonary rehabilitation should have their smoking status assessed and referral to smoking cessation services offered to smokers simultaneously. (✓)
- ▶ Pulmonary rehabilitation provides opportunities to offer smoking cessation advice. (✓)

Chronic respiratory failure

The issue of safety of pulmonary rehabilitation was considered in patients with chronic respiratory failure. Patients with chronic respiratory failure (defined as $\text{PaO}_2 < 8\text{kPa}$, $\text{PaCO}_2 > 6\text{kPa}$ or both) appear to gain similar benefit from pulmonary rehabilitation compared with patients without respiratory failure.⁶¹ A prospective observational study of 1130 patients with severe COPD who underwent inpatient pulmonary rehabilitation showed that patients with and without chronic respiratory failure showed a similar response.⁶¹ The GDG discussed this in light of the available studies and concluded that patients should not be excluded from pulmonary rehabilitation on this basis. Later sections of this guideline discuss the use of oxygen and non-invasive ventilation as an adjunct to pulmonary rehabilitation; see section on Adjuncts to pulmonary rehabilitation.

Evidence statement

- ▶ Patients with chronic respiratory failure gain as much benefit as those without chronic respiratory failure from pulmonary rehabilitation. (Evidence level 3)

Recommendation

- ▶ Patients with COPD can be referred for pulmonary rehabilitation regardless of whether or not they have chronic respiratory failure. (Grade D)

Good practice point

- ▶ When considering the referral of patients with chronic respiratory failure, practitioners should reflect on the receiving setting and skill mix of the attending staff to provide safe pulmonary rehabilitation to these patients who have significant physiological impairment and potential for greater instability by the intended programme. (✓)

Cardiovascular disease comorbidity

From a safety perspective it is logical that patients with unstable cardiovascular disease (eg, unstable angina, unstable arrhythmias) should not enter a rehabilitation programme until stabilised. Accordingly, all such patients are excluded from studies of pulmonary rehabilitation. However, patients should not be excluded from pulmonary rehabilitation on the basis of having stable cardiovascular disease and the initial assessment offers a potential opportunity to assess this aspect of their general health.

A retrospective observational study of 2962 patients with moderate to severe COPD completing pulmonary rehabilitation evaluated the impact of comorbidities, including cardiovascular comorbidity, on outcomes. Patients with a higher number of comorbidities, assessed using the Charlson index, were less likely to gain clinically significant improvement in walking distance and health-related quality of life but the level of comorbidity had no effect on improvement in breathlessness. Relating to cardiovascular comorbidities, their presence led to patients being less likely to show a significant improvement in

quality of life, equally likely to gain significant improvement in breathlessness and more likely to demonstrate an improvement in walking distance.⁶² Further, the GDG considered that the standard MCID used for pulmonary rehabilitation may not be applicable in those with comorbidities—that is, patients may clinically improve by a noticeable amount at values less than the MCID traditionally used for a general rehabilitation population.

A prospective study from the same authors of 316 patients with moderate to severe COPD completing outpatient pulmonary rehabilitation showed no evidence that patients with cardiovascular comorbidity gained less benefit from pulmonary rehabilitation.⁶³ Furthermore there is emerging evidence that pulmonary rehabilitation may favourably benefit cardiovascular risk factors (eg, blood pressure).^{64 65}

A further consideration is abdominal aortic aneurysm (AAA) and exercise. Indeed, AAAs are reported as more prevalent in patients with COPD than in the general population and are related to tobacco smoking and impaired lung function.^{66–69} There was no literature exploring AAA's in patients with chronic respiratory disease and pulmonary rehabilitation. The guideline from the Society for Vascular Surgery (USA) documents that AAA rupture is not precipitated by moderate physical activity.⁷⁰ A small pilot reported relative safety of exercise in people who have AAAs but only studied people with 'small' AAA's (defined as 30–50 mm in diameter).⁷¹ The GDG additionally sought vascular opinions, including that of the Vascular Society, UK, and concluded that in people with an AAA <5.5 cm with controlled blood pressure, a standard multidisciplinary pulmonary rehabilitation incorporating moderate intensity aerobic training should be considered safe.

An AAA >5.5 cm should usually lead to consideration for surgical intervention, although severity of COPD or other comorbidities may preclude surgery. The opinion of the Vascular Society UK was sought: there is no evidence that mild to moderate exercise is associated with an increased risk of rupture. This would include aerobic exercise, for example, walking or riding a bicycle at a steady pace without the need to become too uncomfortable. However, this would exclude exercise which is associated with a risk of transient blood pressure rise, such as lifting weights, press ups or sit ups. The GDG concluded that in subjects with COPD where surgery has been deemed inappropriate by a cardiac or vascular surgeon, pulmonary rehabilitation incorporating mild–moderate aerobic exercise can be considered.

Evidence statements

- ▶ Patients with chronic respiratory disease with coexistent stable cardiovascular disease benefit from pulmonary rehabilitation (Evidence level 3).
- ▶ Patients with aortic aneurysms <5.5 cm in diameter can perform moderate intensity aerobic exercise as part of pulmonary rehabilitation, provided blood pressure is controlled. (Evidence level 4)

Recommendations

- ▶ People with chronic respiratory disease should be referred to pulmonary rehabilitation irrespective of coexistent stable cardiovascular disease. (Grade D)
- ▶ A coexistent AAA <5.5 cm should not preclude referral to pulmonary rehabilitation and being included in moderate intensity aerobic exercise training, provided blood pressure is controlled. (Grade D)

Good practice points

- ▶ The referral process and/or the initial assessment for pulmonary rehabilitation offer an important opportunity to assess

and optimise cardiovascular health and address risk factors for cardiovascular disease. (✓)

- ▶ In patients with COPD who have an AAA >5.5 cm, deemed not fit for surgery, pulmonary rehabilitation incorporating mild–moderate intensity aerobic exercise may be considered, but should not include resistance training. (✓)

Anxiety and depression

It has been considered whether anxiety and depression should be addressed prior to pulmonary rehabilitation in case they affect adherence or willingness to adopt change. Harris *et al*⁵⁴ reported that patients who scored more highly for anxiety and depression were more likely to report breathlessness and fear exercise, irrespective of the MRC breathlessness score. However, we know that pulmonary rehabilitation conveys significant improvement in such parameters for those with mild to moderate depression who undergo rehabilitation.

A prospective non-analytic study of 81 patients with predominantly severe COPD showed no evidence that patients with higher levels of anxiety or depression (assessed using the HADS) obtain reduced benefit from pulmonary rehabilitation.⁷² Indeed another observational study of 95 patients with COPD suggested that patients with a higher baseline level of anxiety gained greater benefit from exercise training.⁷³ A retrospective analysis of 518 patients entering pulmonary rehabilitation demonstrated a significant improvement in anxiety and depression according to the HADS score in those who had ‘presence’ or ‘probable’ anxiety or depression at baseline.⁷⁴ Baseline HADS score did not relate to completion or non-completion.

A systematic review of factors associated with completion of pulmonary rehabilitation indicated that patients with depression have a lower completion rate.⁷⁵ However, many do complete the programme and gain significant benefit.

Evidence statement

- ▶ People with symptoms of anxiety and/or depression benefit from pulmonary rehabilitation and should not be excluded from pulmonary rehabilitation. (Evidence level 3)

Recommendation

- ▶ Coexistent symptoms of anxiety and/or depression in patients with COPD should not preclude referral to pulmonary rehabilitation. (Grade D)

Good practice point

- ▶ The referral process and the assessments for pulmonary rehabilitation offer important opportunities to detect and consider referral for ongoing support and management for depression. (✓)

MRC dyspnoea grade

The traditional view of pulmonary rehabilitation has been to refer patients with an MRC breathless score of 3 or worse. The majority of outcome studies have included patients with COPD who had MRC scores of 3–5 and who attended outpatient programmes. There is overwhelming evidence of benefit from these studies incorporating hundreds of patients, albeit few of these studies stratified according to MRC grade.^{11 12} However, in general, there has been a shift towards addressing COPD earlier in the natural history of the disease and debate has ensued as to whether pulmonary rehabilitation may be of benefit to those with MRC dyspnoea grade 2.

Two retrospective observational studies have shown that patients who have a MRC dyspnoea score of 2 obtain similar improvement in exercise capacity to patients with MRC scores of 3–5.^{76 77} Both studies examined approximately 450 patients who completed outpatient pulmonary rehabilitation and in each

study more than 100 patients with MRC dyspnoea scores of 2 were included.

There is one single-centre, unblinded RCT of 61 patients with COPD who had moderate Global Initiative for Chronic Obstructive Lung Disease (GOLD) II airflow obstruction. Some of these patients had a MRC dyspnoea score of 2 but were not stratified by their MRC breathlessness. They were randomised to either pulmonary rehabilitation or usual care and the group completing pulmonary rehabilitation showed improvement in walking distance and quality of life.⁷⁸ In even milder airflow obstruction (symptomatic GOLD I), ventilatory responses with incremental cycling exercise show reduced exercise capacity compared with matched controls.⁶⁴ A flexible approach may be required to facilitate these patients completing exercise training.

There are conflicting results of pulmonary rehabilitation for those with MRC grade 5 breathlessness, depending on whether or not they are housebound. A well conducted, randomised, placebo-controlled trial of 60 patients with MRC breathless grade 5 who were housebound due to their breathlessness gained little benefit from supervised exercise training in their home.⁷⁹ In contrast, another large retrospective observational study which included 146 patients graded as MRC breathless grade 5, but who were able to attend and complete outpatient pulmonary rehabilitation, gained similar benefit to patients who had MRC scores of 3–4.⁷⁶ The location and nature of the programmes used in these studies and the level of functional limitation of recruited patients with MRC grade 5 may confound the outcomes.

Evidence statements

- ▶ Patients with chronic respiratory disease who are functionally limited because of dyspnoea benefit from pulmonary rehabilitation compared with usual care. (Evidence level 1++)
- ▶ People with COPD with a MRC dyspnoea score of 2 benefit from pulmonary rehabilitation. (Evidence level 3)
- ▶ Patients with COPD who have a MRC dyspnoea score of 5 who are able to attend an outpatient programme gain similar benefit from pulmonary rehabilitation as those with MRC dyspnoea 3–4. (Evidence level 3)

Patients with COPD who have a MRC dyspnoea score of 5 and are housebound are unlikely to gain significant improvement in walking distance, breathlessness and quality of life from supervised pulmonary rehabilitation delivered in their home. (Evidence level 1+)

Recommendations

- ▶ Patients with a MRC dyspnoea score of 3–5 who are functionally limited by breathlessness should be referred for outpatient pulmonary rehabilitation. (Grade A)
- ▶ Patients with a MRC dyspnoea score of 2 who are functionally limited by breathlessness should be referred for pulmonary rehabilitation. (Grade D)
- ▶ Patients with a MRC dyspnoea score of 5 who are housebound should not routinely be offered supervised pulmonary rehabilitation within their home. (Grade B)

Good practice point

- ▶ Flexible and pragmatic approaches should be considered to facilitate exercise training in patients who have less severe COPD and who are less breathless. (✓)

Bronchodilator therapy

The exercise component of pulmonary rehabilitation is beneficial, but the magnitude of benefit may be limited by modifiable factors. Bronchodilator drugs that reduce dyspnoea and dynamic hyperinflation may permit a greater amount of exercise and thus a greater gain from the rehabilitation programme. Two

RCTs have assessed the effect of tiotropium bromide (Spiriva, Boehringer) as an adjunct to pulmonary rehabilitation.^{80 81} The generalisability of the findings of these trials is limited as they did not permit the use of long-acting β agonists or short-acting anti-cholinergics in any subject (thus any additional benefit in the treatment arm could be at least partially explained by treatment reduction in the placebo arm) and a large proportion of subjects took inhaled corticosteroids. In this context, both trials found the addition of tiotropium bromide to further improve dyspnoea, but only one found benefits in walk distance and quality of life. It should be noted that the larger showed pulmonary rehabilitation to be only modestly effective (6MWT improvement of around 10%) and there were no common tests of exercise capacity across the two trials. These studies did not set out to investigate whether there was a synergistic effect of commencing a COPD medication before pulmonary rehabilitation or whether the effects of the two interventions were simply additive. No trial has investigated any other standard COPD medication introduced specifically to attempt to increase the benefit gained from pulmonary rehabilitation.

Evidence statement

- ▶ The commencement of a regular inhaled long-acting muscarinic antagonist drug prior to pulmonary rehabilitation leads to greater improvement in breathlessness and greater improvement in walking distance and quality of life. It is uncertain whether these potential benefits are simply additive, how applicable they are to current standard practice, or what effect other COPD medications have as adjuncts. (Evidence level 1–)

Recommendation

- ▶ Patients with COPD should be taking bronchodilator therapy in line with NICE COPD guidelines prior to referral to pulmonary rehabilitation. (Grade D)

Good practice point

- ▶ Pulmonary rehabilitation offers an opportunity to check and optimise inhaler technique. (✓)

Other considerations regarding referral to pulmonary rehabilitation

The decision to refer may be influenced by other factors—for example, when it may be unsafe, inappropriate or impossible for patients to engage in pulmonary rehabilitation. Studies of pulmonary rehabilitation routinely include a number of standard clinical exclusion criteria resulting in such patients not being included in clinical trials. The main criteria include the presence of unstable cardiac disease, locomotor or neurological difficulties precluding exercise (eg, severe arthritis or peripheral vascular disease), patients in a terminal phase of their illness or the presence of significant cognitive or psychiatric impairment.^{12 82 83}

Good practice points

- ▶ Patients with unstable cardiac disease or locomotor difficulties that preclude exercise (eg, severe arthritis or severe peripheral vascular disease) should not be referred for pulmonary rehabilitation. (✓)
- ▶ Careful consideration should be given to patients who have significant cognitive or psychiatric impairment that would lead to an inability to follow simple commands in a group setting. (✓)
- ▶ In certain individual cases, facilitation of pulmonary rehabilitation may be aided by the support and attendance of a relative or carer. (✓)
- ▶ In case of doubt over the appropriateness of a patient for pulmonary rehabilitation, clinicians are advised to contact their local provider. (✓)

Structure of pulmonary rehabilitation

Frequency of supervised pulmonary rehabilitation sessions

The frequency of supervised sessions during a course of pulmonary rehabilitation has not been clearly established. Traditionally in the UK, pulmonary rehabilitation takes place as an outpatient (either in a hospital or community setting) comprising a minimum of two supervised sessions per week. There is a large body of literature supporting the benefits of pulmonary rehabilitation and these have encompassed two supervised sessions and either a third supervised or formalised unsupervised pulmonary rehabilitation session.^{11 12} In parallel with this, the general advice from the Department of Health recommends five sessions of 30 min of physical activity per week.⁸⁴

A pilot feasibility study evaluating the effectiveness of a once weekly versus a twice weekly supervised programme and a randomised, parallel-group single-blind study experienced significant dropout rates, resulting in neither study being statistically powered.^{85 86} The GDG noted that the improvement in walking distance with pulmonary rehabilitation in the once and twice weekly groups was minimal, raising concern about the programme in the parallel-group study.⁸⁶

The optimum frequency of pulmonary rehabilitation is not known. There is insufficient evidence to demonstrate that once-weekly pulmonary rehabilitation is as effective as twice weekly in terms of improvement in exercise performance and health status. Most pulmonary rehabilitation studies showing benefit in the key outcome measures are based on at least two supervised pulmonary rehabilitation sessions a week.^{11 12}

Recommendation

- ▶ Pulmonary rehabilitation programmes should be a minimum of twice-weekly supervised sessions. (Grade D)

Good practice points

- ▶ In line with published pulmonary rehabilitation studies and the outcomes they demonstrate, a third session of prescribed exercise is recommended. This can be performed unsupervised. (✓)
- ▶ Encouragement of regular physical activity five times a week for 30 min each time is encouraged in line with standard healthy living advice. (✓)

Duration of pulmonary rehabilitation programmes

The optimal pulmonary rehabilitation programme duration is unclear, with huge variation in the length of programme seen across Europe and the rest of the world. In the UK, for practical and economic reasons, programmes lasting longer than 6–8 weeks are not standard; however, there is some ongoing debate as to the efficacy of programmes lasting less than 6 weeks. Consequently we have examined the effect on exercise performance and health status of pulmonary rehabilitation lasting less than 6 weeks to programmes lasting 6–12 weeks. However, we have also commented on studies examining prolonged rehabilitation (greater than 12 weeks).

Programmes shorter than 6 weeks compared with 6–12 weeks

Two RCTs have been published comparing supervised training for 4 and 7 weeks from the same centre but with different subjects. Green *et al*⁸⁷ randomised 44 subjects to 4 weeks (8 supervised exercise sessions) or 7 weeks (14 sessions) of training and compared end of programme difference in health status and exercise capacity. The study power was based on health status (the primary outcome) and when compared with 4 weeks of training the group receiving 7 weeks of training showed significantly greater improvement in total CRQ score and the domains of dyspnoea, emotion and mastery. Exercise performance was a

secondary outcome and the study was not powered to find a difference in this measure. No significant difference in exercise performance was seen between the two groups.

