ERS TASK FORCE POSITION PAPER

Selection criteria and programmes for pulmonary rehabilitation in COPD patients

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Definition and rationale

"Pulmonary rehabilitation is a process which systematically uses scientifically based diagnostic management and evaluation options to achieve the optimal daily functioning and health-related quality of life of individual patients suffering from impairment and disability due to chronic respiratory disease, as measured by clinically and/or physiologically relevant outcome measures".

The rationale for pulmonary rehabilitation is that a process of patient management is required to systematically apply all existing treatment options available for the widest possible range of patients with chronic lung disease. In order to focus on the requirements for successful achievement of these aims, a further definition is now required. This is based on the rationale that the requirements of individual patients vary with time and in relation to other individuals. Programmes must, therefore, be comprehensive and flexible enough to address each patient's needs, and also to advance the healthcare provision for the population with chronic respiratory disease in general. There are a number of components which are provided in piecemeal fashion, depending on the resources available in different countries and medical centres [1–5]. Some of these are not new treatments, but the very implementation of a process incorporates them in a logical systematic fashion into normal practice.

Among chronic lung diseases, chronic obstructive pulmonary disease (COPD) is a well-known example of a frustrating illness not only for patients, who may suffer considerable physical and physiological problems, but also for their physicians, whose medical treatment has only partial success in alleviating symptoms and improving functional capacity. Patients with COPD are responsible for a high proportion of the total health care costs in different countries. So far, however, there has been no systematic attempt either to improve the efficacy of this health care provision or to recognize that such a process is required. This is despite the fact that over the past two decades individual contributors in the field of pulmonary rehabilitation have published their experience and have shown that one outcome can be a significant reduction in health costs, such as hospital bed usage [3]. Fortunately, there is an increasing interest in pulmonary rehabilitation in tandem with the development of improved methodologies, for example for measurement of exercise performance, respiratory muscle function, sleep disturbance and subjective measures of disability, such as breathlessness scoring, psychometric testing and quality of life indices. The rationale for COPD is that not only can clear aims be identified but also, experience suggests, these aims can be realistically implemented [1–5].

Eligibility criteria

A comprehensive rehabilitation programme for respiratory patients includes: medical therapy; reinforcement of smoking cessation; education of the patient and family; exercise reconditioning; physical, nutritional, and occupational therapies; and, for specific cases, long-term oxygen therapy and home mechanical ventilation [1]. Therefore, almost all COPD patients may be incorporated into such a programme, including one or more of these various forms of therapy on the basis of an in- or out-patient programme or even at home [6].

Well-organized criteria of rehabilitation will provide a multidisciplinary team with a medical supervisor [6]. Usually, their recommendation for electing patients is that optimal therapy is already conducted on nonsmoking patients or patients actively involved in a smoking cessation programme [7].

The indication for oxygen therapy and mechanical home ventilation obviously applies to the most severe patients [8, 9]. Pulmonary rehabilitation is conducted through in-patient or out-patient programmes and, for the severely disabled, at home [10, 11]. Measurements of the quality of life by validated questionnaires can be recommended in assessing the effectiveness of the treatment [12, 13].

Apparent contraindications [14] for a rehabilitation programme have been stressed, such as: lack of motivation and compliance of the patient, based on objective evaluation; presence of any diseases interfering with the process of pulmonary rehabilitation, such as cancer, severe heart failure and progressive neuromuscular disorders; and factors requiring special support/attention.

Reasons for possible failure [6, 15] can be: inadequate comprehension due to language problems and/or low intelligence quotient; inadequate home situation with bad environmental considerations; candidates without supportive families; candidates without adequate primary care.
conducted by a general physician; evidence of financial problems; and logistic problems (i.e. distance).

Age and the degree of airway obstruction (forced expiratory volume in one second (FEV1)) [15, 16] are not considered to be parameters for rejecting a patient from a rehabilitation programme. Patients should, on selection, undergo a full clinical, physiological, psychological and social evaluation to determine, on an individual base, the type of rehabilitation programme best suited and, where the criteria are met, allowing for an outpatient or in-patient rehabilitation programme, since not all subjects have obvious need of hospitalization.

**Components of the rehabilitation programme**

Optimal medical treatment and smoking cessation are obvious and essential conditions for every rehabilitation programme. Smoking cessation is the key to the prevention and treatment of COPD. In the early phases of the disease, cessation of tobacco smoking is associated with a reduced rate in the decline of FEV1 to a level similar to that of a nonsmoker. The function lost during the accelerated decline of the smoking period is, however, not regained. In advanced disease, when patients present to hospital clinics, cessation of smoking is still valuable, as a fall in the rate of decline of FEV1 is likely, though unfortunately not achieved in all patients [17]. The greatest challenge is maintenance of abstinence beyond the phase of acute withdrawal and for extended periods thereafter [18]. Since psychological, behavioural and physiological aspects underlie an addiction to tobacco, it is difficult to conceive a smoking cessation programme able to accommodate the needs of every smoker. Multiple methods have been developed for smoking cessation. The various strategies may be divided into pharmacological interventions (nicotine replacement, nicotine antagonists, symptomatic treatment of nicotine withdrawal), and behavioural interventions (using trained staff to maintain self-monitoring, goal-setting, contracting, stimulus control, aversion and psychological adjustment).

**Exercise training**

Impairment of exercise tolerance is a common problem in patients with severe COPD. The cause of exercise intolerance is multifactorial and includes: impairment of lung mechanics and respiratory muscles; cardiac dysfunction; altered gas exchange; poor nutritional status; deconditioning; and psychological problems of varying degrees [19, 20]. At present, exercise training is an important component of pulmonary rehabilitation, but no consensus exists as to the best methods of exercise or the mechanisms whereby improvements are obtained.

