Thorax 1994;49:270–278

Pulmonary rehabilitation in chronic respiratory insufficiency · 8

Series editors: J-F Muir and D J Pierson

Setting up a pulmonary rehabilitation programme

C J Clark

In this series pulmonary rehabilitation has been defined, the effects on exercise described, modalities of treatment such as respiratory muscle training and ventilator therapy considered, and measures of quality of life reviewed. This article outlines a stepwise approach to setting up a pulmonary rehabilitation programme that would be practical in the UK.

Identification of aims

The definition of pulmonary rehabilitation (given in the first article of this series) provides the programme's rationale – to maximise the functions of daily living for individual patients with chronic disabling lung disease by introducing a comprehensive process of assessment and treatment. The focus will be on chronic obstructive pulmonary disease as the predominant chronic lung disease to consider first, and then other applications of pulmonary rehabilitation will be mentioned briefly.

Implicit in the approach of this paper is the assumption that routine services in the UK already contain many components which address patients' needs and do not require duplication. The objective in setting up pulmonary rehabilitation is therefore to *complement* rather than *replace* existing services. The advantage of this approach is that it is (1) less financially prohibitive to add to existing resources, (2) more likely to result in an efficient use of the resources specifically required for pulmonary rehabilitation; and (3) the process of reviewing current practice is likely to identify deficits and thereby improve the standards of routine care.

Table 1 gives a list of possible components of pulmonary rehabilitation which may include those aspects of patient care not currently part of routine service and which could be incorporated into a programme. District general hospital chest clinics usually provide for prescription of drug therapy, demonstration of inhaler technique, basic explanation of the disease process, referral for traditional physiotherapy breathing techniques, and deal with special requirements such as long term oxygen treatment (LTOT) or home ventilator therapy. Thus some components of pulmonary rehabilitation are "already in progress." On the other hand, investigation of activities of daily living, psychosocial function, nutritional status and, in particular, exercise prescription can be viewed as essential prerequisites for successful comprehensive pulmonary rehabilitation, and it is therefore important to concentrate on these aspects of care if not routinely available.

Table 1 Possible components of pulmonary rehabilitation programme (from ref 35 with permission)

Pharmacological therapy
Education
Physical therapy
Exercise conditioning
Occupational therapy
Psychosocial support
Follow up treatment
Oxygen therapy
Nutritional therapy
Respiratory muscles

Deciding the infrastructure requirements

STAFF REQUIREMENTS

Programme director

A chest physician should undertake this role which includes medicolegal responsibility for patient care during rehabilitation. He/she should be responsible for: (1) all aspects of programme design; (2) accurate assessment of suitability of patients for inclusion; (3) ensuring full and informed written consent by the patient; (4) appropriate programme prescription for the individual patient; (5) quality control of programme administration by staff; and (6) ensuring continuity of care between the programme and general practice.

In addition to these administrative responsibilities it is important to leave time to be practically involved in the training programme. This will ensure both that enthusiasm is allowed to develop and that the programme is viewed by the administration as a routine rather than optional service. In practice this requires one fixed session for a pulmonary rehabilitation medical assessment clinic plus time availability to see patients on an ad hoc basis. This latter commitment is unlikely to be frequent if the programme is well structured with supportive staff.

Assistant medical staff

Ideally 2–3 sessional commitments per week of middle grade medical staff should be allocated to the pulmonary rehabilitation programme.

Hairmyres Hospital, East Kilbride, Glasgow G75 8RG
C J Clark

Reprint requests to Dr C J Clark.

One session is for the medical assessment clinic. This should be a fixed commitment, and should be recognised as contributing to the doctor's postgraduate training programme. The second session is required for medical supervision of exercise testing (this may already be covered within existing pulmonary investigation facilities). A third ongoing commitment is valuable for dealing on an ad hoc basis with patient problems arising during rehabilitation. This can be viewed as an extension of the usual resident staff commitment to daily in-hospital referral of patients with chest problems.

Physiotherapist

Pulmonary rehabilitation provides an exciting new opportunity for physiotherapy, extending from the traditional role in lung disease management to a central role in conducting exercise sessions, a core activity in pulmonary rehabilitation. The techniques of breathing retraining are well established adjuncts to the management of chronic disabling breathlessness and routine physiotherapy services normally include a provision for treatment of selected patients. Applied exercise physiology is generally less comprehensively covered in physiotherapy training though important in the context of this widening role. Assume, therefore, that some additional in-service staff training will be required before formally commencing pulmonary rehabilitation.

The following are recommended for physiotherapist in-service training:

1. The principles of individualised exercise prescription[1] should be studied.
2. The local leisure centre fitness programmes for normal individuals should be visited to obtain some experience of standard components used. Advice, particularly concerning "start up" programmes for previously sedentary individuals, should be taken. Commercial organisations are consumer responsive and aspects such as gymnasium lighting and decor, together with careful choice of music, are essential considerations. Patients are also consumers and compliance is enhanced in circumstances that are bright and cheerful (the programme should appear less work and more a "leisure" pursuit)
3. The basic physiology of exercise limitation in lung disease[2,3] should be covered through seminars arranged by the programme director.