Sewell *et al*⁸⁸ randomised patients to either 4 weeks or 7 weeks of supervised exercise. However, in contrast to Green *et al*, the 4-week group was directed to exercise unsupervised for weeks 5–7 and were then reassessed at the end of 7 weeks. The study was powered for equivalence and comparing the groups at 7 weeks and 6 months, there was no significant difference in incremental shuttle walk or health status.

The differences in study design and conflicting outcomes mean it is not possible to make a specific recommendation about programmes with a duration of less than 6 weeks. The study by Sewell *et al* shows that many individuals gained significant improvement in exercise performance and health status after 4 weeks but in this group the further assessment at 7 weeks may have influenced compliance with unsupervised exercise training during weeks 5–7.

Moreover, the overwhelming majority of pulmonary rehabilitation outcome studies are outpatient programmes of 6–12 weeks' duration. While the trials described in this section show that some subjects can gain benefit from programmes of <6 weeks' duration, this evidence base is not robust enough to recommend programmes of <6 weeks' duration are comparable to those lasting 6–12 weeks.

Studies of longer duration pulmonary rehabilitation

Three other RCTs examined pulmonary rehabilitation programme lengths in which at least one group completed rehabilitation lasting longer than 3 months, included in a systematic review.^{89–92} Two of these studies assessed exercise performance as an outcome and demonstrated that the prolonged pulmonary rehabilitation (20 weeks vs 8 weeks and 18 months vs 3 months) significantly improved exercise performance with regard to 12 min walk test, 6MWT and stair climb, respectively.^{89–90} All three studies measured health status or functional disability. Improvement in health status and function appeared to be greater in the groups undergoing prolonged rehabilitation.^{89–92} One study highlighted a gender difference in response to health status improvements, with only men appearing to benefit greater in the long-term group compared with the short-term group.⁹¹ We did not assess and analyse cost effectiveness in the guideline but consideration of a longer programme of >12 weeks would necessitate a full cost evaluation.

In summary, the optimum duration of a pulmonary rehabilitation programmes is not known. The majority of the programmes from which the evidence for pulmonary rehabilitation is based are at least 6 weeks long.¹¹ The RCTs studying shorter-duration programmes have conflicting results for health status and such programmes may be appropriate for specific subjects.^{87–88}

Evidence statements

- ▶ Pulmonary rehabilitation of 6–12 weeks' duration has demonstrated significant benefits in exercise, dyspnoea and health status for patients with chronic respiratory disease compared with usual care. (Evidence level 1++)
- ▶ Pulmonary rehabilitation programmes with less than 6 weeks of supervised exercise can provide exercise and health status benefits for individuals with COPD. (Evidence level 1+)
- ▶ Benefits of pulmonary rehabilitation are even greater from programmes with a duration of more than 3 months, although the cost benefit would require further evaluation. (Evidence level 1+)

Recommendations

- ▶ Pulmonary rehabilitation programmes of 6–12 weeks are recommended. (Grade A)
- ▶ Pulmonary rehabilitation programmes including the attendance at a minimum of 12 supervised sessions are recommended, although individual patients can gain some benefit from fewer sessions. (Grade A)

Good practice point

- ▶ If training for less than 6 weeks is considered, this should be individualised and objective/subjective measures of benefit in place before patients graduate. For some individuals reassessment at 4 weeks and graduation to independent gym training is a feasible possibility. (√)

Rolling or cohort programmes

There is much debate regarding the comparative effectiveness of either a rolling or cohort-based rehabilitation programme. There is no high-quality evidence comparing the two formats. The GDG felt it was important to list the aspects of both types, which might be informative for those considering setting up a service; see appendix G.

Recommendation

- ▶ Cohort or rolling programmes of pulmonary rehabilitation are both acceptable forms of delivery depending on local considerations. (Grade D)

Education

The educational components of pulmonary rehabilitation are fundamentally integral to the format and success of the programme. Education comes into every aspect of pulmonary rehabilitation and in discrete educational sessions. Educational talks are discussed in more detail in appendix H.

The intention of the educational element is to support the lifestyle and behavioural change and assist self-management to promote decision making and self-efficacy. The educational and cultural backgrounds of the subjects and any physical (eg, impaired sight or hearing) and cognitive barriers need to be considered.

Nature of training

Lower limb weakness is common in patients with COPD and a poor prognostic indicator.³³ The standard training delivered for pulmonary rehabilitation is based around aerobic training, usually lower limb endurance training (commonly walking or cycling). The precise intensity for the endurance component has not yet been confirmed for individuals with chronic respiratory disease, although a target intensity of 60% of peak work rate is regarded as a minimum. The aim is to accumulate 30–60 min per session. For some individuals a single bout of 30 min is not achievable and shorter bouts should therefore be advised in order to accumulate 30 min. Progression should be observed in the longest achieved bout, aiming for 30 min of continuous activity.

We explored the evidence for additional resistance (strength) training, involving focused training of specific muscle groups with repetitive manoeuvres against heavy loads. Resistance training involves the major muscle groups, in particular the quadriceps muscles, and two to four sets should be completed, with each set comprising 10–15 repetitions. The weights chosen should be individualised and progressed once all sets can be completed with the selected weight. A minimum of 48 h between each session is advised.

The volume of evidence addressing this was low, with some methodological limitations in a number of trials. A systematic review encompassed several comparisons—combination approach,

resistance training alone and resistance training compared with another intervention.⁹³ Individual trials addressing the potential role of combined resistance compared with endurance training were reviewed. Of seven trials, four carried a high risk of bias.^{94–97} There were three good-quality, albeit relatively small, randomised trials.^{98–100} These trials did not demonstrate any significant additional benefits with the combined approach compared with endurance training alone regarding exercise tolerance as measured with field walking tests. There was an improvement in peripheral muscle strength; however this does not appear to translate into a demonstrable significant improvement in health-related quality of life. Functional outcome measures such as stair climbing were only assessed in the trials with a high risk of bias.^{95 96}

One narrative review considering the longer term effects of resistance training has reported on three trials with inconsistent results.¹⁰¹ Our patient representative acknowledged that patients often report it is harder to maintain progressive resistance exercise at an adequate intensity once supervision is no longer provided. It is of note that trials reviewed focused mainly on progressive resistance exercise delivered at an outpatient programme using weight-lifting exercise machinery. Lastly, the GDG considered that resistance training has other benefits, such as proven to reduce falls in older people in general. An in-depth review of these other benefits is outside the scope of the pulmonary rehabilitation guideline.¹⁰²

Evidence statements

- ▶ Resistance training in combination with aerobic training leads to greater improvements in peripheral muscle strength than aerobic training alone. (Evidence level 1+)
- ▶ In patients with COPD, resistance training in combination with aerobic training does not lead to additional benefit to health-related quality of life, dyspnoea or exercise tolerance compared with aerobic training alone. (Evidence level 1+)

Recommendation

- ▶ To ensure strength and endurance benefits in patients with COPD, a combination of progressive muscle resistance and aerobic training should be delivered during a pulmonary rehabilitation programme. (Grade B)

Good practice points

- ▶ Relevant expertise is required to deliver resistance training. (√)
- ▶ Patients should be capable of continuing effective resistance training once supervised sessions have ended. The supervising rehabilitation therapist should ensure that patients are able and willing to continue with unsupervised resistance training. (√)
- ▶ Prescribing of progressive strength exercise should be individualised for each patient, taking into consideration the initial health screening and any increase in risk from comorbidities. (√)

Interval and continuous aerobic training

Interval training delivers short periods of high-intensity aerobic training interspersed with rest or low-intensity periods. The rationale is that it allows periods of work to be conducted at a higher intensity compared with aerobic training.

A Cochrane review directly considered this subject.¹⁰³ Zainuldin *et al* included RCTs comparing higher training intensity with lower training intensity or comparing continuous training with interval training in people with COPD. Studies that compared exercise training with no exercise training were excluded. Only RCTs were included and the review considered the following outcome measures:

- Maximal incremental cardiopulmonary exercise test: peak exercise intensity, peak oxygen consumption, peak minute ventilation and lactate threshold at isotime or isowork.
- Endurance cardiopulmonary exercise test (cycle or treadmill): exercise time.
- Functional exercise capacity: 6-min walk distance, incremental shuttle walk distance or endurance shuttle walk time (ESWT).
- Symptom scores, health-related quality of life and muscle strength.

Eleven studies were included in the meta-analysis (five being translations from foreign language). Of these, eight studies were specifically related to this subject, with three judged to be of low risk of randomisation bias. Studies had examined a diversity of training protocols, moderate to low sample sizes and potential selective reporting of outcomes. Furthermore, studies investigating interval versus continuous training in patients with COPD tended to compare training of equal work duration.

The results of the review conclude that interval training was not superior to continuous training for improving physiological outcomes, walking time or symptoms in people with moderate to severe COPD.

It must be noted that the training studies reported in the literature have all been completed on a cycle ergometer using a complex training programme and this may present challenges within the programme and pursuing this type of training regime at home and after graduation from rehabilitation.

Evidence statement

- ▶ Interval training and continuous training are equally effective modes of training in patients with COPD. (Evidence level 1++)

Recommendation

- ▶ Interval and continuous training can be applied safely and effectively within the context of pulmonary rehabilitation to patients with COPD. (Grade A)

Good practice points

- ▶ The choice of interval or continuous training will be down to the patient and/or therapist preference. (√)
- ▶ In clinical practice, interval training may require a higher therapist to patient ratio to ensure adequate work rate and rest intervals are achieved compared with continuous training. (√)

Goal setting in pulmonary rehabilitation

There has been discussion whether individualising the pulmonary rehabilitation programme to personal goals may improve outcomes of the programme. Individualised activity programmes have been investigated by a described RCT but trials of goal setting focusing on other aspects of pulmonary rehabilitation have not been reported.²⁵ Sewell *et al*²⁵ randomised 180 patients to either an individually targeted exercise programme or the control arm: a conventional general exercise programme. The 'individually targeted exercise' group chose ADL derived from completed COPM questionnaires—a questionnaire designed to detect changes in domestic function over time; whilst the general exercise programme group was made up of 10 standard exercises focusing on upper and lower limbs, and the trunk. The RCT demonstrated no significant difference between the goal-based therapies and standard treatment, although both groups improved similarly. The authors comment their intervention groups may have been too similar to the control with regard to exercises performed.²⁵

Two other studies were considered in relation to this work but did not address the specific question of goal setting.^{104 105} One aimed to gradually reduce dependency on centre-based group exercising in favour of increasing free living activity

levels¹⁰⁴; while a small RCT explored different combinations of pulmonary rehabilitation—exercise training alone, exercise training plus activity training or exercise training plus lectures in 43 people.¹⁰⁵

Evidence statement

- ▶ Individually targeted exercise programme in pulmonary rehabilitation does not offer any advantage over simple conventional general exercise training in patients with COPD. (Evidence level 1–)

Recommendation

- ▶ Generic exercise training as opposed to individually targeted exercise training is recommended for pulmonary rehabilitation. (Grade D)

Good practice points

- ▶ While generic exercise training is recommended as opposed to an individually targeted exercise programme, the prescription of exercise is individualised to provide correct intensity. (✓)
- ▶ Besides the exercise elements of pulmonary rehabilitation, healthcare professionals commonly use goal setting to address specific hurdles. Given the personalised nature of this intervention to a patient's needs, evidence is difficult to quantify. (✓)
- ▶ The term 'goal setting' may require discussion with the patient. (✓)

Supervision in pulmonary rehabilitation

The majority of the evidence for the role of pulmonary rehabilitation is based on supervised programmes. There is a limited evidence base describing unsupervised pulmonary rehabilitation. Most reported evidence is centred on home-based rehabilitation compared with a hospital-based supervised programme. However, caution is advised, given some of the home rehabilitation schemes included varying degrees of supervision or support.

Studies were reviewed if they randomised rehabilitation participants to a home rehabilitation programme or a supervised programme. Studies comparing home-based rehabilitation with a control group were excluded. All studies reported exercise performance and quality of life as important outcomes. Only one 'home' study was conducted in the UK.¹⁰⁶ The largest study (n=252) comparing home rehabilitation with conventional rehabilitation was conducted in Canada, where the structure of the hospital-based rehabilitation is similar to that offered in the UK.¹⁰⁷ It was powered for non-inferiority. In this study the home exercise training was preceded with 4 weeks of educational sessions at hospital outpatients and then an exercise bike was provided in the home. Exercise was not supervised but was initiated by an exercise specialist in the patient's own home and weekly phone calls were made. Changes in cycle endurance time were similar between and within group, while changes in the 6MWT were minimal (gain of 8–11 m) in both groups, but not different between the groups. A similar approach was adopted by Guell *et al*,¹⁰⁸ with group education before allocating exercise training to either home or hospital; again there were no important differences between the groups after 9 weeks in this small RCT but this was unlikely to be powered for equivalence. Two studies adopted a broadly similar approach to that delivered in the UK; one over 8 weeks and one over 12 weeks.^{109 110} Puente-Maestu *et al*¹⁰⁹ showed differences in the physiological response to the two environments but performance was similar. Both groups had structured exercise regimes to follow. While not supervised exercise, there was a weekly hospital visit to record and encourage compliance with the home programme. A further 12-week home-based rehabilitation incorporated supervised exercise in the hospital and the

home pulmonary rehabilitation setting.¹¹¹ The UK-based study compared brief advice with hospital-based pulmonary rehabilitation with a greater improvement observed in the hospital-based group in terms of exercise performance, although benefit in health-related quality of life was similar (though both small improvements) between groups.¹⁰⁶

The approaches across studies are not consistent and methodological quality is variable. Furthermore, overall the population recruited seems similar at baseline to those routinely recruited to a studied pulmonary rehabilitation programme. All studies recruited patients with moderate to severe COPD with a moderate degree of disability. However, the exercise capacity at baseline seems to be higher than that reported in UK studies, reflecting the selection bias of this trial; that is, recruiting patients who are more able to accommodate a home-based training programme. The largest study provided personal exercise bicycle equipment for the participants to use at home. The education component of rehabilitation was delivered prior to engaging in the unsupervised exercise; this ranged from a 1:1 contact to a 4-week group programme of education.^{106 112}

These trials may allow the scope of pulmonary rehabilitation to be increased in the UK. However, the educational needs of the individual need attention; mechanisms to offer remote supervision, provision of home exercise equipment and patient selection are important factors that need careful consideration.

Telehealth is an innovative consideration of delivering health services to patients with COPD. In the context of pulmonary rehabilitation, technology has the potential to be used as an adjunct to rehabilitation or even provide a 'rehabilitative' service to individuals in isolated areas or with transport difficulties. To date there have been few reports integrating technology into the rehabilitation service.

There are reports of using simple pedometers as adjuncts to rehabilitation or telephone counselling as an alternative approach to improve exercise performance, but there are limited data on using technology in the form of e-health, mobile 'smart' phones or telemedicine.^{113 114} One notable exception showed benefits of mobile phone technology incorporating downloaded music with a tempo to match walking speed and global positioning system to monitor. However, the benefits seen were compared with a no-intervention group.¹¹⁵

Evidence statements

- ▶ The reported exercise and health status benefits of pulmonary rehabilitation have been based predominantly on supervised pulmonary rehabilitation programmes. (Evidence level 1++)
- ▶ Home-based pulmonary rehabilitation can lead to similar improvements in walking distance compared with supervised hospital pulmonary programmes; however, the educational needs, supervision, patient selection and provision of exercise equipment need to be considered. (Evidence level 1+)
- ▶ Brief advice is inferior to low-intensity group pulmonary rehabilitation. (Evidence level 1–)

Recommendations

- ▶ A supervised pulmonary rehabilitation programme is recommended for patients with COPD. (Grade A)
- ▶ If considering a structured home-based rehabilitation programme for selected patients with COPD, the following important factors need careful consideration: mechanisms to offer remote support and/or supervision, provision of home exercise equipment and patient selection. (Grade B)

Good practice point

- ▶ There would be some benefit to increasing the options for pulmonary rehabilitation available to individuals with COPD,

and increase the scope of the service. Geography may limit or stimulate options. (√)

Post-exacerbation pulmonary rehabilitation

The evidence presented thus far has focused on pulmonary rehabilitation delivered to patients who are clinically stable—elective pulmonary rehabilitation. Exacerbations of COPD are associated with worsening symptoms and health-related quality of life that may persist for several months, and increased mortality and healthcare use. Exercise capacity and physical activity levels are impaired during and after an exacerbation, contributing to skeletal muscle dysfunction, particularly of the lower limbs. Clinical studies have therefore explored whether pulmonary rehabilitation delivered in the few weeks following an acute exacerbation of COPD has a role compared with usual post-exacerbation care. This post-exacerbation pulmonary rehabilitation is often termed ‘early’ pulmonary rehabilitation if commencing within 1 month of hospital discharge for an exacerbation.

Outcomes in post-exacerbation pulmonary rehabilitation

A recent Cochrane review aimed to assess the effects of ‘early’ pulmonary rehabilitation within 3 weeks after COPD exacerbations (the majority requiring hospitalisation or hospital at home services) on future hospital admissions (primary outcome) and other patient-important outcomes (mortality, health-related quality of life and exercise capacity).¹¹⁶ Nine trials involving 432 patients were identified which compared ‘early’ pulmonary rehabilitation with conventional community care. Pulmonary rehabilitation significantly reduced hospital admissions with a number needed to treat of 4. However, as healthcare utilisation was only assessed over the short to medium duration of the study, it is unclear whether the reduction in hospital admissions was a result of the programme or increased contact with the study team. Pulmonary rehabilitation also reduced mortality, although the effect of the intervention may have been overestimated due to the small number of events. Nevertheless, no study reported any excess adverse events with the intervention.