Exercise training can be performed in several ways, including (treadmill) walking or cycle ergometer exercise. Improved exercise tolerance has been substantiated, as early as 4 weeks after onset, despite a lack of improvement in pulmonary function [21]. It is suggested that COPD patients gain better physiological benefit from training when they are able to exercise above a “critical level of intensity” [22]. Whether an anaerobic threshold is reached is often used as a way of stratifying patients as regards various training workloads [23]. Because the ability of patients with obstructive lung disease to exceed their anaerobic threshold is poorly correlated with resting pulmonary function tests, patients should be selected on the basis of a preliminary exercise test, rather than on resting respiratory function measurements. Although no “ideal” duration has been established, 8 weeks is a common duration for many exercise programmes.

When the subject is able to exercise for at least 30 min per session 3–5 times a week, the level of exercise must be gradually increased [21]. Although treadmill and bicycle training often showed similar results in exercise improvement, cycle ergometer exercise seems much less prone to “learning effects” and, therefore, might be a more appropriate method for detecting physiological training effects. Although, in several studies, no true aerobic or cardiopulmonary training response has been found in severe COPD patients [24], exercise training has been shown to result in a reduced ventilatory requirement for exercise when blood lactate is reduced [23]. An increase in walking distance or endurance exercise time was often observed, despite the fact that training programmes varied widely [25, 26]. Much of the improvement is likely to be due to better motivation, a decrease in perceived symptoms (i.e. dyspnoea), and an improved sense of well-being after exercise training. A factor which may explain why most programmes of pulmonary rehabilitation might not yield a physiological training response is that the patients were not sufficiently physically stressed because of a lower training intensity, duration or frequency than that described previously. It seemed that high work rate training programmes eliciting a high level of lactic acidosis demonstrated significantly greater physiological change (i.e. greater reductions in blood lactate and ventilation and larger gains in endurance were achieved) than did the low work rate training programmes, in which the response to training was very modest [23].

**Arm exercise**

Activities of arm and shoulder muscles form a special problem in many patients with chronic respiratory impairment. Patients with severe COPD often complain of dyspnoea during activities of daily living, such as combing their hair, brushing their teeth, or shaving. A marked dyspnoea is manifested after simple arm movements, and unsupported arm exercise is more difficult to sustain than leg exercise for these patients [27]. Alterations in breathing pattern, recruitment of expiratory muscles during arm elevation and increased metabolic demands contribute to the exercise load experienced [27].

It has been suggested that pulmonary rehabilitation, including arm exercise, has a supplemental benefit in COPD patients as compared to lower limb exercise only [28]. Several programmes including unsupported and supported arm exercise have shown improved arm-exercise performance and tolerance to dyspnoea. The improvement in arm-exercise tolerance is observed in maximum achieved workload [28, 29], endurance [29], decrease in oxygen consumption (V'O2) at a similar workload after training [29], feeling of well-being [28], and reduction in metabolic requirements and minute ventilation after...
arm of inspiration to total duration of breathing cycle.

The aim of gymnastics is to improve joint motility, trunk flexibility, and equilibrium. The most important aim is, probably, to increase arm strength [30]. The prescription and strategies of arm training are as yet poorly documented. Since the interest in arm training in COPD has only recently been reported, few data are available on the upper extremity work performance in these patients [28], and no specific recommendation can be given.

**Respiratory muscle training and rest**

Inspiratory muscle training is achieved, to a limited extent, through general body training or schedules of hyperpnoea. The role of respiratory muscle training in different forms of chronic respiratory failure remains unclear [31]. Training against resistive loads or pressure threshold loads focuses on the muscles of inspiration. Endurance can increase but whether it may be due to changes in the breathing pattern is not known. Training with threshold loading is achieved independently of inspiratory flow rate. Positive results obtained in controlled studies have been an increase in strength and endurance time of respiratory muscles, and a decrease in dyspnoea during inspiratory loads [2, 5, 31]. When respiratory muscle training is incorporated into a rehabilitation programme, the design of training programme must take into consideration the adequacy of the training stimulus and control of the pattern of breathing [32]. Present knowledge does not permit a final recommendation on these rehabilitation techniques to be given. Targeted inspiratory training may increase exercise performance more than general exercise alone, but criteria for selecting the candidates and the best methods of training remain poorly delineated. Reasonable guidelines involve 15 min training sessions twice daily, 5–7 days per week for at least 8 weeks [31].

Respiratory muscle rest (achieved with negative or intermittent positive pressure ventilation through a nasal mask [33]), may be more appropriate in some severe patients suffering from enhanced respiratory muscle weakness after training, or in hypercapnic patients who have reduced muscle function, marked dyspnoea or nocturnal symptoms [34]. A conflict remains as to how to recognize patients who will benefit either from training or rest, largely due to the difficulty of agreeing on the methods of measuring respiratory muscle fatigue, and much of this area is still the subject of research.

**Breathing retraining**

Breathing retraining techniques, include: low frequency breathing; pursed lips breathing; abdomino-diaphragmatic breathing; and "directed" breathing. The common aim is to modulate and create a new type of breathing pattern, which enhances tidal volume and lowers respiratory frequency without affecting the duty cycle fraction of inspiration to total duration of breathing cycle (TV/tot). In addition, pursed lips breathing may modulate expiratory airflow, avoiding dynamic airway collapse. The work of breathing increases during breathing retraining even if it appears to allow patients to recover more rapidly from exercise breathlessness. With respect to pursed lips and diaphragmatic breathing, data available from the acute setting demonstrate a modification of the breathing pattern (slower and deeper inspiration) with increased oxygenation and better utilization of accessory ventilatory muscles, and decreased dyspnoea during exercise. In the long-term, patients are usually unable to maintain such a modified pattern of breathing. Prospective studies have not been carried out supporting a definite indication for these techniques [5]. Breathing retraining techniques have yet to be established. Until more definitive evidence of the effect on ventilatory control and lung mechanics is available, breathing retraining cannot be recommended [11].

**Chest physiotherapy**

Chest physiotherapy includes: postural drainage; chest percussion; vibration and shaking; cough; and forced expiration techniques [15]. It is recommended in COPD patients with increased production of sputum (>30 mL·day⁻¹), when the problem is retention of secretions in the proximal airways. Forced expiration techniques together with postural drainage seem a more effective technique [11].