Calculation of physiotherapy sessional commitments requires an estimation of the likely patient throughput. For example:

No. patients per session	8–10 maximum
Sessions per week per patient group	2 hospital (plus 1 unsupervised)
Duration of patient programme	3 months
No. physiotherapy exercise sessions weekly:	5
aerobic/mobility	2
multigym	2
conditioning programme for the "severe" patient	1
Physiotherapy assessment clinic	1 session/week

The minimal physiotherapy commitment likely for pulmonary rehabilitation of 30 patients over three months with an annual turnover of 120 patients would be six sessions – that is, 24 hours/week.

Training in techniques for aiding expectoration and breathing retraining should not be devolved from the routine service to pulmonary rehabilitation as "start-up" funding should be allocated to new and not to existing services.

Occupational therapy

This is an essential requirement to ensure adequate time and expertise is available to identify problems – that is, those activities of daily living which can be improved. This would require one session/week (clinic or occupational therapy departmental assessment) and an optional session/week for home visits on an ad hoc basis.

Nurse liaison

The process of pulmonary rehabilitation involves not only the hospital programmes but also liaison with primary care workers. The role of a nurse will be to conduct a weekly clinic whose function is (1) coordinating between the referral clinic, the pulmonary rehabilitation programme, and between the various programme assessments; (2) to conduct patient questionnaire assessments of quality of life and psychosocial functioning at the outset and on completion of the programme; (3) educational, to improve the patients' understanding of his/her illness (table 2 summarises the information to be discussed); (4) before programme completion to ensure that adequate follow up programmes for self-management are established with written guidelines and instructions for primary care professionals (general practitioners, practice nurses); (5) collation of nutritional assessment and advice from the dietician, including documentation and communication with the general practitioner; and (6) additional home

Table 2 Educational topics for discussion (from ref 36 with permission)

Normal anatomy and physiology of the lungs and heart.
Types of lung disease and other conditions that affect the function of the lungs.
Abnormal anatomy and physiology associated with pulmonary disorders.
Types of medical tests that will be performed, procedures for testing, and interpretation and significance of the results.
Medications: drug actions, description of products, desired beneficial effects, side effects, techniques of self-administration, and methods to assist patients to remember to take the medication.
Breathing exercises, including whether to perform them at rest, during exercise, or during recovery from exercise or stress.
Energy conservation techniques associated with activities of daily living.
Relaxation techniques and methods to reduce stress.
Emotional aspects of chronic disease.
Nutrition and fluid intake.
Causes of shortness of breath.
Role of exercise and physical fitness.
Recognising problems associated with their disease: infection, hypercapnia, hypoxia.
How to treat symptoms.
Who to call for problems.

assessment of selected patients, usually those with severe disease where required. The programme should allow for four nurse liaison sessions/week (one assessment clinic, one administration/coordination session, one educational group session, and one "floating" session for home and health centre liaison visits). N.B. Such visits require a budget for mileage allowance.

FACILITIES REQUIRED FOR INITIAL AND ONGOING PATIENT ASSESSMENT

The programme can be conducted as an additional outpatient service in which all assessments take place within existing clinic facilities. A total commitment of three half day sessions should be allowed at the outset – that is, one medical, one nursing, and one physiotherapy/occupational therapy. The appointments should be grouped by patient category to ensure efficient use of time in dealing with issues relevant to that particular group. The different role of each session will be described below. It is, however, useful at this stage to consider the process of pulmonary rehabilitation as in some ways analogous to modern management of diabetes where outpatient services divide assessment and management between doctor, nurse and paramedical staff under overall medical supervision. Similarly, not every patient needs to be processed through every aspect of pulmonary rehabilitation providing that the referral process has included an accurate assessment of needs.

Medical assessment

Apart from the initial and final medical visits, each patient will require an assessment after six weeks on the programme to record clinical progress and to decide whether he/she remains fit to continue. Progress reports from the physiotherapist and nurse coordinator should be available at this visit which can be short and focused on pulmonary rehabilitation as routine patient care remains primarily the responsibility of the general practitioner. This clinic also allows the nurse and/or physiotherapist access for extra medical assessments if required during pulmonary rehabilitation, in addition to the routine visits.

Nursing assessment

Each patient completes the functional questionnaires at the first visit (before the nurse appointment if a self-administered questionnaire is used) and the findings are discussed. The patient's understanding of his/her illness is then explored using guidelines given in table 2, and finally the programme's objectives are outlined. Generic and disease-specific quality of life questionnaires have been reviewed in this series.[4] All of our patients have a disease-specific quality of life assessment combined with a short validated questionnaire for psychological function,[5] and patients with moderate to severe impairment also have an assessment of activities of daily living.[6] A single page "self-efficacy" questionnaire[7] is also helpful to determine whether the patient feels able to comply with the programme. It is then possible to set realistic targets for improvement in those areas identified as deficient in the questionnaires by agreement between the nurse and patient. This must be recorded in brief on a patient proforma which also contains pre-prepared information about his/her illness and the programme content. The topics discussed and the outcome of the interview should also be recorded in a pulmonary rehabilitation case sheet which is used for all aspects of the programme.

Paramedical (physiotherapist/occupational therapist) assessment

While many of the issues the physiotherapist requires to discuss with the patient are covered during evaluation, it is useful to include this session in planning to arrange group meetings and more detailed discussion where appropriate. Important topics include basic principles behind training, dealing with simple problems which occur such as muscle discomfort after exercise, planning increased activity and methods of continuing involvement in exercise on completion of the programme.