There were also statistically and clinically significant improvements in health-related quality of life. Significant improvements (in excess of the recognised minimally important differences) were also seen in exercise capacity (6MWT and ISWT). The longer term benefits in exercise capacity and quality of life are not known.

A further RCT by Ko *et al*¹¹⁷, published after the Cochrane review, was also considered. This trial recruited 60 subjects and compared early post-exacerbation pulmonary rehabilitation within 2–3 weeks of hospital discharge with usual care. Although health-related quality of life was improved at 3 months and 6 months, no differences were seen by 12 months. Furthermore, although there was a trend towards fewer admissions in the first 3 months in the early pulmonary rehabilitation group, this waned with time. However, the study cohort was probably not medically optimised.

To date, only one study has compared ‘early’ post-exacerbation pulmonary rehabilitation with ‘late’ post-exacerbation pulmonary rehabilitation (delivered 6 months after exacerbation) with an 18-month follow-up.¹¹⁸ No significant differences were seen in health-related quality of life or exacerbation rates between the groups. However, due to recruitment issues this study was underpowered.

Evidence statements

- ▶ Pulmonary rehabilitation delivered within 1 month of hospital discharge for acute exacerbation of COPD is not

associated with adverse effects or excess mortality compared with usual care. (Evidence level 1+)

- ▶ Participation in pulmonary rehabilitation delivered within 1 month of hospital discharge for acute exacerbation of COPD reduces short-term risk of future hospital admission compared with usual care. (Evidence level 1+)
- ▶ Pulmonary rehabilitation delivered within 1 month of hospital discharge for acute exacerbation of COPD improves short-term health-related quality of life compared with usual care. (Evidence level 1+)
- ▶ Pulmonary rehabilitation delivered within 1 month of hospital discharge for acute exacerbation of COPD improves short-term exercise capacity compared with usual care. (Evidence level 1+)

Recommendation

- ▶ Patients hospitalised for acute exacerbation of COPD should be offered pulmonary rehabilitation at hospital discharge to commence within 1 month of discharge. (Grade A)

Good practice point

- ▶ Providing post-exacerbation pulmonary rehabilitation alongside elective pulmonary rehabilitation courses can cause practical issues. Evaluation of innovative ways of delivering a combination of both modes of pulmonary rehabilitation in tandem would be useful. (√)

Completion of post-exacerbation pulmonary rehabilitation

It is well recognised that a proportion of patients fail to adhere to or complete elective pulmonary rehabilitation. Given that patients are physically and psychologically vulnerable in the early post-hospital discharge period, and that infective exacerbations often cluster, the GDG considered whether completion rates of ‘early’ post-exacerbation pulmonary rehabilitation (commenced within 1 month of hospital discharge) might be lower than with providing elective pulmonary rehabilitation to the same patients post hospital admission for an exacerbation but when the patient becomes more stable.¹¹⁹

There were no studies that directly addressed this issue. From 12 potential abstracts; nine compared early post-exacerbation pulmonary rehabilitation with usual care; one was a review paper and the ‘early’ intervention in one study was more than 4 weeks after exacerbation. Only one study was reviewed in full.¹¹⁸ This compared ‘early’ (within 2 weeks of exacerbation) with ‘late’ pulmonary rehabilitation delivered 6 months after exacerbation. However, a proportion of exacerbations in this study did not necessitate hospitalisation. The study was also significantly underpowered due to recruitment problems and there were high numbers of dropouts and deviations from planned intervention. Furthermore, the intervention delivered was a mixture of inpatient and outpatient pulmonary rehabilitation which was inconsistent in both groups.

We further examined the individual RCTs considered in the Cochrane review that compared early post-exacerbation pulmonary rehabilitation shortly after hospital discharge with usual care.¹¹⁶ ‘Completion rate’ data were often completion of the research study rather than completion for pulmonary rehabilitation. Only four studies reported any data on the attendance at pulmonary rehabilitation. Man *et al*¹²⁰ reported 67% of the intervention group attending more than 50% of pulmonary rehabilitation sessions, while in the cohort of Seymour *et al*¹²¹, 77% attended more than 50% of pulmonary rehabilitation sessions. Ko *et al*¹¹⁷ reported that 73% of the intervention group attended at least 70% of sessions while only 40% attended more than 75% of sessions in the study of Eaton *et al*,¹²² despite the investigators providing free door-to-door transport.

The GDG considered these data to be in line with published figures of elective pulmonary rehabilitation. There was insufficient evidence to suggest that attendance was lower with pulmonary rehabilitation started within 1 month of hospital discharge compared with elective pulmonary rehabilitation.

However, it should be noted that these patients are highly selected (consenting to participate in a RCT). Studies have suggested poor recruitment for the early post-exacerbation trials, and by extension, poor uptake (acceptance of the referral and commencing the course) for early post-exacerbation pulmonary rehabilitation. Seymour *et al*¹²¹ only managed to recruit 60 patients from three hospitals over a 3-year period. In other studies, less than 50% of patients eligible for the study consented.^{117 122} This raises questions as to whether the benefits of pulmonary rehabilitation shortly after hospital discharge can be generalised to unselected patients.

Recommendations

- ▶ Clinical services providing post-exacerbation pulmonary rehabilitation commencing within 1 month of hospital discharge should carefully record uptake, adherence and completion rates. (Grade D)
- ▶ Patients who initially decline pulmonary rehabilitation commencing within 1 month of hospital discharge should be offered elective pulmonary rehabilitation. (Grade D)

Adjuncts to pulmonary rehabilitation

This section reviews the available evidence for or against additional interventions (adjuncts) to standard multidisciplinary pulmonary rehabilitation. To qualify, the study had to consider the additional intervention delivered in parallel as part of pulmonary rehabilitation. Some of the proposed interventions may or may not have an evidence base for use in chronic respiratory disease in their own right and this was beyond the scope of the pulmonary rehabilitation guideline. The adjuncts were assessed according to patient-centred outcome measures, including walking distance, health status and dyspnoea. In many areas, the studies were of modest size which limits the strength of the evidence. Further, often the adjunct was explored in an unselected group of pulmonary rehabilitation candidates. We therefore do not rule out future research showing potential merit of certain adjuncts in select subgroups. Further, combinations of adjuncts remain relatively unexplored field.¹²³ The following adjuncts are explored in turn: inspiratory muscle training (IMT); hormones and nutritional supplements; non-invasive ventilation (NIV); oxygen; heliox and neuromuscular electrical stimulation (NMES).

IMT and pulmonary rehabilitation

The exercise capacity of patients with COPD is usually limited by dyspnoea.¹²⁴ An intervention that reduced dyspnoea could therefore potentially permit greater exercise and increase the benefits seen with pulmonary rehabilitation programmes. IMT attempts to improve respiratory muscle strength and endurance through two types of training. Inspiratory resistive training uses devices that permit inhalation against resistance at a certain threshold. With normocapnic hyperpnoea the individual is required to achieve supranormal target ventilation while PaCO₂ is kept constant. IMT may improve dyspnoea by favourably altering the ratio between the current inspiratory pressure generated and the maximal inspiratory pressure (PI/PI_{max})^{125–127} and by reducing compromising dynamic hyperinflation^{128 129} through a reduction in inspiratory time.¹³⁰

Normocapnic hyperpnoea involves exercising the inspiratory muscles using periods of rapid breathing and deep inhalation of a controlled gas mix to ensure circulating

normocapnoea. It is therefore more akin to endurance training, but appears to have relevant potential beneficial effects.¹³¹ Its use as an adjunct to pulmonary rehabilitation has been examined in one small quasi-randomised study where it resulted in greater respiratory muscle endurance and PI_{max}, but had no effect on exercise outcome or quality of life.¹³²

Threshold load training is delivered using small handheld devices that allow flow only when inspiratory pressure reaches a preset but adjustable level. It can therefore deliver strength and endurance type training. It appears safe and well tolerated in individuals with a variety of diagnoses, including COPD.¹³³ A pilot study in 36 patients with COPD found that use of IMT in addition to an exercise programme led to greater improvement in walk test distance than those who undertook exercise alone,¹³⁴ although a subsequent RCT in 25 patients with COPD found no such benefit.¹³⁵ Similarly, another pilot study in 42 patients found IMT led to greater improvement in cardiopulmonary exercise test parameters after an exercise programme.¹³⁶ These study findings appear at considerable risk of bias given their limitations in key areas (see evidence tables). These findings were not subsequently replicated in two RCTs assessing IMT as an adjunct to exercise programmes, with low risk of bias.^{135 137}

Given the lack of consistency and the considerable limitations of the studies considered, IMT is not recommended as a routine adjunct to pulmonary rehabilitation. After assessment a respiratory physiotherapist may feel this is an appropriate adjunct for individual patients. However, post hoc subgroup analysis of the available studies did not identify a specific type of patient most likely to respond to IMT, so it cannot presently be recommended more broadly.

Evidence statement

- ▶ IMT using threshold loading devices or normocapnic hyperpnoea does not appear to augment the beneficial effects of general exercise training in patients with COPD. (Evidence level 1+)

Recommendation

- ▶ IMT is not recommended as a routine adjunct to pulmonary rehabilitation. (Grade B)

Hormones and nutritional supplements and pulmonary rehabilitation

Although the exercise component of pulmonary rehabilitation is beneficial, the degree of benefit may be limited by modifiable factors in many patients with COPD. Therefore, there has been research interest in maximising the effects of pulmonary rehabilitation by attempting to address nutritional constraints and the general catabolic state in COPD.

COPD is a catabolic state and individuals are at risk of becoming underweight, which is a poor prognostic feature.¹³⁸ Subclinical nutritional deficiencies may also exist that could constrain the benefits of pulmonary rehabilitation.¹³⁹ Supplementation of calories may therefore allow anabolism during pulmonary rehabilitation programmes and specific supplements may promote improvements in muscle efficiency and strength. The use of a standard supplement drink containing protein, fat and carbohydrate has been evaluated in a well described RCT and an inpatient trial with historical controls.^{46 140} Both studies report additional weight gain of around 1 kg in those receiving supplements but no robust differences in strength or endurance measures.

Several small trials have evaluated specific nutritional supplements, but limitations in study design and lack of replication limit the inference that can be made regarding the efficacy of supplementation with L-carnitine,¹⁴¹ amino acids^{142 143} or

polyunsaturated fatty acids.¹⁴⁴ Creatine supplementation has been studied more widely, though not using the same dose: one trial found significant improvements in limb strength and endurance,¹⁴⁵ but this finding was not replicated in a subsequent study or a larger well conducted RCT.^{146 147} All three studies concurred on the lack of benefit in walk test performance. Despite a lack of evidence supporting any specific nutritional intervention in pulmonary rehabilitation to date, it should be acknowledged that a referral to pulmonary rehabilitation provides an ideal opportunity for anthropometrical and nutritional assessment to take place, thus providing an opportunity to identify individuals at greatest risk of malnutrition, enabling a referral to specialised dietetic primary or secondary care services.

Anabolic steroids have been used to augment the effects of training in healthy individuals and for cachexia in chronic diseases.¹⁴⁸ Their use has been considered as to whether it may therefore augment the gains seen with pulmonary rehabilitation, potentially to a greater extent than in the healthy population due to the general catabolic state in COPD. The effects of testosterone and nandrolone have been explored in randomised placebo controlled clinical trials (in men only).^{35 149} Both of these studies found that anabolic steroids increased fat-free mass. There was no clinically significant improvement in measures of exercise capacity, though maximal leg strength improved with testosterone.

The aforementioned studies have focused on single interventions, but it may be argued that applying concurrent complementary interventions is a more logical approach. Nutritional supplementation, anabolic steroids and pulmonary rehabilitation appear to confer some benefit over controls when used together.¹⁵⁰ However, this multifaceted approach has not been tested against a course of standard pulmonary rehabilitation and as such it is difficult to draw firm conclusions for usual practice.

Evidence statements

- ▶ Additional general nutritional supplementation does not significantly improve measures of exercise performance beyond the gains seen with pulmonary rehabilitation. (Evidence level 1+)
- ▶ Creatine supplementation does not augment the gains in exercise capacity resulting from pulmonary rehabilitation. (Evidence level 1+)
- ▶ Anabolic steroids do not substantially augment the exercise capacity gains achieved with pulmonary rehabilitation but produce small improvements in fat free mass and some measures of muscle strength. (Evidence level 1+)

Recommendation

- ▶ No specific hormonal or nutritional supplement can currently be recommended as a routine adjunct to pulmonary rehabilitation. (Grade B)

Good practice points

- ▶ The optimal approaches for addressing malnutrition, sarcopenia or obesity in COPD are uncertain and this is a wider issue than this guideline covers. However, attendance at a pulmonary rehabilitation course presents an ideal opportunity to screen and educate patients on nutrition. (✓)
- ▶ Patients with a BMI in the underweight or obese range should be considered for specific dietetic support. (✓)

NIV during pulmonary rehabilitation

Given the integration of NIV to the care of some patients with ventilatory failure in COPD, there has been discussion as to whether the use of the NIV during the exercise of pulmonary rehabilitation might improve walking distance and dyspnoea. The GDG were aware of studies that addressed the effects of

concurrent domiciliary NIV with pulmonary rehabilitation,^{151–153} and others, including a systematic review,¹⁵⁴ that examined the acute effects of NIV on exercise capacity rather than as part of a pulmonary rehabilitation/exercise training programme.

There were seven small RCTs which compared assisted ventilation during pulmonary rehabilitation with exercise training alone in patients with COPD. The presence of type II respiratory failure was not necessary for inclusion and the available data suggested that for the most part there was no resting hypercapnia. One study was not reviewed as mild patients were recruited and type II respiratory failure was specifically excluded.¹⁵⁵ Of the remaining studies,^{156–161} all suggested some improvement in exercise performance with NIV either directly or indirectly (eg, lactate levels), but none showed clinically significant improvements in walk distance compared with pulmonary rehabilitation alone. In general, the studies had small numbers, were often unblinded and the randomisation process was unclear. Furthermore, these studies were performed in the laboratory setting with supervised training rather than in the real life outpatient pulmonary rehabilitation setting. Little information was given about patient tolerability/preference and health economic data were lacking.

There was consensus from the GDG that patients with stable type II respiratory failure should not be excluded from pulmonary rehabilitation referral (see section Referral and assessment) of patients for pulmonary rehabilitation – Assessment). Furthermore, it is acceptable for patients established on domiciliary NIV to exercise with NIV during pulmonary rehabilitation if acceptable and tolerable to the patient.

Evidence statement

- ▶ There is not a role for the routine use of assisted ventilation during pulmonary rehabilitation in patients who have type II respiratory failure who are not already on domiciliary NIV. (Evidence level 1–)

Recommendations

- ▶ Long-term domiciliary NIV should not be provided for the sole purpose of improving outcomes during pulmonary rehabilitation. (Grade D)
- ▶ Patients who already receive long-term domiciliary NIV for chronic respiratory failure should be offered the opportunity to exercise with NIV during pulmonary rehabilitation if acceptable and tolerable to the patient. (Grade D)

Supplemental oxygen in patients undergoing rehabilitation

Individuals with COPD are limited by their breathlessness,¹²⁸ and in contrast to healthy individuals, their exertions are predominantly curtailed by limitation of ventilation and oxygenation rather than reaching their maximum heart rate.¹⁶² As supplemental oxygen can increase exercise capacity acutely in those with severe COPD,¹⁶³ it is possible that such supplementation could increase the amount of training that patients with COPD could undertake. Simply being able to undertake a greater amount of training was postulated to augment the benefits from pulmonary rehabilitation. In addition, alleviation of a degree of pulmonary limitation was proposed to allow greater cardiac and muscular stress and thus have further beneficial effects on stroke volume and oxygen extraction.

In light of the above, trials investigating the use of supplemental oxygen with pulmonary rehabilitation have tended to recruit patients with more severe COPD indicated by a variety of criteria: spirometry,¹⁶⁴ desaturation on exercise,¹⁶⁵ both¹⁶⁶ or by fulfilling criteria for ambulatory oxygen.¹⁶⁷ The one trial that was more inclusive still reported a mean forced expiratory volume in 1 s in the total study populations of less than 50%

predicted.¹⁶⁸ The heterogeneity of baseline performance in these papers highlights the difficulty in using a single parameter to assess the severity of COPD. All of these trials were small and only one was double blinded and placebo controlled.¹⁶⁴ This study by Emtner *et al* reported an improvement in health-related quality of life (Short Form 36) and in respiratory rate at isotime (the only trial to study effort independent isotime measurements) but not in other parameters such as dyspnoea, peak work or Chronic Respiratory Disease Questionnaire. These findings are consistent with the lack of additional benefit in walk test distance and short questionnaires seen in other studies.^{165 166 168} A randomised trial considered only individuals who were hypoxaemic on exertion and had improved saturations with supplemental oxygen. This trial reports a very large additional benefit in ESWT,¹⁶⁷ though no commensurate additional gains in quality of life or breathlessness. The GDG felt the study carried a significant risk of bias that influenced its findings. Therefore its results require replication before they can be widely applied.