**Education**

In addition to teaching adequate coping strategies with respect to the physical manifestations of COPD and the psychological consequences, health education in adequate self-management behaviour is of great importance. Adherence to medical advice is a major problem. Benefits in health may be obtained if patients succeed in changing unhealthy behaviour and adapt their lifestyle to the demands of the chronic disease. Several studies have already shown the value of such self-management interventions. A self-management programme should have the following characteristics: 1) complementarity to medical care; 2) a structured educational character (provision of information in a structured way, accompanied by techniques to change cognition and coping behaviour (i.e. cognitive-behavioural intervention)); 3) a multidisciplinary approach; 4) group intervention; 5) participation of partners; 6) self-activity of patients and partners. Education is fundamental in COPD patients in order to maintain a proper compliance to treatment, such as medication, oxygen therapy, smoking cessation, exercise retraining, and nutrition. Studies have demonstrated that education about the disease, in the context of a global rehabilitation programme including exercise, is of objective benefit [5, 35]. Therefore, education has to be recommended in association with the usual rehabilitation modalities.

**Psychological aspects and support**

**Psychological and emotional functioning.** Chronic diseases are frequently accompanied by a host of emotional
responses that contribute to restrictions in vocational, social and family functioning. The most commonly reported emotional consequences of COPD are depression and anxiety [36]. The prevalence of depression among COPD patients has been reported to range 50–70%. Feelings of hopelessness and pessimism, as well social withdrawal and sense of failure are some of the characteristics of depression among COPD patients. Another emotional consequence is disabling anxiety. Several other emotional consequences of COPD include: irritability, somatic preoccupation, dependency and frustration [36]. Relative to healthy controls, COPD patients also report significantly higher levels of anger and hostility [37]. Patients with COPD avoid expressing strong emotions, such as anger, to prevent the physiological arousal that may accompany these emotions. This phenomenon is clinically described as alexithymia, defined as a patient’s inability to label affective states verbally.

Behavioural functioning. Significant lifestyle impairments have been reported, including activities of daily living, employment and sexual functioning [38]. Adherence to medical advice concerning medication, quitting smoking and exercise is poor, ranging 51–67% [39].

Neuropsychological functioning. Cognitive or neuropsychological changes have been observed, especially in relation to hypoxaemia [40] and/or hypercapnia. These changes include impairment of memory, abstract reasoning and perceptual motor speed.

Social functioning. Role patterns may change, and spouses report stress and dissatisfaction with life [41]. Sexual dysfunction is an area of concern, and social and recreational activities may be reduced due to the physical and psychological problems experienced.

Psychosocial support. Psychological support focuses on restoring coping skills and learning stress management. After assessment, intervention will include education and adequate support to achieve mental and physical awareness through various techniques, including biofeedback, relaxation therapy, and individual, family and group therapy.

Given the apparent benefits of exercise for psychological well-being, exercise is clearly a useful psychosocial intervention for these patients. Psychological intervention is designed to help patients cope more effectively with the physical manifestations of their disease and the psychological consequences of having a chronic disease. The use of a paradigm which details cognitive appraisal of physical symptoms and subsequent coping effects, such as that described by LAZARUS and FOLKMAN [42], would seem particularly helpful in understanding the role of emotional factors in COPD. Measurements of the quality of life by validated questionnaires can be helpful in assessing the effectiveness of the treatment [13, 43, 44].

Nutritional therapy

Weight loss and depletion of fat-free mass can be considered as a frequent problem, especially in patients admitted to an in-patient programme [45]. Loss of fat-free mass has important implications for morbidity and even mortality in patients with chronic respiratory failure. Impaired strength and endurance of skeletal and respiratory muscles due to loss of muscle mass and changes in fibre composition of these striated muscles are frequently reported [46]. Weight loss in this group of patients is primarily the result of an imbalance between energy intake and energy expenditure [47]. Resting energy expenditure is frequently elevated, and can be considered to be a feature of nutritional depletion in this patient population. Therefore, nutritional therapy, in combination with supportive pharmacological treatment or exercise training, forms an essential part of in-patient pulmonary rehabilitation.

Obesity can be a problem in a number of patients, and intervention of a dietician to encourage weight loss is a necessity [48].

Nursing care

In addition to experience in intensive care nursing, after intensive care discharge, the respiratory nurse must participate in educational programmes about the patient’s illness and treatment, and has to implement long-term oxygen therapy and be familiar with home care ventilation. Very often, the respiratory nurse is the contact person for patients’ relatives, and co-ordinates the home care delivery.

Outcome measures

Pulmonary rehabilitation requires a multidisciplinary effort to treat an incurable disease which, in its advanced stages, produces disabling symptoms affecting virtually every aspect of life. It is understandable, then, that no single test is sufficient to fully evaluate the effectiveness of the pulmonary rehabilitation process. This has led to the development and utilization of various outcome measures to monitor the progress of chronic lung disease, as listed in table 1.

The individual rehabilitation programme must select which measures to use, and should reflect both the resources of the programme and the purposes of the outcome measurement. The simple evaluation of the individual patient’s clinical response would probably require less thorough and time-consuming testing than formal outcomes research.

Pulmonary function testing

Pulmonary function testing is commonly used to assess the effectiveness of therapeutic interventions in pulmonary

<table>
<thead>
<tr>
<th>Table 1. – Examples of outcome categories</th>
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<tbody>
<tr>
<td>Life expectancy [49]</td>
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<td>Medical resource consumption [49]</td>
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<td>Cost-effectiveness [50]</td>
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<tr>
<td>Respiratory symptoms, especially dyspnoea [51–53]</td>
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<tr>
<td>Exercise ability [17, 18, 54, 55]</td>
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<tr>
<td>Quality of life [13, 44, 56]</td>
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<td>Activities of daily living [57, 58]</td>
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<tr>
<td>Psychological well-being [56, 57]</td>
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<tr>
<td>Cognitive functioning [57]</td>
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<tr>
<td>Nutrition, body composition [59]</td>
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<td>Patient education [5, 10, 35]</td>
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disease, but it is not very useful in evaluating pulmonary rehabilitation, since it does not change appreciably with therapy. However, in a recent study [60], FEV1 and quality of well-being scores were found to be the most significant independent predictors of survival. Other traditionally used outcome areas, such as longevity [49], medical resource consumption [49], and cost-effectiveness [50], although still of obvious importance, are better evaluated by multicentre studies than the individual pulmonary rehabilitation programme. Some clinical outcomes, however, such as exercise ability, dyspnoea, body composition, activities of daily living, and quality of life, are not only important to the patient but are readily measurable and show responsiveness to therapy.