The occupational therapist's involvement in a fixed weekly session is a valuable commitment and the decision to arrange occupational therapy assessment should be made if the initial evaluation of the patient's illness severity and functional handicap by the programme nurse using the activities of daily living questionnaire reveals a need for practical assistance with activities of daily living. Occupational therapy services may already have been provided by the general practitioner or be available from that source, in which case the results of a single pulmonary rehabilitation assessment can be communicated to the community occupational therapist for implementation.

Additional support services

1. Clinical psychology: Liaison with the clinical psychology services is helpful at the outset to explain the programme objectives and to set up a referral process so that patients found on routine screening to have psychological problems can be seen and treated expeditiously as part of the pulmonary rehabilitation programme. Expert advice can also be obtained regarding the interpretation of the psychological questionnaire and indications for patient referral for further assessment. Our policy jointly agreed with clinical psychology is to use the nurse screening process following set criteria obtained from the questionnaire to determine referral requirements.
2. Dietetics: The dietetics department also requires to be informed of the specific requirements of the programme and given written information about the current role of nutritional assessment in the management of chronic obstructive pulmonary disease.[8,9]

FACILITIES REQUIRED FOR EVALUATION OF LUNG AND EXERCISE FUNCTION

While specialist units in the UK have the full range of lung and exercise testing facilities, this paper concentrates on pulmonary rehabilitation within district general hospitals with more basic lung function laboratories. Usual facilities will range from dynamic spirometric testing alone, to include measurement of lung volumes and diffusing capacity (TLCO). Simple spirometric testing is required for pulmonary rehabilitation to provide some measurement of disease severity which is unlikely to alter as a consequence of pulmonary rehabilitation.[10] Whilst TLCO is a useful indicator of resting gas exchange it is not essential, but measurements of arterial blood gas tensions at rest and oxygen saturation during exercise will be required to determine oxygen requirements during pulmonary rehabilitation. All patients should be screened during exercise and not just those considered to be "at risk" (resting hypoxaemia, known history of desaturation, low TLCO).

Where units do not have facilities for progressive incremental exercise testing incorporating gas exchange measurements, adequate exercise evaluation for pulmonary rehabilitation can be performed using "field" tests (six and 12 minute walk tests, Shuttle test[11,12]) or just a treadmill test using the Bruce protocol[13] to evaluate overall (whole body) exercise capacity.

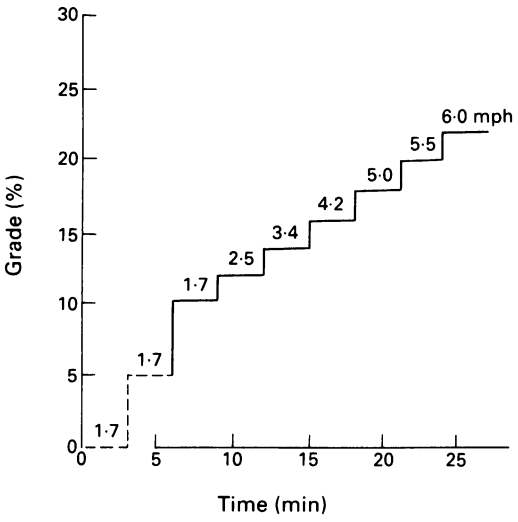
Since most pulmonary rehabilitation programmes involve submaximal endurance training, it is also helpful to measure endurance time and work during submaximal exercise on a treadmill before and after pulmonary rehabilitation.

Finally, for programmes concentrating on individual muscle group training (conditioning and multigym), additional exercise testing is performed in the gymnasium by the physiotherapist. This consists of measuring the effects of training on the endurance of specific muscle exercise repetitions before and after pulmonary rehabilitation.

Patients with known or suspected ischaemic heart disease should be excluded from pulmonary rehabilitation exercise programmes as the additional risk of adverse events is high. All patients should have a 12-lead ECG performed during initial evaluation and immediately after maximal exercise testing as a medicolegal precaution to identify ischaemic heart disease.

Exercise protocols

1. Walking tests: these field tests measure maximal exercise tolerance (distance walked). Provided that conditions are standardised – for example, repeated in the same corridor with the same supervisor – they provide a convenient, valid method of longitudinal assessment in individual patients. Familiarisation with the test is essential before the formal test.
2. Treadmill tests: the work rate increments in the Bruce protocol are given in the figure. It allows for limited tolerance in patients with ischaemic heart disease by reducing the increments of work rate compared with protocols for normal healthy individuals, and is therefore suitable for patients with lung disease. The graded work increments are "enforced" and the test is more reproducible than walk tests. After familiarisation a single test is usually reliable and adequate before pulmonary rehabilitation.