It would seem to be of limited benefit to combine these study results in a formal meta-analysis given the variation in inclusion criteria, interventions, rehabilitation/training programmes and assessment methods.

Overall, there is no clear evidence supporting the routine use of supplementary oxygen for all patients to augment the benefits of pulmonary rehabilitation. Supplemental oxygen may be of benefit in selected individuals, but there is currently little information to inform this choice, especially given the intra-individual variability of oxygen saturations on exercise on a day-to-day basis. No clinical measures have been demonstrated to robustly predict those individuals with COPD who may gain additional benefit (in terms of exercise or quality of life parameters) from supplemental oxygen during pulmonary rehabilitation. Likewise, no parameters have been shown to assess the risk of hypoxia-related harm during rehabilitation or predict who may avoid this with the administration of supplemental oxygen.

The BTS guidance on ambulatory oxygen prescription therefore appears to be a reasonable criterion to apply for patients attending pulmonary rehabilitation in this regard, although previous guidance has always recommended assessing for ambulatory oxygen on completion of pulmonary rehabilitation and hence does not directly address the rehabilitation period itself. At the time of the BTS pulmonary rehabilitation guideline publication, the BTS domiciliary oxygen guideline is being prepared. Pulmonary rehabilitation also provides an opportunity to assess the adequacy of the prescribed flow rate for patients already in receipt of LTOT or ambulatory oxygen.

Profound desaturation on exercise has the potential to lead to end-organ impairment and compromise the benefits of exercise. The trials discussed above largely did not permit saturations to fall below 90% but it is unclear if this threshold is of special significance. No trial reported adverse events during exercise that could have been attributed to hypoxia, and the experience of the guideline group was that this was representative of the apparent safety of pulmonary rehabilitation programmes. Until further evidence is available, the level of exercise-induced hypoxia that is acceptable will depend on clinical judgement in individual cases, and practitioners will have their own thresholds that will prompt further investigation for occult comorbidity or perhaps influence decisions on the nature of the programme instituted. These decisions may be more difficult in patients with lung fibrosis who tend to desaturate more readily on exercise but often with lesser symptomatic awareness. No trials reported adverse events related to oxygen toxicity.

Evidence statements

- ▶ Individuals with COPD who desaturate on exercise may benefit from the use of oxygen during pulmonary rehabilitation and show improved exercise capacity. It is unclear whether patients with other chronic respiratory diseases who desaturate gain the same benefit. (Evidence level 2+)
- ▶ Supplemental oxygen during pulmonary rehabilitation is safe in individuals with moderate to severe COPD. (Evidence level 1+)

Recommendations

- ▶ Supplemental oxygen should not be routinely used for all patients undergoing pulmonary rehabilitation. (Grade B)
- ▶ Supplemental oxygen during pulmonary rehabilitation should be offered to those who fulfil the assessment criteria for long-term or ambulatory oxygen unless there are compelling clinical reasons to use alternative criteria. (Grade D)

Good practice points

- ▶ Individuals who are prescribed oxygen but decline to use it during exercise should have this clearly documented in their notes. (✓)
- ▶ Pulmonary rehabilitation provides an opportunity to assess the adequacy of the prescribed flow rate for patients already in receipt of LTOT or ambulatory oxygen. (✓)

Supplemental heliox in patients undergoing rehabilitation

Heliox is a mixture of helium and oxygen. Most often a mixture of 21% oxygen and 79% helium is used, but up to 40% oxygen has been studied. It has a similar viscosity to air but a significantly lower density. This means it is more likely to be laminar rather than turbulent flow in a given airway, which generates less resistance and can reduce the work of breathing. The administration of heliox has therefore been used for the treatment of large airway obstruction and vocal cord dysfunction, but it is of uncertain benefit in acute obstructive airways disease (potentially because the lower gas density exacerbates small airway collapse).^{169 170} As heliox reduces the work of breathing, it may permit greater exercise capacity in more stable patients with COPD, and as described above potentially increases the benefit from pulmonary rehabilitation.

Two studies have evaluated this intervention. The studies did not find additional benefits in their heliox arm when heliox (60% helium) was compared with supplemental oxygen,¹⁷¹ or heliox (79% helium) was compared with bi-level pressure support NIV¹⁵⁶ or pulmonary rehabilitation alone.¹⁵⁶ These trials were small and the study groups were heterogeneous in baseline function and response to rehabilitation. Hence, a small but meaningful additional beneficial effect of heliox cannot be discounted, but this is unlikely to be cost effective.

Evidence statement

- ▶ Heliox does not appear to augment the benefits of pulmonary rehabilitation. (Evidence level 1–)

Recommendation

- ▶ Heliox should not be used as an adjunct to pulmonary rehabilitation unless there are comorbidities which require its administration. (Grade D)

NMES and pulmonary rehabilitation

Despite the unequivocal benefits of whole body exercise training in stable disease, such intervention may be difficult to deliver in patients with severe ventilatory limitation during acute exacerbations or those with severe muscle wasting. Non-volitional techniques, such as NMES, which are independent of these factors, have been proposed as alternative therapeutic modalities.

The GDG were aware of several randomised studies and systematic reviews that addressed the effects of NMES in COPD.^{172–173} However, only two studies examined the adjuvant use of NMES with exercise training.^{174–175} One of these studies recruited inpatients receiving mechanical ventilation which was beyond the scope of these guidelines¹⁷⁵; hence only one study was reviewed in detail.

In a RCT, 17 highly selected patients with COPD (low BMI, quadriceps weakness, severe limitation in cycle ergometry, recent exacerbation requiring hospitalisation or intensive care) received either 4 weeks of quadriceps NMES (four 30-min sessions per week) with usual rehabilitation or usual rehabilitation alone.¹⁷⁴ The usual rehabilitation included active limb mobilisations with or without aerobic exercise and an educational component. Large improvements were seen in quadriceps maximum voluntary contraction after NMES plus usual rehabilitation compared with usual rehabilitation alone. Furthermore, there was a more significant reduction in breathlessness. Both groups significantly improved 6 min walk distance, but there was no between-group difference. Caution needs to be applied when interpreting the results. The patient group was highly selected and may not be typical of the general outpatient pulmonary rehabilitation population in the UK. The randomisation procedure was not described, there was no sham NMES and the tester was not blinded. Although patients seemed to tolerate NMES, it was not clear whether the NMES was set up by the therapist or the patient themselves. This is potentially important given that staff time is the major contributor to pulmonary rehabilitation costs.

There have been several small, single-centre studies supporting the benefits of NMES in improving quadriceps strength and exercise capacity, particularly in patients with more severe COPD or in the post-exacerbation setting.^{174–176–180}

Evidence statement

- ▶ There is no role for the routine use of NMES as an adjunct to pulmonary rehabilitation in patients with COPD, based on current literature. (Evidence level 1–)

Recommendation

- ▶ If expertise in NMES is available, selected patients (low BMI with evidence of quadriceps weakness) who are unable or unwilling to participate in pulmonary rehabilitation could be considered for NMES. (Grade D)

Pulmonary rehabilitation in people with other chronic respiratory diseases

The vast majority of evidence for pulmonary rehabilitation stems from patients with COPD. Yet there are many patients with other chronic respiratory disease who experience similar symptoms and are functionally limited. It is reasonable to imply that the same mechanisms of deconditioning and lack of confidence are likely to apply to all chronic diseases which have dyspnoea as the core symptom. Few trials have considered the effect of pulmonary rehabilitation, compared with usual care, in populations other than COPD, making it difficult to comprehensively address. We have addressed through a series of structured PICO questions non-CF bronchiectasis, ILD and stable asthma, but recognise that the discussion could encompass a much wider field of conditions and is not meant to bias opinion against those not covered. Further, in general, we recognise that establishing robust evidence in certain conditions for or against the role of a pulmonary rehabilitation programme specifically may not be feasible given the short life expectancy.

Non-CF bronchiectasis

A small RCT of subjects with non-CF bronchiectasis compared pulmonary rehabilitation, pulmonary rehabilitation with IMT and a control group; n=32 in total.¹⁸¹ Both pulmonary rehabilitation groups showed significant improvements in walking distance using ISWT and endurance exercise compared with the control group. There was a significant improvement in quality of life in the pulmonary rehabilitation plus IMT group but not in the pulmonary rehabilitation group alone compared with the controls, although the study was not powered for this outcome. The GDG additionally considered the evidence in the BTS bronchiectasis guideline (2010) and the bronchiectasis quality standards state that all patients with bronchiectasis should have access to and be considered for referral for pulmonary rehabilitation.^{6–182–183}

Evidence statements

- ▶ Patients with non-CF bronchiectasis benefit from pulmonary rehabilitation in terms of exercise capacity compared with usual care. (Evidence level 1–)
- ▶ Patients with non-CF bronchiectasis benefit from pulmonary rehabilitation in terms of quality of life compared with usual care. (Evidence level 1–)

Recommendation

- ▶ Patients with non-CF bronchiectasis who have breathlessness affecting their ADL should have access to and be considered for pulmonary rehabilitation. (Grade D)

Good practice point

- ▶ Unlike in patients with CF, in patients with COPD and non-CF bronchiectasis with multidrug-resistant organisms, for example *P aeruginosa*, there is no current evidence of cross infection. (√)

Interstitial lung diseases

ILDs represent a broad diagnosis and the presentation and prognosis vary according to the specific diagnosis, which makes considering the impact of pulmonary rehabilitation complicated if they are considered as a whole. More specifically idiopathic pulmonary fibrosis (IPF) is often associated with progressive clinical and physiological deterioration over 6–12 months and patients with IPF often show marked desaturation during exercise. Importantly, we have focused on ILD as opposed to the breadth of all restrictive lung diseases, such as chest wall disease and other extra-thoracic causes.

A RCT from Japan included 30 patients with IPF randomised to pulmonary rehabilitation or a control arm. The study showed improvements in walking distance on a 6MWT and in quality of life using the SGRQ, but not in dyspnoea rating.¹⁸⁴

Forty-four patients with ILD, including 25 with IPF, were studied before and after an 8-week pulmonary rehabilitation programme and 6 months later in an uncontrolled study.¹⁸⁵ There was improvement in 6 min walking distance with pulmonary rehabilitation in the IPF (mean 21 m improvement) and other ILD group (mean 43 m), with 40% of the IPF group and 52% of the other ILD group reaching a minimally important difference of 34 m at rehabilitation completion. Similarly, dyspnoea improved in both groups. There was marked variability in response between individuals.¹⁸⁵

Holland *et al*¹⁸⁵ suggested that patients with IPF have greater improvements in functional exercise capacity when pulmonary rehabilitation is delivered early in the course of disease. Patients with other ILDs achieve significant gains in exercise capacity regardless of disease severity and are more likely than those with IPF to achieve sustained improvements in dyspnoea.¹⁸⁵

The GDG were aware of a further well conducted exercise-based RCT in 57 patients with ILD (60% with IPF). This was not pulmonary rehabilitation and discussion ensued as to whether it should be included, given the paucity of literature otherwise. This study demonstrated modest improvements in functional exercise tolerance, dyspnoea and quality of life compared with telephone support.¹⁸⁶ Importantly it was safe and feasible. There were four deaths (two per arm) during the study period, highlighting that patients with ILD can be critically ill. The effects of the exercise training were lost at the 6-month follow-up but this cannot be assumed post pulmonary rehabilitation. The GDG also considered that lack of any sustained benefit at 6 months may be due to underlying disease progression.

The GDG recognised the wide individual variation in the course of the conditions comprising ILD. This may make pulmonary rehabilitation a consideration for some. However, for others, a formalised pulmonary rehabilitation programme would be futile and management should focus on other palliative measures.

Evidence statements

- ▶ Patients with ILD benefit from pulmonary rehabilitation with improvements in exercise and quality of life. (Evidence level 1–)
- ▶ Patients with ILD benefit from exercise training with improvements in exercise and quality of life compared with telephone support. (Evidence level 1+)
- ▶ The benefits of pulmonary rehabilitation in patients with ILD are not sustained at 6 months. (Evidence level 3)
- ▶ The benefits of an exercise training programme in patients with ILD are not sustained at 6 months. (Evidence level 1+)

Good practice points

- ▶ The benefits of exercise and the recommendation of incorporating exercise activities into a healthy lifestyle should be discussed with all patients with ILD. Such discussion needs to be tailored to realistic achievability for that person's condition. (✓)
- ▶ If healthcare professionals consider referring certain patients with stable ILD who are limited by breathlessness in ADL to pulmonary rehabilitation, they should discuss with the patient regarding the likely benefits. (✓)
- ▶ Patients with IPF have a potential for significant desaturation during exercise-related activities. (✓)

Asthma

One RCT studying patients with asthma and COPD (divided into diagnostic groups a posteriori) showed improvements in exercise tolerance and quality of life in those who completed a 12-week programme of pulmonary rehabilitation. However, the study findings are limited by a lack of power calculation in methodology and likely underpowered for the subgroup analysis. Compared with usual care, patients with asthma showed improvements in exercise tolerance, quality of life and a dyspnoea score.¹⁸⁷

While not pulmonary rehabilitation, there is a Cochrane review supporting physical training in subjects with asthma, although the majority of the small population studies were conducted in children and did not focus on symptomatic subjects. It is therefore of little relevance here. The conclusions of the review acknowledged the diversity of the intervention type, duration, subjects and outcome measures of the studies.¹⁸⁸

Standard asthma management should be managed according to the BTS/SIGN asthma guideline and the reader is drawn to the recommendation that physical training should be seen as part of a general approach to improving a healthy lifestyle following a Cochrane review.^{8 189} The BTS/SIGN asthma guideline

raises standard precautions regarding observation for exercise-induced asthma if appropriate.

The GDG accepted that there is often overlap in asthma and COPD diagnoses and that many patients diagnosed with asthma have fixed airflow limitation and present with symptoms of persisting breathlessness and exercise intolerance in a similar manner to COPD. These patients are likely to benefit from pulmonary rehabilitation.

Recommendation

- ▶ The routine referral of patients with asthma to pulmonary rehabilitation is not recommended. (Grade D)

Good practice points

- ▶ The benefits of exercise and the recommendation of incorporating exercise activities into a healthy lifestyle should be discussed with all patients with asthma. (✓)
- ▶ If healthcare professionals consider referring certain patients with stable asthma who are limited by breathlessness in ADL to pulmonary rehabilitation when on optimal therapy, they should discuss with the patient the likely benefits. (✓)
- ▶ The BTS/SIGN asthma guideline draws attention to exercise-induced asthma and precautions to prevent this should be followed if appropriate. (✓)

Other chronic respiratory diseases—in general

Good practice points

- ▶ MCID changes and tools used to assess exercise capacity and quality of life for pulmonary rehabilitation in COPD are not necessarily transferable to other chronic respiratory diseases. While future research should address this, failure of rehabilitation should not be implied if failure to reach the COPD MCID for outcomes. (✓)
- ▶ The educational element of pulmonary rehabilitation should be adapted for other chronic respiratory diseases if appropriate. (✓)
- ▶ Practically, inclusion of patients with other chronic respiratory diseases into pulmonary rehabilitation will be alongside subjects with COPD. (✓)
- ▶ General exercise should be encouraged for all patients with chronic respiratory disease. (✓)

Post pulmonary rehabilitation

Repeat pulmonary rehabilitation programmes

The clinical conditions for which pulmonary rehabilitation is routinely offered result in progressive loss of function over time. It is therefore likely that any benefits arising from an initial programme of pulmonary rehabilitation will decay toward baseline function. There is the potential that a further course of pulmonary rehabilitation at a distant time point may provide further benefit.

Several RCTs and observational studies in which pulmonary rehabilitation is compared with standard care or education alone have followed participants for a protracted period. All studies have found that the initial beneficial effects diminish over time. However, those completing pulmonary rehabilitation courses have significantly greater quality of life, exercise capacity and fewer days in hospital than those in the control groups in the year after the intervention.^{12 190 191} The benefits appear to persist to some degree at 18 months,³⁹ but there are conflicting data on whether a meaningful difference in exercise capacity persists at 2 years.^{192 193}

Repeating pulmonary rehabilitation in those whose condition has deteriorated over time after their initial programme leads to improvements in quality of life and exercise capacity that have been reported to be similar in magnitude to those seen with the first intervention in retrospective reviews and two likely

underpowered RCTs.^{192 194–196} A third session is again of short-term benefit.¹⁹⁴ In those completing pulmonary rehabilitation in the NETT study, patients who had completed pulmonary rehabilitation previously (n=777) did not gain as much improvement in terms of exercise and quality of life on repeat as those for which it was their first programme (n=441), although they did improve.¹⁹⁷

The timing of a repeat course of pulmonary rehabilitation would appear to be influenced by the aim of the intervention. As noted above, the great majority of the initial benefit is lost by 24 months, and two RCTs of routinely repeated pulmonary rehabilitation at a lesser interval have shown no major additional benefit from an intervening extra session in terms of exercise capacity at the end of the study.^{194 195} However, earlier repeat courses do lead to short-term benefits in exercise capacity and quality of life, which may be important in specific circumstances (eg, preoperatively). Additionally, in these studies the frequency of exacerbations appears lower in those who received additional courses,¹⁹⁴ with fewer days spent in hospital.¹⁹⁵ Although these findings are based on a small number of events, it raises the possibility that there is a subgroup of patients who are prone to frequent exacerbation who may benefit from early repeat pulmonary rehabilitation. A single small study followed patients after an initial course of pulmonary rehabilitation and randomised those who had an exacerbation during follow-up to either a further rehabilitation course or standard care.¹⁹⁸ This study found no benefit in its major endpoints, although the occurrence of further exacerbations during follow-up makes it difficult to interpret the results.