Whilst the demonstration of symptomatic and functional improvement in the immediate post-rehabilitation period is desirable, the evaluation of long-term effectiveness in outcome variables is at least equally important. Thus, follow-up testing at longer intervals, such as months or years, following the rehabilitation intervention is strongly recommended.

The following discussion will focus on the rationale for outcome measurement in five areas particularly relevant to patients with advanced chronic airflow limitation: exercise capacity; dyspnoea; body composition; activities of daily living; and health-related quality of life. The individual tests and questionnaires that are discussed are not meant to be an all-inclusive list, but are given as a general outline for outcome measurement in pulmonary rehabilitation.

**Exercise capacity**

Exercise training is a component of virtually every comprehensive pulmonary rehabilitation programme. For most patients with severe lung disease, exercise capacity is respiratory symptom-limited [54]. Exercise tests, which are commonly performed before rehabilitation to assess functional performance, can be used as outcome tools if they are also performed following therapy.

A list of some general categories of exercise tests that are available to the rehabilitation programme is presented in table 2. These range in complexity from the simple to the complex. As outcome measures with repeated measurements, all exercise tests may be influenced by factors other than training, such as learning or practice effects, changes in motivation, and encouragement by health professionals. Therefore, increases in exercise capacity should generally exceed 12–15%, to be considered clinically significant.

Incremental, multistage exercise testing on a stationary bicycle or treadmill, with serial measurements of gas exchange variables, provides the most precise and thorough evaluation of exercise capacity and physiological derangement of the patient with pulmonary disease [12, 23]. This testing also helps to detect exercise-induced cardiovascular problems and to formulate an exercise prescription for future training sessions. As reviewed by CLARK [12], several investigators have shown an improvement in maximal exercise performance following pulmonary rehabilitation. However, because of the complexity and cost of this type of testing, it is not a practical outcome measure for most pulmonary rehabilitation programmes.

A recently introduced incremental exercise test, the shuttle walking test [61], was designed to measure maximal exercise capacity with a minimal amount of equipment. Patients are instructed to walk up and down a 10 m course, with speed set by timed audible signals. This technique should be less influenced by pacing techniques and motivational factors than timed walking tests.

Table 2. – Types of exercise test in outcome measurements

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<tr>
<th>Tests</th>
<th>Equipment</th>
<th>Comments</th>
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<tr>
<td>Multistage, incremental cardiopulmonary exercise test</td>
<td>Treadmill or bicycle ergometer 12 lead ECG, gas analyser</td>
<td>Can include measurements of ventilation and gas exchange variables. COPD patients are frequently symptom limited before they reach a V' O2 plateau. Therefore, results can be influenced by motivation or effort. Because of its comprehensiveness, it can be used to analyse specific components of the effect of exercise training. Responsiveness to pulmonary rehabilitation intervention has been demonstrated. The expense of this testing limits its use as an outcome measure for most pulmonary rehabilitation programmes.</td>
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<tr>
<td>Single-stage endurance test</td>
<td>Treadmill or bicycle ergometer</td>
<td>Measures endurance at a fixed level of submaximal exercise. One study of pulmonary rehabilitation demonstrated &gt;100% improvement in maximal sustained cycle work and time. Influenced by motivation, effort, and mechanical efficiency.</td>
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<tr>
<td>Timed walk test</td>
<td>A large room or corridor</td>
<td>Patients are instructed to walk as far as possible in a set period of time, usually 6 or 12 min. Test can be influenced by a learning effect, motivation, and encouragement by tester. Walk test distance is related to spirometric variables, dyspnoea rating, and quality of life measurements.</td>
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ECG: Electrocardiogram; COPD: chronic obstructive pulmonary disease; V'O2: oxygen consumption
Results correlate well with the maximal oxygen consumption (V'\text{O}_2,\text{max}) [62].

Endurance testing is typically performed to a fixed, submaximal workload (usually 50–60% of predetermined V'\text{O}_2,\text{max}) [62], either with a stationary bicycle or on a treadmill. Endurance time at this submaximal workload is commonly measured. Endurance exercise testing probably relates better to the day-to-day functional limitations of COPD patients than maximal exercise testing [63]. Improvement in exercise endurance has been noted following pulmonary rehabilitation [21].

The timed walking distance [63] is one of the most widely-used outcome measures in pulmonary rehabilitation. For this indirect test of exercise performance, the patient is instructed to walk as far as possible in a set period of time, usually 6 or 12 min. This test is not only simple and requires minimal resources, it is very relevant to daily activities. For patients with moderate-to-severe disease, the 6 min walk test is preferable to the 12 min walk test [64]. Of all commonly-used tests of exercise ability, the timed walk test is probably most affected by biases, such as motivation, encouragement and practice [65, 66]. Therefore, testing should be strictly standardized, especially with respect to encouragement, and practice walks should be given before actual testing. Timed walking distances have correlated reasonably well with the degree of airways obstruction, dyspnoea, and quality of life [43, 44, 67]. This testing shows good responsiveness, with about a 25% improvement following rehabilitation [15, 16].

Dyspnoea

Dyspnoea, the unpleasant sensation of breathlessness, is usually the overriding symptom of COPD. Its importance is underscored by the fact that in COPD it correlates more closely with general health status than physiological measurements, such as the FEV1 [68]. Although this sensation is undoubtedly influenced by multiple factors [69], it can nonetheless be measured [67, 70]. An outline of some commonly used dyspnoea rating measures is given in table 3.

The baseline and transitional dyspnoea indices (BDI/ TDI) of MAHLER et al. [67] provide a rating by the health care worker of the patient's dyspnoea in three areas: functional impairment; magnitude of task; and magnitude of effort. Results from this brief questionnaire correlate with other dyspnoea scores [70] and health status [68]. This questionnaire is responsive, with changes in TDI dyspnoea demonstrated following inspiratory muscle training [71], and comprehensive pulmonary rehabilitation [51].

