Pulmonary rehabilitation

Martijn A. Spruit[1,2]

Affiliations: [1]Dept of Research and Education, CIRO+, Center of Expertise for Chronic Organ Failure, Horn, The Netherlands. [2]REVAL - Rehabilitation Research Center, BIOMED - Biomedical Research Institute, Faculty of Medicine and Life Sciences, Hasselt University, Diepenbeek, Belgium.

Correspondence: M.A. Spruit, Dept of Research and Education, CIRO+, Center of Expertise for Chronic Organ Failure, Hornerheide 1, 6085 NM Horn, the Netherlands. E-mail: martijnspruit@ciro-horn.nl

ABSTRACT Pulmonary rehabilitation is a comprehensive intervention designed to improve the physical and psychological condition of people with chronic respiratory disease and promote the long-term adherence to health-enhancing behaviours. During the 2013 European Respiratory Society Annual Congress in Barcelona, Spain, a Clinical Year in Review session was held focusing on the latest developments in pulmonary rehabilitation. This review summarises some of the main findings of peer-reviewed articles focusing on pulmonary rehabilitation that were published in the 12 months prior to the 2013 Annual Congress.

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Pulmonary rehabilitation is an important part of the integrated care of patients with chronic respiratory diseases http://ow.ly/rAr82

Introduction

Pulmonary rehabilitation is a comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies that include, but are not limited to, exercise training, education and behaviour change, which are designed to improve the physical and psychological condition of people with chronic respiratory disease and promote the long-term adherence to health-enhancing behaviours [1]. It is acknowledged as a core component of the integrated care of people with chronic respiratory disease [2]. During the 12 months prior to the European Respiratory Society Annual Congress 2013 in Barcelona, Spain, numerous new and clinically relevant peer-reviewed English language articles related to the research field of pulmonary rehabilitation were published [3–30]. This review summarises some of the main findings.

Physical activity and pulmonary rehabilitation

Patients with chronic obstructive pulmonary disease (COPD) are physically less active compared to their peers [31, 32], resulting in a loss of lower limb muscle mass and muscle function [33–36]. Indeed, approximately 40% of patients with COPD do not achieve the recommended quantity and/or quality of physical activity [37–39]. This strengthens the rationale for exercise-based pulmonary rehabilitation programmes in patients with COPD [40]. Donaire-Gonzalez *et al.* [37] were the first to point out that patients with severe and very severe COPD perform physical activities in fewer and shorter bouts than those with mild and moderate airflow limitation. These findings provide the first insight into physical activity patterns during the day in patients with COPD, which can be of great value for occupational therapists during pulmonary rehabilitation. Obviously, validated activity monitors need to be used to assess the impact of pulmonary rehabilitation on physical activity in patients with COPD [19, 41]. In the future, we need to optimise pulmonary rehabilitation components to influence meaningful and sustainable behaviour change [1]. This includes further developing strategies and ways to translate gains in exercise capacity into increased physical activity. Egan *et al.* [42] showed that short-term and long-term improvements in exercise

Received: Nov 05 2013 | Accepted: Nov 21 2013

Conflict of interest: None declared.

Provenance: Submitted article, peer reviewed.

capacity did not transfer into increased daily physical activity in patients with COPD, confirming previous findings [43]. Perhaps we also need to focus on behavioural and environmental factors. Indeed, health benefits, enjoyment, continuation of an active lifestyle and functional reasons have been identified by patients with COPD as the main reasons to be physically active; while the weather, health problems, and lack of intrinsic motivation were reasons to be sedentary [44].

Comorbidities and pulmonary rehabilitation

Various authors have reported positive effects of pulmonary rehabilitation on functional exercise performance and/or disease-specific health status in COPD patients with and without self-reported comorbidities at baseline [45, 46]. These authors also confirmed previous observations that comorbidities are present in about 50–60% of the patients with COPD entering pulmonary rehabilitation [47, 48]. Again, self-reported comorbidities were used for analyses [45–48], most probably causing an underestimation of the true prevalence of comorbidities. Indeed, VANFLETEREN *et al.* [49] reported a prevalence of one or more comorbidities based on validated objective measurements in 97% of the patients with COPD entering pulmonary rehabilitation. These authors were also the first to report the presence of five clusters of comorbidities in patients with COPD entering pulmonary rehabilitation: less comorbidity, cardiovascular, cachectic, metabolic, and psychological [49]. Interestingly, the degree of airflow limitation, the functional exercise performance and most biomarkers of systemic inflammation were comparable between clusters. Thus, comorbidities need to be objectified during the initial assessment of pulmonary rehabilitation. To date, it remains unknown whether and to what extent clusters of comorbidities affect the response to pulmonary rehabilitation in patients with COPD or even the minimal important difference. Moreover, future studies may want to consider choosing innovative/explanatory outcomes in addition to the more conventional outcomes, such as exercise performance and health status. For example, OLIVEIRA *et al.* [50] showed that dyspnoeic, non-hypercapnic patients with COPD and well-established chronic heart failure with reduced left ventricular ejection fraction (<40%) have impaired cerebral oxygenation during progressive exercise compared to their COPD peers without chronic heart failure. As the coexistence of COPD and chronic heart failure is highly prevalent in patients admitted to the hospital or entering pulmonary rehabilitation [51–53], these findings warrant further research.