Work rate increments in the Bruce protocol.[13]

Treadmill endurance time and work are obtained from steady state exercise at a predetermined submaximal work rate. While previous estimation of maximal exercise on the treadmill is useful in deciding the approximate treadmill incline and speed required (usually the increments which produce a heart rate of 70% of "symptom limited" maximum heart rate), it is not essential. Familiarity with the performance of endurance tests often allows a "best guess" at the most appropriate increments to use for individual patients. However, we use the "rule of 5's" assessment[14] to give an indication of maximal tolerable work increments for exercise endurance in individual patients and this has several advantages: (1) it is simple to apply, requiring only a treadmill, heart rate monitor, and evaluation of the patients' symptoms; (2) it can be used to measure endurance time – that is, if a tolerable work rate is identified the assessment can be continued to exhaustion; and (3) the information can be used by the physiotherapist to predict the impact of breathlessness during performance of endurance training and to decide on the best programme for the patient. Measurement of endurance at the relatively high work rates involved also ensures that testing time is not too demanding – that is, inordinately long. Prior familiarisation with the treadmill is advisable because sustained patient motivation is required with endurance tests to ensure a valid end point.[15]

Total endurance work (joules) performed is given by the formula:[16]

$$\text{Power (watts)} [0{\cdot}536 \times \text{wt(kg)} \times 0{\cdot}625 \times \text{speed(kph)} \times 0{\cdot}1635] \times \text{time in secs}$$

N.B. In this equation work is underestimated because incline cannot be taken into account, but this is not a problem as incline is unchanged in evaluation of the patient's endurance before and after pulmonary rehabilitation.

All of these tests provide target end points which can be used as indicators of improved exercise tolerance, the magnitude of which will vary between patients depending on a number of factors including the extent of disability on commencement, and the degree to which the patient complies with the programme.

FACILITIES REQUIRED FOR EXERCISE PROGRAMMES

There are two distinct modes of exercise programme requiring separate facilities: (1) aerobic/mobility training, and (2) multigym "weight" training. Both can be supplemented by instruction to the patient to incorporate simple walking into their daily routine. This requires planning – that is, tolerable distances and areas to walk need to be identified by the patient and a log kept of progress in order to document fully the exercise being undertaken during pulmonary rehabilitation.

Although programmes for aerobic/mobility training may vary, they require adequate floor space and heating as provided in a typical indoor gymnasium. Unlike aerobics classes in healthy adults, however, the instructor not only supervises the group but also monitors each individual patient. The size of group at any session is therefore limited to 8–10 patients, and the overall gym area need not be large (225 square metres is adequate).

Multigym training uses specialised equipment to provide a "circuit" of exercises for individual muscle groups. A separate exercise area is essential and again this need not be large as there are the same constraints on patient numbers as already described. Each item of equipment may stand alone, but a combined multiuser apparatus containing up to eight items with one or two extra stand alone items to complete the requirements provides for efficient use of limited space. Table 3 lists the range of equipment items which we have incorporated in the multigym, together with the muscle groups they are designed to condition. A similar approach has recently improved endurance in patients with COPD.[15] N.B. Cardiopulmonary resuscitation facilities with staff training are essential for all exercise programmes.

Implementing exercise rehabilitation programmes

Training benefits are usually seen by six weeks[1 16] and this may suffice if a high patient throughput is essential, but in our experience a 12 week programme is preferable. The longer time often provides a depth of experience about the relationship between exercise and the individual's disease which can be of permanent benefit after the programme has finished.

Endurance training for patients with mild chronic obstructive pulmonary disease

For endurance training to achieve measureable improvements in fitness the following variables need to be controlled: (1) frequency of exercise should be a minimum of three times weekly; (2) duration per session should be a minimum of 20 minutes; (3) exercise intensity per session should be not less than two thirds maximum work rate achievable if the patient had no lung disease; and (4) a programme timescale not less than six weeks should be used.[1 16] This is a group programme conducted in two sessions weekly in the hospital gymnasium supplemented by an unsupervised home session. Patients can join and leave the programme on an ad hoc basis because within a set session the patient performs his/her own exercise prescription. At the first session an exercise programme suitable for sedentary individuals commencing training for the first time is given, and the target intensity is that producing a heart rate of approximately 70% of predicted maximum. Heart rate is variably increased in some patients with chronic obstructive

Table 3 Multigym exercises designed to improve skeletal muscle strength and endurance

These exercises do not require to be performed in a set order. They must, however, be preceded by a five minute period of warm up exercises prescribed by the physiotherapist. Weight ranges are given for each item of equipment.

1. *Supine bench press*: Exercises the chest, front of shoulders, and rear upper arm. Position: the patient lies with shoulders below the handlebar and presses upwards until elbows locked then returns to resting position. Ten repetitions continuously over approximately 20 seconds. The breathing pattern should coincide with repetitions. Rest between sets until Borg score is less than 3. Weight range 12–74 kg with 2 kg increments to 22 kg, 4 kg increments thereafter.
2. *Power squat*: Exercises the buttocks, thighs and low back. Position: the patient stands facing the weights, squats down beneath shoulder pads and grasps bar. Pushes up until knees lock straight then carefully returns to resting position. Repetitions, breathing pattern and rest periods as for exercise 1. Weight range 20–90 kg with 5 kg increments.
3. *Calf raise*: Exercises the ankle extensors. Position: at same equipment station as exercise 2, stand with shoulders beneath the pads and knees straight and locked, feet flat. Lift heels raising weights until fully extended on tip of toes only. Repetitions as for exercise 1. Weight range 20–90 kg with 5 kg increments.
4. *Latissimus pull down*: Exercises the large back muscles, upper chest and front upper arms. Position: stand facing weights, grasp overhead bar and pull down to mid chest and return carefully to resting position. Repetitions as for exercise 1. Weight range 0–70 kg with 5 kg increments.
5. *Upright rowing*: Exercises the shoulder muscles and elbow flexors. Position: stand facing the low pulley, draw weight to thighs then lift handlebar from thighs to shoulder height returning carefully to thighs. Repetitions as for exercise 1. Weight range 5–65 kg with increments of 2·5 kg to 15 kg then 5 kg increments.
6. *Leg press*: Exercises all lower limb muscles in co-ordinated fashion. Position: sitting with knees bent and feet on rotating foot plate, push till knees fully extended leading with heels, not toes and return carefully to resting position. Repetitions as for exercise 1 but allow 30 seconds for each set. Weight range 32–208 kg with 11 kg increments.
7. *Leg extension*: Exercises the quadriceps. Position: sit with back to weights and feet hooked under lower pads. Extend at knees until fully locked and return carefully to resting position. Repetitions etc as for exercise 6. Weight range 7–61 kg with 3 kg increments.
8. *Leg curls*: Exercises the hamstrings. Position: lie flat on bench face down with heels under padded roller. Curl legs till heels are directly above knees then carefully return to resting position. Repetitions as for exercise 6. Weight range 7–61 kg with 3 kg increments.