The Modified Medical Research Council (MRC) Questionnaire and the Oxygen Cost Diagram (OCD) are easily obtained, patient-rated dyspnoea scales. They have both been shown to correlate with the BDI [70]. Changes in exertional dyspnoea following pulmonary rehabilitation have been demonstrated using a 200 mm vertical visual analogue scale (VAS) for dyspnoea [51]. This change in exertional dyspnoea correlated with change in overall dyspnoea measured with the TDI. Category or visual analogue scales can be used to assess not only the intensity of breathlessness but also the distress it evokes [72].

The dyspnoea dimension of the Chronic Respiratory Disease Questionnaire (CRDQ) is another useful dyspnoea instrument. The patient decides which five dyspnoea-producing activities are important to him/her, then rates dyspnoea for each activity using a 7-point scale. This measure is very responsive to therapeutic intervention [44], probably because dyspnoea is rated in areas relevant to the individual patient.

Improvement in dyspnoea following pulmonary rehabilitation may reflect multiple factors, including improvements in exercise efficiency, physical conditioning, and respiratory muscle strength. In addition, desensitization to dyspnoea [73], or a reduction in the affective component of the sensation [51], may be important.

Confusion may arise because different dyspnoea scales use different scores and some of them are in reverse order.

Body composition

A substantial proportion of advanced COPD patients has poor nutritional status [45]. Nutritional depletion, which correlates with disease severity [45, 74], is manifest by decreased fat-free body mass, with or without reduction in body weight [45]. Fat-free mass can be readily estimated by using multiple skin-fold thickness measurements or bioelectrical impedance techniques. Although limited information exists, improvement in nutritional status may lead to increases in functional status [59].

Activities of daily living (ADLs)

Breathlessness from severe COPD often results in difficulty or inability to perform routine ADLs. ADLs include routine tasks, such as self-care, mobility, eating, dressing, household activities, and recreation. Since this important component of functional status undoubtedly affects quality of life, its inclusion as an outcome measure for pulmonary rehabilitation should be strongly considered. Although generic and respiratory-specific quality of life instruments have some items that evaluate ADLs, two new self-complete questionnaires focus on this area: the 56-item Pulmonary Functional Status Scale (PFSS) [57] and the 164-item Pulmonary Functional Status and Dyspnoea Questionnaire (PFSDQ) [58]. Both have demonstrated validity and reliability, but so far neither has been widely-used. Unfortunately, neither is available in a language other than English, and therefore their routine use cannot be supported.

Health-related quality of life

Since a cure for COPD is not possible, the direction of treatment must be toward alleviation of symptoms and reduction of disease impact on activity and wellbeing. This has led to considerable interest in quality of life as an outcome measure in these diseases. Quality of life reflects the individual's perception of well-being and performance in several areas, including physical and occupational function, psychological state, social interaction, somatic sensation, and recreational pastimes.
Health-related quality of life focuses only on the aspects of quality of life influenced by health problems. As outlined by Guyatt et al. [77], instruments measuring quality of life can be either “generic” such as general health profiles, or “specific” to a certain disease, function or problem. Generic quality of life instruments cover a broad spectrum of function relevant to daily life, and therefore have applicability to a variety of diseases. This applicability allows for comparison of quality of life between different diseases. Two commonly used generic health profiles are the Sickness Impact Profile (SIP) [56] and the Medical Outcomes Short-Form Survey [78], which comes in a 20-question and 36-question form (SF-20 and SF-36, respectively) (table 4).

In a large study of quality of life in COPD [37], mildly hypoxaemic COPD patients had substantial abnormalities in multiple areas of the SIP. These areas included ambulation, mobility, social interaction, communication, alertness behaviour, emotional behaviour, sleep and rest, home management, recreation and pastime, and employment. Jones et al. [56] found that abnormal SIP scores in chronic airflow limitation were closely related to the 6-min walking distance but not to FEV1. SIP abnormalities were found to correlate with respiratory symptoms, anxiety and depression in that study. Unfortunately, the SIP may be unresponsive to changes in COPD [43], and its length makes it impractical as an outcome measure for most pulmonary rehabilitation programmes.