Two small studies have sought baseline factors associated with a sustained response to pulmonary rehabilitation: a higher initial PaCO₂ was independently (positively) associated with a maintained initial improvement in quality of life, and a low baseline quality of life with a poor response.^{199 200} Neither of these studies provides sufficient evidence for the creation of a predictive tool.

Evidence statements

- ▶ The benefits from pulmonary rehabilitation persist to some degree for at least 1 year. (Evidence level 2+)
- ▶ Repeating pulmonary rehabilitation after a period of 1 year provides benefits in exercise capacity and quality of life. (Evidence level 4)

Recommendations

- ▶ Repeat pulmonary rehabilitation should be considered in patients who have completed a course of pulmonary rehabilitation more than 1 year previously. The likely benefits should be discussed and willing patients referred. (Grade B)
- ▶ Earlier repeat pulmonary rehabilitation should be considered in individuals with accelerated physiological decline or if additional benefits on a shorter timescale would be clinically valuable. (Grade D)

Good practice point

- ▶ It is unlikely that if the patient completed the pulmonary rehabilitation course originally and failed to gain a benefit, they would benefit a second time round; unless circumstances such as an exacerbation interrupted the initial programme. (√)

Maintenance

Studies evaluating post-pulmonary rehabilitation maintenance exercise demonstrated a range of strategies in terms of exercise type, level of supervision, duration and frequency of maintenance programme. No consensus emerged from the literature about the definition of post-pulmonary rehabilitation exercise maintenance, making it difficult in some cases to distinguish

between a 'maintenance' programme and extension of the initial pulmonary rehabilitation programme.

A small number of RCTs investigated the benefit of maintenance compared with no clear strategy post rehabilitation. Three studies describe the value of a structured maintenance approach after a standard out-patient course of rehabilitation.^{201–203} One UK-based study examined the value of telephone follow-up.²⁰⁴ One small RCT (n=20) described the value of an unsupervised home programme compared with no advice at all, which would essentially reflect best usual care; it would be unusual to graduate from a rehabilitation programme with no advice at all.²⁰⁵ The studies that described maintenance strategies chose different approaches over differing lengths of time. Brooks *et al*²⁰¹ described a monthly supervised exercise session with telephone support in the interim. Measurements were taken at 3-monthly intervals up to 12 months and no benefit was observed in either exercise tolerance or quality of life compared with the control group for this approach. Ries *et al*²⁰² described a large study (n=172), again offering 12 months of maintenance, comprising weekly telephone contact and monthly exercise sessions. Patients were followed up for 24 months. During the intervention period, there were benefits observed in exercise capacity but not in quality of life. Between 12 and 24 months there was no support provided and the difference between the groups narrowed and was not significant. A more intense maintenance programme was provided by Ringbaek *et al*²⁰³ with weekly sessions for 6 months after a 7-week outpatient programme, fortnightly sessions for a second 6 months and no supervision for a final 6 months. At 18 months there was no difference between the two groups. Again, however, examining the 'maintenance' group over the first 12 months, some advantages were observed, largely associated with a decline in performance in the control group, and maintenance of benefit acquired as a consequence of the initial rehabilitation phase with the intervention group. The study by Waterhouse *et al*,²⁰⁴ a UK-based study, looked at a telephone support system only. After completing a RCT of community versus hospital-based rehabilitation, participants were randomised to either telephone maintenance or usual care. There was no discernible benefit associated with this strategy at any time point up to 18 months post graduation from rehabilitation.

There have been a couple of studies exploring maintenance after alternative forms of delivering the initial rehabilitation. Wijkstra *et al*^{206 207} explored two maintenance strategies after a 3-month course of home-based rehabilitation; the study also recruited a control group. The intervention group was divided to receive either weekly exercise supervised by a physical therapist or monthly sessions for a further 15 months. The study was underpowered (n=11 and n=12 respectively) but demonstrated an advantage of both maintenance strategies in quality of life and physical performance. The quality of life was significantly improved in the group receiving the monthly support compared with the control group. The 6MWT distance was maintained during the 18-month period in the maintenance groups, while the control group declined. This was not different between groups but there was a significant within-group decline observed in the control group. More recently, there has been an examination of a maintenance programme after an initial inpatient programme.²⁰⁸ The maintenance approach was coordinated with a health community network that included self-help organisations. In total, the maintenance group received 96 sessions supervised by a healthcare professional over a 12-month period (exercise and psychosocial support). This study 'consecutively allocated' individuals (assume not randomised) to this package of care (n=14) or standard care (n=26). Although a small study, the

data suggested important benefits in exercise capacity and quality of life. Interestingly there was also a reduction in hospital days for respiratory illness. This form of maintenance was probably not dissimilar to many rehabilitation programmes offered in the UK.

Evidence statement

- ▶ Continuation of supervised exercise training beyond pulmonary rehabilitation protects the patient from a decline in exercise capacity compared with a control group. (Evidence level 1–)

Recommendation

- ▶ All patients completing pulmonary rehabilitation should be encouraged to continue to exercise beyond the programme. (Grade A)

Good practice point

- ▶ Patients graduating from a pulmonary rehabilitation programme should be provided with opportunities for physical exercise beyond their rehabilitation programme. (✓)

SUMMARY OF RESEARCH RECOMMENDATIONS

- ▶ To develop validated easy-to-use, sensitive outcome tools that extend the range to incorporate assessment of pulmonary rehabilitation on extra-pulmonary manifestations, such as daily physical activity, skeletal muscle dysfunction, osteoporosis and cardiovascular risk, which are of prognostic significance in COPD.
- ▶ To understand whether pulmonary rehabilitation may preserve health with the aim of reducing long-term disability and dependence in those with milder chronic respiratory disease and how best this rehabilitation is delivered.
- ▶ Poor uptake and adherence remain significant barriers to effective pulmonary rehabilitation. There is a need for robust, well designed trials to explore techniques in the pre and peri pulmonary rehabilitation period that might improve uptake and adherence. This is also pertinent to post-exacerbation pulmonary rehabilitation.
- ▶ Personalisation of pulmonary rehabilitation:
 - To identify clinical phenotypes that may respond differently to pulmonary rehabilitation.
 - Objective tests of patient competency during pulmonary rehabilitation can help personalise and optimise the programme structure at an individual level.
 - Individualising the relative proportions of resistance and aerobic training during pulmonary rehabilitation according to clinical phenotype or skeletal muscle structure/function has yet to be studied.
- ▶ The relative sustainability and duration of benefits of resistance and aerobic training is required.
- ▶ The optimal structure of pulmonary rehabilitation remains unknown. More robust studies are required to determine quality, cost effectiveness and greater choice of delivery. To improve accessibility to pulmonary rehabilitation, such research may include technologies.
- ▶ In comparison to exercise training, there has been considerably less work on the educational element of pulmonary rehabilitation.
- ▶ An unanswered question is whether there is value in delaying post-hospitalisation pulmonary rehabilitation (ie, comparing elective vs early pulmonary rehabilitation following hospitalisation for exacerbation of COPD).
- ▶ Robust research to explore further the role of nutritional supplementation and hormones as adjuncts to pulmonary rehabilitation. This should include:
 - specific clinical phenotypes and/or using alternative regimens for anabolic steroids;

- while some nutritional supplements have been rigorously researched, several studies have been small or used multiple endpoints; similarly, there are opportunities to consider alternative nutritional supplements in combination with pulmonary rehabilitation;
- several muscle anabolic and anti-cachexia drugs are in development and well designed studies are required to test whether these have value as an adjunct to pulmonary rehabilitation and which clinical phenotypes are most likely to benefit.
- ▶ The wider value of ambulatory oxygen, outside of pulmonary rehabilitation, remains contentious. Further study on the optimal threshold for the use of ambulatory oxygen would be welcome as would clarification regarding whether there is potential harm from hypoxia-related or exercise-related systemic inflammation and oxidative stress.
- ▶ Other adjuncts such as NIV in routinely supporting exercise training in the context of a pulmonary rehabilitation programme are required. This is particularly pertinent in patients with chronic respiratory failure. Further, high-quality studies of NMES as an adjunct are required, including the clinical phenotype most likely to benefit.
- ▶ Robust research to optimise pulmonary rehabilitation to produce meaningful and sustainable behaviour change is of particular importance, such as leading to improvement in physical activity.
- ▶ Patients with chronic respiratory diseases other than COPD are increasingly referred to pulmonary rehabilitation. Knowledge gained from patients with COPD has been extrapolated to patients with other chronic respiratory disease and there is a dearth of studies examining specific non-COPD populations. Unanswered questions in people with chronic respiratory disease that require further research include:
 - the appropriateness of outcome measures originally designed in COPD populations for use in other chronic respiratory diseases;
 - the responsiveness of disease-specific outcome measures, particularly health status questionnaires;
 - the effect on healthcare resource usage and health economic benefits of pulmonary rehabilitation;
 - the optimal length and duration of pulmonary rehabilitation;
 - the duration of benefits of pulmonary rehabilitation, including rapidly progressive conditions such as IPF.
 - the relative merits of different components of training (eg, resistance vs aerobic; upper limb vs lower limb);
 - the effects, if any, of individualised goal setting;
 - the value of individualising the education component of PR according to disease;
 - the optimal timing of pulmonary rehabilitation and whether there is value in providing post-hospitalisation pulmonary rehabilitation in exacerbations of other chronic respiratory disease;
 - the impact of exacerbation frequency on pulmonary rehabilitation compliance and response in conditions associated with frequent exacerbations such as bronchiectasis.
- ▶ Repeating pulmonary rehabilitation programmes seems logical given the natural decline in function and health status following the course, but requires further study to elucidate the optimal frequency and the manner of delivery.
- ▶ More studies are needed to determine effective delivery models for maintenance exercise following a pulmonary rehabilitation programme. This might include the use of telehealth technologies.

AUDIT

An audit of pulmonary rehabilitation will be offered as part of the 2013-2016 National COPD Audit Programme (England and Wales) which has been commissioned by the Healthcare Quality Improvement Partnership (HQIP) on behalf of the Department of Health. It is part of the National Clinical Audit and Patient Outcomes Programme.

CONCLUSIONS

This is an evidenced-based guideline for pulmonary rehabilitation. Its focus is on delivering a quality pulmonary rehabilitation programme for appropriate patients with chronic respiratory disease and to this end it includes sections on many aspects: outcomes, referral, content and design, timing, adjuncts, other chronic respiratory disease and the post-pulmonary rehabilitation period. However, in compiling the guideline, we recognise that it could not encompass all the important questions pertaining to pulmonary rehabilitation. We *a priori* opted not to evaluate healthcare utilisation costs.

This is a rapidly progressive research field and the guideline will be reviewed in the next 5 years.

Author affiliations

¹Nottingham Respiratory Research Unit, University of Nottingham, City Hospital campus, Nottingham, UK

²Department of Pulmonary Rehabilitation, Worcestershire Royal Hospital, Worcester, UK

³Respiratory Medicine, University Hospital Aintree, Liverpool, UK

⁴Patient representative, Mansfield, UK

⁵Department of Respiratory Infection and Medicine, Imperial College Healthcare NHS Trust, London, UK

⁶Pulmonary Rehabilitation Department, Kings College NHS Foundation Trust, London, UK

⁷Department of Respiratory Medicine, University Hospitals of Leicester, Leicester, UK

⁸Respiratory Medicine, Royal Victoria Infirmary, Newcastle, UK

⁹Department of Respiratory Medicine, Royal Brompton Hospital, London, UK

¹⁰Department of Respiratory Medicine, NIHR Biomedical Research Unit for Advanced Lung Disease, Harefield, UK

¹¹Respiratory Medicine, University Hospital Llandough, Penarth, S Wales, UK

¹²Respiratory Medicine, Whipps Cross Hospital, London, UK

¹³Department of Cardiac/Pulmonary Rehabilitation, University Hospitals of Leicester NHS Trust, Leicester, UK

¹⁴Heart of England NHS Foundation Trust, Birmingham, UK

Acknowledgements Particular thanks go to Sally Welham, Deputy Chief Executive, BTS for her advice and support during the guideline development and facilitating processes. The GDG would like to thank all the staff at the BTS who assisted. Thank you also to the Standards of Care Committee for their review and advice of the guideline; BTS guideline Chairs who offered opinion in specific areas; Jane Ingham, Director of Clinical Standards, Royal College of Physicians for her guidance throughout and advice and reviews of draft versions; Sharon Swain, Senior Research Fellow, and Mark Perry, Research Fellow, Royal College of Physicians for their training; Dave Fox, Information Specialist, Centre for Reviews and Dissemination, University of York for the literature searches; The Vascular Society, UK for advice on aortic aneurysms and pulmonary rehabilitation.

Funding The meeting room, travel expenses, literature search and associated administration costs were funded by the BTS.

REFERENCES

- Department of Health. *An outcomes strategy for chronic obstructive pulmonary disease (COPD) and asthma in England*. 2011. http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_128428.pdf (accessed May 2013).
- British Thoracic Society Standards of Care Subcommittee on Pulmonary Rehabilitation. Pulmonary rehabilitation. *Thorax* 2001;56:827–34.
- National Institute for Health and Clinical Excellence. Chronic obstructive pulmonary disease. Management of chronic obstructive pulmonary disease in adults in primary and secondary care (partial update). 2010. <http://www.nice.org.uk/nicemedialive/13029/49397/49397.pdf> (accessed May 2013).
- Bott J, Blumenthal S, Buxton M, *et al*. Guidelines for the physiotherapy management of the adult, medical, spontaneously breathing patient. *Thorax* 2009;64(Suppl 1):i1–51.
- Nici L, Donner C, Wouters E, *et al*. American Thoracic Society/European Respiratory Society statement on pulmonary rehabilitation. *Am J Respir Crit Care Med* 2006;173:1390–413.
- Pasteur MC, Bilton D, Hill AT. British Thoracic Society guideline for non-CF bronchiectasis. *Thorax* 2010;65(Suppl 1):i1–58.
- National Institute for Health and Clinical Excellence. *Research services for people with chronic obstructive pulmonary disease*. NICE commissioning guide 43. London: NICE, 2011.
- British Thoracic Society, SIGN. *British guideline on the management of asthma. A national clinical guideline*. 2012.
- Yohannes AM, Connolly MJ. Pulmonary rehabilitation programmes in the UK: a national representative survey. *Clin Rehabil* 2004;18:444–9.
- Yohannes A, Stone R, Lowe D, *et al*. Pulmonary rehabilitation in the United Kingdom. *Chron Respir Dis* 2011;8:193–9.
- Lacasse Y, Goldstein R, Lasserson Toby J, *et al*. Pulmonary rehabilitation for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2006;(4):CD0037993. doi: 10.1002/14651858.CD003793.pub2
- Griffiths TL, Burr ML, Campbell IA, *et al*. Results at 1 year of outpatient multidisciplinary pulmonary rehabilitation: a randomised controlled trial. *Lancet* 2000;355:362–8.
- Singh SJ, Jones PW, Evans R, *et al*. Minimum clinically important improvement for the incremental shuttle walking test. *Thorax* 2008;63:775–7.
- Lacasse Y, Wong E, Guyatt GH, *et al*. Meta-analysis of respiratory rehabilitation in chronic obstructive pulmonary disease. *Lancet* 1996;348:1115–19.
- Redelmeier DA, Bayoumi AM, Goldstein RS, *et al*. Interpreting small differences in functional status: the six minute walk test in chronic lung disease patients. *Am J Respir Crit Care Med* 1997;155:1278–82.
- Jones PW. Interpreting thresholds for a clinically significant change in health status in asthma and COPD. *Eur Respir J* 2002;19:398–404.
- Dodd JW, Hogg L, Nolan J, *et al*. The COPD assessment test (CAT): response to pulmonary rehabilitation. A multicentre, prospective study. *Thorax* 2011;66:425–9.
- Dodd JW, Marns PL, Clark AL, *et al*. The COPD Assessment Test (CAT): short- and medium-term response to pulmonary rehabilitation. *COPD* 2012;9:390–4.
- Ringbaek T, Martinez G, Lange P. A comparison of the assessment of quality of life with CAT, CCQ, and SGRQ in COPD patients participating in pulmonary rehabilitation. *COPD* 2012;9:12–15.
- Pitta F, Troosters T, Probst VS, *et al*. Quantifying physical activity in daily life with questionnaires and motion sensors in COPD. *Eur Respir J* 2006;27:1040–55.
- Watz H, Waschki B, Boehme C, *et al*. Extrapulmonary effects of chronic obstructive pulmonary disease on physical activity: a cross-sectional study. *Am J Respir Crit Care Med* 2008;177:743–51.
- Garcia-Aymerich J, Lange P, Benet M, *et al*. Regular physical activity reduces hospital admission and mortality in chronic obstructive pulmonary disease: a population based cohort study. *Thorax* 2006;61:772–8.
- Cindy Ng LW, Mackney J, Jenkins S, *et al*. Does exercise training change physical activity in people with COPD? A systematic review and meta-analysis. *Chron Respir Dis* 2012;9:17–26.
- de Blok BMJ, de Greef MHG, ten Hacken NHT, *et al*. The effects of a lifestyle physical activity counseling program with feedback of a pedometer during pulmonary rehabilitation in patients with COPD: a pilot study. *Patient Educ Couns* 2006;61:48–55.
- Sewell L, Singh SJ, Williams JEA, *et al*. Can individualized rehabilitation improve functional independence in elderly patients with COPD? *Chest* 2005;128:1194–200.
- Pitta F, Troosters T, Probst VS, *et al*. Are patients with COPD more active after pulmonary rehabilitation? *Chest* 2008;134:273–80.
- Garrod R, Paul EA, Wedzicha JA. An evaluation of the reliability and sensitivity of the London Chest Activity of Daily Living Scale (LCADL). *Respir Med* 2002;96:725–30.
- Yohannes AM, Roomi J, Winn S, *et al*. The Manchester Respiratory Activities of Daily Living questionnaire: development, reliability, validity, and responsiveness to pulmonary rehabilitation. *J Am Geriatr Soc* 2000;48:1496–500.
- Lareau SC, Carrieri-Kohlman V, Janson-Bjerkle S, *et al*. Development and testing of the Pulmonary Functional Status and Dyspnea Questionnaire (PFDQ). *Heart Lung* 1994;23:242–50.
- Law M, Baptiste S, McColl M, *et al*. The Canadian occupational performance measure: an outcome measure for occupational therapy. *Can J Occup Ther* 1990;57:82–7.
- Garrod R, Marshall J, Jones F. Self efficacy measurement and goal attainment after pulmonary rehabilitation. *Int J COPD* 2008;3:791–6.
- Kovelis D, Zabatiero J, Oldenberg N, *et al*. Responsiveness of three instruments to assess self-reported functional status in patients with COPD. *COPD* 2011;8:334–9.
- Swallow EB, Reyes D, Hopkinson NS, *et al*. Quadriceps strength predicts mortality in patients with moderate to severe chronic obstructive pulmonary disease. *Thorax* 2007;62:115–20.