MCNAMARA *et al.* [7] hypothesised that land-based exercise training may exacerbate existing physical comorbidities. Therefore, a randomised controlled trial was designed to compare the effects of water-based exercise training with those of land-based exercise training or a usual care control group in COPD patients with physical comorbidities, including musculoskeletal conditions, peripheral vascular disease, neurological conditions, or obesity with a body mass index $\geqslant 32\ \text{kg}\cdot\text{m}^{-2}$ [7]. Water-based exercise training was significantly more effective than land-based exercise training and the non-exercising control group in improving incremental and endurance shuttle walk distances, and improving aspects of quality of life in patients with COPD with physical comorbidities [7]. These data suggest that water-based training may be more beneficial for patients with COPD and physical comorbidities compared to land-based exercise training. However, baseline values of the exercise tests were dissimilar, and the water-based group trained at significantly higher mean dyspnoea and exertion scores compared to the land-based group. This may partially explain the observed differences. Finally, diagnosis of the physical comorbidity was based on medical referral, patient history and physical examination, which may have underestimated the true prevalence of comorbidities. Therefore, additional studies are warranted on the effects of water-based training in patients with COPD and musculoskeletal comorbidities.

Referral, attendance and adherence to pulmonary rehabilitation

Pulmonary rehabilitation during and directly following hospitalisation because of a COPD exacerbation has shown to be very beneficial and cost-effective for patients with COPD [54–56]. Nevertheless, poor referral and uptake rates for early outpatient pulmonary rehabilitation programmes following hospitalisation for COPD exacerbations occur throughout the world [57–60]. This may, at least in part, be due to a combination of barriers for patients and/or referring physicians, such as: low knowledge of pulmonary rehabilitation for patients with COPD; low knowledge of how to refer patients with COPD to pulmonary rehabilitation programmes; actual or anticipated access difficulties for patients with COPD; and physicians questioning the need to do more to promote exercise behaviour change in patients with COPD [58, 60].

The use of long-term oxygen therapy and living alone have been identified as independent predictors of poor attendance in patients with stable COPD, whereas current smoking, poor shuttle walk distance and hospitalisation are independent predictors of poor adherence to pulmonary rehabilitation [61]. Thus, future international policy statements should be developed to increase patient access to pulmonary rehabilitation, increase the capacity of pulmonary rehabilitation programmes, increase availability and amount of payer funding, and enhance knowledge and awareness of pulmonary rehabilitation among patients with chronic

DOI: 10.1183/09059180.00008013

respiratory disease, healthcare providers and payers. Moreover, we need to define phenotypes to identify responders and nonresponders to pulmonary rehabilitation to optimise the impact of pulmonary rehabilitation [62].

New exercise training modalities and pulmonary rehabilitation

Supervised exercise training is the cornerstone of pulmonary rehabilitation programmes in order to increase exercise performance [1, 63]. Nevertheless, new types of exercise training have been studied in patients with COPD, including high-intensity knee extensor training, T'ai chi, non-linear exercise training and neuromuscular electrical stimulation (NMES).

High-intensity knee extensor training

Most patients with COPD experience a ventilatory limitation during the performance of whole-body endurance exercise training [64]. Training of specific, smaller, lower limb muscle groups will reduce the ventilatory load [64–66] and, in turn, may increase training load and muscle adaptations [11]. BRØNSTAD *et al.* [12] studied the effects of 6 weeks of high-intensity interval aerobic knee extensor exercise training (three times per week) on muscle oxygen uptake and mitochondrial respiration of the vastus lateralis muscle in subjects with COPD. Peak power and maximal mitochondrial respiration in vastus lateralis muscle were restored, and were similar to those of healthy elderly control subjects [12]. Thus, local muscle training seems a valuable exercise training strategy in reversing muscle dysfunction in patients with COPD. However, the sample size of BRØNSTAD *et al.* [12] was rather low (n=7) and, in turn, needs corroboration.