### Table 3. Selected dyspnoea measures

<table>
<thead>
<tr>
<th>Method</th>
<th>Time min</th>
<th>Description</th>
<th>Comments</th>
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<tr>
<td>Baseline and transitional dyspnoea indices (BDI/TDI)</td>
<td>5–10</td>
<td>Category scales are used to rate dyspnoea in three areas: functional impairment, magnitude of tasks, magnitude of effort. Overall baseline dyspnoea is rated with the BDI; change in dyspnoea with the TDI. Determinations are made by the health care worker, not the patient.</td>
<td>The BDI focal score correlated with the FEV1, the 12-min walk distance, the MRC and OCD dyspnoea ratings, and with a physical functioning section of a general health questionnaire. The focal TDI score correlated with change in 12-min walk distance; improvement in its components correlated with improvement in inspiratory muscle strength and changes in exertional dyspnoea.</td>
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<tr>
<td>Oxygen-cost diagram (OCD)</td>
<td>5</td>
<td>A visual analogue type of dyspnoea determination where the patient indicates his/her level of dyspnoea by pointing to a spot on a 100 mm vertical line. The line has descriptors of activities along its length, ranging from sleeping (lowest) to brisk walking uphill (highest).</td>
<td>Scores correlated with BDI and MRC dyspnoea questionnaires.</td>
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<tr>
<td>Modified Medical Research Council (MRC) questionnaire</td>
<td>5</td>
<td>This questionnaire uses a five-point category scale based on degrees of activity that produces dyspnoea. Dyspnoea ratings can range from 0 (not troubled with breathlessness except with strenuous exercise) to 4 (too breathless to leave the house or breathless when dressing or undressing).</td>
<td>Correlates with BDI and MRC dyspnoea questionnaires.</td>
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<tr>
<td>Modified Borg scale of perceived exertion</td>
<td>&lt;1</td>
<td>Exertional dyspnoea is rated by the patient using a 10-point category scale. This scale has been used to measure both perceived dyspnoea and its affective component.</td>
<td>Simple to administer, it is frequently used in exercise testing and training sessions to monitor dyspnoea or level of perceived exertion.</td>
</tr>
<tr>
<td>Visual analogue scale for dyspnoea</td>
<td>&lt;1</td>
<td>Exertional dyspnoea is rated by the patient by pointing along a 100 mm or longer line. The line is usually anchored at both ends with severity descriptors, such as “no breathlessness” and “great breathlessness”.</td>
<td>Often used to measure dyspnoea during exercise testing or training. Although it is a simple measurement, it is responsive enough to show a change in exertional dyspnoea following pulmonary rehabilitation.</td>
</tr>
<tr>
<td>Chronic Respiratory Disease Questionnaire (CRDQ) (dyspnoea dimension)</td>
<td>20–30</td>
<td>The patient first selects five important activities, then rates his/her dyspnoea for each activity using a seven-point category scale. This is one of four dimensions of a 20 question quality of life questionnaire. The dyspnoea dimension can be analysed separately or added to the other three dimensions to give a total quality of life score.</td>
<td>Requires some skill and time to administer to patients. By having the patient select dyspnoea-producing activities it focuses on patient-relevant dyspnoea-producing activities. Demonstrated responsiveness to therapy.</td>
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FEV1: forced expiratory volume in one second.
The SF-20 has been used as a measure of the general health status of COPD patients by MAHLER et al. [68]. Dyspnoea, measured by the BDI, correlated significantly with five components of general health status: physical functioning; role functioning; social functioning; mental health; and health perceptions. Responsiveness to therapy, however, has not been extensively tested with this instrument.

Health-related quality of life instruments specific for respiratory disease focus only on those aspects of daily life that are directly influenced by the disease process. This allows for a shorter instrument with greater responsiveness to change. Two quality of life instruments for chronic airflow limitation are the Chronic Respiratory Disease Questionnaire (CRDQ) of GUYATT et al. [44] and the St George’s Respiratory Questionnaire (SGRQ) of JONES et al. [13] (table 4).

The SGRQ is a patient-completed 76-item questionnaire with three sections: symptoms; activities; and impacts. Section scores correlate with a number of other severity variables, including spirometry, the 6-min walk distance, dyspnoea and other respiratory symptoms, depression and anxiety. Responsiveness to therapeutic intervention has not been extensively tested. This instrument has been validated in several languages, including Italian, Spanish, French and Dutch.

The CRDQ is a 20-item questionnaire that is administered to the patient by a health care worker. Four dimensions are scored: dyspnoea; fatigue; emotional function; and mastery (a feeling of control over the disease). This instrument has demonstrated responsiveness to pharmacological intervention and pulmonary rehabilitation [44]. It has not, to our knowledge, been translated or validated in other languages.

Recommendations for the individual pulmonary rehabilitation programme

As stated previously, the selection of which outcome areas to measure and which instruments or tests to use must depend on the resources and goals of the individual pulmonary rehabilitation programme. For the average clinical programme, the following minimum measurements would seem reasonable: 1) the 6-min walk test as an indirect measure of exercise capacity; 2) the

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Items no</th>
<th>Time min</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sickness Impact Profile (SIP)</td>
<td>136</td>
<td>30</td>
<td>Components: physical, psychosocial, ambulation, mobility, body care and movement, social interaction communication, alertness, behaviour, sleep and rest, eating, home management, recreation and pastime, employment.</td>
<td>A general health profile that has been used in patients with COPD. COPD patients score lower than control subjects in all areas except body care and movement and eating. Walking distance in COPD correlated with the SIP better than with spirometry or arterial oxygen saturation. The length of time to complete the questionnaire is a major drawback for routine outcome measurement. Additionally, the responsiveness to therapeutic intervention in COPD may be low.</td>
</tr>
<tr>
<td>Medical Outcomes Study Short-Form (SF-36)</td>
<td>36</td>
<td>5</td>
<td>A self-report questionnaire measuring limitation of physical, social, and role activities, bodily pain, mental health vitality, and general health perceptions.</td>
<td>A general health profile that is short and easy to administer. Not tested extensively with COPD. Components of a 20-question, shortened version of this questionnaire correlated with dyspnoea, inspiratory muscle strength, and spirometry.</td>
</tr>
<tr>
<td>Chronic Respiratory Disease Questionnaire (CRDQ)</td>
<td>20</td>
<td>15-20</td>
<td>For individuals with COPD, this test must be administered to the patient. Some degree of expertise in administration is needed. Three dimensions: dyspnoea, emotion and mastery (a feeling of control over the disease)</td>
<td>Widely used for COPD, this test is very responsive to treatment (including rehabilitation) interventions. The dyspnoea dimension focuses on patient-determined dyspnoea-producing activities. Total score and dimensions correlate with pulmonary function, walking distance, and other dyspnoea measures.</td>
</tr>
<tr>
<td>St George’s Hospital Respiratory Questionnaire (SGRQ)</td>
<td>76</td>
<td>10-15</td>
<td>Instruments show repeatability in asthma and COPD patients. Significantly correlated with pulmonary function, MRC dyspnoea grade, and SIP scores. Has been translated into Italian.</td>
<td></td>
</tr>
</tbody>
</table>

COPD: chronic obstructive pulmonary disease.
the programme can be expected to provide quantifiable benefits, and to offer the patient a realistic description of the likely benefits and limitations of the programme.

In general, the following criteria can be formulated for participation in in-patient programmes: 1) need for an integrated 24 h supervised monitoring management plan, including training, teaching of coping skills and other aspects of daily life functioning; 2) post-intensive care patients before and after thoracic surgical procedures, including lung transplant patients; 3) post-intensive care patients either with disabling respiratory problems or with weaning failure after acute respiratory support; 6) identification and assessment of patients for long-term oxygen therapy or long-term home mechanical ventilation; and 7) logistic aspects, when out-patient rehabilitation is not available and the travelling distance does not allow the patient to participate in intensive rehabilitation.