- 34 Decramer M, Gosselink R, Troosters T, *et al.* Muscle weakness is related to utilization of health care resources in COPD patients. *Eur Respir J* 1997;10:417–23.
- 35 Casaburi R, Bhasin S, Cosentino L, *et al.* Effects of testosterone and resistance training in men with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2004;170:870–8.
- 36 Clark CJ, Cochrane LM, Mackay E, *et al.* Skeletal muscle strength and endurance in patients with mild COPD and the effects of weight training. *Eur Respir J* 2000;15:92–7.
- 37 Clark CJ, Cochrane L, Mackay E. Low intensity peripheral muscle conditioning improves exercise tolerance and breathlessness in COPD. *Eur Respir J* 1996;9:2590–6.
- 38 O'Shea SD, Taylor NF, Paratz JD. A predominantly home-based progressive resistance exercise program increases knee extensor strength in the short-term in people with chronic obstructive pulmonary disease: a randomised controlled trial. *Aust J Physiother* 2007;53:229–37.
- 39 Troosters T, Gosselink R, Decramer M. Short- and long-term effects of outpatient rehabilitation in patients with chronic obstructive pulmonary disease: a randomized trial. *Am J Med* 2000;109:207–12.
- 40 Kongsgaard M, Backer V, Jorgensen K, *et al.* Heavy resistance training increases muscle size, strength and physical function in elderly male COPD-patients—a pilot study. *Respir Med* 2004;98:1000–7.
- 41 Hoff J, Tjonna AE, Steinshamm S, *et al.* Maximal strength training of the legs in COPD: a therapy for mechanical inefficiency. *Med Sci Sports Exerc* 2007;39:220–6.
- 42 Simpson K, Killian K, McCartney N, *et al.* Randomised controlled trial of weightlifting exercise in patients with chronic airflow limitation. *Thorax* 1992;47:70–5.
- 43 Coventry PA, Hind D. Comprehensive pulmonary rehabilitation for anxiety and depression in adults with chronic obstructive pulmonary disease: systematic review and meta-analysis. *J Psychosom Res* 2007;55:1–65.
- 44 Lan C-C, Yang M-C, Lee C-H, *et al.* Pulmonary rehabilitation improves exercise capacity and quality of life in underweight patients with chronic obstructive pulmonary disease. *Respirology* 2011;16:276–83.
- 45 Franssen FME, Broekhuizen R, Janssen PP, *et al.* Effects of whole-body exercise training on body composition and functional capacity in normal-weight patients with COPD. *Chest* 2004;125:2021–8.
- 46 Steiner MC, Barton RL, Singh SJ, *et al.* Nutritional enhancement of exercise performance in chronic obstructive pulmonary disease: a randomised controlled trial. *Thorax* 2003;58:745–51.
- 47 Greening NJ, Evans RA, Williams JE, *et al.* Does body mass index influence the outcomes of a Waking-based pulmonary rehabilitation programme in COPD? *Chron Respir Dis* 2012;9:99–106.
- 48 Bandura A. Social foundations of thought and action: a social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall, 1986.
- 49 Ries AL, Kaplan RM, Limberg TM, *et al.* Effects of pulmonary rehabilitation on physiologic and psychosocial outcomes in patients with chronic obstructive pulmonary disease. *Ann Intern Med* 1995;122:823–32.
- 50 Arnold R, Ranchor AV, Koeter GH, *et al.* Changes in personal control as a predictor of quality of life after pulmonary rehabilitation. *Patient Educ Couns* 2006;61:99–108.
- 51 Vincent E, Sewell L, Wagg K, *et al.* Measuring a change in self-efficacy following pulmonary rehabilitation: an evaluation of the PRAISE tool. *Chest* 2011;140:1534–9.
- 52 Arnold E, Bruton A, Ellis-Hill C. Adherence to pulmonary rehabilitation: a qualitative study. *Respir Med* 2006;100:1716–23.
- 53 Bulley C, Donaghy M, Howden S, *et al.* A prospective qualitative exploration of views about attending pulmonary rehabilitation. *Physiother Res Int* 2009;14:181–92.
- 54 Harris D, Hayter M, Allender S. Improving the uptake of pulmonary rehabilitation in patients with COPD: qualitative study of experiences and attitudes. *Br J Gen Pract* 2008;58:703–10.
- 55 Fischer MJ, Scharloo M, Abbink JJ, *et al.* Participation and drop-out in pulmonary rehabilitation: a qualitative analysis of the patient's perspective. *Clin Rehabil* 2007;21:212–21.
- 56 van Stel HF, Colland VT, Heins NL, *et al.* Assessing inpatient pulmonary rehabilitation using the patient's view of outcome. *J Cardpulm Rehabil* 2002;22:201–10.
- 57 Graves J, Sandrey V, Graves T, *et al.* Effectiveness of a group opt-in session on uptake and graduation rates for pulmonary rehabilitation. *Chron Respir Dis* 2010;7:159–64.
- 58 Sabit R, Griffiths TL, Watkins AJ, *et al.* Predictors of poor attendance at an outpatient pulmonary rehabilitation programme. *Respir Med* 2008;102:819–24.
- 59 Young P, Dewse M, Fergusson W, *et al.* Respiratory rehabilitation in chronic obstructive pulmonary disease: predictors of nonadherence. *Eur Respir J* 1999;13:855–9.
- 60 Paone G, Serpilli M, Girardi E, *et al.* The combination of a smoking cessation programme with rehabilitation increases stop-smoking rate. *J Rehabil Med* 2008;40:672–7.
- 61 Carone M, Patessio A, Ambrosino N, *et al.* Efficacy of pulmonary rehabilitation in chronic respiratory failure (CRF) due to chronic obstructive pulmonary disease (COPD): the Maugeri Study. *Respir Med* 2007;101:2447–53.
- 62 Crisafulli E, Costi S, Luppi F, *et al.* Role of comorbidities in a cohort of patients with COPD undergoing pulmonary rehabilitation. *Thorax* 2008;63:487–92.
- 63 Crisafulli E, Gorgone P, Vagaggini B, *et al.* Efficacy of standard rehabilitation in COPD outpatients with comorbidities. *Eur Respir J* 2010;36:1042–8.
- 64 Gale NS, Duckers JM, Enright S, *et al.* Does pulmonary rehabilitation address cardiovascular risk factors in patients with COPD? *BMC Pulm Med* 2011;11:20.
- 65 Vivodtzev I, Minet C, Wuyam B, *et al.* Significant improvement in arterial stiffness after endurance training in patients with COPD. *Chest* 2010;137:585–92.
- 66 van Laarhoven CJ, Borstlap AC, van Berge Henegouwen DP, *et al.* Chronic obstructive pulmonary disease and abdominal aortic aneurysms. *Eur J Vasc Surg* 1993;7:386–90.
- 67 Lindholt JS, Heickendorff L, Antonsen S, *et al.* Natural history of abdominal aortic aneurysm with and without coexisting chronic obstructive pulmonary disease. *J Vasc Surg* 1998;28:226–33.
- 68 Sakamaki F, Oya H, Nagaya N, *et al.* Higher prevalence of obstructive airway disease in patients with thoracic or abdominal aortic aneurysm. *J Vasc Surg* 2002;36:35–40.
- 69 Brown LC, Powell JT. Risk factors for aneurysm rupture in patients kept under ultrasound surveillance. UK Small Aneurysm Trial Participants. *Ann Surg* 1999;230:289–96; discussion 296–7.
- 70 Chaikof EL, Brewster DC, Dalman RL, *et al.* The care of patients with an abdominal aortic aneurysm: the Society for Vascular Surgery practice guidelines. *J Vasc Surg* 2009;50(4 Suppl):S2–49.
- 71 Tew GA, Moss J, Crank H, *et al.* Endurance exercise training in patients with small abdominal aortic aneurysm: a randomized controlled pilot study. *Arch Phys Med Rehabil* 2012;93:1788–92.
- 72 Trappenburg JC, Troosters T, Spruit MA, *et al.* Psychosocial conditions do not affect short-term outcome of multidisciplinary rehabilitation in chronic obstructive pulmonary disease. *Arch Phys Med Rehabil* 2005;86:1788–92.
- 73 Withers NJ, Rudkin ST, White RJ. Anxiety and depression in severe chronic obstructive pulmonary disease: the effects of pulmonary rehabilitation. *J Cardpulm Rehabil* 1999;19:362–5.
- 74 Harrison SL, Greening NJ, Williams JE, *et al.* Have we underestimated the efficacy of pulmonary rehabilitation in improving mood? *Respir Med* 2012;106:838–44.
- 75 Keating A, Lee A, Holland AE. What prevents people with chronic obstructive pulmonary disease from attending pulmonary rehabilitation? A systematic review. *Chron Respir Dis* 2011;8:89–99.
- 76 Evans RA, Singh SJ, Collier R, *et al.* Pulmonary rehabilitation is successful for COPD irrespective of MRC dyspnoea grade. *Respir Med* 2009;103:1070–5.
- 77 Man WDC, Grant A, Hogg L, *et al.* Pulmonary rehabilitation in patients with MRC Dyspnoea Scale 2. *Thorax* 2011;66:263.
- 78 Gottlieb V, Lyngso AM, Nybo B, *et al.* Pulmonary rehabilitation for moderate COPD (GOLD 2)—does it have an effect? *COPD* 2011;8:380–6.
- 79 Wedzicha JA, Bestall JC, Garrod R, *et al.* Randomized controlled trial of pulmonary rehabilitation in severe chronic obstructive pulmonary disease patients, stratified with the MRC Dyspnoea Scale. *Eur Respir J* 1998;12:363–9.
- 80 Ambrosino N, Foglio K, Balzano G, *et al.* Tiotropium and exercise training in COPD patients: effects on dyspnea and exercise tolerance. *Int J COPD* 2008;3:771–80.
- 81 Casaburi R, Kukafka D, Cooper CB, *et al.* Improvement in exercise tolerance with the combination of tiotropium and pulmonary rehabilitation in patients with COPD. *Chest* 2005;127:809–17.
- 82 Goldstein RS, Gort EH, Stubbing D, *et al.* Randomised controlled trial of respiratory rehabilitation. *Lancet* 1994;344:1394–7.
- 83 American College of Sports Medicine. *ACSM's guidelines for exercise testing and prescription*. 8th edn. Philadelphia: Lippincott Williams & Wilkins, 2009.
- 84 Department of Health. *At least five a week. Evidence on the impact of physical activity and its relationship to health*. A report from the Chief Medical Officer, 2009. Gateway Ref: 2389.
- 85 Liddell F, Webber J. Pulmonary rehabilitation for chronic obstructive pulmonary disease: a pilot study evaluating a once-weekly versus twice-weekly supervised programme. *Physiotherapy* 2010;96:68–74.
- 86 O'Neill B, McKevitt A, Rafferty S, *et al.* A comparison of twice- versus once-weekly supervision during pulmonary rehabilitation in chronic obstructive pulmonary disease. *Arch Phys Med Rehabil* 2007;88:167–72.
- 87 Green RH, Singh SJ, Williams J, *et al.* A randomised controlled trial of four weeks versus seven weeks of pulmonary rehabilitation in chronic obstructive pulmonary disease. *Thorax* 2001;56:143–5.
- 88 Sewell L, Singh SJ, Williams JEA, *et al.* How long should outpatient pulmonary rehabilitation be? A randomised controlled trial of 4 weeks versus 7 weeks. *Thorax* 2006;61:767–71.
- 89 Berry MJ, Rejeski WJ, Adair NE, *et al.* A randomized, controlled trial comparing long-term and short-term exercise in patients with chronic obstructive pulmonary disease. *J Cardpulm Rehabil* 2003;23:60–8.