T'ai chi

T'ai chi is a traditional Chinese form of conditioning exercise derived from martial arts. When practised correctly, T'ai chi is thought to strengthen the body's vital energy and enhance the passage of this energy throughout the body to confer its health promoting effects [67]. T'ai chi is very popular in healthy and diseased subjects as it may improve physical and emotional functioning [68–75]. In a randomised controlled trial, LEUNG *et al.* [8] compared the effects of Sun-style T'ai chi, which is well known for its smooth flowing movements [76], with usual care in 42 patients with COPD. A twice weekly, supervised Sun-style T'ai chi training regimen in combination with an unsupervised, home-based T'ai chi training programme (including a T'ai chi training booklet and DVD) on the remaining 5 days a week (30 min per day) for a total duration of 12 weeks improved quadriceps muscle strength, balance, incremental and endurance shuttle walk test, health status and mood status compared to the usual care control group [8]. Indeed, the minimal important differences for health status and functional exercise performance were exceeded following T'ai chi [77–79]. This may, at least in part, be due to the relatively high metabolic load during T'ai chi. Indeed, patients with COPD used ~63% of their peak aerobic capacity during a session of Sun-style T'ai chi, which is similar to the mean oxygen uptake during a session of lower limb resistance training [64, 65]. Recently, other forms of T'ai chi have also appeared to be beneficial for patients with COPD [80–82]. Therefore, T'ai chi may even be considered as a long-term maintenance training strategy, due to the fact it can be performed by patients in their home setting.

Non-linear periodised exercise training

Most conventional exercise training programmes that form part of pulmonary rehabilitation use non-varied, linear progressive protocols [83–87]. In contrast, athletes frequently vary exercise training variables (*e.g.* volume, intensity and number of repetitions) to maximise physical performance by avoiding training plateaus [88]. Indeed, the energy systems used during treadmill walking, stationary cycling or resistance training are matched to optimise the physiological adaptation. Until recently, a comparison between conventional linear exercise training and non-linear periodised exercise training had not been performed in patients with COPD. Nevertheless, KLIJN *et al.* [89] compared a 10-week conventional exercise training programme (*i.e.* resistance training and endurance training three times per week) with non-linear periodised exercise training in patients with very severe COPD. Non-linear exercise training was safe and improved the cycle endurance time to a greater extent compared to conventional exercise training in COPD patients with and without a normal baseline fat-free mass index. A similar pattern was found for the changes in health status. However, these patients also received other non-exercising interventions, which may have influenced these results to some extent. Therefore, non-linear exercise training seems beneficial for patients with very severe COPD. Whether and to what extent gains in exercise capacity will also translate into improved activities of daily life remains unknown. Moreover, long-term effects were not studied. The current findings do, however, emphasise that conventional exercise training schedules may not be optimal for patients with COPD.

Neuromuscular electrical stimulation

NMES involves the application of an electrical current through electrodes placed on the skin over the targeted muscles, thereby depolarising motor neurons and, in turn, inducing skeletal muscle contractions [90]. NMES does not evoke dyspnoea in patients with very severe COPD [66]. Therefore, NMES may be of clinical interest to patients with COPD who are admitted to the hospital with an exacerbation. Indeed, patients with COPD are physically less active during a hospital admission [91, 92] and, in turn, experience a further decline is quadriceps muscle function [93]. GIAVEDONI *et al.* [94] presented some pilot data on the feasibility, safety and efficacy of 14 sessions of high-frequency NMES during a COPD exacerbation. NMES was safe, well-tolerated and improved quadriceps muscle strength compared to the nonstimulated control leg [94]. In another pilot study, CHAPLIN *et al.* [95] compared effects of high-frequency NMES (50 Hz) with low-frequency NMES (35 Hz) in patients with COPD admitted to hospital with an exacerbation. Isometric quadriceps muscle strength increased in both groups, while the endurance shuttle walk distance tended to improve significantly compared to baseline. Both studies support previous findings that NMES is effective in counteracting quadriceps muscle dysfunction [96]. To date, the use of NMES in daily clinical practice seems rather limited [97]. This may partly be due to the fact that the optimal NMES frequency remains currently unknown in patients with COPD. Nevertheless, based on the currently available evidence [1, 90], NMES should be considered for use in early rehabilitation of patients with COPD admitted to the hospital [1].