Staffing of in-patient pulmonary rehabilitation programmes

The staffing and structure of a pulmonary rehabilitation programme can vary tremendously. The members of the team must be experienced in the broad spectrum of impairments and handicaps related to chronic respiratory failure. Rehabilitation is more than a process demonstrating the impulse of people of goodwill to make other people whole. Interest, enthusiasm, experience and knowledge of each member of the team should be considered as the key elements for successful rehabilitation. A pulmonary physician should undertake the role of medical director, which includes medicolegal responsibility for patient care during rehabilitation. The medical director is responsible for all aspects of programme design, accurate assessment of suitability of patients for inclusion, appropriate programme prescription for the individual patient, quality control of programme administration by staff, and ensuring continuity of care between the programme and the general practice.

The physiotherapist plays a central role: exercise conditioning and training of respiratory and skeletal muscles form a core activity in every programme. Applied exercise physiology and understanding of the physiological aspects of exercise limitation in patients with chronic respiratory impairment are a prerequisite for every physiotherapist. Depending on the intensity of the physiotherapeutic programme, the physiotherapist often functions as programme manager during the rehabilitation process.

Patients with COPD must often endure many years of progressive and debilitating physical illness, and their survival with this disorder has profound psychosocial ramifications. Impairment in psychological, emotional, behavioural, neuropsychological and social functioning underlies the essential need for a psychologist in the multidisciplinary team.

Other participants in a pulmonary rehabilitation programme are the nutritionist or, at least, dietician, the respiratory nurse; the vocational or occupational therapist, and the social worker. Besides being a confidant for the patient and patient's family, the respiratory nurse functions as an educator and co-ordinator in most rehabilitation programmes.

Programme phases. It is possible to describe four phases in a rehabilitation programme.

1. Clinical. The first aim is to assess the patient clinically: history of the disease, tobacco habits, clinical status, etc. This stage includes a determination of the patient's level of motivation and his/her availability.

2. Assessment. This gives reference data for the final evaluation of the rehabilitation programme and allows an individualized approach in selecting the components of the programme.

3. Rehabilitation.

4. Follow-up. Regular laboratory evaluation is of great importance to ensure follow-up readjustment of treatment.
Out-patient programmes

The specific aim of these programmes are the following: 1) to alleviate dyspnoea; 2) to increase exercise tolerance; 3) to educate patients; 4) to improve quality of life; and 5) to ensure a long-term commitment to regular physical activity. Each of these programme components requires regular evaluation.

Selection criteria for out-patient programmes. Outpatients with symptomatic COPD should be considered for rehabilitation programmes if: 1) they are in a stable state of moderate to severe disease (i.e. if therapy has been optimally stabilized); 2) they are capable of maintaining an independent lifestyle; 3) they do not have major psychological problems; 4) they do not have extrapulmonary disease (congestive heart failure, metastatic cancer, etc.) [11, 79].

These criteria must be respected, out-patient rehabilitation programmes being frequently based on exercise training.

Programme phases. It is possible to describe four phases.

1. Clinical. The first aim is to assess the patient clinically; history of the disease, tobacco habits, clinical status, etc. However, this also includes determining the patient’s level of motivation and his or her availability, taking into consideration professional obligations, living arrangements, travelling distances, etc.

The second aim of this phase is to determine the best choice of activity for the patient, in order to get a long-term commitment to regular physical activity [80]. This choice should be based on: 1) pathophysiological bases (activities at a work rate inducing substantial lactic acidosis are preferable) [81]; 2) patient preference (the physical activity must be enjoyable); and 3) the quality of exercise environment.

2. Assessment. This gives reference data for the final evaluation of the training programme and allows an individualized approach to training, since it is during this phase that the training intensity will be defined from the patient’s physical potential.

The intensity of exercise is usually defined on the basis of relative-percentage heart rate, which is beneficial in normal subjects and in patients with coronary artery disease. This concept is probably irrelevant for respiratory patients because they are limited by ventilatory, not cardiovascular, function [82]. For this reason, the heart rate recorded at the anaerobic threshold [83] may be a better basis for prescribing activity for respiratory patients.

Unfortunately, exercise tests that measure the anaerobic threshold require expensive equipment, which many rehabilitation centres do not have. Using the dyspnoea threshold (DT) to individualize the exercise intensity in terms of heart rate in respiratory patients is the preferred alternative because of the close relationship between these two thresholds [84]. However, when DT determination is not possible, the 60% of the heart rate reserve (HRmax - HRest) can be used if HRmax is measured during exercise, as the anaerobic threshold in most cases corresponds to this percentage.

The different tests to administer during this phase are covered in the “outcome” section.

3. Rehabilitation. The duration of rehabilitation programmes is usually 8 weeks, with three sessions per week of 2.5 h, divided approximately into: 30 min of health education; 45 min of exercise training inside the centre, 30 min of physical therapy and relaxation; and 45 min of gymnastics and/or outdoor exercise training.

The principal aim of health education is to optimize the patient’s compliance with his or her treatment: for example, to ensure a long-term commitment to regular physical activity. Therefore, the patient has to understand his or her disease, therapeutics, etc. Such an aim can be reached by educating patients about lung anatomy and physiology, disease process, the role of physical activity, and therapeutic modalities [85].

The first aim of exercise training is to ensure that the exercise intensities determined in the laboratory are used during actual training. Exercise intensity can be monitored with a cardiofrequency meter, in order to verify that the correct target heart rate (±5 beats·min⁻¹) is being followed, by using programmed alarms.

Concerning the practical aspects, two points should be emphasized. Indoor training, on a bicycle or a treadmill, is usually considered. However, it is important to propose to the patient that he or she do other activities, especially outdoors, such as walking. Indeed, outdoor activities are usually more enjoyable, and the more enjoyable the activity, the better should be the compliance. The second point is that repeated periods of exercise are preferable to a single long period for the same duration of stimulation, at least during indoor training. Indeed, a high level of motivation is well-maintained by the first option [80].