- 90 Swerts PMJ, Kretzers LMJ, Terpstra-Lindeman E, *et al.* Exercise reconditioning in the rehabilitation of patients with chronic obstructive pulmonary disease: a short- and long-term analysis. *Arch Phys Med Rehabil* 1990;71:570–3.
- 91 Foy CG, Rejeski WJ, Berry MJ, *et al.* Gender moderates the effects of exercise therapy on health-related quality of life among COPD patients. *Chest* 2001;119:70–6.
- 92 Beauchamp MK, Janaudis-Ferreira T, Goldstein RS, *et al.* Optimal duration of pulmonary rehabilitation for individuals with chronic obstructive pulmonary disease—a systematic review. *Chron Respir Dis* 2011;8:129–40.
- 93 O'Shea SD, Taylor NF, Paratz JD. Progressive resistance exercise improves muscle strength and may improve elements of performance of daily activities for people with COPD: a systematic review. *Chest* 2009;136:1269–83.
- 94 Ortega F, Toral J, Cejudo P, *et al.* Comparison of effects of strength and endurance training in patients with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2002;166:669–74.
- 95 Panton LB, Golden J, Broeder CE, *et al.* The effects of resistance training on functional outcomes in patients with chronic obstructive pulmonary disease. *Eur J Appl Physiol* 2004;91:443–9.
- 96 Phillips WT, Benton MJ, Wagner CL, *et al.* The effect of single set resistance training on strength and functional fitness in pulmonary rehabilitation patients. *J Cardpulm Rehabil* 2006;26:330–7.
- 97 Dourado VZ, Tanni SE, Antunes LCO, *et al.* Effect of three exercise programs on patients with chronic obstructive pulmonary disease. *Braz J Med Biol Res* 2009;42:263–71.
- 98 Bernard S, Whittom F, Leblanc P, *et al.* Aerobic and strength training in patients with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 1999;159:896–901.
- 99 Mador MJ, Bozkanat E, Aggarwal A, *et al.* Endurance and strength training in patients with COPD. *Chest* 2004;125:2036–45.
- 100 Vonbank K, Strasser B, Mondrzyk J, *et al.* Strength training increases maximum working capacity in patients with COPD—randomized clinical trial comparing three training modalities. *Respir Med* 2012;106:557–63.
- 101 Houchen L, Steiner MC, Singh SJ. How sustainable is strength training in chronic obstructive pulmonary disease? *Physiotherapy* 2009;95:1–7.
- 102 Hauer K, Rost B, Rutschle K, *et al.* Exercise training for rehabilitation and secondary prevention of falls in geriatric patients with a history of injurious falls. *J Am Geriatr Soc* 2001;49:10–20.
- 103 Zainuldin R, Mackey MG, Alison JA. Optimal intensity and type of leg exercise training for people with chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2011;(11):CD008008.
- 104 Berry MJ, Rejeski WJ, Miller ME, *et al.* A lifestyle activity intervention in patients with chronic obstructive pulmonary disease. *Respir Med* 2010;104:829–39.
- 105 Norweg AM, Whiteson J, Malgady R, *et al.* The effectiveness of different combinations of pulmonary rehabilitation program components: a randomized controlled trial. *Chest* 2005;128:663–72.
- 106 White RJ, Rudkin ST, Harrison ST, *et al.* Pulmonary rehabilitation compared with brief advice given for severe chronic obstructive pulmonary disease. *J Cardpulm Rehabil* 2002;22:338–44.
- 107 Maltais F, Bourbeau J, Shapiro S, *et al.* Effects of home-based pulmonary rehabilitation in patients with chronic obstructive pulmonary disease: a randomized trial. [Summary for patients in *Ann Intern Med* 2008;149:156; PMID: 19075202]. *Ann Intern Med* 2008;149:869–78.
- 108 Guell MR, De Lucas P, Galdiz JB, *et al.* Home vs hospital-based pulmonary rehabilitation for patients with chronic obstructive pulmonary disease: a Spanish multicenter trial. *Arch Bronconeumol* 2008;44:512–18.
- 109 Puente-Maestu L, Sanz ML, Sanz P, *et al.* Comparison of effects of supervised versus self-monitored training programmes in patients with chronic obstructive pulmonary disease. *Eur Respir J* 2000;15:517–25.
- 110 Mendes De Oliveira JC, Studart Leitao Filho FS, Malosa Sampaio LM, *et al.* Outpatient vs. home-based pulmonary rehabilitation in COPD: a randomized controlled trial. *Multidiscip Respir Med* 2010;5:401–8.
- 111 Strijbos JH, Postma DS, van Altena R, *et al.* A comparison between an outpatient hospital-based pulmonary rehabilitation program and a home-care pulmonary rehabilitation program in patients with COPD. A follow-up of 18 months. *Chest* 1996;109:366–72.
- 112 Maltais F, Bourbeau J, Shapiro S, *et al.* Effects of home-based pulmonary rehabilitation in patients with chronic obstructive pulmonary disease: a randomized trial. *Ann Intern Med* 2008;149:869–78.
- 113 Hospes G, Bossenbroek L, Ten Hacken NHT, *et al.* Enhancement of daily physical activity increases physical fitness of outclinic COPD patients: results of an exercise counseling program. *Patient Educ Couns* 2009;75:274–8.
- 114 Wewel AR, Gellermann I, Schwertfeger I, *et al.* Intervention by phone calls raises domiciliary activity and exercise capacity in patients with severe COPD. *Respir Med* 2008;102:20–6.
- 115 Liu WT, Wang CH, Lin HC, *et al.* Efficacy of a cell phone-based exercise programme for COPD. *Eur Respir J* 2008;32:651–9.
- 116 Puhan MA, Gimeno-Santos E, Scharplatz M, *et al.* Pulmonary rehabilitation following exacerbations of chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2011;(10):CD005305.
- 117 Ko FWS, Dai DLK, Ngai J, *et al.* Effect of early pulmonary rehabilitation on health care utilization and health status in patients hospitalized with acute exacerbations of COPD. *Respirology* 2011;16:617–24.
- 118 Puhan MA, Spaar A, Frey M, *et al.* Early versus late pulmonary rehabilitation in chronic obstructive pulmonary disease patients with acute exacerbations: a randomized trial. *Respiration* 2012;83:499–506.
- 119 Hurst JR, Donaldson GC, Quint JK, *et al.* Temporal clustering of exacerbations in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2009;179:369–74.
- 120 Man WDC, Polkey MI, Donaldson N, *et al.* Community pulmonary rehabilitation after hospitalisation for acute exacerbations of chronic obstructive pulmonary disease: randomised controlled study. *BMJ* 2004;329:1209.
- 121 Seymour JM, Moore L, Jolley CJ, *et al.* Outpatient pulmonary rehabilitation following acute exacerbations of COPD. *Thorax* 2010;65:423–8.
- 122 Eaton T, Young P, Fergusson W, *et al.* Does early pulmonary rehabilitation reduce acute health-care utilization in COPD patients admitted with an exacerbation? A randomized controlled study. *Respirology* 2009;14:230–8.
- 123 Casaburi R. Combination therapy for exercise intolerance in COPD. *Thorax* 2006;61:551–2.
- 124 Laveneziana P, Parker CM, O'Donnell DE. Ventilatory constraints and dyspnea during exercise in chronic obstructive pulmonary disease. *Appl Physiol Nutr Metab* 2007;32:1225–38.
- 125 Redline S, Gottfried SB, Altose MD. Effects of changes in inspiratory muscle strength on the sensation of respiratory force. *J Appl Physiol* 1991;70:240–5.
- 126 Chlif M, Keochkerian D, Mourlhon C, *et al.* Noninvasive assessment of the tension-time index of inspiratory muscles at rest in obese male subjects. *Int J Obes (Lond)* 2005;29:1478–83.
- 127 O'Donnell DE, Bertley JC, Chau LK, *et al.* Qualitative aspects of exertional breathlessness in chronic airflow limitation: pathophysiologic mechanisms. *Am J Respir Crit Care Med* 1997;155:109–15.
- 128 O'Donnell DE, Lam M, Webb KA. Measurement of symptoms, lung hyperinflation, and endurance during exercise in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 1998;158(5 Pt 1):1557–65.
- 129 O'Donnell DE, Laveneziana P. Dyspnea and activity limitation in COPD: mechanical factors. *COPD* 2007;4:225–36.
- 130 Casaburi R, Porszasz J. Reduction of hyperinflation by pharmacologic and other interventions. *Proc Am Thorac Soc* 2006;3:185–9.
- 131 Verges S, Boutellier U, Spengler CM. Effect of respiratory muscle endurance training on respiratory sensations, respiratory control and exercise performance: a 15-year experience. *Respir Physiol Neurobiol* 2008;161:16–22.
- 132 Mador MJ, Deniz O, Aggarwal A, *et al.* Effect of respiratory muscle endurance training in patients with COPD undergoing pulmonary rehabilitation. *Chest* 2005;128:1216–24.
- 133 Ambrosino N. The case for inspiratory muscle training in COPD. *Eur Respir J* 2011;37:233–5.
- 134 Weiner P, Azgad Y, Ganam R. Inspiratory muscle training combined with general exercise reconditioning in patients with COPD. *Chest* 1992;102:1351–6.
- 135 Berry MJ, Adair NE, Sevinsky KS, *et al.* Inspiratory muscle training and whole-body reconditioning in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 1996;153(6 Pt 1):1812–16.
- 136 Wanke T, Formanek D, Lahrman H, *et al.* Effects of combined inspiratory muscle and cycle ergometer training on exercise performance in patients with COPD. *Eur Respir J* 1994;7:2205–11.
- 137 Larson JL, Covey MK, Wirtz SE, *et al.* Cycle ergometer and inspiratory muscle training in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 1999;160:500–7.
- 138 Chailleux E, Laaban JP, Veale D. Prognostic value of nutritional depletion in patients with COPD treated by long-term oxygen therapy: data from the ANTADIR observatory. *Chest* 2003;123:1460–6.
- 139 Tsiigianni IG, van der Molen T. A systematic review of the role of vitamin insufficiencies and supplementation in COPD. *Respir Res* 2010;11:171.
- 140 Broekhuizen R, Creutzberg EC, Weling-Scheepers CAPM, *et al.* Optimizing oral nutritional drink supplementation in patients with chronic obstructive pulmonary disease. *Br J Nutr* 2005;93:965–71.
- 141 Borghi-Silva A, Baldissera V, Sampaio LMM, *et al.* L-carnitine as an ergogenic aid for patients with chronic obstructive pulmonary disease submitted to whole-body and respiratory muscle training programs. *Braz J Med Biol Res* 2006;39:465–74.
- 142 Baldi S, Aquilani R, Pinna GD, *et al.* Fat-free mass change after nutritional rehabilitation in weight losing COPD: role of insulin, C-reactive protein and tissue hypoxia. *Int J COPD* 2010;5:29–39.
- 143 Kubo H, Honda N, Tsuji F, *et al.* Effects of dietary supplements on the Fischer ratio before and after pulmonary rehabilitation. *Asia Pac J Clin Nutr* 2006;15:551–5.

- 144 Broekhuizen R, Wouters EFM, Creutzberg EC, *et al.* Polyunsaturated fatty acids improve exercise capacity in chronic obstructive pulmonary disease. *Thorax* 2005;60:376–82.
- 145 Fuld JP, Kilduff LP, Neder JA, *et al.* Creatine supplementation during pulmonary rehabilitation in chronic obstructive pulmonary disease. *Thorax* 2005;60:531–7.
- 146 Faager G, Soderlund K, Skold CM, *et al.* Creatine supplementation and physical training in patients with COPD: a double blind, placebo-controlled study. *Int J Chron Obstruct Pulmon Dis* 2006;1:445–53.
- 147 Deacon SJ, Vincent EE, Greenhaff PL, *et al.* Randomized controlled trial of dietary creatine as an adjunct therapy to physical training in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2008;178:233–9.
- 148 Kicman AT. Pharmacology of anabolic steroids. *Br J Pharmacol* 2008;154:502–21.
- 149 Creutzberg EC, Wouters EFM, Mostert R, *et al.* A role for anabolic steroids in the rehabilitation of patients with COPD? A double-blind, placebo-controlled, randomized trial. *Chest* 2003;124:1733–42.
- 150 Pison CM, Cano NJ, Cherion C, *et al.* Multimodal nutritional rehabilitation improves clinical outcomes of malnourished patients with chronic respiratory failure: a randomised controlled trial. *Thorax* 2011;66:953–60.
- 151 Garrod R, Mikelsons C, Paul EA, *et al.* Randomized controlled trial of domiciliary noninvasive positive pressure ventilation and physical training in severe chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2000;162(4 I): 1335–41.
- 152 Duiverman ML, Wempe JB, Bladder G, *et al.* Nocturnal non-invasive ventilation in addition to rehabilitation in hypercapnic patients with COPD. *Thorax* 2008;63:1052–7.
- 153 Kohnlein T, Schonheit-Kenn U, Winterkamp S, *et al.* Noninvasive ventilation in pulmonary rehabilitation of COPD patients. *Respir Med* 2009;103:1329–36.
- 154 van 't Hul A, Kwakkel G, Gosselink R. The acute effects of noninvasive ventilatory support during exercise on exercise endurance and dyspnea in patients with chronic obstructive pulmonary disease: a systematic review. *J Cardpulm Rehabil* 2002;22:290–7.
- 155 Bianchi L, Foglio K, Porta R, *et al.* Lack of additional effect of adjunct of assisted ventilation to pulmonary rehabilitation in mild COPD patients. *Respir Med* 2002;96:359–67.
- 156 Johnson JE, Gavin DJ, Adams-Dramiga S. Effects of training with heliox and noninvasive positive pressure ventilation on exercise ability in patients with severe COPD. *Chest* 2002;122:464–72.
- 157 Costes F, Agresti A, Court-Fortune I, *et al.* Noninvasive ventilation during exercise training improves exercise tolerance in patients with chronic obstructive pulmonary disease. *J Cardpulm Rehabil* 2003;23:307–13.
- 158 Reuveny R, Ben-Dov I, Gaides M, *et al.* Ventilatory support during training improves training benefit in severe chronic airway obstruction. *Isr Med Assoc J* 2005;7:151–5.
- 159 van 't Hul A, Gosselink R, Hollander P, *et al.* Training with inspiratory pressure support in patients with severe COPD. *Eur Respir J* 2006;27:65–72.
- 160 Toledo A, Borghi-Silva A, Sampaio LMM, *et al.* The impact of noninvasive ventilation during the physical training in patients with moderate-to-severe chronic obstructive pulmonary disease (COPD). *Clinics* 2007;62:113–20.
- 161 Hawkins P, Johnson LC, Nikolettou D, *et al.* Proportional assist ventilation as an aid to exercise training in severe chronic obstructive pulmonary disease. *Thorax* 2002;57:853–9.
- 162 Arena R, Sietsema KE. Cardiopulmonary exercise testing in the clinical evaluation of patients with heart and lung disease. *Circulation* 2011;123: 668–80.
- 163 Revill SM, Singh SJ, Morgan MD. Randomized controlled trial of ambulatory oxygen and an ambulatory ventilator on endurance exercise in COPD. *Respir Med* 2000;94:78–83.
- 164 Emtner M, Porszasz J, Burns M, *et al.* Benefits of supplemental oxygen in exercise training in nonhypoxemic chronic obstructive pulmonary disease patients. *Am J Respir Crit Care Med* 2003;168:1034–42.
- 165 Rooyackers JM, Dekhuijzen PN, Van Herwaarden CL, *et al.* Training with supplemental oxygen in patients with COPD and hypoxaemia at peak exercise. *Eur Respir J* 1997;10:1278–84.
- 166 Garrod R, Paul EA, Wedzicha JA. Supplemental oxygen during pulmonary rehabilitation in patients with COPD with exercise hypoxaemia. *Thorax* 2000;55:539–43.
- 167 Dyer F, Callaghan J, Cheema K, *et al.* Ambulatory oxygen improves the effectiveness of pulmonary rehabilitation in selected patients with chronic obstructive pulmonary disease. *Chron Respir Dis* 2012;9:83–91.
- 168 Wadell K, Henriksson-Larsen K, Lundgren R. Physical training with and without oxygen in patients with chronic obstructive pulmonary disease and exercise-induced hypoxaemia. *J Rehabil Med* 2001;33:200–5.
- 169 Rodrigo G, Pollack C, Rodrigo C, *et al.* Heliox for treatment of exacerbations of chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2002;(2): CD003571.
- 170 Ho AM, Lee A, Karmakar MK, *et al.* Heliox vs air-oxygen mixtures for the treatment of patients with acute asthma: a systematic overview. *Chest* 2003;123:882–90.
- 171 Scorsone D, Bartolini S, Saporiti R, *et al.* Does a low-density gas mixture or oxygen supplementation improve exercise training in COPD? *Chest* 2010;138:1133–9.
- 172 Sillen MJ, Speksnijder CM, Eterman RM, *et al.* Effects of neuromuscular electrical stimulation of muscles of ambulation in patients with chronic heart failure or COPD: a systematic review of the English-language literature. *Chest* 2009;136:44–61.
- 173 Roig M, Reid WD. Electrical stimulation and peripheral muscle function in COPD: a systematic review. *Respir Med* 2009;103:485–95.
- 174 Vivodtzev I, Pepin JL, Vottero G, *et al.* Improvement in quadriceps strength and dyspnea in daily tasks after 1 month of electrical stimulation in severely deconditioned and malnourished COPD. *Chest* 2006;129:1540–8.
- 175 Zanotti E, Felicetti G, Maini M, *et al.* Peripheral muscle strength training in bed-bound patients with COPD receiving mechanical ventilation: effect of electrical stimulation. *Chest* 2003;124:292–6.
- 176 Vivodtzev I, Debigare R, Gagnon P, *et al.* Functional and muscular effects of neuromuscular electrical stimulation in patients with severe COPD: a randomized clinical trial. *Chest* 2012;141:716–25.
- 177 Bourjeily-Habr G, Rochester CL, Palermo F, *et al.* Randomised controlled trial of transcutaneous electrical muscle stimulation of the lower extremities in patients with chronic obstructive pulmonary disease. *Thorax* 2002;57:1045–9.
- 178 Neder JA, Sword D, Ward SA, *et al.* Home based neuromuscular electrical stimulation as a new rehabilitative strategy for severely disabled patients with chronic obstructive pulmonary disease (COPD). *Thorax* 2002;57:333–7.
- 179 Dal Corso S, Napolis L, Malaguti C, *et al.* Skeletal muscle structure and function in response to electrical stimulation in moderately impaired COPD patients. *Respir Med* 2007;101:1236–43.
- 180 Abdellaoui A, Prefaut C, Gouzi F, *et al.* Skeletal muscle effects of electrostimulation after COPD exacerbation: a pilot study. *Eur Respir J* 2011;38:781–8.
- 181 Newall C, Stockley RA, Hill SL. Exercise training and inspiratory muscle training in patients with bronchiectasis. *Thorax* 2005;60:943–8.
- 182 British Thoracic Society. *Quality standards for clinically significant bronchiectasis in adults*; 2012. British Thoracic Society Reports, 4.
- 183 Pasteur MC, Bilton D, Hill AT. British Thoracic Society guideline for non-CF bronchiectasis. *Thorax* 2010;65:577.
- 184 Nishiyama O, Kondoh Y, Kimura T, *et al.* Effects of pulmonary rehabilitation in patients with idiopathic pulmonary fibrosis. *Respirology* 2008;13:394–9.
- 185 Holland AE, Hill CJ, Glaspole I, *et al.* Predictors of benefit following pulmonary rehabilitation for interstitial lung disease. *Respir Med* 2012;106:429–35.
- 186 Holland AE, Hill CJ, Conron M, *et al.* Short term improvement in exercise capacity and symptoms following exercise training in interstitial lung disease. *Thorax* 2008;63:549–54.
- 187 Cambach W, Chadwick-Straver RV, Wagenaar RC, *et al.* The effects of a community-based pulmonary rehabilitation programme on exercise tolerance and quality of life: a randomized controlled trial. *Eur Respir J* 1997;10:104–13.
- 188 Chandratilleke MG, Carson KV, Picot J, *et al.* Physical training for asthma. *Cochrane Database Syst Rev* 2012;(5):CD001116.
- 189 Holloway E, Ram FS. *Breathing exercises for asthma*. *Cochrane Database Syst Rev* 2004;(1):CD001277.
- 190 Singh SJ, Smith DL, Hyland ME, *et al.* A short outpatient pulmonary rehabilitation programme: immediate and longer-term effects on exercise performance and quality of life. *Respir Med* 1998;92:1146–54.
- 191 Foglio K, Bianchi L, Bruletti G, *et al.* Long-term effectiveness of pulmonary rehabilitation in patients with chronic airway obstruction. *Eur Respir J* 1999;13:125–32.
- 192 Hill K, Bansal V, Brooks D, *et al.* Repeat pulmonary rehabilitation programs confer similar increases in functional exercise capacity to initial programs. *J Cardipulm Rehabil Prev* 2008;28:410–4.
- 193 Guell R, Casan P, Belda J, *et al.* Long-term effects of outpatient rehabilitation of COPD: a randomized trial. *Chest* 2000;117:976–83.
- 194 Foglio K, Bianchi L, Ambrosino N. Is it really useful to repeat outpatient pulmonary rehabilitation programs in patients with chronic airway obstruction? A 2-year controlled study. *Chest* 2001;119:1696–704.
- 195 Romagnoli M, Dell'Orso D, Lorenzi C, *et al.* Repeated pulmonary rehabilitation in severe and disabled COPD patients. *Respiration* 2006;73:769–76.
- 196 Foglio K, Bianchi L, Bruletti G, *et al.* Seven-year time course of lung function, symptoms, health-related quality of life, and exercise tolerance in COPD patients undergoing pulmonary rehabilitation programs. *Respir Med* 2007;101: 1961–70.
- 197 Ries AL, Make BJ, Lee SM, *et al.* The effects of pulmonary rehabilitation in the national emphysema treatment trial. *Chest* 2005;128:3799–809.
- 198 Carr SJ, Hill K, Brooks D, *et al.* Pulmonary rehabilitation after acute exacerbation of chronic obstructive pulmonary disease in patients who previously completed a pulmonary rehabilitation program. *J Cardipulm Rehabil Prev* 2009;29:318–24.
- 199 Nishiyama O, Taniguchi H, Kondoh Y, *et al.* Factors in maintaining long-term improvements in health-related quality of life after pulmonary rehabilitation for COPD. *Qual Life Res* 2005;14:2315–21.