Pulmonary rehabilitation in chronic respiratory disease other than COPD

Most pulmonary rehabilitation programmes enrol patients with COPD [97]. In addition, patients with other types of chronic respiratory disease are considered for comprehensive pulmonary rehabilitation programmes, as these patients also seem to benefit [1, 98, 99]. Indeed, patients with chronic respiratory disease other than COPD also suffer from daily symptoms, muscle weakness, exercise intolerance, impaired mood status, poor quality of life and physical inactivity, despite optimal medical treatment [100–106]. Most of the new studies confirm the positive effects of exercise-based pulmonary rehabilitation in patients with nonsmall cell lung cancer (pre-/post-lung resection) [107–117], chronic respiratory failure due to kyphoscoliosis [118], pre-/post-lung transplantation [119–122], cystic fibrosis [123], bronchiectasis [124], severe respiratory failure receiving extracorporeal membrane oxygenation [125, 126], interstitial lung disease [6, 127–129], and pulmonary arterial hypertension [130–132]. Existing COPD pulmonary rehabilitation programmes can be adapted to the particular needs of patients with chronic respiratory disease other than COPD, in particular the non-exercising parts [30]. Unfortunately, the referral rates for pulmonary rehabilitation for these patients are still poor due to various barriers [133]. For example, NWOSU *et al.* [134] identified a lack of knowledge of services or referral mechanisms, waiting lists, inadequate rehabilitation services, and the perception that patients do not want rehabilitation as the main barriers for referral of lung cancer patients to pulmonary rehabilitation. Further research in this field is necessary [135].

Novel targets/outcomes in pulmonary rehabilitation

Quality of life, 6-min walk test and dyspnoea have been identified as the three most important outcomes of pulmonary rehabilitation [97]. Nevertheless, several other outcomes have been used to evaluate the efficacy of pulmonary rehabilitation [1], including health transitions, advance care planning and balance.

Health transitions

HALDING *et al.* [136] used qualitative outcomes to evaluate the effects of pulmonary rehabilitation in patients with COPD. Using interviews, 18 patients with COPD reported that participation in pulmonary rehabilitation was perceived as a time of increasing awareness of opportunities for health and well-being with strengthened hope [136]. Thus, pulmonary rehabilitation promotes significant behavioural changes towards health promotion [137].

Indeed, patients undergoing pulmonary rehabilitation experience a complex health behaviour change process [138]. Healthcare professionals need to guide patients through this process by applying an autonomy supportive counselling style, teaching and training self-management skills, and by providing patient-tailored advice [138].

Advance care planning

Advance care planning is the process whereby patients, in consultation with healthcare professionals, family members and significant others, make individual decisions about their future healthcare, should they become incapable of participating in medical treatment decisions [139]. Advance care planning, taking into account the burden of treatment, outcome of treatment and likelihood of outcome, has an important role in patients with severe to very severe chronic respiratory disease [140, 141]. However, physicians rarely discuss prognosis, dying and palliative care [141]; thus, the quality of patient–physician end-of-life care

DOI: 10.1183/09059180.00008013

communication needs to improve. Inclusion of an advance care planning information session in pulmonary rehabilitation and/or maintenance programmes could support a practical solution. BURGE *et al.* [142] studied the introduction of a structured group advance care planning information session from the perspective of participants in pulmonary rehabilitation and maintenance programmes. Only 24% of the patients had previously heard of advance care planning. Most patients appreciated the advance care planning information session and thought pulmonary rehabilitation was an appropriate setting. Therefore, inclusion of advance care planning education into existing pulmonary rehabilitation and maintenance programmes for people with chronic respiratory disease should be contemplated [29].

Balance

Patients with COPD may suffer from a disturbed balance [143] and, in turn, a higher susceptibility to falling [144, 145]. LEUNG *et al.* [8] reported increased balance in patients with COPD following 12 weeks of T'ai chi compared to a non-exercising control group. BEAUCHAMP *et al.* [146] randomly assigned patients with COPD to pulmonary rehabilitation with or without specific balance training, consisting of exercises focusing on stance, transitions, gait, and functional strength. Scores on the Berg Balance Scale and the Balance Evaluation Systems Test improved significantly compared to the control group, while the Activities-Specific Balance Confidence scale did not show group differences [146]. Therefore, balance training as part of pulmonary rehabilitation seems feasible and effective in patients with COPD. Nevertheless, future studies need to assess the long-term effects of balance training on the risk of falling and fractures. Moreover, the optimal outcome to assess balance remains to be determined, as postural control and fear of falling can be assessed using various outcomes and tools [147]. The Berg Balance Scale, the Short Physical Performance Battery, and the Activities-Specific Balance Confidence scale are the most frequently used instruments to assess postural control and fear of falling [147]. Nevertheless, subtle gait changes that have previously been related to fall risk are not always captured by these subjective assessments. Therefore, accelerometry based gait analysis should be considered as an additional objective approach to screen patients with COPD at risk for falling [148].

Conclusion

Between September 2012 and September 2013, numerous peer-reviewed studies have been published focusing on the multiple aspects related to pulmonary rehabilitation. Most of these studies confirm the clinical importance of pulmonary rehabilitation as part of the integrated care of patients with chronic respiratory diseases.

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DOI: 10.1183/09059180.00008013

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