Allow up to 30 minutes for completion of the programme inclusive of warm up, rest periods between sets and different stations plus warm down at end of session.

pulmonary disease[17] and can only be used as an approximate expression of work intensity. If the patient is limited by breathlessness the physiotherapist modifies the programme to the maximal exercise intensity tolerable, and the wrist heart rate monitor is then used to help reproduce the same intensity in subsequent sessions by controlling the frequency of exercise repetitions, while the programme content is standardised in all other respects. Though breathlessness may require modification for individual subjects, significant improvements in exercise tolerance can still be achieved.[18] Patients who complete the programme without modification can be anticipated to improve exercise capacity (Vo_2max) by the same amount as normal sedentary subjects – that is, up to 30%.[16]

Multigym weight training for patients with moderate disease

The principle involved in training specific muscle groups is repetition of "isotonic" contractions – that is, against a fixed weight, usually 60–80% of the maximum weight tolerated by the patient in a single contraction during preliminary testing by the physiotherapist.[16 19] A set of 10 repetitions of each exercise are performed three times with a rest period between sets. Two circuit sessions per week are required and provision of small mobile weights allows a third session at home.

All patients complete a circuit of the same exercises (table 3) with their own individual prescription. The order of exercises is not critical but must be preceded by a five minute conditioning period of stretching exercises designed to prevent muscle, tendon and ligament injuries.

This type of training does not require heart rate monitoring as the objective is not central cardiovascular conditioning but rather improving strength and endurance of individual muscle groups. The key to a successful outcome lies in the suitability of initial prescription and then physiotherapist guidance, particularly regarding the speed of repetitions and the length of rest periods between the stations. The individual's response in terms of breathlessness is of paramount importance to the physiotherapist. Each patient is taught to use the Borg score for breathlessness (table 4) to guide the intensity and number of repetitions plus rest times. Before commencing each new exercise the Borg score should have returned to less than 3 – that is, adequate recovery time is necessary to allow tolerance of the whole range of circuit exercises.

Table 4 Borg score for measurement of breathlessness (from ref 37 with permission)

0	Nothing at all
0·5	Very, very slight (just noticeable)
1	Very slight
2	Slight
3	Moderate
4	Somewhat severe
5	Severe
6	
7	Very severe
8	
9	Very, very severe (almost maximal)
10	Maximal

Mobility (conditioning) programme for patients with severe disease

This group of patients will be unable to participate in whole body endurance training or in multigym weight training. The objective must be to reduce the effects of major skeletal muscle deconditioning and loss of function due to enforced inactivity and poor nutritional status. These patients often have difficulty with the most basic of daily tasks such as rising from bed, dressing, moving from room to room, and washing themselves.

The programme is designed to gently restore locomotor function of individual joint muscles, ligaments, and tendons by a series of careful stretching exercises plus gentle repetitions of muscle contraction and relaxation. By exercising each muscle group *in isolation* and unloaded, breathlessness is minimised as is the risk of musculoskeletal injury. The programme given in table 5 improves individual muscle strength, endurance, and mobility.[20] This contains a range of upper and lower limb movements including simple modifications such as "wall" press-ups and sitting stomach muscle exercises to avoid undue breathlessness due to posture – that is, lying flat. The main attraction of such a programme is that it can be performed at home once learned under careful supervision. One physiotherapy session per week should be allocated to instruction of up to 10 patients and four weekly teaching sessions should suffice for each patient followed by home self-management of a *daily* 20 minute session thereafter.

Patient selection for programmes

REFERRAL SOURCE

At the outset it is advisable to recruit for pulmonary rehabilitation from the pool of patients attending the routine chest clinic. They will already have been assessed, investigated and, hopefully, be receiving optimal medical treatment. It is therefore easier to concentrate on the remaining issues of mobility and psychosocial function of direct relevance to pulmonary rehabilitation. While general practitioners may eventually wish to have direct access for referral, the chest clinic is initially an important filter guaranteeing appropriate usage of the new facilities, particularly until general practitioners develop the necessary experience of the programme as applied to their patients.