- 200 Ketelaars CA, Abu-Saad HH, Schlosser MA, *et al.* Long-term outcome of pulmonary rehabilitation in patients with COPD. *Chest* 1997;112:363–9.
- 201 Brooks D, Krip B, Mangovski-Alzamora S, *et al.* The effect of postrehabilitation programmes among individuals with chronic obstructive pulmonary disease. *Eur Respir J* 2002;20:20–9.
- 202 Ries AL, Kaplan RM, Myers R, *et al.* Maintenance after pulmonary rehabilitation in chronic lung disease: a randomized trial. *Am J Respir Crit Care Med* 2003;167:880–8.
- 203 Ringbaek T, Brondum E, Martinez G, *et al.* Long-term effects of 1-year maintenance training on physical functioning and health status in patients with COPD: a randomized controlled study. *J Cardiopulm Rehabil Prev* 2010;30:47–52.
- 204 Waterhouse JC, Walters SJ, Oluboyede Y, *et al.* A randomised 2x2 trial of community versus hospital pulmonary rehabilitation, followed by telephone or conventional follow-up. *Health Technol Assess* 2010;14:i–v, vii–xi, 1–140.
- 205 du Moulin M, Taube K, Wegscheider K, *et al.* Home-based exercise training as maintenance after outpatient pulmonary rehabilitation. *Respiration* 2009;77:139–45.
- 206 Wijkstra PJ, van der Mark TW, Kraan J, *et al.* Long-term effects of home rehabilitation on physical performance in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 1996;153(4 Pt 1):1234–41.
- 207 Wijkstra PJ, Ten Vergert EM, van Altena R, *et al.* Long term benefits of rehabilitation at home on quality of life and exercise tolerance in patients with chronic obstructive pulmonary disease. *Thorax* 1995;50:824–8.
- 208 Moullec G, Ninot G, Varray A, *et al.* An innovative maintenance follow-up program after a first inpatient pulmonary rehabilitation. *Respir Med* 2008;102:556–66.
- 209 NHS Medical Directorate. COPD Commissioning Toolkit. Pulmonary Rehabilitation Service Specification. 2012. <http://www.dh.gov.uk/health/2012/08/copd-toolkit/> (accessed May 2013).
- 210 Jones RCM, Wang X, Harding S, *et al.* Educational impact of pulmonary rehabilitation: Lung Information Needs Questionnaire. *Respir Med* 2008;102:1439–45.
- 211 White R, Walker P, Roberts S, *et al.* Bristol COPD Knowledge Questionnaire (BCKQ): testing what we teach patients about COPD. *Chron Respir Dis* 2006;3:123–31.

APPENDIX A: COMMITTEE MEMBERS

A full list of the GDG members and the contributors to each section of the guideline is given below, along with individual members representing other organisations.

	Sections
Dr Elaine Bevan-Smith	Referral, elements, post exacerbation, post rehabilitation
Dr John Blakey	Adjuncts, post rehabilitation, lay summary
Dr Charlotte Bolton	Chair
Mr Patrick Crowe	Patient representative, lay summary
Dr Sarah Elkin	Post rehabilitation
Dr Rachel Garrod	Elements, non-COPD rehabilitation
Dr Neil Greening	Outcomes, adjuncts
Ms Karen Heslop	Referral, elements, post rehabilitation, non-COPD rehabilitation
Dr James Hull	Referral
Dr Will Man	Post exacerbation, adjuncts, research recommendations
Professor Mike Morgan, representing the Royal College of Physicians, London	Programme characteristics, adjuncts
Mr David Proud	Programme characteristics, elements, adjuncts
Professor Mike Roberts	Outcomes, adjuncts
Dr Louise Sewell, representing the College of Occupational Therapists	Outcomes, programme characteristics
Professor Sally Singh	Programme characteristics, elements, post rehabilitation
Dr Paul Walker	Referral, programme characteristics
Ms Sandy Walmsley, representing the Primary Care Respiratory Society, UK	Programme characteristics, outcomes

A full list of the GDG declarations of interest can be found on the British Thoracic Society website or by contacting the British Thoracic Society Head Office.

APPENDIX B: LIST OF STAKEHOLDERS

- ▶ Association of Chartered Physiotherapists in Respiratory Care
- ▶ Association of Respiratory Nurse Specialists
- ▶ British Geriatrics Society
- ▶ British Lung Foundation
- ▶ College of Occupational Therapists
- ▶ Primary Care Respiratory Society, UK
- ▶ Royal College of Physicians London

- ▶ Royal College of Physicians and Surgeons of Glasgow
- ▶ The Thoracic Society of Australia and New Zealand

APPENDIX C: PATIENT INFORMATION

More information on pulmonary rehabilitation patient leaflets is available from http://www.improvement.nhs.uk/documents/BLF/PR_BK22_2012_v1.pdf or from the British Lung Foundation.

Some centres opt to formulate their own personalised leaflets discussing venues, timings and how patients can be referred. In addition, contact information for the rehabilitation team can be incorporated.

APPENDIX D: LAY SUMMARY

INTRODUCTION

Pulmonary rehabilitation

Long-term chest problems that interfere with daily life, such as chronic obstructive pulmonary disease (COPD), are common. They are a major cause of suffering, and also a considerable expense to the NHS as they lead to a large number of hospital admissions.

Pulmonary rehabilitation is a programme of exercise and education for people with long-term chest problems. Many studies have shown that pulmonary rehabilitation improves measurements of health and wellbeing, such as the distance an individual can walk or their likelihood of needing to go to hospital.

Why a guideline is needed

It is not clear how to get the most from a pulmonary rehabilitation programme. Basic questions such as who should start on the programme and how long a programme should last are still sources of discussion. Because of this uncertainty, there is a need to come to conclusions on best practice and set standards.

The British Thoracic Society produced its first statement on pulmonary rehabilitation in 2001. Since then, a large number of relevant studies have been published. A more detailed guideline has therefore been produced.

Who is the guideline for?

This guideline will mainly be of use for healthcare professionals who are involved in the care of people with long-term chest problems. It will also be useful for those who are involved in planning and funding services.

How the guideline was developed

This guideline was produced following a standard method. The first step was to gather a group who are involved in pulmonary rehabilitation programmes, including doctors, nurses, physiotherapists, an occupational therapist, a dietician and a patient

representative. The details of this Guideline Development Group are given in appendix A.

This group produced a long list of important questions in a standard format. An independent centre then undertook a detailed search and found a very large number of publications that might help answer the questions. These publications were reviewed in a standard manner in detail by at least two people. The whole group discussed the evidence around each question. Further comments were sought from other healthcare professionals, experts in developing guidelines, and patient groups.

Evidence

Throughout the main guideline document, the type of study providing information is indicated by a number. The strength of the evidence supporting each recommendation is shown by a letter (A=highest). Detailed information on each publication is included in the web appendix.

RECOMMENDATIONS

Outcomes

Currently pulmonary rehabilitation services do not collect the same information on people attending courses.

We recommend that services make assessments before and after rehabilitation. These assessments should measure the distance an individual can walk, their degree of breathlessness, their overall health status, their ability to do everyday tasks, and psychological aspects, such as anxiety.

Referral

There has been discussion around who should be considered for pulmonary rehabilitation. For example, some people have been thought to be too well or too ill to gain benefit. However, we found that people with severe chest problems and those with more mild breathlessness may benefit from pulmonary rehabilitation. Similarly, there is no evidence that current smokers or people with depression will not benefit.

People with unstable heart problems or with very severe muscle or joint problems have other priorities and pulmonary rehabilitation should be deferred.

People who are referred should receive accurate information about the planned pulmonary rehabilitation programme and the likely benefits. There should be an opportunity for discussion of the referral.

People who are referred for pulmonary rehabilitation should have their treatment for their chest condition reviewed at the time of referral. They will often have other conditions so the referral process provides an opportunity to identify problems such as malnourishment, depression, smoking and high blood pressure.

Programme characteristics

A variety of pulmonary rehabilitation programmes are provided in the UK. Most involve a programme lasting at least 6 weeks. This approach is supported by the available research.

Pulmonary rehabilitation programmes should include at least two supervised sessions per week. Less frequent contact may be less beneficial. Participants should be assisted and encouraged to do further exercise at home.

Programmes should include a variety of training types to provide benefits in strength and exercise capacity. There is no clear support for any particular format of this varied training.

Providing rehabilitation at home seems to be feasible, either in person or supported with internet video calls. Presently it is not possible to say who could take part in such programmes and still gain the same benefits as they would have had from standard pulmonary rehabilitation.

Rehabilitation after exacerbations

A rapid worsening in breathlessness and cough, along with a decline in measurements of lung capacity or oxygen levels, is referred to as an exacerbation of COPD. These distressing events may lead to admission to hospital.

Taking part in pulmonary rehabilitation soon after discharge gets people back to their usual level more quickly than they otherwise would. It also reduces the risk of coming back into hospital in the short term, and makes people feel better. We therefore recommend pulmonary rehabilitation for everyone admitted with an exacerbation of COPD. We also recommend that the providers of rehabilitation record the proportion of people who attend and complete these courses.

Aids to pulmonary rehabilitation

Several studies have investigated whether the benefits of pulmonary rehabilitation can be increased by adding something to the programme.

The guideline group examined trials of devices that train the breathing muscles, hormone and nutritional supplements, helium-containing gas mixtures and electrical muscle stimulators. These measures appear safe, but adding them to rehabilitation does not lead to greater benefit in walking distance or breathlessness so they are not routinely recommended.

People with long-term chest conditions may have oxygen or a ventilator at home. These treatments should not be started just for pulmonary rehabilitation.

Pulmonary rehabilitation for other conditions

Almost all studies investigating pulmonary rehabilitation have included people with COPD. However, many people are limited by other long-term chest problems. The guideline group suggests that anyone in this situation has the opportunity to discuss referral for pulmonary rehabilitation.

After rehabilitation

The improvements following pulmonary rehabilitation fade over time. We reviewed studies investigating whether maintenance sessions or repeat programmes were of benefit.

Generally, a repeat programme of pulmonary rehabilitation is of benefit if the last completed programme was more than 1 year ago. A shorter interval should be considered if there is a reason for rapid decline (such as an admission) or a need to be in the best possible condition (such as before a major operation).

All individuals who complete a course of pulmonary rehabilitation should be encouraged to continue to exercise.

APPENDIX E: ESSENTIAL INFORMATION REQUIRED ON A REFERRAL FORM TO PULMONARY REHABILITATION

- ▶ Name, date of birth, contact details.
- ▶ Known communication/language barriers.
- ▶ Respiratory diagnosis:
 - spirometry for those with COPD;
 - height, weight, BP, oxygen saturations at rest are desirable.
- ▶ Medical Research Council breathlessness score.
- ▶ Smoking status.
- ▶ Therapies:
 - current list of medication;
 - use of oxygen:
 - ▷ long-term oxygen therapy, short-burst oxygen therapy, ambulatory;
 - ▷ oxygen saturations;
 - use of domiciliary NIV.
- ▶ Significant and relevant comorbidities:
 - that may need consideration by provider before acceptance, in line with section ‘Referral and assessment of patients for pulmonary rehabilitation’;

- that may need to be considered in risk assessment, in line with section ‘Referral and assessment of patients for pulmonary rehabilitation’.
- ▶ Transport needs—if applicable to that rehabilitation provider: the referrer should have discussed with the patient about the referral and discussed the likely benefit of partaking.

APPENDIX F: SERVICE SPECIFICATION

Staffing is addressed in the Department of Health Service Specification for pulmonary rehabilitation: <http://www.dh.gov.uk/health/2012/08/copd-toolkit>²⁰⁹

It highlights a multidisciplinary staff with sufficient competencies and experience; administration support; sufficient cover for annual leave, sickness leave and maternity leave. Staff should have regular updates and training.

The Service Specification also provides useful and practical advice on equipment and risk assessment.

APPENDIX G: CHARACTERISTICS OF ROLLING AND COHORT PULMONARY REHABILITATION PROGRAMMES

	Rolling	Cohort
Nature of programme	Continuing cycle of sessions, with patients joining when there is a space and leaving after completing a programme of sessions	All patients start and finish the programme at the same time
Waiting list	<ul style="list-style-type: none"> ▶ May enter the programme when a space occurs (eg, from a dropout) so may curtail waiting list and could be more efficient ▶ Permits a fast-track facility for entry of post-rehabilitation subjects ▶ Potentially allows better capacity 	As an accumulative number of patients wait to start a cohort programme, the waiting list is distorted
Rehabilitation delivered at different locations by same team	Not suitable This is only suitable if the programme always runs at the same venue	Suitable
Education programme	The order of educational talks for the individual is governed by the point of entry	Can ‘flow’ in a logical order
Group dynamics	A new patient may be the sole new participant which may potentially be beneficial or a challenge	Patients all start together; permits group learning of lifestyle challenges
Assessments	Requires the ability to perform pre and post assessments in parallel to the course	Dedicated assessment slots can be programmed for all subjects pre and post rehabilitation
Duration of programme	Permits opportunity for early graduation to the gym and/or lengthening programme if required	Fixed length for each programme

APPENDIX H: SUGGESTED EDUCATIONAL TALKS TO ENCOMPASS IN THE PULMONARY REHABILITATION PROGRAMME

- ▶ Anatomy, physiology, pathology—in health and in chronic respiratory disease.
 - ▶ Medication (including oxygen therapy).
 - ▶ Smoking cessation.
 - ▶ Dyspnoea/symptom management.
 - ▶ Chest clearance techniques.
 - ▶ Energy conservation/pacing.
 - ▶ Patient support groups.
 - ▶ Nutritional advice.
 - ▶ Managing travel.
 - ▶ Benefits system and welfare rights.
 - ▶ Advance directives.
 - ▶ Anxiety management and relaxation.
 - ▶ Goal setting and rewards.
 - ▶ Relaxation.
 - ▶ Confidence, self-efficacy and self-management.
 - ▶ Identifying and changing beliefs about exercise and health-related behaviours.
- ▶ Loving relationships/sexuality.
 - ▶ Exacerbation management (including coping with setbacks and relapses).
 - ▶ The benefits of physical exercise.
 - ▶ Opportunities to exercise after pulmonary rehabilitation.

The talks should be delivered by members of the pulmonary rehabilitation staff with the opportunity to address questions. Inviting a former pulmonary rehabilitation graduate or member of a local Breathe Easy group should be considered. Supplementing the talks with written educational information is advised.

Patient satisfaction surveys and questionnaires containing disease-specific information (eg, for the Lung Information Needs Questionnaire or the Bristol Chronic Obstructive Pulmonary Disease Knowledge questionnaire) ensure quality of the educational aspects.^{210 211}

Supplemental practical information is provided by the service specification for pulmonary rehabilitation at <http://www.dh.gov.uk/health/2012/08/copd-toolkit>²⁰⁹