4. Training follow-up. Regular laboratory evaluation is of great importance to ensure follow-up readjustment of training intensity, and to discuss improvements with the patients in order to reinforce their motivation.

Perhaps the most important goal of rehabilitation programmes is to introduce the respiratory patient to a new lifestyle, which includes regular physical activity. Indeed, there is a strong need to develop and implement exercise maintenance programmes that can be followed at home and maintained for the whole of the patient’s residual life. Ideally, these home programmes would be regularly followed.

Home care and rehabilitation

Home care can be defined as any supportive or therapeutic measure provided in the home setting by health care professionals: physicians, nurses, respiratory-, occupational-, speech-, and physiotherapists, social workers, nutritionists, psychiatric services, and personnel of medical equipment manufacturers.

The aim of home respiratory care is to provide the best possible lifestyle for the individual at considerable savings in costs. A well-structured home care programme can assure the treatment of the patient with most of the therapeutic modalities available in the hospital setting. It will allow continued education and a postdischarge
follow-up. The home care team is best supervised by a pulmonologist with the help of a general practitioner, and includes trained personnel combining duties of nurse, physiotherapist and social worker in this area [86].

The extent of home care and therapeutic modalities used depends on the structure of the home care programme [87–90].

**Primary tasks of "home care" rehabilitation.** Home care after successful in-patient or during out-patient rehabilitation should take the following aspects into account: 1) Support of the patient in the adjustment of recommended therapeutic measures (especially technical support devices or changes in the housing environment) to the individual housing and social situation of the patient (e.g. placement and use of oxygen generators, tubing, oxygen conservation devices, nebulizers, home ventilator systems. Reduction of allergen impact, i.e. plants, animals, and house mites).

2) Support of the patient and his/her family in maintenance of technical devices and troubleshooting in case of dysfunction (e.g. assembly and changing of filters, cleaning of nebulizers and tubing).

3) Involvement and training of relatives, friends and neighbours in supportive measures to promote independence of the patient from third-party services and to strengthen social contacts (e.g. connection and disconnection of oxygen or home ventilator tubing, help with bronchial drainage or suction).

4) Reinforcement of patient adherence to therapeutic regimens and intervention in the case of deteriorating compliance (e.g. checking adequate inhaler use and in-time renewal of prescriptions; checking running time indicators on continuous positive airway pressure (CPAP) devices, home ventilators, oxygen concentrators).

5) Intervention during episodes of acute exacerbations of the underlying pulmonary disease process (e.g. in-time contact with the primary care physician in the case of asthma deterioration, to increase medication).

6) Maintenance and further development of skills and functional improvements gained during the rehabilitation process (e.g. training in "activities of daily living" in the home environment).

7) Assessment of success of measures prescribed and functional capabilities of the patient after adequate time intervals (i.e. 3–6 months), and feedback to institutions involved during the preceding or the ongoing rehabilitation process (e.g. feedback on oxygen use, smoking cessation, medication compliance; report on mobility, functional level of independence under home conditions, etc).

**Patients eligible for respiratory home care.** Typical candidates with respiratory diseases would be [1, 14, 86]: 1) newly diagnosed and first-time hospitalized patients with handicaps not eligible for rehabilitation programmes after discharge from acute care hospitals; 2) patients discharged with new respiratory equipment; 3) patients with recurrent exacerbations and repeated hospitalizations (to prevent reoccurrence); 4) patients with ongoing exacerbation treated by the physician at home [91]; 5) anxious, confused, forgetful patients; 6) patients after formal in-patient or out-patient rehabilitation programmes (for follow-up); and 7) end-stage terminal patients who want to stay at home.

**Circumstances justifying home rehabilitation.** Rehabilitation of a mobile patient in his/her house due to lack of adequate facilities (in-patient and out-patient programmes) may be necessary in developing countries or remote areas with lack of transport opportunities.

Additional handicaps or diseases of the patient (mental disorders, dependence on technical or social supportive measures only available in the personal housing situation) may make a patient unsuitable for institutionalized rehabilitation.

**Therapeutic measures in "home care".** In general, therapeutic measures used in acute care and institutionalized rehabilitation programmes as well as methods of post-discharge follow-up will be used in "home care", if they are needed to prevent deterioration.

**Technical supportive devices.** 1) long-term oxygen therapy (LTOT), including oxygen conservation devices; 2) nebulizers; 3) CPAP; and 4) intermittent controlled nasal/oral/tracheal ventilation.

**Personal support:** 1) home visits by physician; 2) respiatory-, occupational-, speech-, physiotherapy; 3) Nutritional support or counselling; 4) technical support and maintenance; and 5) social and psychiatric counselling.

**Advantages and disadvantages of "home care".** The main advantage of "home care" lies in the fact that the patient is treated in his personal environment [92, 93]; consequently, adjustments needed due to the housing situation can be made promptly on the basis of personal observation by the health care professional.

It is mandatory to define the duration of home care treatment (short, mid-, long-term) and the frequency of home visits, according to the needs of the patient and the characteristics of home treatment.

Compared to in-patient treatment, home mechanical ventilation after successful training of the patient during rehabilitation is cost-effective [94–96]. Controlled studies to compare costs or outcome between "home care" and formalized rehabilitation programmes in patients with respiratory diseases have not been carried out.

Disadvantages arise from several aspects: 1) individual treatment at home is “man power consuming” and, thereby, cost-intense; 2) The accepted standard procedure of treatment by a whole "rehabilitation team", consisting of experts for the different medical, social, educational and vocational aspects of rehabilitation, is unlikely to be achieved in all settings; and 3) exchange of opinions and experiences with fellow patients, social contacts, and the accessibility of a wider range of means for education, training and treatment of the patient are limited.

In pulmonary patients, "home care" in the setting of rehabilitation is more an adjunct measure during outpatient programmes or after in-patient programmes for "fine tuning and outcome observation" than an appropriate substitute to formalized rehabilitation programmes [97].

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References


Acknowledgements: M.A.M. Schlösser, P.J.J. Janssen, R. Mostert and A.M.W.J. Schols co-operated in the preparation of the section on "Components of the rehabilitation programme".