REFERRAL CRITERIA

All patients with chronic obstructive pulmonary disease are potential candidates for rehabilitation, either for entry to the complete programme or just to specific aspects. There is recent recognition[21] that severe disease is not the only criterion, provided that a range of programme options is available to suit the spectrum of illness severity. Therefore selection should be very carefully made on the basis of (1) an identifiable problem for which the programme can be expected to provide quantifiable benefit; (2) a realistic attitude and under-

Table 5 Circuit of conditioning exercises designed to improve patient's strength and mobility

1. *Shoulder shrugging*: Circling shoulder girdle forward, down, backwards and up. Keep timing constant allowing two full seconds per circle. Relaxation encouraged throughout. Continue for 30 seconds. Repeat the exercise three times with short rest intervals between sets until Borg score is less than 3.
2. *Full arm circling*: One arm at a time, passing arm as near as possible to side of head, circle arm in as large circles as possible. (Allow 8–10 seconds per complete circle). Repeat for 40 seconds continuously. Repeat the exercise three times with short rest intervals between. Repeat with other arm.
3. *Increasing arm circles*: Hold arm away from body at shoulder height. Progressively increase size of circle for a count of six circles in 10 seconds then decrease for a further count of six. Repeat for 40 seconds. Repeat with other arm.
4. *Abdominal exercise*: Sitting in chair, tighten abdominal muscles, hold for a count of four and then release muscles over four seconds to starting position. Repeat continuously for 30 seconds. Perform the procedure three times with short rest periods in between.
5. *Wall press-ups*: Stand with feet a full arm length distance from wall, place hands on wall and bend at elbow until nose touches the wall, push arms straight again allowing eight seconds approximately from start to completion. Repeat for 40 seconds continuously to a total of five repetitions. Repeat procedure three times with short rest periods in between.
6. *Sitting to standing*: Using dining room chair, sit, stand, sit allowing 8–10 seconds from start to completion. Repeat continuously for 40 seconds to a total of five repetitions. Perform exercise three times with short rest intervals in between.
7. *Quadriceps exercise*: Sitting on chair straighten right knee, tense thigh muscle, hold for count of four, then relax gradually over a further four seconds to a total of five repetitions over 40 seconds. Repeat the exercise three times with short rest periods in between. Repeat procedure with left leg.
8. *Calf exercises*: Holding on to back of chair, go up on to toes, return to floor taking 8–10 seconds to complete the procedure. Repeat continuously for 40 seconds.
9. *Calf alternates/walking on the spot*: Holding on to back of chair, allow one knee to bend, keeping toes on the ground. Bend other knee, whilst straightening first knee and allow four seconds for complete procedure. Repeat this bending/straightening of knees, i.e. walking on the spot, keeping toes on the ground continuously for 40 seconds to a total of 10 repetitions. Repeat the exercise three times with short rest periods in between.
10. *Step-ups*: Step up with right foot onto step then bring up left foot. Step down with right foot then left foot. Allow four seconds for the complete procedure and repeat continuously for 40 seconds. Repeat the exercise three times with short rest periods in between.

standing on the patient's part of the requirements for a regular commitment during the training period plus the likely benefits and limitations of the programme, and (3) availability of places on the programme – that is, on a "first come first serve" basis.

The types of programmes available allow a preliminary streamlining of the selection process. Using the principles outlined in the American Thoracic Society guidelines for evaluation of impairment secondary to respiratory disease[22] we use the following severity gradings to group patients before exercise assessment. Patients with mild chronic obstructive pulmonary disease have values for FEV_1, FVC, and FEV_1/FVC ratio >60% of the normal predicted values, patients with moderate disease have values between 40% and 60% of predicted values, and patients with severe disease have values <40% predicted and/or TLCO <60% predicted. While the results of exercise evaluation finally determine the choice of programme, these broad categories are helpful in the initial selection process. Patients with mild disease may be considered for the aerobic programme at the outset. Patients with moderate disease are more likely to complete successfully the multigym programme and may then be considered for aerobic training. Patients with severe disease should be referred to the conditioning programme and may then graduate to the multigym programme.

Programme evaluation (medical audit)

Every patient's progress should be carefully documented and an overall assessment of the success rate for each programme in achieving these objectives for the three categories of illness severity should be determined annually. The psychosocial assessments such as the quality of life questionnaires are useful in practical terms – that is, individual patient management – but one should not rely on a single aggregate score to determine the success or failure of the programme for the patient. Individual problems may respond successfully to the programme while the total score is unchanged, and these problems should have been identified as targets in the pulmonary assessment.

Finally, it is also worth considering rather more ambitious targets at the outset such as a reduction in hospital inpatient requirements (a significant financial incentive to the administration) and demands on general practitioner services. Similar programmes in which a patient's progress in the year before pulmonary rehabilitation has been compared with the year after and also with subsequent years have successfully achieved these aims in the USA, suggesting that improvements can be maintained in some patients.[23,24] The programme should be viewed primarily as an aid to patient management of his/her illness within the community rather than in hospital.

Continuing care after programme completion

Patients should be reviewed at the pulmonary rehabilitation medical assessment clinic six monthly for two years after programme completion. The objectives are to review progress in achieving targets decided on completion of pulmonary rehabilitation and to provide encouragement to continue. Participation in pulmonary rehabilitation is usually a very positive experience because of improvements in daily functioning and self-confidence, and also because of the companionship offered. The challenge is therefore to find a suitable substitute. Self-help groups of programme "graduates" are extremely useful and the programme director should be affiliated to the group to encourage its development. The following are suggestions to help the process forward: (1) the hospital may be able to provide a regular meeting venue – for example, we use the postgraduate centre; (2) patients should be encouraged to use local authority leisure and fitness centre facilities to continue the programme and to participate in activities such as swimming or bowling. Liaison of the programme physiotherapist with the centre's staff is helpful (these centres may require confirmation that medicolegal responsibility remains with the patient, not the leisure

centre, and also that supervision will not be required); (3) walking in groups is a simple social way of participating in exercise. Our programme has identified several alternative routes adjacent to the hosptial with target distances to walk. Patients can also find convenient areas in town centres to walk and then meet socially; (4) local authorities or voluntary organisations may have a service which can transport patients to meeting points if adequate notice is given.

Consideration of special patient groups

PATIENTS REQUIRING OXYGEN THERAPY

In the UK long term oxygen therapy prescription is covered by existing routine clinical services. The important issue is to determine the patients' requirements for oxygen supplementation during pulmonary rehabilitation exercise programmes. The following steps are necessary: (1) initial documentation of desaturation during exercise (this should be determined at the initial evaluation in the laboratory or field tests); (2) oxygen supplementation for these patients during the exercise programmes on the rationale that the potential for cardiac arrhythmias may be reduced and that exercise may be better tolerated.[25] The conditioning programme for severely disabled patients is the most appropriate choice for these patients at the outset. While desaturation may not be provoked by this programme on a single occasion, oxygen should be routinely administered as a precaution. A major component, however, is conditioning at home. In the UK patients do not have access to portable oxygen by NHS prescription and it will be necessary to provide a renewable oxygen cylinder purely for use during the home unsupervised daily sessions where portable oxygen is not feasible on cost grounds. Prescription of oxygen for exercise *outwith* the rehabilitation programme – for example, to allow greater mobility during activities *outside* the home – remains an unresolved problem while there remains a lack of guidelines within the UK.

PATIENTS WITH ILLNESSES OTHER THAN CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Asthma

Pulmonary rehabilitation has largely been confined to patients with chronic obstructive pulmonary disease, but there is now a recognition that other patient groups may benefit. The principle of asthma rehabilition has been discussed in an editorial in this journal,[14] and programmes for exercise rehabilitation in asthma have recently been extensively reviewed.[26] The issues of drug therapy, education, and compliance are covered by the recent international consensus guidelines as fundamental requirements of routine clinical provision, and the application of pulmonary rehabilitation to asthma largely refers to exercise provision. The principles are the same as those described in this article with some additional considerations. The nature of the illness is different from chronic obstructive pulmonary disease, usually affecting younger patients with different expectations. Separation of training sessions is therefore advisable to allow clear and separate goals to be pursued by each group. Patients with mild asthma provide the largest number of subjects and can greatly benefit both by improving cardiorespiratory fitness[27] and by overcoming the fear and inhibition of exercise which is very common.[28–30] Patients with moderate to severe chronic asthma – that is, with continuing symptoms despite optimal treatment – can also be subjected to the same process of exercise evaluation and training already described for chronic obstructive pulmonary disease. The conditioning programme is a suitable introduction to exercise for steroid dependent asthmatic patients who may then graduate to the other programmes after further assessment. Steroid-induced osteoporosis is not a contraindication to exercise which has been shown to be beneficial in slowing progression of the disease.[31]

Interstitial lung disease, cystic fibrosis and lung transplant patients

Some experience of pulmonary rehabilitation of these patient groups has been published.[32–34] Aspects such as education, psychosocial counselling, nutritional assessment, and drug and oxygen requirements are inherent parts of optimal management in these conditions. The objective of exercise programmes is to improve mobility. The principles outlined in this article apply to lung disease in general and are useful guidelines for specialist units considering commencing exercise programmes for these groups of patients.

Finally, it should be evident that enthusiasm, clear objectives at the outset, and communication particularly with primary care (general practice) are fundamental prerequisites for the successful introduction of a pulmonary rehabilitation programme.

I am greatly indebted to my colleagues in the Department of Respiratory Medicine and, in particular, to Mrs Elaine Mackay who is currently implementing the pulmonary rehabilitation programmes discussed in this paper.

1 American College of Sports Medicine. *Guidelines for graded exercise testing and exercise prescription.* 3rd ed. Philadelphia: Lea and Febiger, 1990.
2 Wasserman K, Hansen JE, Sue DY, Whipp BJ. *Principles of exercise testing and interpretation.* Philadelphia: Lea and Febiger, 1987.
3 Jones NL, Campbell EJM. *Clinical exercise testing.* 2nd ed. Philadelphia: Saunders, 1981.
4 Curtis JR, Deyo RA, Hudson LD. Health-related quality of life among patients with chronic obstructive pulmonary disease. *Thorax* 1994;**49**:162–70.
5 Zigmond AS, Snaith RP. The Hospital Anxiety and Depression Scale. *Acta Psychiatr Scand* 1983;**67**:361–70.
6 Eakin P. Assessment of activities of daily living: a critical review. *Br J Occup Ther* 1989;**52**:11–5.
7 Schwarzer R (ed). *Self-efficacy: thought control of action.* Washington DC; Hemisphere, 1992.
8 Donahoe M, Rogers RM. Nutritional assessment and support in chronic obstructive pulmonary disease. *Clin Chest Med* 1990;**11**:499–512.
9 Mancino JM, Donohue M, Rogers RM. Nutritional assessment and therapy. In: Casaburi R, Petty TL, eds. *The principles and practice of pulmonary rehabilitation.* Philadelphia: Saunders, 1993.
10 Hughes RL, Davidson R. Limitations of exercise reconditioning in COLD. *Chest* 1983;**83**:241–9.
11 Butland RJA, Gross ER, Pang J, Woodcock AA, Geddes DM, Two-, six-, and 12-minute walking tests in respiratory diseases. *BMJ* 1982;**284**:1607–8.
12 Singh SJ, Morgan MDL, Scott S, Walters D, Hardman E.

Development of a shuttle walking test of disability in patients with chronic airways obstruction. *Thorax* 1992;**47**:1019–24.
13 Bruce RA. Exercise testing of patients with coronary artery disease. *Ann Clin Res* 1971;**3**:323–32.
14 Clark CJ. Asthma and exercise: a suitable case for rehabilitation. *Thorax* 1992;**47**:765–7.
15 Simpson K, Killian K, McCartney N, Stubbing DG, Jones NL. Randomised controlled trial of weight lifting exercise in patients with chronic airflow limitation. *Thorax* 1992;**47**:70–5.
16 Astrand PO, Rhodahl K. *Textbook of work physiology*. 2nd ed. New York: McGraw-Hill, 1992.
17 Belman MJ. Exercise in patients with chronic obstructive pulmonary disease. *Thorax* 1993;**48**:936–46.
18 Casaburi R. Exercise training in chronic obstructive lung disease. In: Casaburi R, Petty TL, eds. *The principles and practice of pulmonary rehabilitation*. Philadelphia: Saunders, 1993.
19 Brown AB, McCartney N, Sale DG. Positive adaptation to weightlifting training in the elderly. *J Appl Physiol* 1990;**69**:1725–33.
20 Mackay E, Cochrane LM, Clark CJ. The effects of sequential isolated muscle training on peripheral muscle conditioning and exercise tolerance in patients with COPD. *Eur Respir J* 1992;5(Suppl 15):30S.
21 European Respiratory Society Rehabilitation and Chronic Care Scientific Group. Pulmonary rehabilitation in chronic obstructive pulmonary disease (COPD) with recommendations for its use. *Eur Respir Rev* 1991;**6**:1–568.
22 American Thoracic Society. Evaluation of impairment/disability secondary to respiratory disease. *Am Rev Respir Dis* 1982;**1**:945–51.
23 Mall RW, Medeiros M. Objective evaluation of results of a pulmonary rehabilitation programme in a community hospital. *Chest* 1989;**94**:1156–60.
24 Bebout DE, Hodgkin JE, Zorn EG, Yee AR, Sammer EA. Clinical and physiological outcomes of a university-hospital pulmonary rehabilitation programme. *Respir Care* 1983;**28**:1468–73.
25 Patessio A, Iolo F, Donner CF. Exercise prescription. In: Casaburi R, Petty TL, eds. *The principles and practice of pulmonary rehabilitation*. Philadelphia: Saunders, 1993.
26 Clark CJ. The role of physical training in asthma. In: Casaburi R, Petty TL, eds. *The principles and practice of pulmonary rehabilitation*. Philadelphia: Saunders, 1993.
27 Cochrane LM, Clark CJ. Benefits and problems of a physical training programme for asthmatic patients. *Thorax* 1990;**5**:345–51.
28 Strunk RC, Mrazek DA, Fukuhara JT, Masterton J, Ludwick SK, LaBrecque JF. Cardiovascular fitness in children with asthma correlates with psychological functioning of the child. *Pediatrics* 1989;**26**:2798–86.
29 Weston AR, Macfarlane DJ, Hopkins WG. Physical activity of asthmatic and non-asthmatic children. *J Asthma* 1989;**26**:279–86.
30 Meyer R, Kroner-Herwig B, Sporkel H. The effect of exercise and induced expectations on visceral perception in asthmatic patients. *J Psychosom Res* 1990;**34**:455–60.
31 McLatchie GR. Sport and exercise in the prevention and treatment of disease. In: McLatchie GR, ed. *Essentials of sports medicine*. 2nd ed. London: Churchill Livingstone, 1993.
32 Foster S, Thomas M III. Pulmonary rehabilitation in lung disease other than chronic obstructive pulmonary disease. *Am Rev Respir Dis* 1990;**141**:601–4.
33 Orenstein DM, Noyes BF. Cystic fibrosis. In: Casaburi R, Petty TL, eds. *The principles and practice of pulmonary rehabilitation*. Philadelphia: Saunders, 1993.
34 Biggar DG, Malen JF, Trulock EP, Cooper JD. Pulmonary rehabilitation before and after lung transplantation. In: Casaburi R, Petty TL, eds. *The principles and practice of pulmonary rehabilitation*. Philadelphia: Saunders, 1993.
35 Make BJ. Pulmonary rehabilitation: myth or reality? *Clin Chest Med* 1986;**7**:519–40.
36 Gilmartin M. Patient and family education. *Clin Chest Med* 1986;**7**:619–27.
37 Burdon JC, Juniper EF, Killian KJ, Hargreave FE, Campbell EJM. The perception of breathlessness in asthma. *Am Rev Respir Dis* 1982;**128**:825–8